Biodiversity Conservation Alliance

Working to Protect Native Species and Their Habitats

P O Box I5 12. Laramie, WY 82073 (307) 742-7978 fax 742-7989

October 19, 2006

Linda Slone
Casper RMP/EIS
BLM Casper Field Office
2987 Prospector Drive
Casper, WY 82604-2968

Comments of Biodiversity Conservation Alliance et al. on the Casper RMP Draft EIS

Dear Ms. Slone:

The following are the comments of Biodiversity Conservation Alliance, The Wilderness Society, Wyoming Wilderness Association, World Wildlife Fund, Californians for Western Wilderness, Sagebrush Sea Campaign, and Natural Resources Defense Council (hereinafter, "BCA") on Draft Environmental Impact Statement ("Draft EIS" or "DEIS") for the BLM's revision of its Casper Management Plan ("Casper RMP" or "RMP"). Please consider these comments in detail and respond to them prior to reaching a Decision on this long-term management plan.

Of the available alternatives, Alternative B comes closest to providing the balance of resource uses and conservation that will be ecologically sustainable over the long haul. Of particular note we support the commitment not to lease large blocks of contiguous habitat in the northwest part of the planning area (including the South Fork of the Powder citizens' proposed wilderness), the more generous ACEC designations, and the stronger wildlife protections under this alternative. The seasonal restrictions for sensitive habitats (big game crucial ranges, areas within *3* miles of sage grouse leks, within 1-2 miles of raptor nests, etc.) relied upon by the various alternatives still have never been tested by BLM for effectiveness; N SO is the appropriate prescription for these habitats.

Under the Federal Lands Planning and Management Act ("FLPMA"), the BLM must manage the public lands and resources for multiple use objectives. According to this mandate,

> The term "multiple use" means the management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; the use of some of the land for less than all of the resources; a combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and non-renewable resources, including, but not limited to, recreation, range, timber, minerals, watershed, wildlife and fish, and natural scenic, scientific and historical values; 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

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> resources and not necessarily to the combination of uses that will give the greatest economic output or the greatest unit output.

43 C.F.R. § 1702(c). BLM's general land-use planning mandate flows directly from its multiple use mission:

> The BLM's mission is to sustain the health, diversity, and productivity of the public lands for the use and enjoyment of present and future generations. Land use plan decisions will further this mission by identifying desired outcomes and actions that restore and maintain the health of the land; preserve natural and cultural heritage; reduce threats to public health, safety, and property; and provide opportunities for environmentally responsible recreational and commercial activities.

BLM Manual § 1601.6(A)(2). The National Environmental Policy Act ("NEPA") regulations state,

> Federal agencies shall, to the fullest extent possible...use all practicable means, consistent with the requirements of the Act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment.

40 C.F.R.§ 1500.2(f). By definition, "To the fullest extent possible means...unless existing law applicable to the agency's operations expressly prohibits or makes compliaces impossible." 40 C.F.R. § 1500.6. Only Alternative B among the alternatives in the Casper RMP DEIS appears to conform to the aforementioned mandates.

Overall, the environmental impacts analysis in the Casper RMP DEIS is sorely lacking, particularly for wildlife species. For instance, how many acres of BLM-administered surface or subsurface are crucial big game winter range, and how many of these acres would be available for oil and gas leasing and other industrial uses, and under what protective restrictions, under each alternative? How much acreage of federal surface and subsurface is within 3 miles of an active or inactive sage grouse lek, and how many of these acres would be available for oil and gas leasing and other industrial uses, and under what protective restrictions, under each alternative? How much acreage of federal surface and subsurface is in active prairie dog colonies, and how many of these acres would be available for oil and gas leasing and other industrial uses, and under what protective restrictions, under each alternative? How much acreage of federal surface and subsurface is within 1 mile of a raptor nest, and how many of these acres would be available for oil and gas leasing and other industrial uses, and under what protective restrictions, under each alternative? How much acreage of federal surface and subsurface is in mountain plover nesting concentration areas, and how many of these acres would be available for oil and gas leasing and other industrial uses, and under what protective restrictions, under each alternative? For each species of BLM Sensitive, Threatened or Endangered, or other wildlife that is likely to be impacted by activities authorized under this plan, these questions must be evaluated and answered in a comprehensive way. As it currently stqands, there is so little impacts analysis in the Casper RMP DEIS that it cannot possibly meet NEPA's 'hard look' requirements.

A LONG-TERM PLAN WITH A GREATER EMPHASIS ON CONSERVATION AND MORE INTENSIVE MANAGEMENT OF OIL AND GAS DEVELOPMENT IS NEEDED

The Preferred Alternative allows oil and gas development to continue in more or less the same unrestricted fashion as it has during the past decade, a period during which the impacts of oil and gas

production have metastasized, and during which open spaces throughout Wyoming have shrunk, sensitive species have declined, and wild places have been converted into industrial landscapes. The status quo is not acceptable. This is why there is an overwhelming public outcry for less drilling and more conservation. lnstead of continuing to bumble blindly down the garden path to destruction, the BLM should use the opportunity presented by the planning process to step back and take stock of the current state of affairs and long-term trend of accelerating degradation, and implement serious and far-sighted reforms. Oil and gas development need not be a rogue use of the land, incompatible with other multiple uses. The technology is available today to radically reduce the impacts of oil and gas development, to exploit reservoirs under sensitive habitats without ever disturbing the lands on the surface, and therefore to produce the burgeoning mineral resources beneath the public lands of the Casper Field Office while protecting sensitive lands that deserve to be left alone. In these comments, we provide the blueprint for using these advanced technologies to balance oil and gas extraction with the need for responsible land stewardship. and we urge the BLM to adopt our recommendations in full.

Whenever oil and gas development is pursued under the new RMP, it should employ available technologies in a way that minimizes damage to the environment. In areas where surface disturbance from drilling is appropriate (i.e., outside areas recommended for No Surface Occupancy, or "NSO" stipulations or withdrawal from leasing), directional drilling and other technologies should be employed in every case where they reduce the environmental impacts over conventional methods. Because clustering wells on a few isolated pads for full-field development or drilling horizontally from existing wellpads in infill situations results in a radical decrease in road, wellpad, and pipeline construction, directional drilling is likely to become the standard drilling procedure under this Alternative.

In addition, pitless drilling permits smaller well pads and eliminating toxic reserve pits filled with toxic chemicals. In cases where this and other state-of-the-art technology reduces the overall environmental impacts, it should be required under the RMP.

Finally, for areas where surface disturbance is permissible, drilling activities should occur in a staged manner, allowing landscapes impacted by wellfields to heal at the same rate as new landscapes are gobbled up. While staged development would at first appear to be a difficult program to implement, we have devised a simple method to facilitate this process. The BLM should first identify all parcels of 3,000 acres or more that are free of "roads" as defined under BLM Handbook H-6310-1, regardless of the presence or absence of wilderness qualities. This alternative would require a "No Net Loss" policy to be instituted for these qualified roadless areas, so that new roadless areas could not be entered for the purpose of roadbuilding and oil and gas development until a similar acreage already impacted was restored to "roadless" status.

Wildlife

One of our primary concerns about land and resource management under the Casper RMP is the health of wildlife and ecosystems under the new plan. We are concerned that oil and gas development in Wyoming is being allowed to proceed in the absence of adequate safeguards to protect wildlife and maintain healthy ecosystems. Tangible evidence of this is the mule deer population declines on the Pinedale Anticline (Sawyer et al. 2005a) and the sage grouse declines in the Pinedale Anticline and Jonah Fields (Holloran 2005) and in the Powder River Basin CBM fields (Naugle 2006a,b). Clearly, stronger measures are needed than the standard mitigation measures that have been used by BLM for mitigation in sensitive wildlife habitats in recent years.

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Wildlife and fishes are explicitly listed as multiple uses for which the BLM must manage its lands under FLPMA. 43 C.F.R. § 1702(c). In addition, for priority populations, species, or habitats of fish and wildlife, BLM must take the following actions:

> Identify actions and areawide use restrictions needed to achieve desired population and habitat conditions while maintaining a thriving natural ecological balance and multiple-use relationships.

BLM Land Use Planning Handbook H-1601-1, Appendix C at 7.

Of the current slate of alternatives in the Casper RMP DEIS, only Alternative B has any chance to maintain "a thriving natural ecological balance" and "multiple-use relationships." In fact, each of the other alternatives seems designed to result in the demise of numerous populations of sensitive species, long-term reductions in big game populations, and an overall degradation in ecosystem health across vast swaths of the planning area to the point that ecological function is no longer maintained even at a basic level. In addition, multiple use under the four alternatives seems destined to be replaced with the single use of oil and gas development over immense stretches of the planning area, to the exclusion of most other uses of the land.

For most wildlife species, substantially stronger mitigation measures than those provided in any of the alternatives are needed to ensure the viability of populations within the planning area. The Casper RMP should provide for properly functioning condition for all wildlife habitats, not just for riparian habitats as under the Healthy Rangelands provisions of the various alternatives. In addition, much more careful management is needed of oil and gas development to ensure that full-field development does not entail complete obliteration of wildlife habitat function for many species of wildlife, as it does for many if not most lands under current management and the alternatives presented in the DEIS.

Under Emerging Issues and Changed Circumstances (DEIS at 1-7), the BLM should list an emerging understanding of the impacts of oil and gas development on wildlife. Over the past several years, new studies have shown that roads in open country have a greater impact than previously suspected on elk (Sawyer et al. 2005b), oil and gas development can displace mule deer from crucial winter range and lead to major herd declines (Sawyer et al. 2005a), CBM development can contribute to major sage grouse declines and result in displacement of birds from important habitats (Naugle 2006a,b), and conventional gas development, even under current BLM mitigation policies adopted in the Casper RMP EIS, leads to displacement of sage grouse and significant declines (Holloran 2005). These last three studies demonstrate that the Wyoming Greater Sage-Grouse Conservation Plan (see DEIS at 1-6) is completely obsolete, and its recommendations, when followed, are likely to lead to sage grouse declines in the face of energy development.

According to BLM, "Alternative D allows the most surface disturbance of any alternative, potentially resulting in substantial adverse impacts to wildlife resources." DEIS at 4-132. Yet the Preferred Alternative has virtually the same amount of surface disturbance as Alternative D (61,274 acres versus 63,649 acres in Alternative D). DEIS at 4-101. Indeed, Alternatives A, C, D, and E are all within 5,000 acres of each other with regard to surface disturbance; Alternative B represents the only departure from this basic estimate at 36,650 acres of surface disturbance. This clustering of 4 of the 5 alternatives around this figure, together with other commonalities shared among 4 of the 5 alternatives, lead us to believe that BLM has not crafted a true range of reasonable alternatives pursuant to its NEPA obligations.

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Big Game

Under the Draft EIS, all alternatives appear to rely heavily on seasonal stipulations to "protect" big game crucial ranges. There is no alternative that would put these sensitive habitats off-limits to future surface disturbance. It is important to note that impacts to wintering big game are not limited to the construction phase of oil and gas development, but continue at a significant level throughout the production phase. Stipulations that limit only construction and drilling activities do little to prevent the long-term disturbance and displacement of big game from their crucial winter ranges and calving areas. Thus, these seasonal stipulations are inadequate to prevent major impacts to big game populations on their crucial winter ranges. Crucial habitat is defined as "the determining factor in a population's ability to maintain itself at a certain level" (WGFD 2000).

BLM's approach to big game crucial winter range appears to contradict itself. Under the Preferred Alternative, there are seasonal restrictions on construction and drilling in crucial habitats, but there would even be waivers available if a wildlife mitigation plan was in palce. DEIS at 4-128. Certainly, big game crucial winter range and calving areas qualify as seasonally sensitive habitats that deserve strong, not qualified, protections.

Based on our reading of the provisions of this alternative, only drilling and construction activities would be restricted during the sensitive time period. Site visits to wells by operators ("well tripping"), large truck traffic associated with condensate removal, and casual public vehicular use in crucial winter range during the sensitive season would in fact be allowed to continue. These activities certainly qualify as disruptive activities as far as big game behavior is concerned, and would inevitably result in disturbance to big game during the critical time periods.

The Sublette Mule Deer Study (Sawyer et al. 2005,2006 Attachments 1 and 2) offers an object lesson in how these types of disturbance result in big game avoidance of crucial winter range during the production phase of the wellfield in similar habitats where identical seasonal stipulations were in place. As a result of these internal inconsistencies, the BLM's Preferred Alternative impacts analysis on big game must be rejected as insufficient.

In the Red Desert, elk have been shown to avoid habitats within 0.6 mile of roads and wellsites in the winter, and within 1.2 miles of roads and wellsites in the summer (Powell 2003). It is important to note that this study considered wellfield developments in the production phase, not the construction and drilling phase, when seasonal stipulations as proposed under the Casper RMP might result in some positive benefit. If one considers 160-acre well spacing, with 0.6-mile buffers around each well, it is obvious that a standard 160-acre-spacing wellfield contains 0% land area that is farther than 0.6 mile from a well site. Thus, in a full-field development with 160-acre (standard) spacing, the entire wellfield would be an avoidance area for elk. These impacts have been demonstrated for mule deer in the Pinedale Anticline Project, where a monitoring study funded by industry has shown that the Pinedale Mesa crucial winter range became an avoidance area as winter habitat use shifted to areas previously avoided by deer, and the animals showed no evidence of acclimation to development post-drilling (Sawyer 2004).

In the Rawlins RMP Draft **EIS,** the BLM recognized that "Increased development and roads in crucial winter range compounds impacts to big game species by increasing public access to the winter range for road maintenance, condensate removal, pumpers (meter readers), recreation, potential poaching, and other factors." RRMP DEIS at 3-132. It is important to recognize that these impacts are not limited to crucial winter ranges and apply equally to all other big game habitats as well.

It is apparent that the Casper RMP DEIS provides no protective measures or mitigation related to maintaining the function of big game migration corridors, and mapped by the Wyoming Game and Fish Department. Big game migration can be interrupted by oil and gas development; this has been found in the Piney Front Elk Study (Lindzey 2005) and a study on pronghorn migration in the Upper Green River Valley (Berger 2006). BLM must disclose baseline information on the location and types of migration corridors in the Casper planning area, provide mitigation measures that prevent loss of function for these migration corridors, and take a "hard look" at the impacts of the various alternatives on these migration corridors. To date. the agency has failed to do so.

Bighorn Sheep

The Draft EIS does not appear to acknowledge the major issue that disease transmission from domestic sheep to wild bighorns poses to the Laramie Peak bighorn sheep herd. Ion the BLM's Rawlins RMP Draft EIS, the Preferred Alternative proposed to pasture domestic sheep at least 9 miles away from wild bighorn populations, to prevent disease transmission. This provision should be adopted for the Casper RMP as well.

BLM manages many of the lands adjacent to the Laramie Peak unit of the Medicine Bow National Forest. The Medicine Bow Forest Plan provides, in the Laramie Range, strong language requiring the separation of domestic sheep and wild bighorns in order to prevent disease transmission that could wipe out the bighorn population. The Forest Service has acknowledged that allowing bighorn sheep to mix with domestic sheep and goats is incompatible with maintaining a viable population of bighorns:

> A summary report "Bighorn/Domestic Sheep Management Strategy" by Schommer and Woolever (2001) is filed in the Administrative Record. This report summarizes and provides references for studies on mortality of bighorns following contact with domestic sheep. It strongly suggests that <u>grazing domestic sheep and maintaining bighorns are incompatible goals if the two species are close enough to provide potential contact</u>.

Medicine Bow Forest Plan FEIS at Appendix L-207, emphasis added. The agency went on to recognize in even stronger terms the fundamental incompatibility between domestic sheep and wild bighorns:

> …the infection of the herd by *Pasteurella haemolycta* carried in by domestic sheep does not have a graduated response, increasing with the number of infected vectors: rather, once the disease is in the bighorn herd, mortality is 75% to 100%, and surviving ewes often do not reproduce for several years (Schommer and Woolever 2001). The response is "all or none," and is devastating to the bighorns.

Medicine Bow Forest Plan Revision FEIS Appendix D-124.

In describing changes in the Historic Range of Variability among factors that affect the species, the Forest Service notes that "The presence of new diseases and parasites has had the most effect on bighorns." FEIS at Appendix D-123. These impacts derive from diseases that are not native to North America, the were not present during the evolution of Rocky Mountain bighorns, and which have been introduced into wild bighorn populations through contact with domestic sheep. Bighorns have never evolved the immunological defenses to survive exposure to many of these diseases, including pasteurella and others. The Forest Service points out that "The primary threat is the introduction of parasites and diseases (especially *Pasteurella haemolycta*) by domestic sheep." FEIS at Appendix D-123, citation omitted.

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BLM Sensitive Species

Instruction Memorandum (IM) 97-118 governs BLM Special Status Species management and requires that actions authorized, funded, or carried out by the BLM do not contribute to the need for any species to become listed as a candidate, or for any candidate species to become listed as threatened or endangered. It recognizes that early identification of BLM sensitive species is advised in efforts to prevent species endangerment, and encourages state directors to collect information on species of concern to determine if BLM sensitive species designation and special management are needed. In addition, for special status species, including sensitive species, BLM must:

> Identify strategies and decisions to conserve and recover special status species. Given the legal mandate to conserve threatened or endangered species and BLM's policy to conserve all Special Status Species, land use planning strategies and decisions should result in a reasonable conservation strategy for these species. Land use plan decisions should be clear and sufficiently detailed to enhance habitat or prevent avoidable loss of habitat pending the development and implementation of implementation-level plans. This may include identifying stipulations or criteria that would be applied to implementation actions. Land use plan decisions should be consistent with BLM's mandate to recover listed species and should be consistent with objectives and recommended actions in approved recovery plans, conservation agreements and strategies, MOUs, and applicable biological opinions for threatened and endangered species.

BLM Land Use Planning Handbook H-1601-1, Appendix C at 5. Additionally, if Sensitive Species are designated by a State Director, the protection provided by the policy for candidate species shall be used as the minimum level of protection. BLM Manual 6840.06. The policy for candidate species states that the "BLM shall carry out management, consistent with the principles of multiple use, for the conservation of candidate species and their habitats and shall ensure that actions authorized, funded, or carried out do not contribute to the need to list any of these species as threatened/endangered." BLM Manual 6840.06. Specifically, BLM shall:

(1) Determine the distribution, abundance, reasons for the current status, and habitat needs for candidate species occurring on lands administered by BLM, and evaluate the significance of lands administered by BLM or actions in maintaining those species.
(2) For those species where lands administered by BLM or actions have a significant affect on their status, manage the habitat to conserve the species by:
    a. Including candidate species as priority species in land use plans.
    b. Developing and implementing rangewide and/or site-specific management plans for candidate species that include specific habitat and population management objectives designed for recovery, as well as the management strategies necessary to meet those objectives.
    c. Ensuring that BLM activities affecting the habitat of candidate species are carried out in a manner that is consistent with the objectives for those species.
    d. Monitoring populations and habitats of candidate species to determine whether management objectives are being met.
(3) Request any technical assistance from FWS/NMFS, and any other qualified source, on any planned action that may contribute to the need to list a candidate species as threatened/endangered.

BLM Manual 6840.06. Clearly, the BLM must survey for special status species before allowing any ground disturbance in lease parcels, must develop site-specific management plans for these species, and

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must monitor special status species populations within the lease parcels to ensure that the agency is promoting their recovery. The BLM must acquire baseline data and analyze the impacts of the alternatives on these species. In the Draft EIS, the BLM has flouted its special status species obligations, which makes this safety net less meaningful and increases the need for Endangered Species Act protection.

We believe that a moratorium on surface disturbing activities in the crucial habitats of BLM Sensitive Species would be a very wise decision, and should be implemented in the final Casper RMP. These crucial habitats should be mapped and presented in the Final EIS or Supplemental Draft **EIS.**

Sage Grouse

Sage grouse appear to be on the road to Endangered Species listing based on the increasing industrial development and habitat fragmentation of their core habitats, and the BLM's failure to respond through adaptive management to the increasing problems and require scientifically sound mitigation measures, particularly for oil and gas development. According to Naugle et al. (2004), "if we are to prevent sage-grouse from going extinct on their remaining range, we must find a way to provide high-quality habitats that support robust, genetically diverse populations capable of withstanding stochastic disease events." Pat Deibert (2005) of the U.S. Fish and Wildlife Service ranked oil and gas as the #1 threat to sage grouse persistence in the eastern part of its range, which includes all of Wyoming. According to Joe Bohne (2005), chairman of the National Sage-Grouse Conservation Planning Framework Team,

> The ball is in our court and we have a responsibility to complete the planning effort and to make changes in land management to address the impacts from habitat loss, habitat degradation and habitat fragmentation that appear to be the root cause of sage-grouse declines in the last 50 years. This means real changes in management and substantive work on the ground. In my opinion, changes in management philosophy and land management practices are needed for this to occur. The Bureau of Land Management and U.S. Forest Service must take the lead in this effort because these agencies control well over 50% of the currently occupied sage-grouse habitat. Current efforts to revise land use plans for these agencies need to address sage-grouse conservation issues. This is particularly problematic as we face unprecedented energy development on our western rangelands....Simply put, we cannot continue business as usual, as practiced in our management of western rangelands and hope to maintain or enhance sage-grouse populations when considered either from a local or range-wide perspective. We have a window of opportunity to address management issues in fixing what is broken, serving as an umbrella species for an array of sagebrush obligate wildlife species that are facing some level of risk. In my judgment, land management practices and actions over the next 10 years will be pivotal in determining whether we can maintain current sage-grouse populations and distribution.

We could not agree more. And yet none of the alternatives provides the most basic protections for sage grouse as outlined by Connelly et al. (2000) and Braun (2006).

Wyoming sage grouse populations are some of the largest left in the nation and are relatively stable (showing a 17% decline from 1985-1994). Sage grouse populations have experienced major declines rangewide in recent decades (Connelly and Braun 1997). WGFD (2000) reported that since 1952, there has been a 20% decline in the overall Wyoming sage grouse population, with some fragmented populations declining more than 80%; Christiansen (2000) reported a 40% statewide decline over the last 20 years. These declines can be attributed to habitat loss (due to agriculture, mining and energy

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development, reservoirs, roads, and buildings), habitat fragmentation (due to fences, powerlines, roads, and reservoirs), habitat degradation (due to overgrazing, changes in fire regime, and mechanical and chemical sagebrush control efforts), drought, predation (the importance of which is controlled by the amount and quality of sage grouse habitat), and hunting (Braun 1998). It is crucially important that the new long-term plan for the Casper Field Office provide for the maintenance and recovery of sage grouse populations, because this bird is headed for the Endangered Species List if population losses continue. Currently it does not.

A number of raptors and medium-sized mammalian carnivores prey on sage grouse. Sage grouse nest predators include bobcats, golden eagles, red fox, badgers, common ravens, and coyotes (Heath et al. 1997). Hulet et al. (1986) found that the Uinta ground squirrel was the most important nest predator in their southern Idaho study area. The maintenance of appropriate habitat and adequate cover, particularly on nesting and brood-rearing habitats, is important to ensure that predation rates do not increase to abnormal levels. In addition to maintaining cover, it is important to avoid the construction of tall structures that serve as raptor perches and concentrate predation pressure, like powerlines and gas condensate tanks, near these habitats. It is also important to limit cross-country geophysical activities to areas farther than 3 miles from lek sites, so that the scars left behind by geophysical equipment do not become travel corridors for terrestrial predators that lead them to nesting sage grouse.

Sage Grouse Habitats

To ensure the viability of sage grouse populations, it is important to consider nesting, brood-rearing, and winter habitats (Call and Maser 1985). Connelly et al. (2000) proposed comprehensive guidelines regarding the management of sage grouse, focused around the conservation of breeding/nesting habitat, late summer brood-rearing habitat, and wintering habitat. Braun (2006) refined these recommendations and provided a concrete blueprint for sage grouse recovery. See Attachment 3. We recommend that the alternatives in the Draft **EIS** be modified so that Braun's guidelines be implemented in the forthcoming RMP, with the modification of a 3-mile NSO and no surface disturbance/vegetation treatment buffer for sage grouse leks in order to protect the leks themselves as well as adjacent nesting habitat.

Breeding and Nesting Habitats

Autenreith (1985: 52) considered the lek site "the hub from which nesting occurs." Grouse exhibit strong fidelity to individual lek sites from year to year (Dunn and Braun 1986). During the spring period, male habitat use is concentrated within 2 km of lek sites (Benson et al. 1991). Young males may establish new leks in order to take part in breeding (Gates 1985). Because leks sites are used traditionally year after year and represent selection for optimal breeding and nesting habitat, it is crucially important to protect the area surrounding lek sites from impacts.

The maintenance of high-quality sagebrush steppe habitats, particularly nesting and wintering habitats, is necessary to maintain sage grouse viability on the landscape scale. Sage grouse are dependent on sagebrush steppe habitats, and sage grouse distribution is closely linked with the distribution of big sagebrush (McCall 1974). Numerous studies have shown that female sage grouse show strong fidelity to specific nesting areas from year to year (Berry and Eng 1985, Fischer et al. 1993, Lyon 2000). Fischer et al. (1993) concluded, "Because Sage Grouse hens appear to seek suitable habitat within a relatively small area, nest-area fidelity may reduce nesting if large areas of nesting habitat are destroyed" (p. 1040). Thus, it is important to foster sagebrush growth at levels useful to sage grouse and to avoid activities that destroy suitable sagebrush habitat.

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The optimum height and cover of sagebrush for sage grouse nesting habitats varies from region to region. In their eastern Oregon study, Call and Maser (1985) reported that sagebrush between 30 and 60 cm made the best nesting habitat, while a range of 15-80 cm was suitable for nesting. In the foothills of the Sierra Madres, shrub height at nest sites averaged 22 cm (Klott and Lindzey 1989). In other studies, nesting habitat is typified by greater shrub height and shrub cover (Wallestad and Pyrah 1974, Sveum et al. 1998). Dunn and Braun (1986) found that grouse selected areas with taller shrubs and more homogeneous sagebrush densities, and closer distance to wooded or meadow edges. But in Idaho, Klebenow (1969) found that sage grouse did not nest in areas where sagebrush cover exceeded 35%. Within suitable nesting habitat, nest sites tend to be located under taller-than-average shrubs, particularly sagebrush (Hulet et al. 1986).

Mesic meadows and surface waters are focal points of sage grouse activity during certain times of year. Mesic sites associated with springs, seeps, and streams are critical for sage grouse on a yearlong basis, and assumes even greater importance as brood rearing habitat (Autenreith et al. 1982). Call and Maser (1985) stated, "We believe that free water is an essential component of sage grouse habitat", but noted that "[s]age grouse may do well in the absence of free water where they have access to succulent vegetation." (p. 4). Oakleaf (1971) found that the presence of surface water was an important factor that increased the value of meadows as grouse rearing habitat. Thus, management for sage grouse should include special emphasis on protecting wet meadows, springs, and seeps. Special provisions are outlined in these comments to protect these habitats.

Habitat attributes have a direct effect on sage grouse population dynamics. Connelly et al. (1991) found that nest success was higher for birds nesting below sagebrush (53%) versus other shrubs (22%), and hypothesized that avian predation was the key to nest success. In central Washington, Sveum et al. (1998) found that sagebrush cover at successful nest sites averaged 51%, and height averaged 64 cm, while at depredated nests cover and height averaged 70% and 90 cm, respectively. Wallestad and Pyrah (1974) found that sagebrush cover exceeded 15% for all nest sites, and cover of sagebrush was positively correlated with nest success. Several studies have shown that successful nest sites have greater cover of tall grass (Gregg et al. 1994, Sveum et al. 1998). With this in mind, Holloran (1999) recommended leaving residual grass heights greater than 12 cm following removal of livestock in autumn. Thus, not only sagebrush height and density but also understory grass cover are important to maintain in sage grouse nesting areas.

Early and Late Brood Rearing Habitats

Sage grouse may move some distance from nesting sites for early and late brood rearing. In western Wyoming, Lyon (2000) found that sage grouse moved an average of 1.1 km from the nest site for early brood-rearing, and late brood-rearing habitats averaged 4.8 km distant from the early brood-rearing areas. In Bates Hole, Holloran (1999) found that early brood rearing habitats are typified by decreased sagebrush cover and height and increased forb abundance, and movement to riparian sites occurred as uplands became dessicated. This pattern of movement and habitat selection is echoed in the findings of Oakleaf (1971). In western Wyoming, wet meadows, springs, seeps, and other green areas within sagebrush steppe were important for early brood-rearing, while late brood rearing focused on irrigated hay meadows, wet meadows, and drainage bottoms which remained green when early brood rearing habitats were withering (Lyon 2000). This researcher found that most recruitment loss occurred during the early brood rearing stage, and that this may be a limiting factor in sage grouse populations (Ibid.). In Nevada, Oakleaf (1971) found that meadows with succulent forbs, while occupying only 2.3% of grouse home ranges during the brood rearing period, were disproportionately important as brood-rearing habitat. In central Washington, Drut et al. (1994b) found that during late brood-rearing, habitat use shifted from low sagebrush to big sagebrush sites, with heightened use of meadows and lakeshores. Kaiser (2006) found

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that late-brood-rearing success (an index for recruitment into the population) was significantly lower for hens breeding inside gas fields versus hens breeding on leks in undisturbed areas. Brood-rearing habitats should thus be identified and managed to maximize sage grouse recruitment success.

The availability of forage with a high nutritional content is an important factor determining brood success. Broods require forbs, insects and cover for growth, concealment and shade (Autenreith 1985). The diet of sage grouse chicks is dominated by insects in the first week of life, with forbs becoming more important as time progresses (Call and Maser 1985). Oakleaf (1971) reported that succulent forbs dominated the diets of brood-rearing hens and juveniles until the chicks reached 11-12 weeks of age. Drut et al. (1994a) found that in the area with high sage grouse productivity, insects and forbs made up 80% of chicks' diets, while sagebrush buds made up 65% of diets in the area of low sage grouse productivity. These researchers reached the following conclusions: "Substantially lower consumption of forbs and invertebrates and increased reliance on sagebrush may affect chick growth and survival, which would be reflected in long-term differences in productivity between areas. Insects are a critical nutrition source for developing chicks" (p. 93). Dunn and Braun (1986) argued that meadows, as important forb-producing areas, should be preserved. Thus, the BLM should manage sage grouse brood-rearing habitat to maximize high-quality forage for chicks.

Wintering Habituts

Non-migratory sage grouse winter on their nesting and brood-rearing habitats, while migratory populations may travel some distance to winter on traditional wintering areas. For non-migratory populations, nesting habitat and wintering habitat are one and the same (e.g., Wallestad and Pyrah 1974). In a western Wyoming study, however, sage grouse were migratory and traveled at least 35 km to separate wintering grounds (Berry and Eng 1985). In Colorado's North Park, Beck (1977) found that grouse migrated 5-20 km away from breeding areas during winter. In a southeastern Idaho study, Connelly et al. (1988) found that some adult sage grouse moved more than 60 km to winter range, and some juveniles moved more than 80km, despite the availability of suitable wintering habitat nearby. In some cases, sage grouse may be widely dispersed during mild winters but concentrate during severe winters (e.g., Autenreith 1985).

Sage grouse may be keying in on several habitat variables when selecting appropriate wintering habitat. In the southern Red Desert, Kerley (1994) found that wintering sage grouse moved to tall sagebrush stands on steep south-facing slopes, where the sagebrush were exposed above the snow. Conversely, Beck (1977) found that in North Park, Colorado, 66% of sage grouse wintered on slopes of less than 5%, while only 13% of sage grouse use occurred on slopes greater than 10%. In Montana, Eng and Schladweiler (1972) found that 82% of winter sage grouse sightings occurred in canopy cover greater than 20%, and a preference was shown for dense stands on lands with little slope. The BLM must identify sage grouse wintering habitats within the planning areas and emplace strong measures to protect them from vegetation treatments and industrial projects.

Researchers appear to be unanimous in their recommendations that sage grouse winter habitat be protected from disturbance. Kerley (1994) recommended, "Because shrub stands used during winter (category 3 stands) make up a small proportion of available habitats, these patches on south facing slopes, as well as other traditional wintering sites, should not be treated [to remove or reduce shrubs]" (p.113). Connelly et al. (2000) concurred, recommending against habitat manipulation in sagebrush stands of 10-30% canopy cover heights of at least 25 cm to protect winter habitats. According to Beck and Braun (1980), "Areas of winter concentrations of sage grouse need to be documented and afforded maximum protection" (p. 564). Lyon (2000) recommended that sage grouse wintering habitats be placed off-limits

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to oil and gas development. Thus, in the Casper planning area, the BLM needs to rapidly identify sage grouse winter concentration areas and place the areas off-limits to surface disturbance and vegetation treatments.

Vegetation Treatments

Because the sage grouse is dependent on sagebrush, sagebrush treatments are likely to have major impacts on sage grouse population viability. Call and Maser (1985) asserted that the spraying of sage grouse nesting habitats is deleterious because it reduces nest cover from avian predators and suppresses forbs that are important in the sage grouse diet. According to Kerley (1994), "shrub stands of 20-40% cover are needed for successful nesting and this shrub coverage should be maintained on identified breeding complexes [within 3.2 km of leks]" (p. 113). Wamboldt et al. (2002: 24) stated:

> Natural or prescribed burning of sagebrush is seldom good for sage-grouse. This assessment recommends that fires within sage-grouse habitat be avoided in most cases, and should be allowed only after careful study of each local situation. The evidence also indicates that habitat loss due to fire may well be the most serious of all the factors contributing to the decline of sage-grouse.

Heath et al. (1997) went even further: "Based on our results, we recommend no reduction or control of sagebrush in areas containing between 18-30% live sagebrush canopy coverage within 4.5 km of leks" (p.50). According to Beck and Braun (1980: 563),

> At present we do not know the relative value of a small versus large strutting ground to the population. Therefore we should afford equal merit to all and strive to maintain the adjacent habitats, especially areas with sagebrush (Artemesia) suitable for nesting and brood rearing.

Call and Maser (1985) stated that spraying should not occur within the breeding complex (which they defined as within 2 miles of a lek), and should also be forbidden in known grouse winter ranges. Taking into account the negative effects of vegetation treatments on sage grouse nesting and lekking areas, and uncertainty in the overall extent of sage grouse nesting habitat surrounding lek sites in the Casper region, the BLM should prohibit vegetation treatments within ***3 miles*** of sage grouse lek sites.

Strip Mining

Coal mining can impact sage grouse populations through major local decreases in recruitment (Braun 1986); local distribution patterns and decreases in lek use are the principal effects, with disturbance, rather than habitat loss, being the primary factor (Remington and Braun 1991). Klott (1987) recommended that areas near sage grouse leks be avoided for the purposes of strip mining. We concur, and ask the BLM to withdraw lands within 3 miles of a sage grouse lek from lands suitable for surface mining under the Surface Mining Control and Reclamation Act (SMCRA).

Road Development

Road development can lead to lek abandonment (e.g., Braun 1986). In western Wyoming, Lyon (2000) found that for sage grouse leks within 3 km of oil and gas developments, grouse hens successful at raising their broods selected habitats farther from roads than unsuccessful hens. Holloran (2005) also found proximity to roads as a factor correlated with declines in lek attendance. This finding indicates that

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habitats near roads experience reduced brood survivorship. Thus, we seek a moratorium on all road-building within 3 miles of a lek site.

Impacts of Oil and Gas Development

Oil and gas development poses perhaps the greatest threat to sage grouse viability in the region. In a study near Pinedale, sage grouse from disturbed leks where gas development occurred within **3** km of the lek site showed lower nesting rates (and hence lower reproduction), traveled farther to nest, and selected greater shrub cover than grouse from undisturbed leks (Lyon 2000). According to Lyon (2000), impacts of oil and gas development to sage grouse include (1) direct habitat loss from new construction, (2) increased human activity and pumping noise causing displacement, **(3)** increased legal and illegal harvest, (4) direct mortality associated with reserve pits, and *(5)* lowered water tables resulting in herbaceous vegetation loss. Pump noise from oil and gas development may reduce the effective range of grouse vocalizations (Klott 1987). Thus, lek buffers are needed to ensure that booming sage grouse are audible to conspecifics during the breeding season. Connelly et al. (2000) recommended, "Energy-related facilities should be located >3.2 km form active leks" (p. 278). But Clait Braun (pers. comm.), the worlds most eminent expert on sage grouse, recommended even larger NSO buffers of **3** miles from lek sites, based on the uncertainty of protecting sage grouse nesting habitat with smaller buffers. Thus, areas within **3** miles of a sage grouse lek should be put under year-round "No Surface Occupancy" stipulations.

Livestock Grazing

Livestock grazing can influence sage grouse habitat suitability, particularly overgrazing which can reduce understory grasses below critical thresholds and alter the density of sagebrush. In their study on sage grouse in eastern Oregon, Call and Maser (1985) made the following basic assumption: "Where there are conflicts between sage grouse and livestock on public lands, it may be essential to give priority to sage grouse if they are to continue to exist on these areas" (p. **3).** According to Autenreith et al. (1982), heavy livestock grazing during the sage grouse nesting or brood rearing seasons is deleterious. According to Gregg et al. (1994), "Land management practices that decrease tall grass and medium height shrub cover at potential nest sites may be detrimental to sage grouse populations because of increased nest predation....Grazing of tall grasses to <18 cm would decrease their value for nest concealment....Management activities should allow for maintenance of tall, residual grasses or, where necessary, restoration of grass cover within these stands" (p. 165).

The potential conflict between livestock grazing and sage grouse is intensifies near water sources due to the importance of these areas to sage grouse. Heavy cattle grazing near springs, seeps, and riparian areas can remove grasses used for cover by grouse (Klebenow 1982). According to Call and Maser (1985), "rapid removal of forbs by livestock on spring or summer ranges may have a substantial adverse impact on young grouse, especially where forbs are already scarce" (p. 17). We support the BLM's current policy of fencing off natural springs and placing livestock water sources outside the fences rather than at the spring itself.

Holloran (1999) documented that livestock disturbance caused a sage grouse hen to abandon her nest in one case. Call and Maser (1985) noted that nest desertion is most prevalent in the vicinity of sheep bedgrounds, and reached the following conclusion: "There is no indication that livestock are a serious factor in the destruction of nests, although desertion of nests because of livestock activities is frequent under certain conditions" (p. 17). In addition, the presence of livestock in nesting habitats can cause problems for sage grouse. Livestock drives could also negatively impact sage grouse populations during the nesting season. According to Call and Maser (1985), "Hens abandon their nests with little provocation during the egg-laying period (mid-April through early May). Yearling hens are prone to abandon their

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nests even when disturbed during incubation. The impact of a livestock drive could, therefore, be great because yearling hens are usually the largest reproductive age class" (p. 18). For allotments where sage grouse nesting is known to occur, shifting on-off dates (if necessary) could minimize the chances of impacts to nesting sage grouse, and livestock drives should be routed to avoid sage grouse leks during the strutting and nesting seasons.

Off-Road Vehicle Use

Certainly, off-road vehicle use in sage grouse nesting habitats has negative consequences for the grouse. Call and Maser (1985) made the following recommendations concerning off-road vehicle use and sage grouse:

> "Organized motorcycle or four-wheel drive races across sage grouse nesting habitat, however, can cause substantial loss of production from direct destruction of nests, from abandonment of nests during egg-laying, from destruction of young chicks, or from all three. If sage grouse production is a management goal, then it is wise to postpone such races until after the first of September when the birds are old enough to **fly** out of harm's way'' (p. 19).

We concur, and urge the BLM not only to avoid the proliferation of new roads and user-created vehicle routes in nesting habitats but also to schedule events away from nesting habitats and avoid scheduling them during the nesting period.

Insecticide and Herbicide Spraying

In addition to destroying the insects and forbs required by sage grouse broods, the spraying of insecticides and herbicides may cause direct mortality of sage grouse. In a Montana study, Wallestad (I975) found that treatment of 24% (751 acres) of suitable sagebrush habitat around one lek resulted in a SO% reduction of cocks, while treatment of 11% (640 acres) of suitable habitat around a second lek showed no change in sage grouse numbers; during the same time period, sage grouse numbers at control leks with no sagebrush treatment increased over 300%. Klebenow (1970) found that spraying of nesting habitat caused a long-term cessation of nesting activity in the area. Blus et al. (1989) found that the spraying of two types of insecticides over grouse was fatal to 78% of grouse, and hypothesized that insecticides have played a role in region-wide sage grouse declines. Standards should be issued preventing the spraying of insecticides in sensitive sage grouse habitats during periods where these habitats are occupied.

Lek Buffers

Current BLM nest buffers of ¼ mile for controlled surface disturbance and 2 miles for seasonal stipulations are grossly inadequate to maintain sage grouse viability in the Casper planning area. The lek buffer must be based not only on maintaining the lek but also the nesting habitat that surrounds the lek. In addition, seasonal prohibitions that prohibit only construction activities near leks are pointless: If roads or wells are built near leks during the off-season, the resulting regular vehicle traffic will have major negative impacts when the sage grouse are present, effectively circumventing any mitigative value of delaying construction activities.

As a rule, breeding and nesting activity are concentrated in the habitats adjacent to the lek site. In a Montana study, Wallestad and Schladweiler (1974) found that no male sage grouse traveled farther than 1.8 km from a lek during the breeding season. But following breeding, males may make long migrations to distant summer ranges (Connelly et al. 1988). Hulet et al. (1986) found that 10 of 13 hens nested within 1.9 miles of the lek site during the first year of their southern Idaho study, with an average distance of 1.7

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miles from the lek site; 100% of hens nested within 2 miles of the lek site during the second year of this study, with an average distance from lek of 0.5 mile. In Montana, Wallestad and Pyrah (1974) found that 73% of nests were built within 2 miles of the lek, but only one nest occurred within 0.5 mile of the lek site.

But in Bates Hole, Wyoming, Holloran (1999) found that average nesting distance from lek site was 3.25 km for adults and 5.27 km for yearlings. Wakkinen et al. (1992) cautioned that leks were poor predictors of sage grouse nest sites; although 92% of sage grouse nested within 3.2 km of a lek in this study, sage grouse did not necessarily nest near the same lek where breeding took place.

Lyon (2000) pointed out that quarter-mile lek buffers were insufficient to maintain the viability of grouse populations. Connelly et al. (2000) recommended that sage grouse habitat should be protected within 3.2 km of lek sites under ideal habitat conditions, within 5 km when habitat conditions are not ideal, and within 18 km where sage grouse populations are migratory. Furthermore, these researchers stated that in areas where 40% or more of the original breeding habitat has been lost, all remaining habitat should be protected.

But Beck (1977) cautioned that protection of lek sites only is insufficient to maintain sage grouse winter habitats. And Connelly et al. (1988) later cautioned, "Protection of sagebrush habitats within a 3.2 km radius of leks may not be sufficient to ensure the protection of year-long habitat requirements" (p. 116). And Braun (pers. comm.) recommended even larger buffers of 3 miles from lek sites where surface disturbance and vegetation treatments should be prohibited, based on the uncertainty of protecting sage grouse nesting habitat with smaller buffers. Thus, areas within 3 miles of a sage grouse lek should be put under year-round stipulations preventing habitat alterations.

Holloran and Anderson (2004) reported that oil and gas development in northwest Wyoming, and particularly road traffic, was correlated with sage grouse declines:

> Mean annual declines in the maximum number of males attending leks impacted by a drilling rig with 3.2 km or a road within 500 m were 32 and 19%, respectively, compared to 2% average annual declines for leks > 6.5 km form gas field disturbance (controls). …the data suggest that the presence of a drilling rig within 5.5 km directly and indirectly influenced sage grouse.

Upon reviewing the Lower Bush Creek Coalbed Methane Project (just west of the Rawlins Field Office boundary in the Red Desert), the U.S. Fish and Wildlife Service stated,

> The cause of sage grouse decline is not known and may be a combination of several factors which affect habitat and reproductive abilities. However, anecdotal information, from several sources in Wyoming, suggest that sage grouse populations are negatively affected by the activities associated with oil and gas development, even when mitigative measures are implemented.

Comments of Michael Long, Lower Bush Creek DR/FONSI at 36. A recent Canadian study observed that human activity near leks could result in site abandonment, which may reduce breeding success (Aldridge and Brigham 2003).

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Thus, human activity and vehicle traffic occurring during the post-drilling production phase would continue to have negative effects on breeding sage grouse. This finding supports our contention that seasonal stipulations to protect sage grouse lek sites is largely ineffectual, and undercuts BLM's conclusion that such seasonal stipulations will reduce impacts to sage grouse populations to a level of insignificance. Protection for lek sites would be anchored to a seasonal "controlled surface use" stipulation and prohibition of aboveground facilities for lands within ½ mile of active sage grouse strutting grouse, limiting activities between 6 p.m. and 9 a.m. DEIS at **A9-2.** A Canadian study concluded that direct habitat loss, habitat fragmentation, increased vulnerability to predation, and mortality due to vehicular traffic are all results of oil and gas development (Aldridge and Brigham 2003). Vander Haegen et al. (2002) found that nests in fragmented habitats were nine times as likely to suffer from predation than nests in unfragmented habitats.

Areas with mere seasonal stipulations will continue to suffer from habitat fragmentation and the effects of disturbance post-drilling. The effectiveness of the 'A mile NSO buffer to protect For these reasons, the 2-mile buffer with seasonal stipulations and ¼ mile NSO buffer proposed for sage grouse leks ahould be replaced with a 3-mile NSO buffer to adequately protect both breeding and nesting habitat.

West Nile Virus

In addition to the habitat degradation impacts that have caused the decline of the sage grouse over the past 50 years, West Nile Virus constitutes a new and powerful threat to sage grouse survival throughout the planning area. West Nile Virus has been linked with coalbed methane development in the Powder River Basin, because CBM wastewater reservoirs serve as breeding grounds for mosquitoes that are vectors of the disease. According to Walker et al. (2003), "hen survival on the CBM site (15%) was dramatically lower than on control sites (62%), primarily due to an outbreak of West Nile Virus restricted to the CBM site." In addition, coalbed methane reservoirs have been directly linked with increases in the species of mosquito that carries the West Nile Virus. According to Johnson (2003), "we have more mosquitoes (an order of magnitude greater) in CBM than control sites and >90% of all mosquitoes regardless of capture site are *Culex* genus (the vector of interest)." In a continuation of this study, among radio-collared sage grouse in the Powder River Basin, West Nile Virus was the cause of death in **18** of 22 mortalities, or 82% (Naugle et al. 2004). Survival in the Powder River Basin under this study declined by 25%, while survival rates in the Upper Green River Valley (absent West Nile Virus) remained steady. Individuals were 3.4 times more likely to die in the West Nile Virus study area than birds in virus-free areas over the same two months. According to Naugle (2005), "Unexpected impacts of WNV [West Nile Virus] are disturbing because range-wide habitat loss and degradation already threaten populations."

In addition, West Nile Virus is also a hazard to human health and safety. In light of the threat of the West Nile Virus and the inevitability of its spread throughout the RMPPA, BLM has an affirmative responsibility to ensure that actions permitted under the Casper RMP do not contribute to an elevated risk of West Nile Virus to both sage grouse and humans. Thus, BLM must not permit to construction of wastewater reservoirs associated with coalbed methane development. If surface discharge is to be allowed under any circumstance (and we recommend against this course of action), wastewater should not be allowed to stagnate in ponds. In addition, BLM must require measures to prevent mosquito breeding in the reserve pits of conventional oil and gas wells.

Mountain Plover

USFWS recently withdrew its proposal to list the mountain plover as Threatened under the Endangered Species Act, despite the fact that two separate status reviews by USFWS noted that this species continues to teeter on the brink of extinction. We remain deeply concerned about the continued viability of the

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mountain plover within the Casper Field Office boundaries, particularly in light of the increased industrial development projected under all each of the BLM's alternatives in this Draft EIS.

Oil and gas development in nesting concentration areas is a direct threat to mountain plover population viability. The U.S. Fish and Wildlife Service found that the Seminoe Road Coalbed Methane project "is likely to adversely affect the proposed mountain plover," stating that wellfields are likely to become an "ecological trap," attracting feeding plovers to roadways where they become susceptible to vehicle-related mortality, or alternately increased vehicle traffic could drive plovers away from preferred nesting areas (Long 2001). The USFWS (1999) added that vehicle traffic on roads could lead to stress and chick abandonment. These officials noted that any human disturbance that significantly modifies adult behavior could cause death to chicks, which can die in as little as 15 minutes due to exposure to sun at temperatures greater than 81° F. Long (2001) noted that construction equipment and permanent structures inherent to oilfield development constitute a radical increase in raptor perches that could result in increased predation pressure. In addition to these problems, wellfield development can lead to increased invasion rates of non-native weed species, which can have serious impacts on plover nesting habitat by decreasing the availability of bare ground (Good et al. 2001).

Wind-power developments can be equally harmful to plover nesting habitats. According to Johnson et al. (2000), nesting plovers abandoned the southern third of the Foote Creek Rim during wind farm construction activities in 1998, abandonment of the southern half of the Foote Creek Rim in 1999, and overall reductions in use of this area heavily impacted by roads and wind turbines during previous years, was likely related either to construction activities or reduced habitat effectiveness due to the presence of roads, trenches, or other project-related impacts.

We believe that mountain plover nesting concentration areas must be protected from intensive development and the heavy vehicle traffic that accompanies it. No surface occupancy should be required in mountain plover concentration areas, and these areas must be mapped and presented in the EIS in fulfillment of NEPA's baseline information requirements. Please confirm that these particular known mountain plover nesting concentration areas will be placed under No Surface Occupancy standards under the Preferred Alternative of the Casper RMP. In cases where lands would be placed off-limits to future surface disturbance in the form of oil and gas drilling wells are sited within ½ mile of concentration areas, a ground-level marker rather than a 4-foot tall marker with perch inhibitor would more effectively ensure that raptor predation near nesting areas is not artificially increased.

Preble's meadow jumping mouse

BLM notes that the USFWS has designated critical habitat for the Preble's meadow jumping mouse in several drainages within the planning area. DEIS at 3-72. USFWS took pains to designate critical habitat on federal lands, as these areas are more secure from mismanagement by a hostile landowner and are less controversial. The potential for land disposals in Goshen and Converse Counties raises the specter of disposal of Preble's critical habitat, which should under no circumstances be allowed. The Draft EIS erroneously states that USFWS recently proposed to delist the Preble's. DEIS at 3-81. This is not the case. The State of Wyoming has submitted a petition to delist the mouse, upon which the USFWS has taken no action to date.

Northern Leopard Frog

This BLM Sensitive Species occurs within the planning area (DEIS at 3-82), and has been petitioned for listing under the Endangered Species Act. The Draft EIS should disclosed the location and estimated population size of northern leopard frog populations within the planning area, and provide protections for northern leopard frog habitats. These protections should include protection from overgrazing and off-road

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vehicle use, protection from chemical spills and produced water from oil and gas and CBM operations, and protection from draining of wetlands.

Sagebrush Birds

Sagebrush birds, and particularly sage thrashers, sage sparrows, and Brewer's sparrows, are sensitive to habitat fragmentation and degradation resulting from industrial development. According to Knick et al. (2003), "Agriculture, mining, oil, gas, and coal-bed methane development, powerline and natural-gas corridors, urbanization, and expansion of road networks have fragmented landscapes or completely eliminated sagebrush from extensive areas." (Internal citations omitted). A complete review of the impacts of habitat fragmentation and oil and gas development on sagebrush birds is provided in the section on habitat fragmentation below. "BLM is a participant in the Wyoming Partners in Flight, and specific biological objectives and recommendations for land birds are presented in the Wyoming Bird Conservation Plan." DEIS at 3-128. While the Appendices seem to indicate that the Partners in Flight objectives and recommendations will be adopted into the Casper RMP, these should be explicitly carried into the plan formally as nondiscretionary standards.

Several sagebrush-dependent species are sensitive to overgrazing. Baker et al. (1976) classified sage grouse, sage thrasher, sage sparrow, and Brewer's sparrow as sagebrush obligates, while green-tailed towhee and vesper sparrow were classified as near obligates. Bock et al. (1993b) reviewed the impacts of livestock grazing on birds, and reached the following conclusion: "All of these factors lead us to conclude that there is an urgent need for protection, restoration, and long-term study of shrubsteppe ecosystems (including their avifaunas) dominated by native perennial grasses, cryptogams, and moderate densities of shrubs, as we suspect these ecosystems existed prior to introductions of domestic livestock" (p. 304). The adoption of strong standards to prevent overgrazing should be codified in the new Casper RMP.

While the Affected Environment section of the DEIS contains a section on black-footed ferrets, it fails to provide baseline information on the status and trend of black-footed ferrets within the RMPPA beyond noting that "suitable habitat does exist." DEIS at 3-138. In fact, there is a wild black-footed ferret population that occurs in the Shirley Basin region of the RMPPA, using lands that include BLM-administered public surface. This population has already survived a sylvatic plague episode among its host prairie dog population. The Affected Environment section of the **EIS** needs to present the best available population estimates for this population for every year that this data is available, note (at least generally) where these ferrets are known to live, and provide locations for other ferret reintroduction sites within the RMPPA which are currently under consideration for ferret reintroduction.

Prairie dog colonies within 7 km of each other should be viewed as a "complex" for the purpose of black-footed ferret reintroduction (USFWS 1989). Based on minimum viable population estimates for ferrets, viable ferret populations require prairie dog colonies of at least 3000 hectares, with a 4000-6000 hectare size being a more optimal minimum (Forrest et al. 1985). These researchers recommended that only towns with burrow densities greater than 10/ha be considered "colonies" for the purpose of reintroduction, and that intercolony distances should not exceed 20 km to facilitate ferret interchange. Past studies indicate that there may be sites matching these criteria within the Casper planning area, and such sites would be of primary conservation concern. Prairie dog colonies must be protected and restored to present new potential ferret release sites, such as those near Saratoga and Wheatland Reservoir Number 2. The presence of one of the world's most endangered mammals should certainly have a strong bearing on the management of the lands on which they are found, and therefore this baseline information is critically important to the BLM's ability to make sound and well-informed decisions on long-term land management pursuant to NEPA.

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As BLM recognizes, "Black-footed ferret numbers have been shown to be directly linked to fluctuations in the prairie dog population." DEIS at 3-138. It is therefore critically important to maintain prairie dog populations in areas currently inhabited or potentially habitable by black-footed ferrets. In addition, black-footed ferrets may be indistinguishable from prairie dogs to untrained observers or at a distance. While mainly nocturnal, ferrets can and do emerge at the surface of prairie dog towns during daylight hours. With these facts in mind, prairie dog shooting should be prohibited in areas known to be inhabited by ferrets or within a reasonable distance that suggests that dispersing ferrets may be present. Such a policy would minimize the chances of ESA "take" of ferrets by prairie dog shooters, which could lead to stiff penalties.

The BLM should designate the nominated Shirley Basin/Medicine Bow white-tailed prairie dog complex as an ACEC because of the national importance of this ferret reintroduction site to overall ferret recovery goals and the need for special management if prairie dog populations are to be conserved and the ferret recovered. In fact, the Vernal Field Office of the BLM is proposing Research Natural Area designation for the Coyote Basin black-footed ferret reintroduction site under all alternatives considered in its draft Resource Management Plan revision except the No Action alternative. The Shirley Basin/Medicine Bow complex is much larger than the Coyote Basin complex and clearly merits special designation

Prairie Dogs

Virtually the entire area managed by the Casper Field Office is habitat for either the white-tailed or black-tailed prairie dog. Collectively, all species of prairie dogs have been reduced to only 2% of their historical range (Miller et al. 1990). White-tailed prairie dogs have declined to 8% of their native range in North America, and the survival of remaining populations is threatened by habitat destruction and modification, sylvatic plague, recreational shooting, poisoning, oil, gas, and mineral extraction, fire suppression, overgrazing, off-road vehicle use, noxious weeds, and climate change (Center for Native Ecosystems et al. 2002). In Wyoming, the white-tailed prairie dog occupies less than 2% of the suitable habitat for the species (Center for Native Ecosystems et al. 2002). For Wyoming's Great Divide Basin, Maxell (1973) noted, "Most active prairie dog towns were located some distance from the main thoroughfares in the Basin, probably due to human predation in the form of varmint hunters" (p.85). In the Casper planning area, prairie dog colonies are radically reduced from historic distributions, and are in need of protection and recovery.

It is not clear that any alternative under the Casper RMP would provide a buffer around prairie dog colonies where surface-disturbing activities would be precluded or even acoided. In contrast, USFWS has recommended 500 m buffers: "Stipulations should specify a no surface occupancy of at least 500 meters surrounding the prairie dog colonies" (USFWS 2004, p. 10). According to the multistate Conservation Assessment (Seglund *et al*. 2004), the Moab Field Office of the BLM is proposing half-mile buffers around white-tailed prairie dog colonies. The BLM should should provide such buffers to be in line with USFWS and other BLM Field Offices.

Prairie Dogs are Ecosystem Regulators

Prairie dogs are fundamental regulators of ecological processes within the area occupied by active colonies. According to Miller et al. (1990), "Prairie dogs have been implicated as ecosystem regulators that influence primary productivity, species composition, species diversity, soil structure, and soil chemistry by their burrowing and grazing" (p. 765). Hansen and Gold (1977) concluded, "This study, compared with previous research, provides evidence that blacktail prairie dgs [sic] are an important ecosystem regulator as they disturb the soil, increase plant diversity (Gold 1976), increase animal diversity, and cause a decrease in primary production of the areas they use." p. 2 13. Agnew et al. (1986)

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labeled prairie dogs as ecosystem regulators, maintaining shortgrass habitats. As regulators of ecosystem processes, prairie dogs are keystone species in shrubsteppe and grassland habitats.

On the High Plains, Ingham and Detling (1984) found that root-eating nematodes were more abundant and root biomass lower on a heavy-grazing prairie dog site, while available soil nitrogen was higher on the prairie dog colony. Holland and Detling (1990) subsequently found that nitrogen mineralization was highest in active prairie dog colonies and lowest in uncolonized grassland. Root biomass is lower within prairie dog colonies that on uncolonized sites (Holland and Detling 1990). In Wyoming's Shirley Basin, Schloemer (1991) found that prairie dog burrowing improves growing conditions for sagebrush by increasing snow entrapment, water infiltration, and deep percolation. Kotliar et al. (1999) concurred that the prairie dog clearly functions as a keystone species in the ecosystems it inhabits, creating habitat through its burrow networks, altering vegetation patterns, and providing an important prey base.

The Prairie Dog Ecosystem is Crucial to Many Wildlife Species

According to Miller et al. (1990), "Ecologically, the prairie dog ecosystem is an oasis of species diversity on the arid plains" (p. 764). Sharps and Uresk (1990) found that 134 vertebrate wildlife species are associated with prairie dog colonies in western South Dakota. In a comparative study which incorporated Wyoming sites, Clark et al. (1982) found that white-tailed colonies showed a greater number of associated vertebrate species (83 species) than either black-tailed or Gunnison prairie dogs; larger towns had a greater species diversity than smaller towns.

Agnew et al. (1986) found that avian density and species richness were significantly greater on High Plains prairie dog colonies. On the High Plains, Hansen and Gold (1977) found that desert cottontails were abundant on prairie dog towns but scarce elsewhere. O'Meila et al. (1982) found that rodent biomass (excluding prairie dogs) was almost twice as great on prairie dog towns than off; this higher rodent abundance was echoed in the results of Agnew et al. (1986). Goodrich and Buskirk (1998) demonstrated that badgers have a heavy dependence on white-tailed prairie dogs in Wyoming. The importance of prairie dogs as prey for raptors has been noted in many studies (e.g., Tyus and Lockhart 1979, Campbell and Clark 1981, MacLaren et al. 1988, Jones 1989, Cully 1991, Kotliar et al. 1999).

Many rare and declining species, notably black-footed ferret, mountain plover, burrowing owl, ferruginous hawk, and swift fox are dependent on prairie dogs for their own persistence (Kotliar et al. 1999). Based on study of the last remaining wild ferret population that was extirpated near Meteetsee, Forrest et al. (1985) reported that black-footed ferrets are confined almost exclusively to prairie dog colonies. In Wyoming, other species associated with white-tailed prairie dogs that are of particular note due to special status or management concern include the eastern short-horned lizard, northern plateau lizard, Great Basin gopher snake, midget faded rattlesnake, prairie falcon, merlin, sage grouse, burrowing owl, sage thrasher, Brewer's sparrow, sage sparrow, swift fox, and pronghorn (Clark et al. 1982).

Prairie dogs can be an important mainstay of raptor diets. In a study near Medicine Bow, Wyoming, white-tailed prairie dogs made up 38% of the biomass in the diets of prairie falcons, 18% for golden eagles and red-tailed hawks, and 22% of ferruginous hawk diet biomass (MacLaren et al. 1988). Prairie dog colonies are also important to the survival of raptor populations on their wintering areas. Jones (1989) studied winter raptor aggregations on the High Plans of Colorado "Aggregations of ferruginous hawks, red-tailed hawks, and bald eagles were frequently observed in the vicinity of prairie dog colonies." p. 256. In this study, golden eagles, ferruginous hawks, and red-tailed hawks were observed taking prairie dogs, while bald eagles and northern harriers competed for the captured prairie dogs. Declines in prairie dog colonies as a result of a plague epidemic resulted in a more than 60% decline in wintering bald eagles, ferruginous hawks, and red-tailed hawks (Ibid.). Numbers of wintering ferruginous hawks also declined

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dramatically following a crash in prairie dog populations in New Mexico (Cully 1991). Thus, full recovery of prairie dog populations would be the optimal outcome for maintaining and recovering raptor populations.

Mountain plovers are often found closely associated with prairie dog colonies of all species. Kotliar et al. (1999) listed the mountain plover as a species that is dependent on prairie dog colonies for its persistence, with abundances higher on prairie dog colonies, habitat selection for prairie dog colonies, reproductive fitness higher on colonies, and population declines occurring when prairie dogs decline. An analysis of pre-settlement records of mountain plover occurrence in Montana indicates that this species was closely associated with prairie dog colonies even before the arrival of EuroAmerican settlers (Knowles et al. 1999). Knowles (1999) went so far as to state that prairie dog colonies are "necessary to provide suitable habitat for mountain plovers" on Montana's Great Plains, and termed prairie dogs "necessary for the long-term persistence of mountain plovers" in that region (Knowles 1999). This study also found that even small areas of active colonies are important plover habitat. In Wyoming, the distribution of plovers has been linked with the widespread occurrence of white-tailed prairie dogs (Oakleaf et al. 1996).

The reduction in prairie dog colonies has been directly implicated as an important cause of mountain plover declines rangewide. Knowles et al. (1999) found that the disappearance of prairie dogs due to plague and/or recreational shooting also led to abandonment of nesting habitat by plovers, and plover numbers increased on sites where prairie dog populations were expanding. According to the **U.S.** Fish and Wildlife Service (1999), "Further loss of prairie dog towns within the current breeding range of the mountain plover would be detrimental to plover conservation. Conversely, the conservation of the mountain plover can be enhanced by implementing strategies to increase the distribution and abundance of prairie dogs on breeding habitat" (p. 7594). Thus, the conservation of prairie dog colonies is a prerequisite to maintaining viable populations of mountain plover.

Habitat Selection and Colony Attributes

In the Red Desert, Maxell (1973) found that prairie dogs were restricted to sagebrush-grass communities with shrub height less than 12 inches and cover less than 40%, on loam and clay textured soils. In the Shirley Basin, Orabona-Cerovski (1991) found that average plant cover on towns was 38%, with high amounts of bare ground. These preferences should be borne in mind when evaluating habitats for potential prairie dog recovery efforts.

The spatial distribution of prairie dog colonies is an important conservation priority. Clark et al. (1982) made the following observation for white-tailed prairie dogs in Wyoming: "Prairie dog colonies were found clumped in suitable habitat, and nearby colonies served as sources for colonizing animals" (p. 579). The dispersal ability of the white-tailed prairie dog is not great; Orabona-Cerovski (1991) found that less than 1% of juvenile males and 3% of juvenile females dispersed more than 200m from their natal burrows. Thus, maintaining a few isolated colonies is by far inferior to maintaining colony complexes with a high degree of connectivity to facilitate dispersal.

Clark et al. (1982) found that burrow densities for white-tailed prairie dogs averaged 25.8/ha, versus 32/ha for the black-tailed and Gunnison. But Campbell and Clark (1981) found that individual white-tailed colonies were as large and dense as black-tailed colonies, but white-tailed colonies were even more numerous and dense on the landscape. This was probably related to site productivity rather than any intrinsic propensity to create dense colonies by either species, as the white-tailed site in this study was located on moist, high-quality soils while the black-tailed site was on drier uplands (Ibid.). Burrow densities in the Shirley Basin ranged from 50-190/ha (Orabona-Cerovski 1991). In the southern part of the

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Rawlins Field Office, Smith et al. (1981) found burrow densities ranging from 12/ha to 42/ha, with an average of 27/ha, while **a** later survey (Smith et al. 1982) found burrow densities ranging from 13-68/ha, with a mean of 36/ha.

The Myth of Prairie Dogs as Meaningful Competitors for Livestock Forage

There is a perception among some in the ranching community that prairie dogs are a major source of forage loss for domestic cattle. However, the level of competition is fairly negligible and that prairie dogs may in fact increase forage palatability and nutrient content as a result of their herbivory. Hansen and Gold (1977, p. 2 13) noted that the diets of prairie dogs and cattle are broadly similar, and that prairie dogs do reduce the amount of available forage, but elucidated the ecological role of prairie dogs much more completely and accurately: "This study, compared with previous research, provides evidence that blacktail prairie dgs [sic] are an important ecosystem regulator as they disturb the soil, increase plant diversity (Gold 1976), increase animal diversity, and cause a decrease in primary production of the areas they use." In fact, Collins et al. (1984), finding that 7 hectares of prairie dog poisoning was required to yield an increase of only 1 AUM, concluded that prairie dog poisoning costs exceeded the value of forage produced.

Sylvatic Plague

Sylvatic plague is a major threat to the viability all species of prairie dog. Sylvatic plague has been documented in Natrona County, and plague has been present continuously in the Shirley Basin since 1985 (Cully and Williams 2001). These researchers stated that "all 4 species of prairie dogs are highly susceptible to plague infections" (Ibid., p. 895). Plague devastates black-tailed prairie dog colonies, but outbreaks may spread more slowly in white-tailed colonies than in black-tailed colonies. According to Ubico et al. (1988), "The Meteetsee area has a short, cool summer season...a plague epizootic under these circuinstances probably progresses more slowly over several years, although the end result of almost complete depopulation could be the same" (p. 404). Clark (1977) recorded a plague epizootic in a small colony of white-tailed prairie dogs in Wyoming that killed 85% of the colony. According to Cully and Williams (2001), the comparative low density of white-tailed prairie dog colonies slows the spread of plague, allowing the disease to persist for long periods of time, rather than wiping out a colony and dying out quickly as is the case with black-tailed prairie dogs. For black-tailed prairie dogs, Cully and Williams (2001) postulated that a ***3*** kilometer distance between colonies is enough to interrupt the spread of plague and assure the probable survival of neighboring colonies. There is currently no effective method to control the spread of plague in prairie dog colonies. Because prairie dogs in the Casper planning area are already stressed by endemic or epidemic levels of sylvatic plague, stronger conservation measures are needed to prevent impacts from activities that can in fact be controlled.

Conservation Measures

The ecological importance of prairie dogs, when paired with their low and declining population levels and imminent threats to colony viability, make the compelling case that strong measures must be put in place to protect and restore prairie dogs in the Casper planning area. Large prairie dog colonies, plus a half-mile buffer, should be withdrawn from all surface-disturbing activities with minerals leased only under "No Surface Occupancy" provisions. Under the Preferred Alternative, the BLM has not done enough to protect these species. Poisoning would be allowed, there would be no areas protected from shooting, and surface disturbing activities would be allowed even within colony boundaries. DEIS at 4-175. But even Alternative B, with its prairie dog ACEC, limitations on poisoning, and some areas where shooting would be prohibited, does not eliminate surface-disturbing activities within colony boundaries, a necessary mitigation measure.

Prairie dogs have many positive effects on the forage base for livestock which go unrecognized in the DEIS. On the High Plains, lngham and Detling (1984) found that root-eating nematodes were more abundant and root biomass lower on a heavy-grazing prairie dog site, while available soil nitrogen was higher on the prairie dog colony. Holland and Detling (1990) subsequently found that nitrogen mineralization was highest in active prairie dog colonies and lowest in uncolonized grassland. Root biomass is lower within prairie dog colonies that on uncolonized sites (Holland and Detling 1990). In the RMPPA, Schloemer (1991) found that white-tailed prairie dog burrowing improves growing conditions for sagebrush by increasing snow entrapment, water infiltration, and deep percolation. Krueger (1986) found higher shoot nitrogen in prairie dog towns, indicating enhanced forage quality for all grazers. Thus, while forage quantity may decrease slightly in response to prairie dog herbivory, forage quality may in fact increase as a result of the presence of prairie dogs.

O'Meila et al. (1982) found that although prairie dogs reduced the available forage for cattle, cattle on prairie dog plots failed to show a statistically significant decrease in weight gain over control animals. These researchers concluded, "The statistically similar steer weight gain performances during the green-herbage period indicates that sufficient herbage was available to meet the demands of both steers and prairie dogs, even under a regime of heavy utilization" (p. 583). Knowles (1986) found a symbiotic relationship between livestock and prairie dogs: Prairie dogs selected areas disturbed by overgrazing to establish colonies, while livestock preferentially foraged on prairie dog colonies due to higher-quality of forage.

Unfortunately, the DEIS's discussion of white-tailed prairie dog biology and ecology is extremely weak and sketchy; the analysis boiled down to a few sentences under each alternative. Under the Preferred Alternative, prairie dog poisoning would be allowed within 0.5 mile of a private land boundary at the owner's request, if poisoning was concurrently being pursued across the BLM boundary. DEIS at 2-59. How much of the Casper Field Office's 1.4 million acres falls within 0.5 mile of a private boundary? This is critical information that is needed to compare the acreage of land open to prairie dog poisoning under each alternative. This important analysis has apparently been neglected in the Draft EIS, and is needed to satisfy NEPA 'hard look' requirements. Prairie dog poisoning should not be allowed or supported on BLM land, as these are public lands, and prairie dogs are a valuable keystone species in prairie ecosystems. Both the black-tailed and white-tailed prairie dogs are BLM Sensitive Species, with a current trend toward listing under the Endangered Species Act.

Black-Footed Ferrets

Prairie dog colonies within 1.5 km of each other should be viewed as a "complex" for the purpose of black-footed ferret reintroduction (Biggins et al. 2006). Based on minimum viable population estimates for ferrets, viable ferret populations require prairie dog colonies of at least 3000 hectares, with a 4000-6000 hectare size being a more optimal minimum (Forrest et al. 1985; Captive Breeding Specialist Group 2004). These researchers recommended that only towns with burrow densities greater than 10/ha be considered "colonies" for the purpose of reintroduction, and that intercolony distances should not exceed 20 km to facilitate ferret interchange. Past studies indicate that there may be sites matching these criteria within the Casper planning area, and such sites would be of primary conservation concern. Prairie dog colonies must be protected and restored to present new potential ferret release sites.

As BLM recognized in its Rawlins RMP DEIS, "Black-footed ferret numbers have been shown to be directly linked to fluctuations in the prairie dog population." Rawlins DEIS at 3-138. It is therefore

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critically important to maintain prairie dog populations in areas currently inhabited or potentially habitable by black-footed ferrets.

Under Alternatives B and C, some 145,641 acres would be designated for black-footed ferret reintroduction. DEIS at 2-10. This measure should be carried forward into the Casper RMP. The black-footed ferret recovery area should be placed off-limits to prairie dog shooting and poisoning activities, and improved gravel road density should not be allowed to exceed 1.5 miles per square mile.

Swift Fox

The swift fox was determined to be "warranted but precluded" for listing under the Endangered Species Act by the U.S. Fish and Wildlife Service in 1995 (60 Fed. Reg. 31663). The swift fox is listed as a Species of Special Concern by the Wyoming Game and Fish Department, and is protected from intentional take by state regulations (Oakleaf et al. 1996). This species has been listed as dependent on the prairie dog for its persistence, and that its populations decline when prairie dogs decline (Kotliar et al. 1999). After a substantial absence, small populations of swift fox recolonized their native range in Montana during the 1970s (Moore and Martin 1980). Swift fox are also found in the Shirley Basin, and their range expansions elsewhere are a hopeful sign that this species may begin a broad-based recovery within the Casper planning area.

Comparatively little is known about swift fox biology and habitat requirements. Swift foxes pair for life and have one litter per year (Kilgore 1969). Dens are complex warrens with multiple tunnels and entrances, and prairie dog burrows may be enlarged into swift fox dens (Kilgore 1969). Uresk and Sharps (1986) found that swift fox dens tend to be constructed on or near hilltops. In one study, swift fox home ranges averaged 32 km^2. The diet of swift fox in various parts of its range is dominated by prairie dogs, grasshoppers, and beetles (Uresk and Sharps 1986), small rodents, including prairie dogs (Kilgore 1969), mainly lagomorphs (particularly jackrabbits) with some prairie dogs (Zumbaugh et al. 1985), and may include carrion and plant matter (Hines and Case 1991).

Swift fox face a number of threats to their viability. According to Kahn et al. (1997), "Swift fox are frequently observed along roadways, which may increase the rate of animals being killed specifically by vehicles. Factors such as road density, miles traveled and driver speed may increase the rate of swift fox mortalities" (p. 17). Kilgore (1969) noted, "The chief mortality factors to which swift foxes are subjected are those associated with the activities of man. These foxes are frequently killed crossing highways and county roads, shot by hunters or farmers, and killed by farm implements" (p. 525). Swift fox are also particularly vulnerable to poisoning programs targeted at rodents or other carnivores (Kilgore 1969, Uresk and Sharps 1986). In their conference opinion on the Seminoe Road Coalbed Methane Project, the USFWS recommended that activities which might disrupt denning swift fox be prohibited between March 1 and July 31 (Long 2001). Denning areas should be identified and protected under the Casper RMP from any activities that threaten the viability of swift fox populations.

Raptors

Raptor populations are on the rebound following declines based largely on insecticide spraying, predator poisoning programs, and shooting in the 1960s and 1970s. Raptors of special concern include the golden eagle, prairie falcon, northern goshawk, peregrine falcon, ferruginous hawk, merlin, and burrowing owl. Because they require large natural areas for survival, raptors may be good umbrella species for the protection of entire ecological communities (Burnham and Holroyd 1995).

Most raptor species are sensitive to human disturbance in the form of foot or vehicle traffic during the nesting period. According to BLM, "Most of these [raptor] species are also sensitive to disturbance,

especially during the nesting cycles." Rawlins RMP DEIS at 3-128. The primary impact to raptor populations is direct disturbance of raptors on the nest, leading to reductions or loss of viability for eggs or nestlings. Disturbance of nesting raptors may cause nest abandonment, damage to the eggs, subject eggs or nestlings to cooling, overheating, or dehydration leading to mortality, prevent young nestlings from receiving sufficient feedings to remain viable, and cause premature fledging (Parrish et al. 1994). Thus, the BLM should establish adequate nest buffers (on the order of 2 miles in diameter for ferruginous hawks, which are especially sensitive, and 1 mile for other species) around nest sites, preventing all construction of developments (such as wells and roads) that would lead to future disturbance of nesting raptors through focusing human activities and/or vehicle traffic in these areas. Seasonal restrictions are insufficient; a well or road constructed outside the nesting season is still likely to lead to nest abandonment or reductions in recruitment due to disturbance from vehicle traffic that does occur during the nesting period.

The overall landscape-scale effects of widespread industrialization threaten the viability of raptor populations through habitat loss and fragmentation. Nest buffers currently in force are unlikely to safeguard the viability of native raptors in the Casper planning area; a more conservative approach is needed in order to safeguard raptor viability in this region. White and Thurow (1985) stated: "We would prefer to see ecosystems kept intact (cf. Wagner 1977) rather than divided into isolated islands set aside for nesting raptors, because aspects of general land use other than restricted areas also affect the health of raptor populations" (p. 21). The large areas prioritized for reducing habitat fragmentation under Alternative B fit this model. Thus, not only should nest buffers be implemented, but the overall integrity of the landscape should be maintained (or improved in areas where it is currently degraded) in order to better provide for raptor viability.

Cliffs provide important nesting substrates preferred by a broad spectrum of raptors. A study near Medicine Bow, Wyoming found that cliffs provided the single most important nesting habitat for raptor species in the region, and 93% of all prairie falcon nests were found on cliffs, despite the comparative rarity of this landform in the Medicine Bow area (MacLaren et al. 1988). In a Utah study, prairie falcons and golden eagles nested exclusively on cliff sites (Smith and Murphy 1982). Thus, in terms of value to nesting raptors, areas with cliff topography may be of heightened conservation importance. For this reason, cliff areas with a history of raptor nesting should be accorded the same nest buffers (2 miles) as ferruginous hawk nests. Cliff habitats and raptor nest sites should be mapped and disclosed in the Casper RMP FEIS.

Golden eagles, their nests and young are strictly protected under the Bald Eagle Protection Act. 16 USC § 668(a)-(d). This species is very popular with the wildlife viewing public, and conversely has historically suffered from shooting as well as poisoning directed at terrestrial predators. The maintenance of viable golden eagle populations should be an important consideration in the new RMP. Conservation efforts should focus on protecting nest sites and important foraging areas, such as prairie dog colonies. Golden eagles are highly territorial. Even when surface-disturbing activities such as strip mining are located away from golden eagle nest sites, the destruction of important foraging habitats, such as prairie dog colonies, within the territory of nesting pairs can be a major problem for the viability of nesting golden eagles (Tyus and Lockhart 1979). In New Mexico, plague-related declines in prairie dog abundance from 30 per hectare to less than 1 per hectare triggered a decline in the nesting population of golden eagles (Cully 2001). Thus, golden eagle protection is linked with the maintenance and recovery of prairie dog colonies.

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Ferruginous Hawk

The ferruginous hawk has been experiencing declines across the continent for the past 30 years, although Wyoming is often viewed as a stronghold for the species. The ferruginous hawk has been petitioned for listing under the Endangered Species Act in the past, and more recently it has been identified by the Wyoming Game and Fish Department as a Species of Special Concern (Oakleaf et al. 1996). **As** a result, ferruginous hawks are of special concern and deserve the strongest protection available in the context of this long-term management plan.

Oil and gas development and the associated human activity can have major impacts on raptor nest success. The primary impact to raptor populations is direct disturbance of raptors on the nest, leading to reductions or loss of viability for eggs or nestlings. Disturbance of nesting raptors may cause nest abandonment, damage to the eggs, subject eggs or nestlings to cooling, overheating, or dehydration leading to mortality, prevent young nestlings from receiving sufficient feedings to remain viable, and cause premature fledging (Parrish et al. 1994). Thus, the BLM should establish adequate nest buffers (a minimum of 1 mile in diameter for <u>all</u> species, with larger buffers for ferruginous hawks) around nest sites, preventing all construction of developments (such as wells and roads) that would lead to future disturbance of nesting raptors through focusing human activities in these areas. Seasonal restrictions are insufficient; a well or road constructed outside the nesting season is still likely to lead to nest abandonment or reductions in recruitment due to disturbance from vehicle traffic that does occur during the nesting period.

Ferruginous hawks are among the most sensitive of all raptor species, and are prone to nest abandonment if disturbed (Parrish et al. 1994). Nest abandonment, egg mortality, parental neglect, and premature fledging are common results of disturbing ferruginous hawk nests (White and Thurow 1985). It is important to note that the aforementioned study was undertaken specifically to examine the potential impacts of oil and gas development on nesting ferruginous hawks. Smith and Murphy (1978) noted that increased human access is a primary threat to the viability of ferruginous hawk nest success. For their central Utah study, these researchers found that "in all instances of nesting failure where the cause could definitely be determined, humans were at fault" (p. 87). White and Thurow (1985) found that walking disturbance and vehicle use had the greatest effect on ferruginous hawk nest success, while vehicle use had the greatest flushing distance. Instead of becoming habituated, most hawks in this study increased their flushing distances with repeated disturbance (Ibid.). In addition, disturbed nests averaged one less offspring fledged per nest when compared to undisturbed control nests. Oakleaf et al. (1996) pointed out that the cumulative effects of oil and gas development may impact large areas of ferruginous hawk habitat.

White and Thurow (1985) recommended quarter-mile nest buffers during years of prey abundance, but noted that sensitivity to disturbance increased when prey were scarce, and recommended that nest buffers be "considerably larger" during years of prey scarcity. Although Olendorff (1993) recommended buffer zones of only ½ mile for ferruginous hawk nests, he recommended much larger buffers during periods of prey scarcity. Because it is impractical to move roads away from nest sites when prey bases decline, the appropriate way to ensure the persistence of ferruginous hawks at traditional nesting sites is to use large buffers within which ground-disturbing activities are prohibited. Cerovski et al. (2001) reviewed the issue of appropriate nest buffers and recommended a 1-mile buffer, kept free from human disturbance. Thus, a minimum of 1-mile buffers **<u>prohibiting surface disturbance</u>** should apply to ferruginous hawk nest sites as well as <u>all</u> other raptor nest sites.

Raptor nest buffers presented in all alternatives in the Draft **EIS** are completely insufficient. In the Preferred Alternative, surface-disturbing activities, such as well, road, and pipeline construction, could

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occur close to active nests, as long as construction/drilling activities occurred outside the nesting season. During years of prey scarcity, which can certainly be expected over the 15-to 20-year life of the plan, no alternative provides the minimum recommended protection found in the scientific literature. The larger 0.5-mile to 1.5-mile buffer zones around active raptor nests in the various alternatives offer only seasonal protections and apply only to construction activities; vehicle traffic, maintenance, and production activities would be allowed to occur within a quarter mile of active raptor nests during the nesting season, with a strong likelihood of disturbing nesting raptors, causing temporary and/or permanent nest abandonment, and leading to the deaths of eggs and/or nestlings in the process. This is an unacceptable state of affairs, constitutes "unnecessary and undue degradation" to these wildlife populations, and therefore constitutes a violation of FLPMA.

It is all well and good to prevent construction near nest sites while the hawks are present, but nests are used traditionally from year to year, and if a road or well site is constructed near a nest during the off-season, that nest site will be rendered non-viable the following year when the hawks return to their nesting territory. In addition, ferruginous hawks use the same nest from year to year and also build alternate nests within the same territory (Smith and Murphy 1978). Thus, historic as well as active nests deserve a strong degree of protection for traffic-related surface disturbances. The BLM must emplace solid, year-round protections that prevent the construction of roads and well-sites, which will inherently receive regular vehicle traffic throughout their productive lifetimes, regardless of nesting seasons, within 1 mile of ferruginous hawk nests, both active and historic.

The Migratory Bird Treaty Act prevents the taking of any migratory birds, their parts, nests, or eggs except as permitted by regulations and does not require intent to be proven. 16 USC § 703. The Bald and Golden Eagle Protection Act prohibits knowingly taking, or taking with wanton disregard for the consequences of an action, any bald or golden eagle or their body parts, nests, or eggs, which includes collection, molestation, disturbance, or killing. 16 USC § 668. All of the alternatives apparently will allow 'take' of nesting raptors through initiating nest abandonment and reproductive failure in raptors.

The overall landscape-scale effects of widespread industrialization threaten the viability of raptor populations through habitat loss and fragmentation. Nest buffers currently in force are unlikely to safeguard the viability of native raptors in the Casper planning area; a more conservative approach is needed in order to safeguard raptor viability in this region. White and Thurow (1985) stated: "We would prefer to see ecosystems kept intact (cf. Wagner 1977) rather than divided into isolated islands set aside for nesting raptors, because aspects of general land use other than restricted areas also affect the health of raptor populations" (p. 21). Oil and gas development results in habitat fragmentation and increased levels of human disturbance, impacting raptor species; nesting and foraging habitat loss can be substantial in the case of full-field development (Postovit and Postovit 1989). Even when surface-disturbing activities such as strip mining are located away from golden eagle nest sites, the destruction of important foraging habitats, such as prairie dog colonies, within the territory of nesting pairs can be a major problem for the viability of nesting golden eagles (Tyus and Lockhart 1979). Thus, not only should nest buffers be implemented, but the overall integrity of the landscape should be maintained (or improved in areas where it is currently degraded) in order to better provide for raptor viability.

Burrowing Owls

Nationwide, the burrowing owl is a species on the decline. As of 1997, over half of the agencies across North America tracking burrowing owl population trends reported declining populations, while none reported increasing populations (James and Espie 1997). Burrowing owl populations are highly susceptible to stochastic disturbances such as drought, and thus may decline more rapidly than would be predicted on the basis of demographic factors alone (Johnson 1997). In Wyoming, data suggest an overall

population decline, with 17.5% reoccupancy of historic sites, but the spotty quality of historical data makes comparisons difficult (Korfanta et al. 2001). The burrowing owl has been identified as a species of concern by both the BLM and the Wyoming Game and Fish Department. Given the rarity of this species, BLM should put strong measures in place to restore and increase burrowing owl populations, as they would appear to be on a trend toward listing under the Endangered Species Act.

Dependence on Prairie Dog Colonies

Burrowing owls are in a select group of wildlife most closely tied to prairie dog colonies, and prairie dog burrows are preferred nest sites for burrowing owls. Thompson (1984) reported that owls preferred abandoned prairie dog burrows in the early stages of succession. Green and Anthony (1989) found that nest burrows lined with dung were less susceptible to predation, perhaps explaining this unusual behavioral attribute. On the Great Plains, Sidle et al. (n.d.) found that burrowing owls actively selected for active prairie dog towns, and showed much lower usage of towns that had been decimated by plague, shooting, or poisoning. Desmond and Savidge (1999) found that burrowing owl nest success was positively correlated with density of active prairie dog burrows, and recommended preserving prairie dog colonies to maintain the viability of burrowing owl populations. And in the Columbia Basin, where prairie dogs are absent, burrowing owls nested in badger burrows, but as a result were subjected to badger predation (Green and Anthony 1989). Thus, the ongoing loss of prairie dog colonies has undoubtedly been a prime factor in the decline of the burrowing owl.

In the planning area, the ties of burrowing owls to prairie dogs vary by region. Thompson (1984) found that burrowing owls near Casper were associated with white-tailed prairie dogs, while near Torrington they were associated with black-tailed prairie dogs. But in eastern Wyoming, fewer than half of the nesting burrowing owls were associated with inactive prairie dog towns (Korfanta et al. 2001). This underlines the need to maintain and restore healthy prairie dog populations by protecting colonies from surface disturbance, geophysical activities and the construction of nearby overhead perching structures.

Hunting Habits

Burrowing owls hunt most actively during the twilight hours (Thompson 1984). In the Columbia Basin, pocket mice are the primary mammalian prey (Green and Anthony 1989). In Wyoming, insects are the most frequent prey item, but small mammals dominate the dietary biomass (Thompson 1984). Due to the importance of insects (particularly grasshoppers) in the diets of burrowing owls, the widespread use of pesticides would most likely result in impacts to burrowing owl viability. This underlines the importance of an impacts analysis on general (non-BLM Sensitive) rodent populations in the Casper planning area, an analysis which has not been performed in the Draft EIS.

Effects of Livestock Grazing

Bock et al. (1993b) reported that burrowing owls probably respond positively to grazing in grassland habitats, but negatively in shrubsteppe habitats. The BLM should bear these trends in mind when drafting individual Allotment Management Plans, and analyze impacts of various alternatives on burrowing owls.

Peregrine Falcons

Cliffs in the Casper Field Office meet the peregrine falcon nesting habitat criteria and might possibly be used by peregrine falcons as nest sites; there is one nest record in the planning area. With this information in mind, the BLM should provide a detailed analysis of impacts to peregrine falcons in the FEIS.

Laramie False Sagebrush

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BLM notes that the Laramie false sagebrush is globally imperiled, and that it occurs on limestone outcrops which are sometimes targeted for mining. DEIS at 3-68. The new plan should require field surveys of potential habitat on federal land and recommend withdrawal from mineral entry all areas containing this rare plant.

THE DRAFT EIS FAILS TO PROVIDE SUFFICIENT BASELINE DATA

BLM's obligation to provide baseline information at the land-use planning stage is vested in both NEPA and FLPMA. In addition to NEPA's requirement to provide baseline information (outlined below, FLPMA provides a separate and equally binding directive for the BLM to maintain an inventory of resources through the land-use planning process:

> The national interest will be best realized if the public lands and their resources are periodically and systematically inventoried and their present and future use is projected through a land use planning process coordinated with other federal and State planning efforts;

43 U.S.C. § 1701(a)(2). Furthermore,

> [BLM shall] prepare and maintain on a continuing basis an inventory of all public lands and their resources and other values (including, but not limited to, outdoor recreation and scenic values), giving priority to areas of critical environmental concern. This inventory shall be kept current so as to reflect changes in conditions and to identify new and emerging resources and other values.

43 U.S.C. § 1711(a). In addition, BLM must also monitor these resource values for at-risk species and habitat on an ongoing and continuous basis:

- The State Director is responsible for determining "the condition of the populations and their habitats, and how discretionary BLM actions affect those species and their habitats." BLM Manual § 6840.04(E).
- The BLM must monitor and evaluate ongoing management activities to ensure conservation objectives for listed species are being met. BLM Manual § 6840.06(A)(1).
- The BLM must monitor "populations and habitats of candidate species to determine whether management objectives are being met." BLM Manual § 6840.06(C)(2)(d).
- The BLM must monitor "populations and habitats" of sensitive species to determine whether management objectives are being met. BLM Manual § 6840.06(E) and 6840.06(C)(2)(d).

Importantly, 40 C.F.R. § 1502.15 requires agencies to "describe the environment of the areas to be affected or created by the alternatives under consideration." Establishment of baseline conditions is a requirement of NEPA. In *Half Moon Bay Fisherman's Marketing Ass'n v. Carlucci*, 857 F.2d 505, 510 (9th Cir. 1988), the Ninth Circuit states that "without establishing . . . baseline conditions . . . there is simply no way to determine what effect [an action] will have on the environment, and consequently, no way to comply with NEPA." The court further held that, "The concept of a baseline against which to compare predictions of the effects of the proposed action and reasonable alternatives is critical to the NEPA process." These data need to be presented in the **EIS;** their availability in other publications cannot satisfy NEPA's requirements for the Casper RMP. Further directives also support that baseline information must be gathered: "If the incomplete information relevant to reasonably foreseeable

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significant adverse impacts is essential to a reasoned choice among alternatives, and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement." 40 C.F.R. § 1502.22(a). Clearly, BLM has failed this basic duty in this DEIS and should provide this information in a supplemental Draft EIS so that environmental consequences can be satisfactorily assessed.

The Reasonably Foreseeable Development scenario for number of oil, gas, and coalbed methane wells; the miles of road construction and upgrades to gravel surface; and the miles of pipeline construction to be permitted pursuant to the Casper RMP under the various alternatives are buried in the Appendices and are difficult to access. This information provides the most basic foundation for the impacts analysis (many impact variables are dependent not on the acreage of surface disturbance but on the number of well sites volatilizing volatile hydrocarbons, or the number of drilling rigs discharging exhaust, or the number of CBM wells discharging saline wastewater, et cetera. This information provides a critical baseline for the analysis which should be prominently displayed in the FEIS.

Baseline Data on Visual Resources

The Draft EIS includes a description of how many acres fall into each Visual Resource Management class (which describes current management), but does not describe the acreage of land that occurs in high-value viewsheds (the descriptor of actual visual resources). DEIS at 3-90. Lands in the viewsheds of backcountry scenic byways, historic trails, recreation sites, and citizens' proposed wilderness would reasonably be seen as high-value visual resources. BLM makes no effort to catalog and quantify these in the Casper RMP.

Computer programs that analyze topography and determine which areas lie within the viewsheds of important overlook points or areas are readily available, and indeed the BLM has used such software to determine and display the viewsheds of the Overland Trail and other historic trails in the Rawlins RMP Draft EIS. It is baffling that, given the importance of the viewsheds described above, the BLM has failed to apply the same technology to generate needed baseline data on the viewshed and visual resources of important landscapes in the Casper planning area.

Baseline Data on Surface Water Quality

The DEIS talks about baseline water quality in the RMPPA, but fails to provide any data; in fact, the DEIS describes surface water quality as "variable" without even describing the range of variability. DEIS at 3-13. Intelligent management of surface water quality begins with an examination of existing water quality. Management actions should have as their goals to prevent degradation of current water quality, and to improve water quality in areas where it is impaired. Activities that would potentially impair surface water quality (e.g,. surface discharge of coalbed methane wastewater or produced water as a byproduct of production in depleted oilfields) must be regulated to prevent such impairment. However, it is impossible for BLM to analyze potential impacts to water quality without disclosing current water quality conditions. The failure to provide this baseline data is an egregious one, and calls into doubt the analysis of impacts to surface water quality.

Baseline Data on Groundwater Quality

The DEIS also fails to provide baseline data on the quality of groundwater from various aquifers. This information is critically important to a 'hard look' analysis because salts and heavy metals found in the groundwater in coal seams have the potential to poison aquatic life and riparian vegetation downstream when coalbed methane wastewater is discharged untreated into waterways or infiltration reservoirs. The composition of groundwater from coal seams likely to be exploited by reasonably foreseeable coalbed methane development must be disclosed as key baseline data in the Casper RMP EIS, and the BLM has

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thus far failed to do so. This information has been displayed by BLM in the past based on water quality measured for water wells tapping the same formation as CBM development would exploit. By now, exploratory CBM wells in the planning area have been drilled, and substantial dewatering has occurred; also, depleted oil fields are also producing water discharged at the surface, which is available for testing. Direct water quality data from these exploratory wells should be available to the BLM both through direct testing of produced waters from these wells and through the NPDES permit system, administered by the Wyoming Department of Environmental Quality. It is an inexcusable omission for the BLM to have failed to present these key data, without which a hard look at the impacts of surface discharge of CBM wastewater on receiving surface water bodies and near-surface aquifers is impossible.

Baseline Data on Wildlife Populations and Population Trends

Waterfowl and shorebirds are dependent to one degree or another on the maintenance of wetlands. Data from the Wyoming Natural Diversity Database indicate records for the following shorebird and waterfowl species of concern within the boundary of the Casper Field Office: common loon, Clark's grebe, American white pelican, American bittern, white-faced ibis, ring-necked duck, bufflehead, snowy plover, upland sandpiper, long-billed curlew, Wilson's phalarope, and three species of tern. According to WGFD (2002), observations of long-billed curlews suggest breeding activities north of the Seminoe Mountains and in the vicinity of the Pedro Mountains. WGFD (1 995) recommended censusing waterfowl and shorebirds on all surface waters, and in particular getting counts of breeding pairs. The large number of sensitive or rare waterfowl and shorebirds found in the lands managed by the Casper Field Office make it imperative that the few wetlands found on these lands receive ample protection. Baseline data on the species of waterfowl and shorebirds, and their relative abundance and population trends, are absent from the DEIS. *See* DEIS at 3-79 through **81.**

Baseline data on raptor populations are absent from the DEIS. See DEIS at 3-177 through 3-79. The BLM should posses data on raptor nest locations by species, and also data on whether these nests are active, inactive, or historic (abandoned for more than 10 years). It seems reasonable to expect the BLM to assemble some graphs showing the number of active raptor nests, as well as trends in raptor nest success (measured in fledglings per nest), over the course of recent years. Such baseline data is necessary to determine for each species of raptor whether populations are increasing, decreasing, or remaining stable under the current management and level of development. Without knowing population trend for the various birds of prey (including BLM Sensitive Species such as the ferruginous hawk and burrowing owl), the BLM has no way of knowing whether remedial action is needed through the RMP and whether current or accelerated rates of industrialization can be sustained without threatening the viability of raptor populations.

Sage Grouse

Baseline data on sage grouse is also absent from the Casper RMP DEIS. While the Affected Environment section provides a list of upland bird species, and a very gross description of their geographic ranges within the planning area, there is no data provided as an index of population size and trend for these two BLM Sensitive Species. The Wyoming Game and Fish Department has been keeping records of sage grouse and sharp-tailed grouse activity at lek sites, which are used traditionally from year to year. The number of leks within the planning area, as well as an accounting of trend of active versus inactive and historical leks, is needed to determine whether sage grouse and sharp-tailed grouse populations are increasing, decreasing, or remaining stable under existing management and current levels of development. These data, though available and a necessary prerequisite to an informed analysis of impacts and choice among alternatives, are woefully absent from the Casper RMP DEIS. According to a local resident, several leks on BLM land along the Ornsby Rd. are not currently recognized by BLM, but should be. The BLM should conduct field inventories of this area to determine the presence of active leks.

Sensitive Species

Similarly, there are no population or trend data presented in the DEIS for any of the Threatened, Endangered, Candidate, or Wyoming BLM Sensitive Species. See DEIS at 3-72 *et seq.* Baseline data on geographic occurrence is also not presented. BLM admits that there has never been a complete inventory of the planning area for Sensitive Species. DEIS at 3-72. This NEPA process is supposed to be the vehicle under which a complete inventory is conducted. Indeed, FLPMA requires the BLM keep a complete and ongoing inventory of resources to help inform the planning process. Sensitive wildlife are a prime resource of public concern, and the BLM should therefore correct the error of omission in failing to conduct a complete and comprehensive inventory for Sensitive Species in the Draft EIS. Data for geographic occurrence of sensitive species is readily available through the Wyoming Natural Diversity Database, and should have been included in the DEIS.

BLM notes that there are four bat species of management concern in the planning area, yet despite their reliance on unique habitats (snags, mines, caves), BLM has not made an inventory of these unique habitat components. DEIS at 3-64. Does the BLM know of no roosting sites or hibernacula at all?

BLM does not discuss the presence of BLM Sensitive fishes downstream from the planning area in the Powder River watershed. DEIS at 3-71. These include the sturgeon chub, shovelnose sturgeon, and others, and are likely to be affected by activities permitted under the Casper RMP on upstream lands.

BLM notes correctly that Wyoming Natural Diversity Database has rare species occurrences for the planning area. DEIS at 3-65. These should be gathered by BLM and published in the Draft EIS as part of NEPA's baseline information requirement. It is unclear from the EIS whether BLM has actually even made a data request from WYNDD, or if so, whether these data formed the basis of any analyses contained therein. It is therefore unclear whether BLM considered these data in its formulation of the EIS.

Baseline Data on the Transportation System

The BLM discusses the road network in the planning area at several points in the DEIS. See DEIS at 3-100. And yet nowhere in the DEIS is presented a full accounting of the present location of high-standard, improved gravel roads that spiderweb the planning area. *See* Map 48, showing only the paved highways. This information should be in BLM's possession, since the construction of roadways and the granting of rights-of-way for road alignments on public lands rests exclusively with the BLM. In addition, this information can be readily derived from recent statewide aerial overflights and satellite images that are readily available to the BLM. Therefore the BLM has no excuse for not gathering and presenting this important baseline information in the DEIS. In addition, the preferred alternative proposes allowing OHV use within 300 feet of existing roads. DEIS at 2-72. The BLM should perform a spatial analysis of what proportion of the RMPPA is encompassed by this 300-foot buffer around existing routes.

The assessment of the road network and management of future road construction activities is an integral part of the planning process; the public will not stand idly by while the BLM approves a long-term land-use plan that allows road construction to go ahead in a disorderly, disorganized, and unplanned fashion. In its Pinedale Anticline EIS, the BLM itself has stated that road densities greater than one mile per square mile have negative impacts on pronghorn. Apparently, no alternative provides a limit on road densities. See DEIS at 2-73. The road network must be managed like any other permitted activity, and cannot be allowed to go completely unmanaged at the RMP stage. A prerequisite for both future management and planning of the roads network and a credibly analysis of road network impacts is the full and detailed presentation of the present location of roads within the planning area.

Baseline Data on Paleontological Resources

About half the planning area is described as having a Probable Fossil Yield classification of 4 or 5. DEIS at 3-87. These are typified as highly productive of vertebrate fossils with easy access to outcrops. Yet there is no map showing the distribution of fossil resources across the planning area. The spatial distribution of fossil-rich outcrops will determine the likelihood and level of environmental impacts when projects are authorized pursuant to the Casper RMP. Without this baseline information, the BLM cannot present information on how many acres of surface disturbance will occur in lands of each Probable Fossil Yield category, an analysis that needs to be performed for each alternative to satisfy NEPA's 'hard look' requirements.

THE CASPER DEIS FAILS TO TAKE A HARD LOOK AT ENVIRONMENTAL IMPACTS

NEPA's purpose is *to* maintain a national "look before you leap" policy in regard to all major federal actions. Congress' intent in establishing this objective was to avoid uninformed agency decisions that could have serious environmental consequences. Thus, NEPA's mandate is that all federal agencies analyze the likely effects of their actions, as well as address the potential alternatives. "Agencies are to perform this hard look *before* committing themselves irretrievably to a given course of action so that the action can be shaped to account for environmental values. NEPA § 102(2)(c) requires the agency to consider numerous factors [including] irreversible commitments of resources called for by the proposal." *Sierra Club* v. *Hodel,* 848 F.2d 1068 (10th Cir. 1988) (reversed on other grounds)(emphasis added). NEPA provides procedural protections for resources at risk by requiring analysis of impacts *before* substantial decisions are made that set development in motion. See *Conservation Law Foundation v. Watt,* 560 F. Supp. 561, 581 (D. Mass. 1983), *aff'd by Massachusetts v. Watt,* 716 F. 2d 946 (1st Cir. 1983).

A related serious flaw that permeates the entire EIS concerns qualitative versus quantitative impact assessments. BLM has mastered the obvious in being able to state the *types* of impacts but has done very little in actually telling the public *what the actual impacts to various resources will be*. Examples include: roads will fragment wildlife habitat; compressor stations will cause noise; soil loss will affect vegetation communities; produced wastewater will increase sedimentation; hundreds of wells/miles of roads will cause soil loss, and so forth. Simply stating the obvious that massive industrial development will cause qualitative impacts really misses the point of a NEPA analysis; BLM must examine what the actual degree of impacts will be. As with other areas, this deficiency by BLM will result in the federal courts sending BLM back the EIS to try again. *See, e.g., Defenders of Wildlife,* 130 F. Supp. 2d 121, 128 (D. D.C. 2001) (setting aside agency's EIS where it "states that noise would be increased and both the pronghorn and their habitat would be disturbed" but contained "no analysis of what the nature and extent of the[se] impacts will be"); *National Parks & Conservation Association v. Babbitt,* 241 F.3d 722, 743 (9th Cir. 2001) (NEPA document inadequate where it identified "an environmental impact" but "did not establish the intensity of that impact."); *Neighbors of Cuddy Mountain v. U.S. Forest Service*, 137 F.3d 1372, 1379-80 (9th Cir. 1998) ("General statements about 'possible' effects and 'some risk' do not constitute a 'hard look' absent a justification regarding why more definitive information could not be provided. . . . Nor is it appropriate to defer consideration of cumulative impacts to a future date...").

In applying the "hard look" test where, as here, the agency, relies existing documents to satisfy NEPA, the agency must establish an administrative record that documents clearly that it took a "hard look" at (1) whether new circumstances, new information, or unanticipated environmental impacts warrant new analysis or supplementation of existing NEPA documents and (2) whether the impact analysis is valid for the proposed action. *Colorado Environmental Coalition,* 149 IBLA 154, 156 (1999) at n 4. The documentation can be concise but must adequately address the criteria. *Id*; 40 C.F.R. § 1502.9(c)(1)(i),(ii).

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The Draft EIS Fails to Take a Hard Look at Impacts to Birds of Prey
The "Impacts Analysis" section on impacts to raptors of the Preferred Alternative is exactly one paragraph long, and is comprised entirely of a recitation of the mitigation measures in this alternative. The BLM makes no quantitative or qualitative assessment of the magnitude or nature of impacts to raptors that will arise as a consequence of activities or projects permitted under the Casper RMP. Likewise, the BLM makes no quantitative or qualitative assessment of the effectiveness of the mitigation measures it enumerates in lieu of an impacts analysis. This section does represent that management actions would be beneficial for rator prey species. DEIS at 4-130. However, there is no baseline provided against which these advantages can be measured. Certainly, the 1,800 or so wells inherent to this alternative, with the mitigation measures proposed (essentially the same ones as were in use under the original Casper RMP) will have an additive negative effect on the viability of raptor populations, versus the existing wells that are already there. Only the degree of the decline is in question. There is no discussion about what the impact on raptors of adding another 1,800 wells to the thousands already drilled in the Casper Field Office might be; it is our conclusion that this impact will undoubtedly be negative and is likely to be quite substantial. Regardless, the BLM has failed to provide any assessment on the impacts of the more than 1,800 oil and gas wells, undisclosed hundreds miles of roads associated with these wells, and other associated facilities that are reasonably foreseeable consequences of actions to be approved under this plan.

The DEIS Fails to Take a Hard Look at **Impacts to Big Game**
The Casper RMP DEIS fails to take a hard look at impacts to big game. In order to thoroughly analyze direct and cumulative impacts to big game, the BLM would need to present population and trend data on a herd unit level (which appears to be present in the appendices), project current and future levels of impact on the big game habitats (not just crucial winter and calving habitats, but also migration corridors, transitional ranges, summer ranges – which may become limiting at the levels of oil and gas development proposed, and parturition areas for all big game – not just elk). The projected levels of impact could (and should) be estimated spatially, based on current fluid mineral lease holdings, and the resulting impact on population size and trend should be listed for each herd, under each alternative.

BLM should also have projected population increases and decreases at the Herd Unit level resulting from activities permitted under the Casper RMP. This **EIS** is the appropriate stage at which to examine the cumulative impacts of all of the permitted actions that are reasonably foreseeable during the lifespan of the new RMP. The fact that BLM has failed to analyze these impacts, which will ultimately determine the fate of elk, deer, bighorn sheep, and antelope herds, violates NEPA's hard look requirements.

The DEIS Fails to **Take a Hard Look at Impacts to Air Quality**
The BLM has an obligation under FLPMA and the Clean Air Act to ensure that permitted activities do not result in exceedences of state and federal air quality standards. Pursuant to this obligation, BLM must take the hard look required by NEPA at the impacts of permitted activities under each alternative of the Casper RMP on air quality. BLM begins its Air Quality analysis by stating that the analysis will be qualitative rather than quantitative. DEIS at 4-5. This statement is indicative of the fact that BLM has failed its obligation to take the required "hard look" at impacts to air quality. To fulfill NEPA's obligations, the air quality analysis should not be only qualitative, but also quantitative. The BLM does quantify the gross levels of pollutants produced under each of the alternatives. *See* Table 4-6. However, it is not clear how these levels of impacts will influence attainment or nonattainment of air quality standards for Class I and II airsheds (including visibility parameters in wilderness areas) and other areas of concern under the Clean Air Act. This information is critically important to allow a reasoned comparison of the alternatives and an informed decision at the end of the process.

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While the Draft EIS does provide some estimates of pollutant outputs from reasonably foreseeable developments, the agency has failed to take a hard look at the impacts of these pollutant outputs on air quality, particularly in Class I airsheds, which are protected under the Clean Air Act. It is unclear whether volatile emissions from condensate tanks are included in estimates of present emissions from oil and gas fields. The BLM does not note how the tonnage of air pollutants released pursuant to the Casper RMP will affect air quality with respect to the Wyoming Ambient Air Quality Standards, Colorado Ambient Air Quality Standards, or National Ambient Air Quality Standards. If the Casper RMP allows actions that lead to exceedences of Clean Air Act air quality standards, then the Draft EIS is itself in violation of the Clean Air Act. In addition, a regionwide air quality analysis, which should encompass the Upper Green River Valley, Red Desert, Pwder River Basin, northwestern Colorado and the Piceance Basin, the Uinta Basin in Utah, and the Salt Lake City basin, as well as other areas that impact the airshed of the planning area or downwind areas affected by Casper area pollutants, is needed. As BLM itself has noted for air quality, "there is a need for a regionwideregion wide [sic] analysis." Rawlins RMP DEIS at 1-7. This regionwide analysis has not been provided in the Draft EIS, in violation of NEPA's requirement to take a "hard look" at cumulative impacts to air quality as a key ingredient of the human environment (at the very top of Maslow's Hierarchy of Needs).

Projects in the Upper Green River Valley, which shares a common airshed with areas affected by Casper area developments (particularly the Wind River Basin), are already beginning to exceed their air quality criteria. With this in mind, it is critical that the Casper RMP EIS analyze the magnitude of further air quality degradation as a result of reasonably foreseeable projects under the Casper RMP. This is not done; instead the BLM merely displays tonnages headed skyward, with no hard look at their consequences. For all of the reasons outlined above, the BLM has failed to take the requisite "hard look" at the impacts of permitted actions under the Casper RMP on air quality.

The DEIS Fails to Take a Hard Look at Impacts to Groundwater

BLM notes that impacts to groundwater quality are likely to occur under all alternatives. DEIS at 4-22. But there is no alternative-by alternative comparison or attempt to quantify the level of these impacts by alternatives. *See* DEIS at 4-23 through 25. There is an unsupported statement that impacts to groundwater quality would be "minimized through the use of surface protection of water resources and conservation measures" for the Preferred alternative. DEIS at 4-25. However, the surface protection and conservation measures in the Preferred Alternative are minimal compared with, for example, those in Alternative B. It is therefore inappropriate for BLM to characterize impacts to groundwater as "minimized" under Alternative E because these impacts are actually much lower under Alternative B. Even Alternative B does not truly "minimize" these impacts, as an alternative that did not allow any surface disturbing activities or activities that use industrial contaminants would have impacts on groundwater quality that are lower still.

The BLM must prevent impacts to both the quantity and quality of groundwaters, in order to preserve ecosystem and economic values such as wellwaters, springs and seeps, and inputs to stream systems. In the grassland environment managed by the Casper Field Office, the availability of surface- and groundwater is perhaps the linchpin holding the entire ecosystem together. Hyporheic, or groundwater, systems have their own unique faunas and nutrient dynamics. Hyporheic communities include both detritovores and predators, all living in the waters that flow far underground. Boulton et al. (1991) reported that hyporheic communities include both detritovores and predators; during this study, copepods, ceratopoginid larvae, nematodes, water mites, and oligochaete worms were collected within 2 days of rehydration in previously dry hyporheic sediments.

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Groundwater and surface streams are intimately interconnected from a hydrologic standpoint; groundwater in the upper layers upwells directly into stream and river channels or into floodplain springbrooks (Brunke and Gonser 1997). Groeneveld and Griepentrog (1985) found that the depletion of subsurface aquifers led to the decline of riparian vegetation, which in turn in turn led to increased bank erosion. These researchers concluded, "The slow drainage by aquifers which intersect streamcourses serves to maintain channel flow during dry periods and to support the plant species which structure the productivity and character of the riparian ecosystem. This balance may be particularly sensitive to alteration" (p. 44). Benson (1953) found that water inputs to the Pigeon River, Michigan through groundwater upwelling actually controls populations of brook and brown trout by determining the location of spawning habitats. Boulton et al. (1991) recommended that analysis of hyporheic communities should be included in analyses of stream ecosystems.

Groundwater supports its own unique biological component of microorganisms and detritus which contributes important nutrient inputs into streams and rivers at upwelling zones, sustaining high levels of aquatic biodiversity (Brunke and Gonser 1997). Ford and Naiman (1989) found that nutrients, particularly carbon and nitrogen, carried by groundwater are important inputs to stream systems, and that these nutrients are rapidly utilized within the hyporheal zone (sub-sediment) or at the sediment/water interface. Hyporheic fungi and bacteria are an important food source for aquatic invertebrates, some of which may also inhabit the hyporheic zone (Barlocher and Murdoch 1989). Dissolved organic carbon in groundwater is rapidly immobilized upon reaching the hyporheic zone of streams. According to Fiebig and Lock (1991), "We conclude that groundwater can contribute substantial amounts of DOC [dissolved organic carbon], both high and low molecular weight, to a stream ecosystem. The stream bed is the site at which much of this material could be initially immobilized and made available to the stream trophic structure" (p.45).

Some groundwater aquifers may be as much as 35,000 years old, with negligible modern recharge (e.g., Phillips et al. 1986). If such aquifers are the source of well water, springs, or surface streams, then their depletion through activities such as coalbed methane extraction will potentially have long-term effects including (but not limited to) the desertification of entire watersheds, the loss of wildlife populations dependent on water sources, and the long-term degradation of downstream rivers and streams in communication with the depleted aquifer.

In order to fulfill NEPA's hard look requirements, the BLM should have mapped groundwater flows in the various aquifers in the Casper planning area, and provided analysis on the impacts of permitted activities on these groundwaters, with at minimum specific reference to quantity and forseeable location of groundwater withdrawals for coalbed methane and other projects, as well as impacts to groundwaters resulting from hydraulic fracturing and other activities associated with conventional oil and gas development.

The Draft EIS Fails to Take a Hard Look at Habitat Fragmentation

The Casper RMP DEIS does recognize habitat fragmentation as an important problem in the planning area, and provides prescriptions in several alternatives designed to reduce habitat fragmentation in some parts of the planning area. The Casper RMP concentrates on preventing mineral leasing as a method to reduce habitat fragmentation, and this method is certainly an effective one. But habitat fragmentation can also be reduced in developed areas, through the use of directional drilling and clustering multiple wells on a signle pad (sometimes referred to as "pad drilling"). There is also a discussion of habitat fragmentation in the Cumulative Impacts analysis, which is admirable. But the BLM has failed to undertake a quantitative analysis of habitat fragmentation, both the baseline condition of habitat fragmentation and the

progression of habitat fragmentation that is foreseeable under each of the alternatives. This violates NEPA.

Habitat fragmentation is readily quantifiable. To quantify fragmentation, one must buffer existing (or proposed) gravel or paved roads (or well sites) by a biologically appropriate buffer for the species in question. For instance, the buffer for sagebrush obligate songbirds should be 60 meters, after the findings of Ingelfinger (2001). For elk, the appropriate buffer in 0.6 miles in winter, and 1.2 miles in summer (Powell 2004, Sawyer et al. 2005). For sage grouse, the appropriate buffer is 1.9 miles for roads and active wells (Holloran 2005). For each of these categories, BLM should model the existing and future transportation and well network by alternative and determine the acreage and spatial distribution of remaining unfragmented habitats under each alternative. BLM undertook a similar fragmentation analysis for the Jonah Infill Development Project Final EIS. The Casper RMP should undertake such an analysis as described here and publish the results in the Final EIS in order to comply withy NEPA's 'hard look' requirements.

Habitat fragmentation occurs whenever there is a change in the spatial continuity of the habitat that affects occupancy, survival or reproduction in a particular species, whether or not a net loss of habitat accompanies the spatial change (Franklin et al. 2002). This has been noted as an important impact of oil and gas development by the Wyoming Game and Fish Department (WGFD 2004). According to Knick et al. (2003), "Accurate rangewide estimates of total area degraded, fragmented, converted to agriculture, or invaded by exotic weeds are needed to grasp fully the magnitude of changes and their impact on [sagebrush obligate] birds." Oil and gas development, with its sprawl of drilling pads, access roads, and pipelines, is the primary cause of habitat fragmentation in the habitats of the Casper planning area. The Preferred Alternative fails to require a well spacing pattern that will prevent habitat fragmentation over the long term; we urge the BLM to adopt a new Preferred Alternative that uses directional drilling and well clustering to minimize habitat fragmentation, and thus avoid the unnecessary and undue degradation of lands and resources inherent to the current Preferred Alternative as well as Alternatives A-D.

BLM has failed to provide any baseline information on the current state of habitat fragmentation in the Casper Field Office. It would certainly be feasible for the BLM to examine the pattern of the landscape which has already been fragmented by oil and gas development: At minimum, all fields or exploratory areas that currently meet or exceed 640-acre spacing (1 surface wellpad per square mile) should be considered substantially fragmented. BLM should then quantify the acreage of public lands that are fragmented as an overall percentage of public lands in the planning area. But the agency should also present the proportions of fragmented habitats for all biologically meaningful subunits of the planning area. For instance, the BLM should publish habitat fragmentation percentages for each big game herd management unit and each upland bird habitat management unit. This is the appropriate level of baseline information on habitat fragmentation that is a necessary prerequisite for a credible impacts analysis on the effects of habitat fragmentation in the Casper planning area.

According to the U.S. Fish and Wildlife Service,

> We believe limiting the discussion to quantity of disturbance underestimates actual impacts to wildlife. Total impact area includes not only the footprint of disturbance, but also surrounding areas within which wildlife may be affected by noise, human activity, etc.

(Long 2002, unnumbered *3)*. We also note that current BLM analyses that attempt to quantify disturbance by the acreage of the footprint are grossly inadequate. And yet, despite these concurring conclusions that

direct acreage disturbed is not a biologically meaningful measure of the impacts of oil and gas development, and that in fact this measure grossly underestimates the true impacts of this type of development, BLM continues to rely heavily on this misleading statistic to argue that significant impacts to wildlife habitats will not occur.

Habitat fragmentation occurs whenever there is a change in the spatial continuity of the habitat that affects occupancy, survival or reproduction in a particular species, whether or not a net loss of habitat accompanies the spatial change (Franklin et al. 2002). Oil and gas development, with its sprawl of drilling pads, access roads, and pipelines, is the primary cause of habitat fragmentation in the grasslands of the Casper planning area.

Although the portion of the landscape physically disturbed by roads, wellpads, and pipelines is often a relatively small percentage of the overall landscape, GIS analysis of full-field oil and gas development incorporating quarter-mile buffers to account for habitat degradation due to edge effects indicates that almost 100% of lands within a fully developed gas field are degraded (Weller et al. 2002). In this way, the development of an oil and gas field results in widespread habitat destruction that extends well beyond the acreage of roads and wellpads that are bulldozed in.

Fragmentation of shrubsteppe habitats has a particularly strong negative impact on birds. Knick and Rotenberry (1995) and found that sage sparrows and sage thrashers decreased with decreasing patch size and percent sagebrush cover, and reached the following conclusion:

> Our results demonstrate that fragmentation of shrubsteppe significantly influenced the presence of shrub-obligate species. Because of restoration difficulties, the disturbance of semiarid shrubsteppe may cause irreversible loss of habitat and significant long-term consequences for the conservation of shrub-obligate birds" (p. 1059).

Ingelfinger (2001) found significant declines in nesting songbirds within 100m of gas field roads, and also found that sage sparrows declined near pipelines. Kerley (1994) found that 67% of songbird species selected for the tallest available sagebrush stands, and nest success was associated with 41% shrub cover, while the two nests in 15% shrub cover were both unsuccessful.

Ingelfinger (2001) conducted a study of sagebrush birds in a western Wyoming gas field and found that as gravel roads increased, densities of sagebrush obligate birds, Brewer's sparrows, and sage sparrows declined, while horned larks (a grassland species) increased. According to his findings, "roads associated with natural gas development negatively impact sagebrush obligate passerines. Impacts are greatest along access roads where traffic volume is high'' (p. 69), but "bird densities are reduced along roadways regardless of traffic volume" (p.71). Kerley (1994) found that small patches had fewer shrub-nesting species than large patches, and the green-tailed towhee, an interior sagebrush species, was entirely absent from small patches. Remnant patches smaller than 1 ha will not support sagebrush shrub-nesting birds (Kerley 1994).

Predation is believed to be the major factor in the decline of burrowing owl populations in Canada, and habitat fragmentation serves to increase predation risk in burrowing owls (James et al. 1997, Hjertaas 1997).

Thus, habitat fragmentation can result in many indirect effects which are not adequately measured or indexed by the number of acres subjected to direct disturbance. BLM must provide an analysis of habitat fragmentation, both the degree to which it has already occurred, and analysis of the future fragmentation

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impacts resulting from activities permitted under the various alternatives of the proposed Casper RMP, in order to satisfy NEPA's hard look requirements.

The BLM Fails to Take a Hard Look at Impacts to Prairie Dogs

The BLM ignores white-tailed prairie dog management at its peril. The state wildlife agencies found the following in their Conservation Assessment (Seglund *et al.* 2004):

> Loss of habitat due to oil/gas development under current Bureau of Land Management (BLM) policies may be a significant threat. In Wyoming, 77% of the white-tailed prairie dog predicted range is being developed at some level for oil and gas (p. 10)

The Conservation Assessment also states:

> **Oil/Gas exploration and extraction**
> This impact has the potential to rise to the level of a threat to the continued existence of the species over a significant portion of its range, and therefore has the potential to justify listing under the ESA in the foreseeable future. Oil and gas exploration is occurring at a phenomenal rate on public lands. Since the BLM owns and manages 55% of the land in the predicted range of the white-tailed prairie dog, significant impacts are possible, primarily during development of oil and gas fields with close well spacing and associated roads. As stated previously in this Conservation Assessment, recent data from Colorado, Wyoming and Utah indicate that white-tailed prairie-dog complexes shift on a landscape scale, possibly in response to plague or other factors not currently identified. Therefore **all suitable habitat within and adjacent to complexes must be protected from direct habitat loss on a landscape scale** if expansion opportunities are to be retained. Current BLM policies do not adequately protect white-tailed prairie dogs during oil and gas development. With the increased amount of leasing and oil and gas development in the white-tailed prairie dog range (77% of the white-tailed prairie dog range in Wyoming has the potential to be impacted by oil and gas development) this could lead to the need for listing the species under the ESA. **Revision of BLM Land Use Plans to control leasing and development in white-tailed prairie dog complexes to address prairie dog management needs and maximize habitat potential must be initiated on a state-by-state basis to prevent further, more drastic actions, including listing the white-tailed prairie dog under the ESA.**

At p. 80, emphasis added. The Assessment recommends: "It is critical that the BLM through its Land Use Plans, manage oil and gas leasing and development in white-tailed prairie dog complexes to maximize prairie dog habitat potential" (p. **83).**

USFWS recently issued a negative 90-day finding because of political interference, and this decision will be challenged in court. However, the finding did emphasize the important role that RMP revisions in Wyoming will have in determining the future status of this species:

> The Wyoming BLM is currently revising its Resource Management Plans (RMPs) in the white-tailed prairie dog range. These RMP revisions are primarily driven by a recent emphasis on oil and gas development activity, and are or will be addressing white-tailed prairie dogs. The BLM also has had nominations submitted by several environmental groups for the designation of prairie dog "areas of critical environmental concern." **A**

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> BLM Statewide, programmatic, biological evaluation is being prepared for white-tailed prairie dogs, the results of which will be incorporated into RMPs.
>
> The Conservation Assessment concludes that many State Field Offices in Wyoming, Utah, Colorado, and Montana currently do not consider the white-tailed prairie dog in oil and gas development unless it is associated with black-footed ferret reintroduction efforts. Because of this, most current plans throughout the range of the white-tailed prairie dog do not address white-tailed prairie dog species-specific needs, but address white-tailed prairie dog [sic] as black-footed ferret habitat. In addition, they do not address maintaining habitat for expansion and shifts in occurrence outside of currently mapped colonies and they address impacts at a colony level rather than a complex or landscape level. Finally, RMPs do not address the impact of road development and the potential for an increase in shooting/direct take of white-tailed prairie dog [sic] as a result of oil and gas development. (69 Fed. Reg. 64899-64900 (Nov. 9, 2004))

The states and the Service have more or less stated that the Wyoming BLM has not demonstrated that its regulatory mechanisms are adequate to prevent the extinction of this species, and that RMP revision is key to changing this, yet the DEIS fails to adequately take a hard look at the impacts to white-tailed or black-tailed prairie dogs, abide by the BLM's Sensitive species obligations, follow the BLM Manual's and FLPMA's guidance regarding ACECs, or take other steps that would change this situation. This is a major missed opportunity for the agency.

The impacts analysis on prairie dogs is woefully absent. What is the current population (or even acreage of occupied colonies) of prairie dogs encompassed by BLM administered lands and minerals? What proportion of that acreage would be subjected to poisoning or surface-disturbing activities under each alternative? What impact would these activities have on the viability of individual colonies and populations, and what would be the estimated prairie dog population (or occupied colony acreage) under each of the alternatives? BLM must perform a credible analysis to answer these important resource questions in order to meet NEPA's "hard look" requirements.

THE DRAFT EIS FAILS TO TAKE A HARD LOOK AT CUMULATIVE IMPACTS

NEPA regulations define the circumstances under which multiple related actions must be covered by a single **EIS.** 40 C.F.R. § 1502.4. To determine the proper scope of an **EIS,** agencies must consider three types of actions: 1) connected actions, "which means that they are closely related and therefore should be discussed in the same impact statement;" 2) cumulative actions, "which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact statement;" and *3)* similar actions, "which when viewed with other reasonably foreseeable or proposed agency actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography." 40 C.F.R. § 1508.25. Furthermore, the regulations state that agencies such as the BLM should include such actions on once statement "when the best way to assess adequately the combined impacts of similar actions or reasonable alternatives to such actions is to treat them in a single impact statement." *Id.*[1]

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[1] See also, CEQ's Forty Most Asked Questions 24a: Two considerations are especially helpful in reviewing the decision not to prepare a programmatic EIS: (1) could the programmatic EIS be sufficiently forward looking to contribute to the decisionmakers' basic planning of the overall program? And (2) does the decisionmaker purport to "segment" the overall program, thereby unreasonably constricting the scope of . . . environmental evaluation:) *NWF* v. *Appalachian Regional Comm'n*, *677* F.2d **883, 889** (D.C. Cir. 1981).

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Clearly, there are basin-wide impacts, in terms of changes to the water quantity and quality of the Powder River and Platte River systems, and cumulative impacts to the common airshed, to which oil and gas projects and coal mining in northeastern Utah, northwestern Colorado, Wyoming, and the Dakotas all contribute in common. Because these environmental parameters share a common geography, BLM must analyze all of the impacts that affect them. NEPA does not allow the agency to pick and choose the impacts that it measures based on convenience, nor may the BLM bury its head in the sand and ignore additional sources of cumulative impacts affecting the Casper Field Office because they may originate across state lines.

While federal agencies have considerable discretion in determining the scope of a NEPA document, there are situations where an agency must consider several related actions in a single NEPA document.* In *Fritiofson v. Alexander*, the Fifth Circuit held that in a cumulative impact analysis, an agency should consider "(1) past and present actions without regard to whether they themselves triggered NEPA responsibilities and (2) future actions that are 'reasonably foreseeable,' even if they are not yet proposals and may never trigger NEPA-review requirements. 772 F.2d 1225, 1245 (5th Cir. 1985). The court stated:

> Sections 1508.7 and 1508.27 require an analysis, when making the NEPA-threshold decision, as opposed to the EIS-scoping decision, whether it is "reasonable to anticipate cumulatively significant impacts" from the specific impacts of the proposed project when added to the impacts from "past, present, and reasonably foreseeable future actions," which are "related" to the proposed project. ***The regulation does not limit the inquiry to the cumulative impacts that can be expectedfrom proposed projects; rather; the inquiry also extends to the effects that can be anticipatedfrom "reasonablyforeseeable future actions."***

Id. at 1243 (emphasis added). Thus, the BLM's obligation to analyze impacts extends beyond the immediate impacts of the planning document at hand to include the cumulative impacts of the project, taken together with the impacts of existing, proposed, or reasonably foreseeable projects, on the environment.

Oil and gas development is occurring at a breakneck pace all across Wyoming, and yet the DEIS completely ignores the cumulative effects of the massive roading, habitat fragmentation, construction, and increased activity on Wyoming's native wildlife. According to Ingelfinger's (2001) study of sagebrush birds in Wyoming,

> "the cumulative impact of state wide patterns of [oil and gas] development in sagebrush communities could cause substantial habitat fragmentation that impacts the sagebrush avian community negatively" (p.34), and "While the population consequences of development of one natural gas field may not be important, the development of multiple gas fields simultaneously, accompanied by historic sagebrush management practices, could have important long-term population ramifications. Given the inability of sagebrush obligate passerines to expand their populations quickly...it may take decades for sagebrush obligates to recover following reclamation" (p. 72).

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*See. e.g.. *Kleppe v. Sierra Club*. 427 U.S. 390. 409 (1976): "Thus, when several proposals for coal-related actions that will have cumulative or synergistic environmental impact upon a region are pending concurrently before an agency, their environmental consequences must be considered together. Only through comprehensive consideration of pending proposals can the agency evaluate different courses of action."

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Similar cumulative effects are being felt by mountain plovers, prairie dogs, elk, pronghorns, sage grouse, and burrowing owls, all of which are sensitive to disturbance. Postovit and Postovit **(1989)** stated, "Although individual energy projects will seldom severely affect raptors over large geographic areas, such developments are often clustered and could thereby affect regional populations" (p. 171). Parrish et al. (1994) echoed these concerns regarding raptors, noting that "even less radical habitat alterations may have a significant impact over a large area – e.g., numerous small/medium alterations in close proximity, such as gas fields" (p. 53). Thus, a credible cumulative impacts analysis is needed on the basis of the ecological needs of wildlife on a regional scale.

NEPA does not allow the agency to skip a cumulative impacts analysis on the basis that agency personnel believe (in the absence of any scientific support) that mitigation measures are adequate to prevent cumulative impacts. Indeed,

> **NEPA requires that an agency charged with preparing an [EIS] take a "hard look" at the environmental consequences of the project, and that it disclose the risks, present the alternatives,** *and respond with reasoned analysis to the opinions of reputable scientists* **concerning the hazards.**

Kleppe v. Sierra Club, 427 U.S. 390, 410 n. 21 (1976), emphasis added. The BLM has cited no reputable scientists or published, peer-reviewed studies that even suggest that its proposed mitigation measures in the Casper RMP will prevent cumulative impacts.

The CEQ regulations also require broad federal actions to be evaluated (1) Geographically, including actions occurring in the same general location, such as a body of water, region, or metropolitan area and (2) Generically, including actions which have relevant similarities, such as common timing, impacts, alternatives, methods of implementation, media, or subject matter. 40 C.F.R. §1502.4(b). In this case, a number of oil and gas projects listed below, as wells as RMPs for neighboring lands share common geography and common methods (the creation of full-field oil and gas development of various types, or oil and gas leasing that confers rights to explore for and develop oil and gas resources). More important, environmental impact statements are to be prepared on these broad programs before they reach the stage of investment or commitment likely to "determine subsequent development or restrict later alternatives." §1502.4(c). *Environmental Defense Fund, Inc. v. Adams*, 434 F. Supp. 402 (D.D.C.1977) (holding that the scope of a program impact statement required similar "geographic, temporal, and subject matter."); *Natural Resources Defense Council, Inc. v. Hodel,* 435 F. Supp. 590 (D. Or. 1977), *affd on other grounds sub nom. NRDC v. Munro*, *626* F.2d 134 (9th Cir. 1980) (requiring a program impact statement for regional power planning in the Pacific Northwest).

Currently, the BLM is failing to comply with these statutory and regulatory requirements. The BLM is currently evaluating a number of oil and gas projects pending in the Pwder River Basin and Wind River Basin, each of which will have a connected and cumulative effect on resources ranging from elk and pronghorn herds to bird of prey populations, sage grouse populations, air quality, water quality (and erosion and sedimentation), and overall potential for primitive recreation and hunting opportunities in the area.
And yet the BLM has failed to provide any cumulative impacts analysis as to how the aforementioned projects, all occurring in one region of south-central Wyoming, will cumulatively impact the aforementioned resources. addition. the following programmatic land-use documents are currently being initiated or revised:

- Jack Morrow Hills Coordinated Activity Plan

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- Pinedale RMP
- Kemmerer RMP
- Casper RMP
- Price RMP
- Vernal RMP
- Little Snake RMP

Each of these land-use plans shares a common airshed, watershed, wildlife populations, recreation visitor base, and/or regional economy with the Casper Field Office. The impacts approved in the Casper RMP will therefore impact these other planning units, and conversely, activities in these other planning units will have cumulative impacts on lands and resources in the Casper Field Office. For this reason, the cumulative impacts analysis in the Casper RMP DEIS must consider the cumulative effects of all of these plans, together with the more direct impacts of activities permitted under the Casper RMP, on the lands and resources of the Casper Field Office.

Most of the white-tailed prairie dog's range is located both in areas that are undergoing rapid oil and gas development and in areas that are undergoing RMP revision. The BLM needs to evaluate the cumulative impacts of the habitat loss and degradation that are occurring throughout the white-tailed's range, and needs to come up with a rangewide strategy for recovering the species. It is ridiculous for the cumulative impacts analysis in the DEIS to be limited to sage grouse and ungulates. The BLM must take seriously the rapid pace of habitat conversion in the Casper Field Office and complete a real cumulative impacts analysis for each individual special status species.

The BLM has thus failed to take a broader look at the cumulative impacts of the proposed action taken together with other oil and gas projects currently underway in the same area. It is not suffiecient to provide a table showing that cumulative impacts are expected to occurr (without even disclosing whether these impacts are negative or positive for the resource in question). See DEIS at 4-298.

The BLM is examining the impacts of water depletions on downstream threatened and endangered species in the Platte River system. DEIS at 4-304. Why is there no cumulative impacts analysis on the impacts of surface water disposal on sensitive aquatic species in the Powder River Basin? Certainly, oil and gas activities are dumping wastewater into the Powder River system. BCA reported a violation by Beren Energy on a facility beside Okie Draw in which wastewater laden with toxic petroleum byproducts was being discharged directly into a watercourse, and Beren was later given a citation by DEQ for the violation. What is the quality of wastewater that will foreseeably be discharged into this river system under each of the alternatives, and how will the pollutants and changes in water temperature, flow rates, and timing of flows impact native fish populations downstream in the Powder River system, populations which will simultaneously be impacted by developments and wastewater discharge permitted pursuant to the Powder River Basin CBM **EIS? A** credible cumulative impacts analysis needs to be undertaken so that each alternative's impacts can be objectively evaluated by the BLM.

There should also be a cumulative impacts analysis for important species of birds and terrestrial wildlife that routinely migrate beyond the boundaries of the Casper planning area. This analysis should also consider cumulative impacts on wildlife populations limited to the planning area but which move between BLM and private lands. The habitat fragmentation cumulative impacts analysis presented in the DEIS touches on this issue in passing, but fails to present any hard data on expected population changes resulting from cumulative impacts under any of the alternatives. And there should be cumulative impacts analyses on a species-by-species basis for at least BLM Sensitive wildlife that travels beyond the planning

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area, including but not limited to mountain plover, loggerhead shrike, greater sage grouse, burrowing owl, ferruginous hawk, northern goshawk, peregrine falcon, Brewer's sparrow, sage sparrow, sage thrasher, white-faced ibis, long-billed curlew, trumpeter swans, and yellow-billed cuckoo.

The cumulative impacts analysis on air quality does not analyze the projected cumulative impact of Casper RMP emissions on Class I airsheds. DEIS at 4-308. It references a table that presents the projected tonnages of pollutants from Casper RMP related activities, but does not present the cumulative impact of these pollutants, together with airborne pollutants from other areas in the same common airshed, on Class I areas in the region. This analysis also does not predict whether Class I air quality standards will be exceeded, and if so, for which pollutants. This section therefore merely highlights the BLM's failure to attempt a cumulative impacts analysis, rather than serving as such an analysis itself.

THE CASPER RMP PROPOSES INEFFECTUAL MITIGATION MEASURES

Mitigation measures proposed under the five alternatives of the Casper RMP, which are intended to reduce the impacts of development on wildlife and other resources, are too often insufficient to achieve their intended purpose – the reduction of impacts to a level of insignificance. These shortcomings render the mitigation measures in question deficient from a practical standpoint. In addition, the BLM has too often failed to provide any scientific or technical evidence to support the effectiveness of these mitigation measures. These shortcomings render the mitigation measures deficient from a legal standpoint.

BLM has an affirmative duty in any environmental analysis to develop, study, analyze and adopt mitigation measures to protect other resources. The ability to adopt post-leasing mitigation measures – *see* 43 C.F.R. § 3101.1-2 – is quite broad, as all reasonable measures not inconsistent with a given lease may be imposed by BLM. This is particularly true given that BLM, pursuant to FLPMA, must manage public lands in a manner that does not cause either "undue" or "unnecessary" degradation. 43 U.S.C. § 1732(b). Put simply, the failure of BLM to study and adopt these types of mitigation measures – especially when feasible and economic – means that the agency is proposing to allow this project to go forward with unnecessary impacts to public lands, in violation of FLPMA.

Mitigation measures can be relied upon to lower impacts to the level of insignificance, but only in cases when the effectiveness of said mitigation measures has been demonstrated. In other words,

> When the adequacy of proposed mitigation measures is supported by substantial evidence, the agency may use those measures as a mechanism to reduce environmental impacts below the level of significance that would require an **EIS.**

National Audubon Society v. Hoffman, 132 F.3d 7,17 (2d Cir. 1977). On the other hand, when the efficacy of mitigation measures in not supported by evidence, a FONSI is not permitted: a "perfunctory description" or '"mere listing' of mitigation measures, without supporting analytical data, is insufficient to support a finding of no significant impact." *National* ***Parks*** *conservation Association v. Babbitt,* 241 F.3d 722, 734 (9th Cir. 2001, citations omitted). In *Wyoming Outdoor Council v. U.S. Army Corps of Engineers* (351 F. Supp.2d 1232, D. Wyo. 2005), the Court held that mitigation measures proposed by the Corps were "vague and speculative" and that the Corps "failed to present a shred of evidence that wetland replacement is a successful mitigation measure." In the aforementioned case, the Court found that "the record is devoid of any information whatsoever that would support the efficacy of wetland replacement mitigation." *Id.* at *33*. The Preferred Alternative for the Casper RMP incorporates many measures of unproven effectiveness, and indeed many mitigation measures for which the preponderance of scientific knowledge suggests ineffectiveness. It would be far superior to put in place mitigation measures that have

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a proven effectiveness, or at least have some basis for an expectation of effectiveness based on the scientific literature.

Mitigation measures which have been shown by published science to be ineffective include: Seasonal stipulations and NSO protection buffers of less than 3 miles for sage grouse leks (Holloran 2005, Naugle 2006a, Kaiser 2006), and seasonal stipulations for winter ranges of mule deer (Sawyer at al. 2004,2005) and elk (Powell 2004, Sawyer et al. 2005). BLM has been spending taxpayer dollars to monitor the impacts of oil and gas operations for many years; the agency should analyze the results of this monitoring effort, qalong with the published science, and disclose the effectiveness, or lack thereof, of proposed mitigation measures under the various alternatives. In addition, the Casper RMP **EIS** fails to present a range of reasonable mitigation measures among alternatives; BCA in its scooping comments recommended a number of scientifically sound mitigation measures that would more effectively minimize the impacts of permitted actions under the Casper RMP, and most of these do not appear to have been considered under even one of the BLM's proposed alternatives. Please review the list of proposed mitigation measures presented at the end of these comments under at least one alternative, and perform an in-depth impacts analysis so they can be compared to the other alternative mitigation measures, in the Casper RMP FEIS.

THE CASPER RMP DEIS FAILS TO CONSIDER A RANGE OF REASONABLE ALTERNATIVES

NEPA requires BLM to "rigorously explore and objectively evaluate" a range of alternatives to proposed federal actions. See 40 C.F.R. §§ 1502.14(a) and 1508.25(c). Formulation of alternatives during the NEPA disclosure and study process is at the heart of Congress' choice of NEPA as the procedural method that guides federal agencies' management of the public lands. See *Natural Resources Defense Council v. Hodel,* 865 F.2d 288,299 (D.C.Cir. 1988) (citing *Kleppe v. Sierra Club,* 427 U.S. 390, 410 (1976)). In fact, NEPA requirements state that "no action concerning the proposal should be taken which would: (1) Have an adverse environmental impact; or (2) Limit the choice of reasonable alternatives." 40 C.F.R. § 1506.1(a). *Catron County v. U.S Fish and Wildlife Service,* 75 F.2d 1429 (10th Cir. 1996)(partial NEPA compliance is not enough.) In particular, federal agencies must explore alternatives to proposed actions that will avoid or minimize adverse effects on the environment, 40 C.F.R § 1500.2(3), alternative kinds of mitigation measures, 40 C.F.R. § 1508.25(c)(3), alternatives that would help address unresolved conflicts over the use of available resources (e.g. roadless areas and/or potential wilderness), 40 C.F.R. § 1501.2(c), and other reasonable courses of action, 40 C.F.R. § 1508.25(c)(2). The requirement to consider such less damaging alternatives helps agencies meet NEPA's primary purpose of promoting "efforts which will prevent or eliminate damage to the environment and biosphere..." 42 U.S.C. § 4321. These requirements are affirmed in BLM policy: "BLM officials may not so narrow the scope of a planning/NEPA document as to exclude a reasonable range of alternatives to the proposed action..." USDI Instruction Memorandum No. 200 1-075.

The BLM should note that this basic, fundamental requirement that is the touchstone of *every* NEPA document has not gone unnoticed on the federal judiciary in sending back environmental studies that fail to meet this requirement. *See e.g., Calvert Cliffs Coordinating Comm., Inc. v. United States Atomic Energy Comm'n*, 449 F.2d 1109, 1114 (D.C. Cir. 1971) (detailed EIS required to ensure that each agency decision maker has before him and takes into account all possible approaches to a particular project. . . which would alter the environmental impact and the cost-benefit balance); *Natural Resource Defense Council v. Callaway*, 524 F.2d 79, 93 (2d Cir. 1975); ("The duty to consider reasonable alternatives is independent from and of wider scope than the duty to file an environmental statement."); *Simmons v. United States Army Corps of Engineers,* 120 F.3d 664, 660 (7th Cir. 1997) ("The highly restricted range of alternatives evaluated and considered violates the very purpose of NEPA's alternative analysis requirement: to foster informed decision making and full public involvement."); *Alaska Wilderness*

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Recreation & Tourism v. Morrison, 67 F.3d 723, 729 (9th Cir. 1995) ("The existence of a viable but unexamined alternative renders an environmental impact statement inadequate."); *Dubois v. U.S. Dept. of Agric.*, 102 F.3d 1273, 1288 (1st Cir. 1996) **(EIS** invalid because agency did not consider alternative of using artificial water storage units instead of a natural pond as a source of snowmaking for a ski resort); *Libby Rod & Gun Club v. Poteat*, 457 F. Supp. 1177, 1187-88 (D. Mont. 1978), *rev'd in part on other grounds,* 594 F.2d 742 (9th Cir. 1979) (Army Corps violated NEPA in an **EIS** for a hydroelectric dam by only cursorily addressing the alternatives of meeting the Northwest's energy needs through other sources or conservation.); *Northwest Envt'l Defense Center v. Bonneville Power Admin.,* 117 F.3d 1520, 1538 (9th Cir. 1997) ("An agency must look at every reasonable alternative, with the range dictated by the nature and scope of the proposed action."); *Southern Utah Wilderness Alliance,* 150 IBLA 158 (1999) (When the record establishes that the BLM failed to consider reasonable alternatives, a finding of no significant impact or record of decision based on an environmental assessment will be set aside.).

In particular, federal agencies must explore alternatives to proposed actions that will avoid or minimize adverse effects on the environment, 40 C.F.R § 1500.2(3), alternative kinds of mitigation measures, 40 C.F.R. § 1508.25(c)(3), alternatives that would help address unresolved conflicts over the use of available resources (e.g., important wildlife habitats), 40 C.F.R. § 1501.2(c), and other reasonable courses of action, 40 C.F.R. § 1508.25(c)(2). The requirement to consider such less damaging alternatives helps agencies meet NEPA's primary purpose of promoting "efforts which will prevent or eliminate damage to the environment and biosphere..." 42 U.S.C. § 4321. Such objective evaluation is gravely compromised when agency officials bind themselves to a particular outcome or foreclose reasonable alternatives at the outset. In this case, the BLM has failed to analyze an alternative that would avoid or minimize impacts.

The failure to examine the full range of reasonable alternatives is related to the agency's duty in any environmental analysis to develop, study, analyze and adopt mitigation measures to protect other resources. The ability to adopt post-leasing mitigation measures – *see* 43 C.F.R. § 3101.1-2 – is quite broad, as all reasonable measures not inconsistent with a given lease may be imposed by the BLM. Put simply, the failure of BLM to study and adopt these types of mitigation measures – especially when feasible and economic – means that the agency is proposing to allow this project to go forward with unnecessary and undue degradation to public lands.

As the Ninth Circuit pointed out, the failure to fully investigate an alternative that is more consistent with the agency's mandate is fatal:

> Although NEPA does not require the Forest Service to "consider every possible alternative to a proposed action...," we are troubled that in this case, the Forest Service failed to consider an alternative that was more consistent with its basic policy objectives than the alternatives that were the subject of final consideration.

Muckleshoot Indian Tribe v. United States, 177 F.3d *800,* **8**13 (9th Cir. 1999) (remanding the **EIS** and requiring the Forest Service to consider alternatives to land exchange more consistent with FLPMA's policies) (citing *Seattle Audubon Society v. Moseley, 80* F.3d 1401, 1404 (9th Cir. 1996), emphasis added.

BLM has failed to take a hard look at the full range of reasonable alternatives, a fundamental underpinning – the "heart" – of an **EIS.** *See* 40 C.F.R. § 1502.14.

BLM should note that this basic, fundamental requirement that is the touchstone of *every* EIS has not gone unnoticed on the federal judiciary in sending back EISs that fail to meet this requirement. *See e.g., Calvert Cliffs, Coordinating Comm., Inc. v. United States Atomic Energy Comm'n*, 449 F.2d 1109, 1114 (D.C. Cir. 1971) (detailed **EIS** required to ensure that each agency decision maker has before him

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and takes into account all possible approaches to a particular project . . . which would alter the environmental impact and the cost-benefit balance); *Natural Resource Defense Council v. Callaway,* 524 F.2d 79, 93 (2d Cir. 1975); ("The duty to consider reasonable alternatives is independent from and of wider scope than the duty to file an environmental statement."); *Simmons v. United States Army Corps of Engineers,* 120 F.3d 664, 660 (7th Cir. 1997) ("The highly restricted range of alternatives evaluated and considered violates the very purpose of NEPA's alternative analysis requirement: to foster informed decision making and full public involvement."); *Alaska Wilderness Recreation & Tourism v. Morrison,* 67 F.3d 723, 729 (9th Cir. 1995) ("The existence of a viable but unexamined alternative renders an environmental impact statement inadequate."); *Dubois v. US. Dept. of Agric.,* 102 F.3d 1273, 1288 (1st Cir. 1996) (EIS invalid because agency did not consider alternative of using artificial water storage units instead of a natural pond as a source of snowmaking for a ski resort); *Libby Rod & Gun Club v. Poteut,* 457 F. Supp. 1 177, 1187-88 (D. Mont. 1978), *rev'd in part an other grounds*, 594 F.2d 742 (9th Cir. 1979) (Army Corps violated NEPA in an EIS for a hydroelectric dam by only cursorily addressing the alternatives of meeting the Northwest's energy needs through other sources or conservation.); *Northwest Envt'l Defense Center v. Bonneville Power Admin.,* 1 17 F.3d 1520, 1538 (9th Cir. 1997) ("An agency must look at every reasonable alternative, with the range dictated by the nature and scope of the proposed action.")

BLM has refused to consider new or expanded wilderness study areas in the DEIS as a result of the settlement in *Utah v. Norton* and subsequent administrative direction. DEIS at 2-6. However, the NEPA requires the agency to analyze a broad range of alternatives, and "[i]nclude reasonable alternatives not within the jurisdiction of the lead agency." 40 C.F.R. § 1502.14(c). While the *Utah v. Norton* settlement currently places the creation or expansion of Wilderness Study Areas outside the jurisdiction of the BLM to implement *at this time,* the legality of this settlement is currently under challenge, and we expect that it will be overturned by the courts. An overturn of this settlement could conceivably come even before the release of the Casper RMP FEIS, rendering a new WSA an attractive option. We are putting the BLM on notice now that new and expanded WSAs are likely to fall within the BLM's authority to establish in the near future. With this in mind, the agency must not foreclose on its options by failing to perform a NEPA analysis on expanding the WSA system within the Casper Field Office through the DEIS process.

The BLM's set of alternatives seems unnecessarily truncated. No alternative contains scientifically sound mitigation measures for raptor nest buffers, sage grouse lek buffers, or big game crucial ranges, as noted elsewhere in these comments. As for projected oil and gas development levels, all but one alternative project between 1660 and 1830 wells to be drilled over the life of the plan (a very narrow range), while the other alternative projects 190. Yet while there are roughly nine times as many wells projected in Alternatives **A,** C, D, and E as in Alternative B, the projected surface disturbance in Alternative B is only half the other alternatives. How does BLM account for this discrepancy (it would seem that oil and gas development drives surface-disturbing activities in the planning area, which would make the surface disturbance estimates proportional to the well estimates)? And, more importantly, why is there no alternative that projects no additional surface disturbance in the planning area? While we might not recommend that BLM adopt such an alternative, it serves as a useful baseline for comparison when evaluating the magnitude of impact of the other alternatives. It would also be reasonable on its face to consider an alternative with no future oil and gas leasing in the planning area. Under such an alternative, existing leases (which are certainly widespread) could be developed throughout the life of the plan, maintaining development levels at or slightly below current levels. Why are these reasonable alternatives not captured within the range of alternatives presented in the Draft EIS?

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BLM has Failed to Analyze an Alternative that Would Maintain Air Quality at Current Levels

In the comparison of Total Emissions, all alternatives predict a steady increase in air pollution by 2020. There is no alternative that would hold airborne pollutants to the current level being experienced as of 2006 for most pollutants. Even the Alternative B would cause a 50% increase in air pollution within the planning area. **DEIS** at 4-9. Given the fact that oil and gas development was heavy and rapid during 2006, it would seem to be unreasonable that there is no alternative that holds airborne pollutant levels at the 2006 level, or indeed below these levels, as the 2006 air pollution levels do not include the use of Best Available Control Technology on drilling rigs or production facilities, nor do they represent any particular effort to minimize air pollution beyond the standard, nominal measures. Viewed by pollutant constituents, there are major increases forecast under all alternatives for nitrogen oxides carbon monoxide, and volatile organic compounds. See Tables 4-21 through 4-24. Here, the same problem applies: Why is there not an alternative that reduces these increases to zero, or even causes net decreases in air pollution? What measures would be required to lower pollutant levels to meet this goal? These important questions should be answered in the FEIS.

Alternative Requiring Block Surveys for Archaeological and Paleontological Resources in Advance of Leasing

In each of the four alternatives, it is anticipated that significant impacts to cultural resources would occur. BLM further states for each alternative that mitigation measures for known sites should prevent significant impacts. However, impacts to archaeological and cultural sites will inevitably be greater, and indeed significant, in cases where unknown sites are bumbled into by bulldozer crews or other untrained personnel during the course of ground-disturbing activities. This fact cries out for the adoption of preventative measures that would require block surveys for archaeological and cultural sites before leasing occurs, as a hard-and-fast standard codified in the RMP. Such surveys would increase the chances of discovering significant sites prior to the leasing stage, when a limited property right to explore and develop is conveyed to the lessee. Protective stipulations would then be applied to the area, and attached to any subsequent leases, requiring the protection of NRHP-eligible sites and their settings. The same could be done for paleontological resources. This is a perfectly reasonable alternative – indeed, these block surveys should have been conducted in advance as part of gathering baseline data and conducting the NEPA "hard look" at impacts to historical and cultural resources in the Casper RMP EIS. We, the undersigned groups, support block surveys in advance of leasing and request that BLM institute this common-sense measure in the Casper RMP. The fact that the BLM has failed to even consider an alternative that requires block surveys in advance of mineral leasing or other permitted actions that result in surface-disturbing activities violates NEPA's range of alternatives requirement.

The Draft EIS Fails to Consider a Phased Leasing Alternative

The BLM should also consider an alternative that would require phased development of the Field Office as far as oil and gas is concerned. We recommend that such an alternative would be best implement at the leasing stage, so that complex unitization issues need not impede the process. Under such an alternative, the BLM would offer only a small fraction of the Field Office for future leasing at any one time (perhaps starting with only the areas which are currently under full-field development). As gas fields are reclaimed back to their natural state, similar areas of new territory could be opened to mineral leasing. Such an alternative would appear to be legally sufficient and readily implementable from a practical standpoint. We see this as a strong possibility in terms of sustainable management of oil and gas resources, and well worthy of the BLM's detailed consideration in the Casper RMP **EIS** process.

BLM also proposes to adopt many standard conditions of approval and mitigation measures without taking a hard look at whether these measures are effective – numerous oil and gas projects in this region have adopted many of the same mitigation measures over the past twenty years and BLM failed to

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inventory these sites to measure their effectiveness. 40 C.F.R. § 1502.22 is triggered here. This provision requires "the disclosure and analysis of the costs of uncertainty [and] the costs of proceeding without more and better information." *Southern Oregon Citizens Against Toxic Sprays, Inc. v. Clark*, 720 F.2d 1475, 1478 (9th Cir. 1983). "On their face these regulations require an ordered process by an agency when it is proceeding in the fact of uncertainty." *Save Our Ecosystems v. Clark*, 747 F.2d 1240, 1244 (9th Cir. 1984).

This NEPA regulation imposes three mandatory obligations on the BLM in the face of scientific uncertainty: (1) a duty to disclose the scientific uncertainty; (2) a duty to complete independent research and gather information if no adequate information exists unless the costs are exorbitant or the means of obtaining the information are not known); and *(3)* a duty to evaluate the potential, reasonably foreseeable impacts in the absence of relevant information, using a four-step process. Unless the costs are exorbitant or the means of obtaining the information are not known, the BLM must gather the information in studies or research. 40 C.F.R. § 1502.22. Thus, the present EIS is deficient by not taking a hard look at the effectiveness of the chosen mitigation measures, and particularly so given the duty to look at, and availability of, readily accessible data from projects such that totaled 1,775 oil and gas wells drilled *before* 1987, or 16 years ago. DEIS at 1-12. That means there is a *lot* of readily available data out there that BLM has ignored in evaluating the effectiveness of the mitigation measures in this case. Simply listing and not analyzing the effectiveness of these measures also results violation of NEPA. See *Northwest Indian Cemetery Protective Association v. Peterson*, 764 F.2d 581, 588 (9th Cir. 1985), *rev'd on other grounds* 485 U.S. 439 (1988) (where the court determined that NEPA requires agencies to "analyze the mitigation measures in detail [and] explain how effective the measure would be. ... A mere listing of mitigation measures is insufficient to qualify as the reasoned discussion required by NEPA.").

A. The Casper RMP DEIS Fails to Even Consider Adequate or Scientifically Supported Mitigation Measures for Sage Grouse

BCA incorporates the Great Divide RMP Draft EIS Comments of Dr. Clait Braun, the world's leading sage grouse expert, into our Casper DEIS comments. See Attachment 4. Dr. Braun recommends a minimum 3-mile buffer inside which surface disturbance would be forbidden year-round. It is indeed pointless to have a seasonal moratorium on construction of roads and wells within 2 miles of a sage grouse lek if the birds will return the following season to find their lek and nesting habitat converted into an industrialized landscape. A thorough review of the scientific literature on sage grouse, which leads to the inescapable conclusion that the Casper RMP in its four current variations will lead to major impacts to remaining sage grouse populations.

And where BLM has failed to provide a literature review to back up its assertions, BCA has provided an overarching literature review in which experts in the field uniformly recommend 2 to 3 miles as the minimum distance for an NSO buffer. In fact, literature reviews by Connelly et al. (2000) recommend siting all oil and gas facilities farther than 2 miles from the lek site, and a literature review compiled by Clait Braun for the Rawlins Field Office recommended a three-mile NSO buffer (Braun 2003). Against this weight of scientific expertise, the BLM is unable to marshal even a single peer-reviewed study which indicates that a quarter-mile 'no surface disturbance' buffer is sufficient. The BLM has thus failed to show scientific support for and credibility of its proposed mitigation measures for sage grouse.

It is important to note that sage grouse populations are already virtually extinct in the Continental Divide – Wamsutter II project area (see Figure 5-3, Desolation Flats Draft EIS at 5-20), as a result of the failure of mitigation measures implemented under that project. It is telling that sage grouse mitigation measures

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are virtually identical in the Continental Divide – Wamsutter II project and the Preferred Alternative of the Casper RMP. In the Continental Divide – Wamsutter II ROD,

12. Operators will not conduct surface-disturbing activities within 0.25 mi. of active sage grouse leks.
13. Operators will limit construction activities between March 1 and June 30 within a 2.0-mi. radius of active sage grouse leks on suitable nesting habitat as determined during on-site reviews of proposed development areas.

Continental Divide – Wamsutter II ROD at F-27. These mitigation measures have been proven a dismal failure; as shown on Figure 5-3 of the Desolation Flats Draft **EIS,** all sage grouse lek sites in the Continental Divide – Wamsutter II project area south of Interstate 80 have been converted to "historic leks," i.e., they are now extinct. This recipe for extinction is now repeated in the Preferred Alternative of the Casper RMP DEIS.

Thus, the measures in the Preferred Alternative are essentially identical to those implemented in Continental Divide – Wamsutter II, which resulted in the virtual extinction of sage grouse within the project area south of the Interstate. And the BLM find itself trapped in a cycle of making the same mistakes over and over again, instead of learning from the results of its monitoring. An in addition to failing to implement the recommendations of scientific experts, the BLM has failed to even rigorously explore and objectively evaluate these recommendations as an alternative course of action. The BLM's disregard for NEPA's range of alternatives requirement in this matter is disappointing.

The failure of these mitigation measures have also been shown in the Pinedale area, where grouse are expected to be extinct in gas fields within 19 years according to the results of modeling by Holloran (2006), and in the Powder River Basin, where Naugle (2005a) found that there has been an 84% decline in sage grouse populations since 1988, largely attributable to habitat degradation resulting from CBM and conventional oil and gas development under the same mitigation guidelines proposed for the Casper RMP.

The results are in – the BLM's current sage grouse mitigation policies are a failure – and new, stronger measures are needed if BLM is to fulfill its policy mandate to prevent the further slide of sage grouse, as a BLM Sensitive Species, toward listing under the ESA and ultimate extinction.

Connelly et al. (2000) provide a review of the many short- and long-term effects of energy development on sage grouse, and recommended siting oil and gas roads and facilities at least 2 miles distant from lek sites. Aldridge (1998) noted that oil and gas development has contributed to the serious decline of Canadian sage grouse populations, stating,

> the removal of vegetation for well sites, access roads, and associated facilities can fragment and reduce the availability of suitable habitat. Furthermore, human and mechanical disturbance at wells may disrupt breeding activities, and traffic on access roads could cause some fatalities of birds.... Even if sites are reclaimed at a later date, birds may fail to return to previously used habitats.

Currently, only 7 of 31 historic lek complexes remain active in Canada (Braun et al., in press). For this Canadian population, these researchers have stated, "The future plans for oil and gas developments within the range of sage-grouse are unknown, but expansion is expected. The cumulative impacts of further activities could result in reduction of the Alberta sage-grouse population to non-viable levels."

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Perplexingly, the BLM's impact analysis makes no mention of the potential impacts of permitted actions on sage grouse population viability.

B. BLM Fails to Provide Scientifically Supported Mitigation Measures for Big Game Crucial Ranges

The Draft EIS analyzes weak and insufficient mitigation guidelines for crucial winter ranges, and fails even to consider adequate measures to protect crucial winter range. Timing stipulations preventing construction activities would apply to crucial big game winter ranges between November 15 and April 30. These stipulations would allow road and facility construction in the heart of crucial winter ranges, as long as it didn't occur during the winter season, and furthermore would allow for waivers that would permit winter construction activities in crucial winter range.

The BLM reaches no conclusions and ventures no guesses as to the impacts of the Preferred Alternative of big game populations. DEIS at 4-129. The Wyoming Game and Fish Department (2004) lists first among "Critical Misconceptions about Oil and Gas Effects" the following myth:

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

This document goes on to point out that habitats like crucial winter range and sage grouse nesting habitat are typically limiting to populations, and that "Consequences of such displacement are lower survival, lower reproductive success, lower recruitment, and ultimately lower carrying capacity and reduced populations." *Id.*

BCA has provided a comprehensive survey of the scientific literature demonstrating clearly that elk are highly sensitive to roading and industrialization of crucial ranges. In addition to the Steamboat Mountain elk study (Powell 2004), we would like to point out the results of two new Wyoming studies on the impacts of oil and gas development on game animals. The 2003 and 2004 results from the Sublette Mule Deer Study, undertaken by WEST, Inc., indicate that mule deer are in many years showing a complete avoidance of the Pinedale Mesa crucial winter range, an area where drilling has occurred outside the winter season, but where ongoing production level activity is apparently sufficient to cause mule deer to completely avoid the area. In addition, in the Piney Front Elk Study, results indicate that elk are avoiding suitable crucial winter range to the north of LaBarge Creek, where migration is impeded by full-field oil and gas development, but are using identical range south of the creek where there are no impediments to migration (Fred Lindzey, pers. comm.). Thus, the true impacts of full-field development in crucial winter ranges and migration corridors in the planning area is likely to be abandonment of winter ranges and obstruction of migrations, resulting in, to quote WGFD (2004) once again, "lower survival, lower reproductive success, lower recruitment, and ultimately lower carrying capacity and reduced populations."

Mitigations in the Draft EIS Violate WGFD's Mitigation Policy

WGFD (**1998**) has set forth recommendations for allowing habitat-disturbing activities and mitigation for these activities if allowed. Federal Candidate Species and Native Species Status 1 and 2 receive a mitigation category of "Vital," for which habitat directly limits populations and restoration may be impossible; **habitat function must be maintained if habitat modification is allowed to occur.** In the Casper Field Office, species in this category likely to be impacted by the project include mountain plover,

bald eagle, and Townsend's big-eared bat. Habitats such as Crucial Winter and Crucial Winter Relief Ranges also receive a mitigation category of "Vital," regardless of whether or not the crucial ranges of two or more species overlap.

Native Species Status *3* receive a mitigation category of "High," for which WGFD recommend **no net loss of habitat function** through enhancement of degraded habitat when a habitat disturbing project is proposed. In the Casper planning area, species in this category likely to be impacted by the project include the merlin, peregrine falcon, long-billed curlew, white-tailed prairie dog, black-tailed prairie dog, and swift fox. Big game winter-yearlong ranges and parturition areas also fall under the "High" reclamation category, demanding no net loss of habitat function. Furthermore, for Endangered or Threatened Species such as the bald eagle and black-footed ferret, WGFD recommends exclusion of any habitat impacting activity. For these species, "The Commission recognizes that some wildlife or wildlife habitats are so rare, complex and/or fragile that mitigation options are not available. Total exclusion of adverse impacts is all that will ensure preservation of these irreplaceable habitats" (Ibid., p. 4). We concur wholeheartedly, and point out that FLPMA carries a legal requirement for the BLM to manage its lands in accord with state directives such as the WGFD Mitigation Policy.

It is important to note that FLPMA requires the ROD to conform to established state policies and laws, including the Wyoming Game and Fish Department's Mitigation Policy. Currently, mitigation measures in the Proposed Action are not sufficient to prevent a net loss of habitat function for big game crucial ranges, prairie dog colonies, and juniper obligate songbirds. The Draft EIS for the Casper RMP therefore violates FLPMA's requirements to maintain consistency with established state policies.

ROAD NETWORK

Roads are a principle form of impact to wildlife, water quality, air quality, and visual resources throughout their lifespan, not just during the construction phase. Vehicle traffic along roadways is a source of constant disturbance and displacement to wildlife. The current network of roads is already much more extensive than is necessary to facilitate public use and other transportation needs within the planning area. The fact that only two percent of the planning area currently qualifies for wilderness status is a strong indictment of the BLM's failure to prevent the proliferation of developed roadways. With this in mind, the conversion of two-track roads to developed roads in cases where two-tracks are experiencing substantial erosion is a solution that does more harm than good. In stead, when two-tracks are subject to substantial erosion, the BLM should first determine whether the route serves a purpose, and consider reclamation as a first alternative, and the installation of water bars to mitigate erosion as a second alternative if the route has a valid purpose.

The use of two tracks for access to well sites as an alternative to engineered roadways should be used to the maximum extent possible. Engineered roads cause much greater impacts in terms of habitat fragmentation, loss of wildlife due to collisions with vehicles (engineered roads allow higher speeds), and erosion and sedimentation when compared with two-track vehicle routes.

UTILITY LINE CORRIDORS AND COMMUNICATION SITES

Powerlines and pipelines corridors have a number of unique impacts. Utilities are having an increasing visual impact on public lands. Even buried fiber-optic lines leave obvious visual effects. In addition to focusing raptor predation on nearby prey populations, Brum et al. (1**983)** observed that powerline ROWs can become access ways for ORV use, serving as a means of gaining access to previously undisturbed areas. Bruin et al. also found that effects of disturbance in the Mojave Desert were still apparent *33* years after construction, including depressed mycorrhizal activity, high seedling mortality, and poor shrub recruitment (lbid.). Under the Casper RMP, utility corridors should follow existing heavy-impact rights-

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of-way (such as county roads and highways) and be excluded from sensitive areas. None of the alternatives presented have adequate avoidance areas for utility/transportation systems or communication sites.

Powerline towers are likely to concentrate raptor nesting and perching activities, to the potential detriment of prey species. Transmission towers may be particularly attractive as nest sites for ravens, and Steenhof et al. (1993) reported that 133 pairs of ravens had colonized transmission towers on a single stretch of powerline in Idaho during its first 10 years of existence. Gilmer and Wiehe (1977) found that nest success for ferruginous hawks was slightly lower for transmission towers than other nest sites, and noted that high winds sometimes blew tower nests away. Steenhof et al. (1993) also found that transmission tower nests tended to be blown down, but found that nest success was not lower on towers for ferruginous hawks and was significantly higher on towers for golden eagles. In North Dakota, Gilmer and Stewart (1983) found that ferruginous hawk nest success was highest for powerline towers and lowest for nests in hardwood trees. Thus, although powerlines can be designed to minimize impacts to raptors, these corridors should be sited more than 2 miles away from prairie dog colonies and sage grouse leks to prevent major impacts to these sensitive prey species.

Communication facilities should be co-located with existing communication sites in the forthcoming Casper RMP. In addition, powerlines and pipelines should also be co-located to the greatest extent possible. In no case should communication sites be permitted in currently unimpacted locations. In addition, communications sites and antenna structures will not be built in or adjacent to wildlife crucial winter ranges, crucial winter relief areas, and birthing areas, other Areas of Critical Environmental Concern as outlined in these comments, areas within 1 mile of active raptor nests, areas within 5 miles of active sage grouse or sharp-tailed grouse leks, large prairie dog colonies and complexes, or those inhabited by BLM Sensitive Species such as black-footed ferret, burrowing owl, mountain plover, or swift fox, and critical habitats of Endangered and Threatened species.

COALBED METHANE

The Affected Environment section of the Draft **EIS** fails to disclose and analyze groundwater quality for coalbed methane targets in the Fort Union or other coal-bearing formations. See DEIS at 3-14. Detailed information should be easy to gather and analyze from past CBM and/or conventional oil/gas wells and/or water wells producing water from these formations. BLM should disclose the range and distribution of groundwater pollutants including salts, ions, heavy metals, and other constituents with the potential to affect surface water quality if CBM wastewater is to be released at the surface. BLM's failure to disclose groundwater quality levels from potential CBM target strata is an important failure of NEPA's requirement to gather and disclose baseline information.

URANIUM MINING

According to BLM, there are over a quarter million acres of BLM lands or minerals with a moderate to high potential for uranium mining, with high to moderate potential for mining activity. DEIS at 4-26. BLM states that most recovery will occur with in-situ mining. BLM should explain this mining method and its potential environmental impacts to surface waters, groundwaters, wildlife, and public lands. The BLM goes into some detail on the potential impacts of mineral withdrawals and special designations on mining efforts. However, the BLM has neglected to study the various environmental impacts of the various forms of mining on the lands and resources of the planning area.

DIRECTIONAL DRILLING

The current alternatives presented in the Casper RMP **DEIS** ignore the need to minimize environmental impacts of oil and gas drilling. BLM should take advantage of advanced technologies by mandating the

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use of directional drilling to both cluster impacts in full-field development scenarios and displace the surface impacts of drilling away from sensitive landscapes and wildlife habitats. We have attached a report, *Drilling Smarter: Using Directional Drilling to Reduce Oil and Gas Impacts in the Intermountain West,* to provide a detailed technical basis, founded on the petroleum engineering literature produced largely by the oil and gas industry itself, which concludes that directional drilling is feasible and economical in virtually any geologic setting, including the setting presented by the CRMPA. Please read and respond to this report in detail as a comment by the undersigned groups on the Casper RMP DEIS.

The BLM should adopt a maximum density of 5,760-acre surface spacing of wells and facilities as a standard stipulation throughout the planning area; in areas where surface spacing is already denser than 5,760 acres, additional wells should be permitted only at existing wellpads. Unitization can be employed to work around potential complexities of lease ownership. The clustering of many wells at a single site will certainly make these wellpads a higher local amount of surface disturbance. In Pinedale, Questar plans to cluster 32 wells on a pad. The resulting wellpad would be 11 acres, versus 4 to 6 acres for a single-well pad. However, the impacts of one 11-acre pad are dwarfed by the impacts of having 32 pads of 4-6 acres each, and all the extra roads and pipelines required to access them.

Directional drilling, when designed properly, results in major reductions in environmental impact. BLM has admitted that "drilling of multiple well bores from a single pad would reduce impacts to wildlife by reducing the number of surface locations and surface area disturbance, but notes that this technique would be used only occasionally under all alternatives. DEIS at 2-214. BLM also notes that surface disturbing activities increase sedimentation to streams, and an increased number of road crossings of streams would further fragment fish populations and increase siltation in streams, impacts that would also be reduced by fewer roads and wellpads associated with clustered directional drilling.

President George W. Bush made the implementation of lower-impact directional drilling technologies the cornerstone of his energy policy. The President's National Energy Policy contains a section titled, "21st Century Technology: The Key to Environmental Protection and New Energy Production," which states:

> Producing oil and gas from geologically challenging areas while protecting the environment is important to Americans and to the future of our nation's energy security. New technology and management techniques will allow for sophis- ticated energy production as well as enhanced environmental protection ... Smaller, lighter drilling rigs coupled with advances in directional and extended-reach drilling significantly increase protection of the environment...Modular drilling rigs, 'slimhole' drilling, directional drilling, and other advances enable: [...]
>
> • production of oil and gas with increased protection to wetlands and other sensitive environments;
>
> Other examples of advanced technology include: [...]
>
> • highly sophisticated directional drilling that enables wells to be drilled long horizontal distances from the drilling site[.]"

National Energy Policy, May 2001, "Reliable, Affordable, and Environmentally Sound Energy for America's Future: Report of the National Energy Policy Development Group," p. 5.5.

Likewise, the former Secretary of the Interior, who is responsible for implementing much of the National Energy Policy, has emphasized the need to begin utilizing directional drilling technology:

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> We must also harness 21st Century technology to help our environment. Where we once needed scores of wells to tap underground reserves, today in some areas we can use one hole on the surface to drill for oil in a circle extending seven miles. We can use the resources below ground while we preserve the landscape and habitat above.

Presentation of Gale Norton, Secretary of Interior, to the National Newspaper Association (Washington, DC, March 23, 2001). These policy statements represent an unequivocal commitment on the part of the administration to implement less environmentally damaging directional drilling technologies.

In the Draft EIS, the BLM has failed to give detailed consideration and analysis to an alternative that requires directional drilling as a standard practice to minimize impacts to lands and wildlife.

Any added costs associated with directional drilling will be mitigated by the benefits to the public in terms of avoided environmental impacts and impacts on hunting and other recreation. These environmental impacts are in fact costs externalized by the oil industry and paid for by the public. Environmental benefits of directional drilling need to be estimated and included and directional drilling should be re-considered with more complete information. We incorporate this report and its conclusions in full into these comments, and expect the BLM to respond to it as the agency would to any other public comment in the NEPA process. We also incorporate the comments of Ken Kreckel on the Rawlins RMP DEIS by reference into these comments. See Attachment 5.

It may be true that directional drilling comes with increased drilling costs: on average, a 15% increase over conventional methods. On the other hand, with current gas prices hovering above $5/mcf, the increased cost of directional drilling would reduce the profit margins of oil and gas operators by only 3 percent, still leaving obnoxiously high profit margins to the private corporations that seek to exploit the public lands for their mineral resources. Given the fact that the oil industry is the most profitable industry in the world, generating billions in profits from Wyoming alone, it is insulting to assert that industry is unable to foot the bill to do their job with the lowest possible impact on the land. The possibility of increased cost associated with directional drilling is far outweighed by the environmental and social costs of failing to implement this method: Destroyed wildlife habitats, defiled viewsheds, and an unnecessary and undue degradation of virtually every other resource managed by BLM.

Directional drilling is also suitable for coalbed methane exploration and production. According to Doug Wight of CDX Gas, their Z-Pinnate Directional Drilling system can be used to drain an area of 1,280 acres of coalbed methane from a single pad (Wight 2004). These wells have produced 90% of the coalbed methane ("CBM") in place over a 3-year time horizon, versus only 10-40% of the CBM for vertical well layouts over the course of decades (Ibid.). This technology is effective at depths greater than 800 feet; this fits well with the coal seams found in the Casper planning area. Several "pinnates" can be drilled to take advantage of disjunct coalbed methane deposits at different depths. *Id.* In the San Juan Basin of Colorado, use of this technology cost $1,635,006 for each 1,280-acre layout, versus over $2 million to drain the same area with vertical wells *(Id.)*.This technology should have been considered as an alternative to a conventional well layout, with its tangle of roads, pipelines, and wellpads. CDX Gas has drilled the first Z-Pinnate well for coalbed methane in Wyoming west of Baggs, the Smith Rancho well. This well appears to have been successful in accessing coalbed methane at a fairly shallow depth (Tom Dimelow, CDX Gas, pers. comm.).

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There are a number of inaccuracies and incomplete analyses contained in the Draft EIS regarding directional drilling, which are used by BLM as rationales for eliminating directional drilling as a required practice. This entire section has been drafted without citation to published studies or authories, which makes it difficult to judge the relative merit of assertions contained therein. The DEIS states at 2-5, "directional drilling requires precise control of target locations in three dimensions." While this may be true for horizontal wells, other types of directional drilling (e.g., s-turn wells) are not subject to this limitation and perform like vertical wells with regard to penetrating pay zones of varying thicknesses. BLM also claims that directional drilling is 1.5 to 4 times more expensive than vertical drilling, yet the agency cites to no study corroborating this outlandish claim. See DEIS at 4-34.

Directional drilling experience in the Jonah Field sheds additional light on the costs of this technology. According to EnCana, who has drilled over 160 directional wells in the Jonah Field as of 2005, "Experience to date indicates that there is no correlation between [horizontal] reach and additional well cost. In fact, some of the low reach wells have experienced more problems than longer reach wells. This suggests that other factors are more important in determining the incremental cost." Attachment 6 at 16. The cost premium on directional wells in the Jonah Field has decreased to a low of $50,000 per well, but are projected to range from $200,000 to $400,00 per well. Attachment 6 at 16. This is consistent with the 15% cost premium that has been reported for directional drilling nationwide.

As noted in the *Drilling Smarter* report, directional drilling has proven successful in every imaginable drilling situation. Successful directional wells have been drilled from 363 feet deep to over 20,000 feet deep. They have been successful for conventional oil and gas, tight sands, coalbed methane, and heavy oil. They have been successful in continuous, basin-centered plays and areas with discontinuous deposits at many different depths. In other words, for every geological situation, there is a directional drilling solution that produces the fluid mineral resources while reducing impacts to the surface.

Further, BLM claims that directional drilling is not feasible for coalbed methane, because these deposits are typically too shallow for the use of this technology. DEIS at 4-35. This is also false; directional wells have been successfully completed in Wyoming at depths of as little as 363 feet to produce coalbed methane.

BLM asserts that sage grouse lek buffers under NSO restrictions preclude the full development of oil and gas resources beneath them. DEIS at 4-35. As directional wells have been drilled with a 6.5-mile horizontal displacement (see Attachment 7), one could theoretically have an NSO buffer of 6.5 miles and still put the borehole directly beneath the lek to produce fluid mineral resources. If the BLM is aware of any published studies refuting this principle, please publish references to these in the FEIS.

BLM also states that borehole collapse is likely in directional wells during fracture stimulation, an assertion that appears to be based on incomplete analysis. This may be true for open-hole completions; however, many directional wells are completed using liners. What is the difference between borehole collapse in lined versus unlined boreholes? Can the BLM demonstrate a performance difference between directional and vertical wells when both have casings? We have significant doubts as to whether such a difference exists. In addition, the risk of borehole collapse should theoretically be identical in the vertical member of S-turn wells (which is where fracking occurs) as with vertical wells fracked in the same formation. If the BLM has any evidence that an S-turn well has a greater chance of borehole collapse than a vertical well in the same formation, the agency should produce it in the EIS; we have seen no such evidence in our review of the applicable petroleum engineering/geology literature.

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BLM also blindly asserts that directional drilling could result in wells not drilled and consequently reserves not recovered. DEIS at 2-6. This is a speculative assertion at best; as oil and gas prices continue to rise with the continued depletions of these resources, wells uneconomic today will be drilled (and their resources recovered) in the future. At this point, the resources will be even more valuable economically and to the nation's energy picture than they are at present.

We have attached the report, *Drilling Smarter: Using Directional Drilling to Minimize Oil and Gas Impacts in the Intermountain West* as a primer on the petroleum engineering on directional drilling. See Attachment 7. We incorporate by reference the 162 published studies and reports, primarily generated by the petroleum industry, contained in the *Literature Cited* section of this report. BLM should substantiate any of its claims that directional drilling is inferior to vertical drilling or is not feasible for widespread application with references to published authorities, in order to satisfy the scientific integrity requirements of NEPA.

We ask that the BLM evaluate these studies and then re-draft its impacts analysis section concerning directional drilling, and also provide alternatives that require directional drilling and well clustering to minimize impacts. The Glenwood Springs Field Office in Colorado has issued a Final EIS for drilling on the Roan Plateau in which the preferred alternative requires No Surface Occupancy on tracts larger than those described in the Casper RMP DEIS (at 4-35), which requires well clustering and a maximum surface pad density of 4 per square mile, and which required phased development in which the planning area is divided into six regions to be developed sequentially, with activity commencing in the second unit only after the first unit is finished, and so forth. We request that such an alternative be evaluated and selected for the Casper RMP. If BLM fails to do so, the agency must then explain why it is not arbitrary and capricious and an abuse of discretion to require implementation of these measures in one area while precluding their consideration in another.

BLM should require the use of officially recognized BMPs, including directional drilling and well clustering to reduce the footprint of oil and gas activities and thereby also reduce the available gravel surface for fugitive dust transmission into the air. BLM should make explicit its commitment to require cluster drilling to protect air quality through the FEIS.

The BLM states that directional drilling should be applied for all oil and gas applications under its Best Management Practices language. See BLM BMP website referenced in Appendix K. However, we and the general public demand a higher standard of accountability: Well clustering for general applications and stand-off drilling for sensitive habitats should be required by BLM of all operators. Federal law and regulation is clear that the agency's mandate is to provide for multiple use, sustained resource output, and minimization of environmental impacts (not maximization of corporate profits). The BLM has an affirmative responsibility to require the most advanced technology that will do the job of extracting the subsurface minerals but minimize the destruction of surface resources and values. The use of these responsible drilling techniques should be viewed not as an imposition on industry, but as part of the cost of doing business on federal lands that have a multiple-use mandate.

PITLESS DRILLING

Under the Preferred Alternative, pitless drilling is required if there is an impact to surface or groundwater resources or soils. DEIS at 2-8. A larger well pad will always have increased impacts on soils, and therefore pitless drilling should be required in all cases under the Casper RMP. This requirement should be made explicit. in a direct way, in the FEIS.

FORESTRY

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Clearcutting has been a primary method for timber harvesting in throughout Wyoming over the past 50 years. BCA explicitly requests a moratorium on clearcutting in the new Casper RMP. There appears to be not a single alternative analyzed by BLM in which this eminently reasonable alternative for forestry was considered. We recommend the approach outlined below for management of commercial forestry activities.

Timber management on Wyoming's public lands has historically emphasized maximizing board-foot production and providing cheap and easy timber harvest methods, rather than providing for a broad spectrum of multiple uses other than timber and harvesting timber at sustainable rates, as set forth in federal law. BLM timber operations in the Casper area have been small from an economic standpoint, and yet some clearcutting has been done on BLM lands. Timber management can usefully be classified in to even-aged methods (e.g., clearcutting, seed-tree cutting, and shelterwood harvest) and uneven-aged methods (single-tree and group selection harvests). This section will discuss the relative merits of timber harvest options, and outline ecologically acceptable methods.

Fire, insect outbreaks, and blowdown events are the natural arbiters of forest structure on a landscape scale, and they create a shifting mosaic of stand ages and compositions that determines the availability of habitat for plants and wildlife in undisturbed forest ecosystems (Knight and Reiners 2000). Timber harvest in Wyoming has been based heavily on clearcutting during the past 50 years (see, e.g., Baker 1994, von Ahlefeldt and Speas 1996). This practice has been espoused as a substitute for natural fire despite the fact that it is the least acceptable harvest method to the public. Although the Forest Service has long contended that silvicultural practices can take the place of natural disturbance, science contends that logging is not a substitute for natural disturbance patterns and processes (DellaSala et al. 1995, Aplet 2000), and even that logging creates long-term obstacles to restoring natural patterns. Noss (1983, p.704) summed up the difficulty posed by forest fragmentation: "The complication in restoring a semblance of the old-growth system in a fragmented landscape is that the natural pattern of disturbance and recovery has been so terribly disrupted that the shifting mosaic has virtually nowhere to shift."

In its DEIS, BLM notes that lodgepole pines forests are suffering from a lack of age-class diversity and are vulnerable to beetles, and states that this is a result of the need for fire and forest management to achieve ecological health. DEIS at 3-38. This is an unsupported and unsupportable position, and has its foundation in ecological ignorance. First of all, lodgepole pine is a fire-dependent invader with a strong need for sunlight to achieve seedling establishment, which means that lodgepole pines have a natural tendency to form even-aged stands following a disturbance – thus, the lack of age class diversity is not a sign of an unhealthy forest but a natural byproduct of lodgepole pine's ecological requirements. Secondly, there is nothing particularly natural about introducing a human-caused disturbance, be it fire or logging, to recycle lodgepole pine stands. In fact, lodgepole pine stands naturally devolve after 275 years or so, and are typically overtaken by spruce-fir or other forest types (which coincidentally have a greater value for wildlife and forest plants, when compared to the biologically depauperate lodgepole stands that preceded them). BLM should re-examine the ecological underpinnings of the Draft EIS, so that counterproductive management activities (like logging declining lodgepole stands) will not be pursued based on a lack of understanding of forest ecology.

Even-Aged Management

Clearcutting has heretofore been considered the preferred silvicultural treatment because it is the cheapest and least labor-intensive method of timber harvest (Alexander 1986). In lodgepole pine forests, clearcutting can maximize board-foot production of timber (Alexander and Edminster 1981). But legal mandates clearly require the BLM to manage for multiple uses and sustainable yields; there is no legal mandate for maximizing timber volume or minimizing extraction costs. Indeed, the Multiple Use

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Sustained Yield Act states that management will occur "with consideration being given to the relative values of the various resources, [but] not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output." 16 USC 531 § 4(a).

Fifty years of intensive forest management have led to an inevitable conclusion: Clearcut logging is a poor substitute for natural disturbance regimes. Superficially, clearcutting would appear to mimic wildfire inasmuch as it creates a mosaic of stand ages (Dillon and Baker, in prep.). However, the fact that clearcutting does not recreate natural landscape patterns has been amply demonstrated in the Pacific Northwest (Wallin et al. 1996), Wisconsin (Mladenoff et al. 1993), and Colorado (Lowsky and Knight 2000). Huff et al. (1995, p. 36) pointed out that "[b]ecause ecosystems change and fire events are essentially random, rigid maintenance of historical patterns poorly reflect the stochastic nature of ecosystem patterns and processes." Franklin et al. (1997, p.114) stated that "[i]t is very doubtful that a forest ecosystem can be re-created by silvicultural treatments that is compositionally, functionally, and structurally complete, even over long rotations." According to Hessburg and Smith (1999), "At the landscape level, we lack almost any knowledge of the combination of mosaics and patterns best suited to specific populations, and we have little understanding of how to maintain the total landscape for regional biodiversity." Dillon and Knight (in prep.) concluded that the mosaic created by past clearcutting on the Medicine Bow National Forest did not resemble the natural fire and disturbance mosaic of presettlement times.

On a stand scale, clearcutting does not mimic the ecological benefits of fire. Clearcutting removes much more coarse woody debris and stem biomass than does fire, which means fewer long-term nutrient inputs into the soil than would occur following fire (Wei et al. 1997). Tinker (1999, p.88) found that "[n]atural fires may create up to four times more CWD during a 100-year period than current post-harvest slash treatments in the MBNF in Wyoming...regardless of fire-return interval." at p. 88. In addition, the soil scarification (e.g., tractor walking, rollerchopping) that takes place in post-clearcut site preparation has disastrous effects on rhizometous plants and soil biota that has no counterpart in wildfire disturbance.

Moreover, clearcutting has a number of serious ecological consequences that render it incompatible with the maintenance of healthy, functioning ecosystems. For instance, clearcutting increases the likelihood of insect irruptions by weakening trees along the edges and creating single-aged monocultures of insect-intolerant early successional tree species (Berryman 1986). The Irland Group (1988, p. 80) evaluated clearcutting as a timber management tool for the Maine Department of Conservation and offered the following caution: "Shoddy, exploitive clearcutting is clearly one of the more destructive forest management practices ...It is not forestry and it is certainly not land stewardship...Clearcutting in these cases is simply cheap logging and not a planned silvicultural practice."

First of all, clearcutting has significant long-term effects on soil communities that lead to loss of forest productivity. Clearcuts increase the outflow of nutrients from forest soils (Knight et al. 1985). When compared to openings left by wildfire, nutrients left behind by clearcutting do not persist as long as post-fire nutrients (Wei et al. 1997), leading to a long-term nutrient drain on forest soils. Harvey et al. (1994) noted that heavy losses of organic matter due to clearcutting can affect water holding capacity, aeration, drainage, and cation exchange in soils, and may affect long-term productivity. These researchers further noted that clearcutting causes greater loss of soil organic matter than other harvesting systems. Harvey et al. (1980) found that all soil mycorrhizae in clearcut areas were dead by the summer following harvest, except in areas within 5m of a living tree. These declines in soil mycorrhizae can have serious consequences for future forest productivity. Mosses and lichens also disappear following clearcutting (von Ahlefeldt and Speas 1996). Erosion from clearcuts is known to increase nutrient inputs to streams

and impact water quality (Harr and Fredricksen 1998), and has been shown to increase in-stream siltation (Eaglin and Hubert 1993).

Second, clearcutting creates forest edges of a type that have harmful ecological effects. The forest edge created by clearcutting bears little resemblance to the edges of natural forest openings, which are typified by gradual transitions and high levels of available cover (Rosenburg and Raphael 1986). Researchers have found that the hard edges left behind by clearcuts make nesting birds more susceptible to predators than more gradual natural edges (Ratti and Reese 1988, Rufenacht and Knight 2000). These high-contrast edges interfere with the migrations and dispersal of some salamanders (deMaynardier and Hunter 1998). In addition, 22% of bird species in the study by Ruefenacht and Knight (2000) on lodgepole pine forests in northern Colorado used only edge habitats surrounding natural openings, and were not found along clearcut openings. The "hard" edges created by clearcutting also allow light and wind to penetrate into the adjacent forest, causing changes in forest microclimate in terms of sunlight, temperature, wind, and humidity (Chen et al. 1993, Vaillancourt 1995). Clearcut edges also increase windthrow in adjacent, uncut stands (Alexander 1967).

Third, clearcutting creates favorable environments for the invasion of nonnative plant species, which prefer open, disturbed habitats. Selmants (2000) found that 87% of clearcuts studied on the neighboring Medicine Bow National Forest contained exotic species of plants, while Dion (1998) found that exotic plants constituted a significant percentage of overall plant cover on clearcuts in Wyoming. Nonnative species can have disruptive effects on native ecosystems, and their invasions should be actively discouraged through forest management.

Science has demonstrated that clearcutting is absolutely incompatible with the habitat needs of many forest species, and may lead to local extinctions. Niemela et al. (1993) noted that two species of beetle never successfully recolonized second growth stands following clearcutting, and suggested that clearcutting reduces the abundance and diversity of generalist beetles. Interior forest species found in this region that are adversely affected by clearcutting include cavity-nesting birds (Scott and Oldemeyer 1983), bole- and canopy-feeding birds (Franzreb and Ohmart 1978), red-breasted nuthatch and brown creeper (Chambers et al. 1999), American martens (Thompson 1994, Potvin and Breton 1997, Hargis and Bissonette 1997), mountain lions (Van Dyke et al. 1986), and northern goshawks (Crocker-Bedford 1990). Koehler (1990) suggested that clearcutting interferes with lynx dispersal. Keller and Anderson (1992) found that brown creeper, red-breasted nuthatch, and hermit thrush declined in response to clearcutting on the nearby Medicine Bow National Forest; Mannan and Meslow (1984) found that these species and the golden-crowned kinglet were significantly more abundant in old-growth than in managed forests. Selmants (2000) demonstrated that the loss of grouse whortleberry from clearcut areas can last at least 30-50 years following clearcutting.

The decline of interior forest species leads directly to a forestwide decrease in species diversity. Although clearcuts may initially show small-scale increases in species diversity, clearcutting has been shown to cause significant reductions in old-growth obligates such as red-backed voles (Sullivan et al. 1999). A similar relationship has been shown for birds (Rosenburg and Raphael 1986) and insects (Niemela et al. 1993). Hejl et al. (1995) reviewed the scientific literature and found that 11 species of forest birds were always less abundant in clearcut-logged forests. Thus, although on-site diversity may increase as edge-adapted and open-country species invade the forest, overall species diversity declines as interior forest species disappear altogether.

Clearcutting may meet the objectives and requirements of the timber industry, but it constitutes irresponsible land management and results in long-term damage to forest ecosystems, as outlined above.

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Due to the devastating effects of clearcutting on ecosystem health, we conclude that that a moratorium on clearcutting is needed for the Casper planning area. We recommend moratorium on clearcutting throughout the area, and even-aged harvest methods that create clearcuts over the long term, such as seed-tree cuts and two-stage selection cuts, will also be prohibited. Three-stage shelterwood cuts may in some cases be compatible with the ecological requirements of forest species, and will remain as the sole even-aged timber harvest option under the Western Heritage Alternative. Crompton (1994) found that shelterwood cuts had negative effects on interior forest birds and increased numbers of nest-parasite cowbirds, but had little effect on assemblages of small mammals. The use of three-stage shelterwood harvest should be implemented where their use is compatible with other multiple uses.

Partial Cutting

There are a number of uneven-aged harvesting strategies can be applied to coniferous forests. Foresters contend that individual-tree and group selection cuts are appropriate for spruce and fir (Alexander et al. 1984, Alexander 1986). While some agencies have contended that single-tree selection is inappropriate for lodgepole pine forests (e.g., MBNF 1985), some 1,145 million board-feet of timber, mostly lodgepole pine, were selectively harvested on the Medicine Bow between 1868 and 1950 (Baker 1994). Studies show that partial cutting in lodgepole pine stands does not result in significant mortality from windthrow or other factors when the trees removed represent less than 45% of the stand basal area (Alexander 1966, Alexander 1975). Thus, uneven-aged harvesting, both group selection (defined as cuts no larger than 2 tree heights in diameter, Franklin et al. 1997) and individual-tree selection, are appropriate for use throughout Wyoming from a silvicultural standpoint, although there certainly are areas that should be excluded from logging for other reasons.

Uneven-aged harvesting is less harmful to forest ecosystems when compared with clearcutting. Uneven-aged timber harvest results in a more homogeneous landscape (Aplet 2000), which over the short term can mitigate the effects of forest fragmentation. Single-tree selection, as a form of late thinning, is compatible with the habitat needs of lynx (Koehler and Brittell 1990). Group selection cuts were found to be less destructive to forest bird communities than either clearcutting or selective harvest that removes most of the forest overstory (Chambers et al. 1999). It is important to note, however, that single-tree selection and thinning does not create forest communities that sufficiently mimic old-growth characteristics to maintain old-growth wildlife assemblages such as small mammals (Wilson and Carey 2000).

It is important to recognize that uneven-aged timber harvest can also cause serious ecological problems when abused. For example, the benefits of single-tree selection in maintaining a forest overstory are dependent on maintaining an adequate period of time between harvest entries. Chambers et al. (1999) found that selective harvest which removed 75% of the overstory caused bird diversity and abundance to decline almost as much as in clearcuts. If half of the trees in a harvest unit were selectively removed, and then a second entry was made five years later to remove the remaining large trees, then the selection cut would have effectively been transformed into a clearcut, with all of the attendant ecological ramifications. Foresters are encouraged to use aggregate retention techniques, which leave behind intact soil and moisture regimes and contribute to a variety of structural classes (Franklin et al. 1997).

In the past, federal agencies have acted in bad faith regarding its responsibility to manage timber harvest in a responsible, sustainable, and ecologically sound manner. It is therefore necessary for the revised Casper RMP to include ironclad standards to ensure that partial cuts are conducted in a manner that minimizes their ecological impacts. With this in mind, a maximum of 40% of the forest canopy may be removed in any timber harvest entry, and a minimum period of 60 years between entries shall be enforced for shelterwood and group selection cuts, and single-tree selection entries shall be separated by a

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minimum period of 80 years. Note also that timber harvest schedules shall be made to conform to additional limitations presented through standards written into the RMP.

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Salvage Logging and Thinning Treatments

Too often, fires and insect outbreaks have been used as an excuse to approve large-scale timber grabs in the western United States. With new directives to reduce susceptibility of forests to fire comes additional pressure for accelerated thinning on a broad scale. But both thinning and salvage logging have serious ecological drawbacks. Frissell and Bayles (1996, p. 231) concluded that "many of the proposed cures (e.g., salvage logging and massive thinning programs, continuing existing livestock policies) pose far greater threats to fish populations and aquatic ecosystem integrity than do fires and other natural events..."

Hutto (1995, p. 1053) evaluated the effects of post-fire salvage logging, and reached the following conclusion: "If some bird species require burned forests for the maintenance of viable populations (which is strongly suggested by this study), then post-fire salvage cutting may be conducted too frequently to be justified on the basis of sound ecosystem management." In addition, woody debris left behind by forest fires plays an important role in protecting regenerating aspens from ungulate browsing (Ripple and Larsen, in press). Thus, the snags and woody debris created by forest fires play an important role in maintaining the forest ecosystem. Like other forms of logging, salvage cuts and thinning must be limited to cases where they are consistent with maintaining ecosystem health and function. Thus, "sanitation sales" that log off trees that are population centers for beetle or mistletoe would be prohibited because they interfere with the natural function of the ecosystem. Salvage logging should not be permitted because it destroys the architecture of post-disturbance landscapes.

The effectiveness of thinning to prevent or reduce wildfires is dubious and unproven. According to the Huff et al. (1995) study, "In general, rate of spread and flame length were positively correlated with the proportion of area logged..*AN harvest techniques* were associated with increasing rate of spread and flame length..." (emphasis added). In a study on fire severity following thinning and prescribed burning on the Wenatchee National Forest, high tree mortality was found on 43% of the area that experienced fuels reduction, compared with only 37% for the untreated area (USDA 1995). In northern California, Weatherspoon and Skinner (1995) higher levels of crown scorch in thinned stands than in adjacent unthinned stands, with the lowest levels of crown scorch in unmanaged stands. Prescribed fire is a more favorable fuels reduction treatment, resulting in lower fire intensity (Stephens 1998). Because the result of fuels treatment thinning to reduce fire are at best unproven and counterproductive at worst, prescribed fire will be the preferred method of fuels reduction under this alternative. No fuels treatment of any sort will be allowed outside Urban-Forest Interface areas, defined as within ¼ mile of currently existing structures.

Snag Retention

Snag retention is an important means to maintain structural diversity in managed areas and to provide habitat for snag-dependent wildlife. Several studies have documented the value of retaining snags in maintaining populations of cavity-nesting birds (e.g., Scott and Oldemeyer 1983, Cunningham et al. 1980). Other wildlife associated with snags include boreal owls (Herren et al. 1996), American marten (Ruggiero et al. 1998), and woodpeckers (Loose and Anderson 1985). Some studies indicate that snag retention can be effective at creating habitat for cavity-nesting birds even in clearcuts (Scott and Oldemeyer 1983). Cavity-nesting birds prefer larger snags (Cunningham et al. 1980, Bull 1983, Scott and Oldemeyer 1983, Winternitz and Cahn 1983) and snags with broken tops (Bull 1983). Retaining snags only in riparian buffer zones does not sufficiently address the needs of cavity nesters (Cline and Phillips 1983). High-cut stumps are inadequate for providing appropriate habitat for cavity nesters (Morrison et al. 1983).

Timber Removal and Post-Harvest Treatments
Under this alternative, methods of timber removal should be closely examined, and minimum-impact timber removal practice will be used. Swank et al. (1989) noted that "road building, skidding and stacking logs, and some site preparation activities can produce major soil surface disturbance that greatly increases the erosion on a site." Romme et al. (2000) suggested using large-wheeled vehicles or winter horse logging to minimize the impacts of roadbuilding within harvest units. The creation of winter, packed-snow roads is far less damaging than summer skidding. Helicopter and high-line logging techniques also reduce road proliferation and minimize soil disturbance and should be employed in managed forest settings wherever possible. Post-harvest treatments such as scarification increase rates of soil nutrient loss, resulting in long-term losses in forest productivity (Harvey et al. 1994). Scarification of soils and reductions in soil organic layers as a result of site preparation hinder the survival of mycorrhizae (Harvey et al. 1981). Post-harvest treatments such as rollerchopping and tractor-walking also hinder the survival of grouse whortleberry (Dion 1998, Selmants 2000), a principal understory species in lodgepole pine stands in this region. In the future, post-harvest treatments should minimize soil disturbance.

Sustainable Timber Harvest Rotations
Timber harvest on BLM lands must be sustainable, both in terms of sustaining availability of timber and sustaining natural ecosystems. Timber harvest rotations in current use in Wyoming are unsustainable over the long term, accelerate forest fragmentation, interfere with forest succession, and prevent the establishment of a natural pattern of patch dynamics (see *below).* Long rotations offer the advantages of reducing the cumulative effects of logging on forest ecosystems, allowing a reduction in road density, and increasing the quality of wood products (Franklin et al. 1997). Ceroski et al. (2001) recommended lengthening harvest rotations to improve habitat for brown creepers. In this alternative, timber harvest rotations are set to accurately mimic the intervals of natural forest disturbances.

To add to the ecological problems of past forestry practices, the harvest rotations historically used by federal agencies are completely incompatible with the natural cycle of stand replacement in southern Wyoming. In subalpine forests, natural return intervals for stand replacement fires have been established at 202 years in Colorado (Veblen et al. 1994), 300-400 years in Yellowstone National Park (Romme 1982), and 300 years on drier slopes and 600 years in valley bottoms for the Medicine Bow National Forest (Romme and Knight 1982). By contrast, harvest rotations have historically been set at 90-140 years for lodgepole pine and 100-180 years for spruce-fir (see, e.g., MBNF 1985). These harvest rotations are uniformly half as long as natural stand turnover periods, and transform the forest from mature forest to young, seral stages. **As** a result, stands 200 years old and older are much rarer today than they were before the advent of forest management (Veblen 2000). Clearly, stand turnover under the current regime of cutting does not reflect natural rates of turnover. Wallin et al. (1996) noted that longer harvest rotations were needed to return forests to their natural range of variability. The BLM needs to recognize that mistaken assumptions have been made about the recovery times of timber-producing stands, and lengthen harvest rotations to reflect the natural rates of stand turnover under which the forest ecosystem has evolved.

Experts agree that during presettlement times, the forested ranges of Wyoming were characterized by broad, interconnected expanses of mature timber punctuated by isolated tracts of younger forest. According to research by Kipfmueller and Baker (2000), before **1869** on the Medicine Bow, "[t]he landscape contained a matrix of connected old forest, perforated by a few younger patches." Knight and Reiners (2000) add that "...the structural properties of interior forests would have been widespread prior to intensive timber harvesting, especially in areas with little relief, such as in the Medicine Bow Mountains of southern Wyoming." Characterizing the pre-settlement landscape of the Medicine Bow Range, Kipfmueller and Baker (2000) stated that "...large patches of connected forest would nearly

always have dominated, because patterns of infrequent, large fires retain dominance in the landscape during a period when small fires occur." They concluded that, "[a] period of restoration (e.g., road closures), rather than continued harvest and road construction, is needed if the goal is to achieve a landscape within the range of variability of the pre-EuroAmerican landscape." Aerial photos taken circa 1953 clearly show that prior to the onset of clearcutting, the Medicine Bow and Sierra Madre Ranges were comprised of vast tracts of mature forest interrupted by a few, widely scattered natural openings. The modern pattern of isolated tracts of mature forest in a sea of roads and clearcuts bears no resemblance to the landscape in which this forest ecosystem evolved.

FENCES

Fences can impede wildlife migration and dispersal, serve as raptor perches (increasing predation on prey species), and lead to direct mortality of big game animals. According to BLM's analysis in the Rawlins RMP Draft EIS, "crucial winter range of mule deer in some locations is in poor health because of loss of habitat and restricted movement as a result of highways and fences." Rawlins RMP DEIS at 3-106. Studies show that woven-wire fences cause higher mortality for pronghorns: According to Riddle and Oakley (1973) woven wire fences in south-central Wyoming accounted for 83% of the pronghorn fence mortality, despite making up only 53% of the fences.

Barbed-wire fences are known to be a major impediment to pronghorn migration and dispersal. Taylor (1975: 1) reported. "Fences were an important factor preventing optimum range use by antelope." He added that "[u]npublished department data indicate that the wintering areas have been reduced by roughly one half because of fences" (p.2). Bruns (1977) found that fences are major impediments to winter travel, as are roadways with high traffic volume. During the severe winter of 1971-72, fences impeded antelope movements to crucial winter relief ranges: Some 1,500-2,000 antelope were trapped by the highway fence beside what is now U.S. 191 near Farson before the fence was cut, allowing them to proceed; hundreds of antelope were trapped in fenced pastures outside Evanston, and open gates apparently were insufficient to allow them to escape (many died despite supplemental feeding); and 66 antelope were found dead beside the railroad right-of-way fence outside Granger (Julian 1973). Julian concluded, "The lack of fences, mainly high net wire fences in Southwestern Wyoming, probably prevented antelope losses from being higher" (p. 10). Fences also aid coyotes in catching pronghorns (e.g., McNay and O'Gara 1982), potentially inflating predation losses.

Taylor (1975) recommended that "Fences which cross migration routes should be removed or at least modified to allow ready passage by pronghorns under adverse weather conditions..." (p. 47). Bruns (1977) recommend a minimum clearance of 46 cm and a barbless lower strand for fences. Rosentreter (1997) recommended that fences which could affect pronghorn dispersal be modified so that the bottom wire is smooth (not barbed) and is kept more than 60 cm (24 inches) above the ground.

Illegal fences must be removed as a standard in the new plan, and existing fences that are non-compliant with WGFD standards must be brought into compliance. There should be no new fence construction. Intensive grazing management systems should be achieved through active herding of livestock, rather than passively by permitting the construction of new fences.

SPECIAL MANAGEMENT AREAS

The Casper RMP proposes to decrease the acreage of designated ACECs from the previous Platte River RMP from 217,253 acres to just 19,998 acres in the Preferred Alternative. Management of Special Management Areas is not always as strong as is needed. We concur that the Salt Creek ACEC need not be carried forward into the new RMP, but this should be a priority landscape for intensive rehabilitation.

The current network of protected landscapes is inadequate to ensure the long-term viability of wildlife within the planning area. For sagebrush obligate songbirds, for instance, Knick et al. (2003, p. 623) recommended:

> Approximately 4.2 million ha of sagebrush lands would need to be placed in nature reserves if we are to meet the conservation goal of protecting 10% of the distribution. To develop this network of reserves, we need to prioritize the landscape by identifying and providing protection or other appropriate management to those relatively large areas of sagebrush in good condition. We then need to enlarge existing protected blocks, increase connectivity in the landscape, and employ basic principles of landscape management to ensure long-term survival of sagebrush habitats and birds.

The designation of Areas of Critical Environmental Concern ("ACECs") is a key requirement in BLM land-use planning. FLPMA repeatedly emphasizes the importance of ACECs in managing BLM lands:

> The Congress declares that it is the policy of the United States that - …
>
> 11. regulations and plans for the protection of public land areas of critical environmental concern be promptly developed...FLPMA Title I Sec.102(a) [43 USC § 1701]
>
> The Secretary shall prepare and maintain on a continuing basis an inventory of all public lands and their resource and other values (including, but not limited to, outdoor recreation and scenic values), giving priority to areas of critical environmental concern. FLPMA Title II Sec. 201(a) [43 USC § 1711]

In the development and revision of land use plans, the Secretary shall - …

> 1. give priority to the designation and protection of areas of critical environmental concern.…

FLPMA Title II Sec. 202(c) [43 USC § 1712]. The BLM must furthermore "give priority to designation and protection of areas of critical environmental concern…" 43 U.S.C. § 1712(c). Finally, BLM is directed to "consider the relative scarcity of the values involved..." FLPMA Title II Sec. 202(c)(6). [43 U.S.C. § 1712].

Balck-Tailed Prairie Dog ACEC

We support the designation of an ACEC for the black-tailed prairie dog complex. This proposed ACEC should be expanded to include adjacent lands that have suitable habitat for the expansion of the complex. The proposed mitigation measures should be put in place, except that in lieu of a maximum 160-acre well density, the mitigation measures should provide that surface disturbance is prohibited within ¼ mile of active prairie dog colonies. Also, BLM should define "natural fire regime;" there is a great deal of controversy among experts regarding the natural return interval for fire on shortgrass prairie systems.

Cedar Ridge ACEC

We support the designation of Cedar Ridge together with its Periphery area as an ACEC, with no leasing or no surface occupancy designation for fluid minerals, recommendation for withdrawal from surface mining, and a moratorium on communications or renewable energy facility siting.

North Platte River
It seems that Special Recreation Management Area is the most appropriate designation for this area. The measures as applied in Alternative B should be implemented in this area.

Sand Hills SMA
We support the establishment of a Sand Hills SMA with provisions as described for BLM's Preferred Alternative. Sand hills systems are typified by fragile soils and have a high rate of animal and plant endemism. BLM should survey this area for the presence of blowout penstemon as part of its baseline inventory requirements, and the results should be published in the FEIS.

South Big Horns/Red Wall ACEC
We support the establishment of the South Big Horns/Red Wall ACEC with boundaries as described in Alternative B. This is probably the part of the Field Office that is richest in non-mineral resources values (wildlife, cultural, recreation, etc.). The Northern Plains Conservation Network has identified this area (as the 'Hole in the Wall core area") as one of the ten most important conservation areas in the northern Great Plains. This area should be prioritized for protection of the integrity of the landscape and the ecosystem, and for the enjoyment of the public. It would be appropriate to include the South Fork citizens' proposed wilderness within the ACEC boundary.

Alcova ACEC
We support the establishment of the Alcova Fossil Area ACEC. This area should be protected for the pterosaur tracks and other resources there. All proposed facilities to accommodate visitor use and enjoyment of the site should recognize the preservation of the fossil bed as the first and foremost priority.

Jackson Canyon ACEC
For the Jackson Canyon ACEC, mineral development would be subject to NSO provisions, and timber harvest would be precluded. This is the appropriate level of protection for all ACECs. In addition, road construction should not be allowed, as under Alternatives B and C. There is no need for thinning and/or silvicultural practices to optimize the area for bald eagle roosting. There is no evidence that roosting bald eagles benefit from silvicultural intervention of any kind.

Bates Hole ACEC
The wildlife mitigation measures for this ACEC are wholly insufficient for application for non-ACEC lands, much less an Area of Critical Environmental Concern. Crucial big-game winter ranges, areas within 3 miles of a sage grouse lek, and areas within 1 mile of a raptor nest should by placed off-limits to future minerals leasing or at minimum placed under NSO stipulations. In addition, because BLM has identified this area as a priority for sage grouse protection and enhancement, early- and late-brood-rearing habitats and wintering habitats should also be identified and put under NSO stipulations. We do approve of the moratorium of new power/pipeline corridor ROWs in the ACEC.

Wilderness
BCA has identified over 28,000 acres that qualify for wilderness status within the Casper Field Office (submitted separately as a comment to the Casper RMP revision and as an independent petition pursuant to 5 USC § 555(e)). To our knowledge, this is the sole qualifying parcel, but we have not performed a comprehensive wilderness inventory on other lands within the Casper Field Office. We request that BLM evaluate and protect this area through the Casper RMP. According to BLM, "While the Citizens' Proposal areas may be reasonably natural and contain opportunities for solitude and primitive and (or) unconfined recreation, they are not of sufficient value to warrant management for wilderness character." DEIS at 2-7. BLM appears to admit that this area meets the naturalness and solitude/primitive recreation criteria for

wilderness, and at over 33,000 acres, it obviously meets the size requirement. Thus, BLM should set the area aside and manage it for wilderness qualities until such time as Congress, the only true arbiter of wilderness character, can determine if the wilderness qualities are of "sufficient value" to warrant wilderness protection.

These lands would be closed to mineral leasing under Alternative B, along with many other lands (see Map 9). However, they would be open to future leasing under Alternative E (Map 12). BLM should give this area special designation and manage it to maintain and improve the wilderness characteristics found here.

Visual Resources
Currently, there are zero lands within the planning area in VRM Class I. DEIS at 3-90. It is shocking that there are no lands in the Casper Field Office managed for retention of their visual character. At a minimum, the South Fork of the Powder proposed wilderness should be managed as a VRM Class I area. Lands within 5 miles of the Oregon National Historic Trail and Bridger and Bozeman trails should be managed at a VRM Class I level to protect the historic setting, pursuant to the NHPA. In addition, lands within 2 miles of the Red Wall and Seminoe Road Scenic Byways should also be managed as VRM Class I.

The area of the Salt Creek and Teapot Dome fields is in need of rehabilitation from both the VRM and ecological perspectives.

Global Warming
The impacts of global warming on Wyoming ecosystems are becoming increasingly apparent. It is likely that global warming, in the years ahead, will result in longer and more protracted droughts, increased number and severity of forest insect outbreaks, increased number and severity of forest fires, and a creeping upward of the timberline and associated shrinkage and/or disappearance of alpine habitats and their obligate wildlife. The air quality analysis displayed the outputs of carbon monoxide (CO) and other pollutants, but not carbon dioxide, methane or other global warming pollutants (see DEIS at 4-10). In order to fulfill NEPA's mandates, the BLM must include a cumulative impacts analysis on the outputs of global warming pollutants under the various alternatives. This analysis should include the proximate sources of global warming gases as well as the ultimate sources (i.e., after produced fossil fuels are combusted, likely outside the planning area).

OFF-ROAD VEHICLE USE
Off-road vehicle use is causing damage to visual resources in a number of parts of the planning area DEIS at3-91.

1. Travel management decisions should be made in the Casper RMP.

BLM's internal guidance states that "each RMP will divide planning areas into OHV area designations that are open, limited or closed." IM No. 2004-005; *see also* 43 C.F.R. § 8342.2(b). This internal guidance was also incorporated into the updated version of BLM's *Land Use Planning Handbook.* H-1601, Appendix C, Section II.D (Comprehensive Trails and Travel Management). The *Land Use Plunning Hundbook* states that BLM should:

> Complete a defined travel management network (system of areas, roads and/or trails) during the development of the land use plan, to the extent practical. If it is not practical to define or delineate the travel management network during the land use planning process, a preliminary

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network must be identified and a process established to select a final travel management network. (emphasis added)

The *Land Use Planning Handbook* (Appendix C, Section II.D) also sets out requirements for travel management at both the land use and implementation planning levels:

- At the land use plan level, BLM must identify areas for use based on program goals and objectives, primary users, reason for "allowing travel" into an area, setting character to be maintained (including Visual Resource Management and Recreation Opportunity Spectrum classifications), and primary means of travel appropriate to meet objectives and keep setting character; and
- At the implementation level, BLM must define a detailed travel management network, "establish a process" to identify roads, trails, etc. with criteria for selections, guidelines for management, monitoring and maintenance, and indicators for future plan maintenance.

Recommendations: We urge BLM to seize the opportunity presented by this RMP process to complete a comprehensive travel management plan in conjunction with the RMP, at minimum for sensitive areas, such as ACECs and citizen-proposed wilderness. If the agency does not complete a travel management plan as part of the Casper RMP, then the RMP must identify not only areas for use, but also reasons for permitting travel into an area and appropriate criteria for determining routes that will be made available for different uses, taking into account such factors as undeveloped recreation opportunities available and natural settings.

2. Landscape level planning.

Travel planning requires the agency to manage human travel across the landscape. The land use planning process, which addresses the broader landscape within a planning area, provides one of the best opportunities to make travel planning decisions in the appropriate context. While we understand that BLM does not have authority to close or relocate highways, major roads, or County roads, BLM must include these routes when analyzing the transportation network as they have a great impact on habitat fragmentation and reduction in core area size (discussed in length later in these comments). The placement and design of travel routes defines which areas will remain or become roadless, and which areas will be disturbed and how. In other words, route decisions determine the fragmentation of the landscape, and, thus, how naturally or unnaturally a landscape will behave in terms of water flow and quality, wildlife migration, and species composition and function.

NEPA requires federal agencies to assess the direct, indirect and cumulative environmental impacts of proposed actions, taking a "hard look" at environmental consequences and performing an analysis commensurate with the scale of the action at issue. 42 U.S.C. § 4321 et seq; 40 C.F.R. § 1508.8.[3] Travel planning affects the entire landscape and can only be thoroughly and properly assessed by considering potential impacts and making decisions at a comparable level. In terms of how to evaluate the potential impacts of travel management decisions, NEPA's definition of "cumulative impact" is instructive:

> the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

[3] *See also* Metcalf v. Daley, 214 F.3d 1135, 1151 (9th **Cir.** 2000); Robertson v. Methow Valley Citizens Council, 490 U.S. 332, 348 (1989).

40 C.F.R. § 1508.7. (emphasis added). BLM must account for the direct, indirect, and cumulative impacts of all roads in the Casper RMP planning area when completing a comprehensive travel management plan.

Recommendation: BLM should address travel management on a landscape-wide basis by addressing the impacts of all roads in the planning area and accounting for the landscape-wide impacts of these roads.

3. Legal definition of "Road."

BLM must apply a legal definition of "road" within the planning process, develop appropriate criteria to accurately gauge what is or is not a road, ensure that illegal "ghost roads" are not legitimized, and in fact, close and reclaim such "ghost roads." Some legal roads serve important travel needs and are appropriate for motorized use. However, routes that are not "roads" should not receive equal consideration. The agency has a definition of "road," and this definition should be adopted and used consistently in order to create a regular expectation and approach on BLM lands. We note however, that merely meeting the definition of a road is not sufficient to justify designating a route. In fact, the BLM must still consider whether a route has negative impacts to sensitive or protected resources, such as by the process recommended in this document, and should only designate those that do not impact these resources.

The legal definition of road for the BLM public lands is derived from the definition of "roadless" in the legislative history of FLPMA:

> The word "roadless" refers to the absence of roads which have been improved and maintained by mechanical means to insure relatively regular and continuous use. A way maintained solely by the passage of vehicles does not constitute a road. (H.R. Rep. No. 94-1163 at 17 (1976)).

In addition, the Code of Federal Regulations (43 C.F.R. § 19.2(e)) establishes the following definition:

> An improved road that is suitable for public travel by means of four wheeled, motorized vehicles intended primarily for highway use.

Therefore, it is incumbent upon BLM to exclude "user-created'' routes from the inventory presented in the Draft RMP. To include these routes is to legitimize and "grandfather in" illegally created routes and/or routes which have not been improved or maintained by mechanical means to ensure regular use. The Preparation Plan mentions working with ORV groups to both identify suitable riding areas and "get help in inventory of routes." While BLM could certainly benefit from obtaining input on areas that these groups believe would be appropriate for their use, any inventory or proposal of routes to be included in the transportation system for the Casper Field Office should exclude user created routes.

Recommendations: BLM should use a legal definition of "road" (as defined above) when designating routes and exclude "user created" routes from the inventory.

4. Habitat fragmentation.

As mentioned in the beginning of this section of our comments, BLM must address travel management on a landscape level to ensure that BLM meets its responsibility as stewards of the public land and mitigates against habitat fragmentation. We have included The Wilderness Society's most recent Science and Policy Brief, "Habitat Fragmentation from Roads: Travel Planning Methods to Safeguard BLM Lands".

We also refer BLM to the following reports on this issue prepared by The Wilderness Society, enclosed and available on-line:

1) **Fragmenting our Lands: The Ecological Footprint from Oil and Gas Development** - http://uww.wilderness.org/Library/Documents/upload/Energy-Footprint-Full-Report.pdf;
2) **Ecological Effects of a Transportation Network on Wildlife** - http://wwu.wilderness.org/Library/Documents/upload/Missouri-Breaks-Transportation-Effects-fulI-report-u-o-covers.pdf;
3) **Protecting Northern Arizona's National Monuments: The Challenges of Transportation Management"** - http://wwu.wilderness.org/Library/Documents/AZStripTransportation.cfm; and
4)"**Wildlife at a Crossroads: Energy Development in Western Wyoming.**" – http://www.wilderness.org/Library/Documents/pinedale.cfm

In addition to summarizing the four reports listed above, "Habitat Fragmentation from Roads: Travel Planning Methods to Safeguard BLM Lands" provides a summary of available scholarly and government reports and studies on the impact of habitat fragmentation on wildlife, provides methods for calculating habitat fragmentation, and provides recommendations on how to integrate fragmentation analysis into travel management.

We also recommend you look at the travel planning criteria set out in the Record of Decision for the Dillon (MT) RMP (relevant sections **attached** and also available on-line at: http://www.mt.blm.gov/dfo/rod/contents.htm), as an example of criteria that incorporate key aspects of BLM's ORV regulations as well as ecological metrics. While this field office did not complete a comprehensive travel management plan as part of its RMP revision, it included road density targets and included an appendix outlining the principles it will use when completing a comprehensive travel management plan during implementation.

Recommendation: BLM should use the information provided in Appendix 1 to measure habitat fragmentation, conduct a thorough fragmentation analysis, and inform decisions regarding road closure and other limitations on use in the Casper RMP.

5. Principals of travel management.

When completing a comprehensive travel management plan, it is vital **to** complete it in a systematic and transparent manner.

Key principles of travel planning

(1) Travel management is part of land use planning and should address both recreation and transportation needs from a landscape perspective.

(2) Prior to conducting an inventory or designation of routes, BLM should assess the present resources, requirements for protection, and which uses for recreation and development are compatible with these resources, requirements and other users.

(3) BLM should use a legal definition of "road" when designating routes.

(4) BLM's consideration of ORV use should take into account its potential damage to resources and other uses, including exclusion of other users.

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(5) Where BLM presents a baseline travel system, it must present route maps in a responsible manner that does not legitimize illegally-created routes.

(6) BLM should include a detailed closure and restoration schedule in the plan.

(7) BLM should include and implement a monitoring plan.

(8) BLM should include and implement education and outreach in the plan.

The Wilderness Society and the Colorado Mountain Club have developed a template for conducting travel management planning, which we have **presented below** and recommend that the BLM incorporate into the Casper RMP as the process for further planning.

Recommendations: BLM should follow the eight travel planning principals detailed above to ensure that only routes which truly serve a valid purpose for the public remain open. In addition, the BLM should conduct travel planning in accordance with the template provided with these comments.

Recommended Travel Management Planning Process Template

The following sets out the ten steps that should be completed in order to develop a comprehensive travel plan, from an initial assessment of goals and resources, through developing appropriate management (including route designation) and ongoing monitoring, evaluation and adjustment. These steps can be followed as part of the resource management plan revision, in which case much of the baseline data will be assembled concurrently, or in preparation of a separate travel management plan, in which case baseline data assembled during preparation of the RMP may be used and updated. The Casper RMP should specify at what level travel management planning will be undertaken.

Step 1. Identify recreation and transportation goals for the planning area.

A. Transportation and recreation goals from concurrent or approved RMP
B. Regional goals for transportation connectivity
C. Public destinations on BLM lands
D. Valid and existing rights that require specific access
E. Area-wide goals for type and quantity of non-motorized recreation from (Recreation Opportunity Spectrum) ROS or other description of the landscape
F. Area-wide goals for type of quantity of motorized recreation from ROS or other description of the landscape

Step 2. Assemble resource data.

Note: The agency should use **GIS** technology and digital data sets as appropriate.

A. Biologic

1. Non-game wildlife and plant population or habitat coverages (*e.g.*, state Natural Heritage element data and potential conservation areas)
2. Game wildlife coverages (*e.g.*, state Division of Wildlife data)
3. Unique habitats (*e.g.*, riparian or wetland areas, unique geology such as hanging gardens)
4. Other relevant data sets (*e.g.*, endangered or threatened species, special status species)
5. Expert opinion on likely occurrences/habitat for important biological resources that do not have existing data coverages
6. Compile information in #1-#7 into one data set that identifies high priority biological resources.

B. Cultural
   1. Cultural site locations
   2. Cultural and historic landscapes
   3. Traditional religious and cultural properties significant to Tribes
   4. Historic trails
   5. Compile information in #1-#4 into one data set that identifies high priority cultural resources.
   6. Compile information in #1-#4 into one data set that identifies properties on or eligible for the National Register of Historic Places.
C. Physical
   1. Soil types (simplified to erodible vs. less erodible or similar categories)
   2. Watersheds, stream segments, and sites with perennial water
   3. Unique geologic occurrences or structures
      i. Paleontological site locations or likely paleo-rich formations
      ii. Springs or seeps
      iii. Unusual structures such as volcanic necks
      iv. Aesthetic structures such as narrow canyons
D. Substantial natural areas (1000 acres or greater) of unfragmented habitat, contiguous vegetation or opportunities for primitive recreation
E. Landscape Health
   1. Areas in which land health standards are being achieved
   2. Stream segments that are and are not in functioning condition
   3. Other existing measures of landscape health such as the state Clean Water Act Watch List
   4. Areas damaged by off-road vehicle use
   5. Compile information in #1 - #3 into one data set that identifies areas that are not achieving identified standards.

Step 3. Identify baseline travel system.

A. Non-motorized hiking or biking routes
B. Motorized routes that are used predominantly by four-wheeled, motorized vehicles (which are primarily used on highways) and that have been improved and are maintained to insure ongoing use by such vehicles.
C. Routes designated in prior planning processes
D. Roads with public destinations (e.g., viewpoints, ruins, towns, trailheads)
E. Roads that are regional connecting travel corridors.
F. Reasonable access routes to valid and existing rights (including commercial uses)
G. Routes necessary for "emergency or authorized administrative purposes."
H. Classify these routes based on:
   - Route maintenance requirements (e.g., needs reconstruction, needs occasional maintenance, needs frequent maintenance)
   - Route use requirements (e.g. street-legal vehicle, 4WD/high-clearance, ATV)
   - Route conditions (e.g. reclaiming, single track, primary road unpaved, secondary road unpaved, tertiary road unpaved)

Step 4. Summarize public recreation desires and current recreational opportunities

A. Types and quantities of motorized and non-motorized recreation desired by the public – today and projected into the future.
B. Types and quantities of recreational facilities (e.g., roads, trails, trailheads, educational tours, outhouses, campsites) that exist today.

C. Current ROS or other description of the landscape that quantifies motorized vs. non-motorized recreation.

Step 5. Analyze present and predicted future fiscal and personnel resources.

A. Enforcement capability
   1. Enforcement staff per acre available to enforce travel rules
   2. Rangers per acre available to enforce travel rules
   3. Future predicted enforcement and Ranger availability
   4. Hours available for education and outreach

B. Monitoring capability
   1. FTEs available to monitor landscape condition as it relates to transportation and access
   2. Future predicted monitoring capability

C. Maintenance capability
   1. Equipment and people hours available for road and trail maintenance
   2. Funds for maintenance material (e.g., borrow)
   3. Future predicted maintenance equipment, material, and FTEs

Step 6. Calculate route density and quantify route distribution in comparison to:

A. High priority biological resource layer
B. High priority cultural resource layer
C. Watersheds with erodible soils
D. Watersheds with perennial water
E. High importance geologic occurrences (e.g., paleontological resources, unique features)
F. Natural areas (as identified in Step 2 D above)
G. Landscape areas not achieving standards

Step 7. Identify geographic subunits that constitute logical distinct recreation planning areas. Summarize the existing character and condition of each subunit.

A. Current transportation and recreation opportunities/facilities
B. The type and character of the experience the subunit currently offers
C. The resource values in the subunit
D. The management the area currently receives (e.g., enforcement, monitoring, and maintenance)
E. The route density and distribution in the subunit, and the relationship of routes to high priority resource values

Step 8. Develop Management Alternatives. For each alternative:

A. Develop a visitor access vision for each subunit, derived from the overall recreation and transportation goals (developed in Step 1), considering the subunits' existing character, existing mandates to protect resources (e.g., Endangered Species Act, Clean Water Act, National Historic Preservation Act, etc.), predicted management capacity, and public desires.
   1. Develop a desired future condition for each subunit.
      a. Define experiential conditions
      b. Define resource conditions
      c. Identify recreation/transportation/interpretive facilities that will exist
      d. Identify recreation/transportation facilities that will be removed
      e. Identify management capacity requirements (e.g., enforcement, interpretation, cultural resource stabilization, route maintenance, monitoring)
      f. Identify management style (e.g., obvious ranger presence, management will be subtle and unobserved by the visitor, trails will be rough and narrow with minimal signage, etc.)

2. Develop transportation/recreation goals and objectives derived from the desired future condition.
3. Develop quantifiable and enforceable standards that establish thresholds that will not be exceeded (related to both experiences and resource conditions).
4. Identify indicators (e.g., measurement parameters) that measure whether the standards are exceeded. Choose only a few indicators that are easy to measure yet reasonably indicate whether the resources or the experiences are declining or improving.
5. Establish monitoring plan.
   a. Specify how often and where each indicator will be measured
   b. Specify required changes to management where desired future conditions are not being met
   c. Specify what management changes will be instituted if fiscal resources are inadequate to implement travel management plan
6. Establish education and outreach plan.
7. Estimate fiscal requirements for full implementation of management approach, monitoring plan, and education and outreach plan.

B. Site-level non-motorized route/trail assessment of baseline routes identified in Step 3.
   1. If the answers are "no" to the following questions, close the route/trail.
      a. Does the route have a publicly recognized destination (e.g. scenic vista,) or appropriate recreational purpose (per FLPMA's standard of no unnecessary or undue degradation)?
      b. If so, does it contribute to the goals and objectives of the subunit?
      c. If so, is the BLM reasonably capable of managing visitors on and near the route/trail?
   2. If any of the answers are "no" to the following questions, then consider closing the route or otherwise mitigating the identified impacts, including rerouting, closing seasonally, closing permanently, enhancing ranger presence and/or education.
      a. Does the route/trail avoid impacts to high priority resources (identified in Step 2 A-D)?
      b. If so, does the route decrease the chance of non-compliance with existing conservation mandates and/or desired future conditions (see Step **8** A)?

C. Site-level motorized road/route assessment for baseline routes identified in Step 3.
   1. If the answers are "no" to the following questions, close the route. Closed routes should be considered for restoration and/or conversion to non-motorized use.
      a. Does the route have a publicly recognized destination (e.g., campground, trailhead, vista) or appropriate recreational purpose (per FLPMA's standard of no unnecessary or undue degradation)?
      b. If so, does it contribute to the goals and objectives of the subunit?
      c. If so, is the BLM reasonably capable of managing visitors on and near the route?
   2. If any of the answers are "no" to the following questions, then consider closing the route or otherwise mitigating the identified impacts, including rerouting, closing seasonally, closing permanently, enhancing ranger presence and/or education.
      a. Does the route avoid impacts to high priority resources (identified in Step 2 **A-D)?**
      b. If so, does the route decrease the chance of non-compliance with existing conservation mandates and/or desired future conditions (see Step **8 A)?**

D. Supplemental motorized road/route assessment for baseline routes identified in Step ***3*** as reasonable access to valid and existing rights, or as necessary for "emergency or authorized administrative purposes":
   1. Is the route the **only** reasonable access to valid and existing rights, or is it critical for "emergency or authorized administrative purposes"?
   2. If no, and if the route would be closed or subject to limitations under **8-B,** then close the route. If yes, were any of the answers in Step B "no"?

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3. If no, keep the route open. If yes, then limit access to administrative or authorized purposes only, and consider seasonal closure or rerouting to protect high priority resources.

Step 9. Landscape level review. Review the final route assessment to:

A. Ensure that recreation and transportation goals and objectives are being met.
B. Ensure that landscape health standards are not being exceeded.
C. Ensure that the transportation and recreation system can be reasonably managed given predicted and existing fiscal capacity.
D. Ensure that high priority biological, physical, and cultural resources are adequately protected within the planning area.

Step 10. Monitoring, evaluation and adiustment. Implement the monitoring plan, including hiring sufficient enforcement personnel, to:

A. Evaluate whether use of the route is greater than anticipated, requiring further restriction and/or maintenance.
B. Evaluate whether use of the route is less than anticipated, meriting consideration for closure as unnecessary.
C. Evaluate whether desired future conditions are being met based on indicators and measurements identified in Step 8.A.5 above.
D. Adjust management based on results of monitoring and evaluation to better achieve desired future conditions and, in the event that fiscal resources are inadequate, implement management changes identified in Step 8.A.5 above.

Economic Issues

The Casper RMP/EIS failed to consider the impact of budget constraints on the agency's ability to successfully mitigate, monitor and enforce the commitments made in the plan. Successful organizations cannot afford to ignore budgets when developing long-term management plans. Unfortunately, we can find no analysis of costs and budgets anywhere in the Casper RMP/EIS.

BLM should always consider budgets and appropriations when developing and evaluating management alternatives, yet the BLM failed to this common sense task.
Even though the BLM has, unfortunately, passed on a majority of oil and gas monitoring responsibilities to the industry (see Appendix N), some oversight, on-site monitoring, and enforcement by BLM staff will be needed. BLM oversight will surely be needed as the oil and gas industry has a poor track record on past efforts at self monitoring. In order to insure the BLM's commitment *to* minimize impacts, agency staff must monitor the acres disturbed, roads built, acres reclaimed, etc. How much will the oversight, monitoring, and enforcement cost and where will the funding come from? BLM must examine budgets and costs, yet the Draft EIS provides no analysis of what the enforcement and monitoring will cost and how that cost compares to expected budget levels.

We specifically request that budget restrictions be examined. Simply holding annual historic budgets constant for 20 years is one relatively easy method for examining budget constraints. Additional sensitivity analysis of budgets would also be a useful exercise for dealing with budget uncertainty. For example, examining the commitments that can or cannot be completed if annual budgets decline from historic levels is essential information for successfully planning adaptive ecosystem management.

The lack of any budget analysis in the DEIS is a major concern, as history strongly suggests that Congress and the BLM will not adequately fund the monitoring and mitigation measures necessary to protect the

multiple use and ecological values of the Casper Field Office. Essentially, the resource protections, mitigations and commitments promised to the public by the BLM in the plan are unfunded mandates.

The U.S. General Accounting Office (1 992) reviewed federal land management budgets and found that the funding received by public land management agencies has been significantly less than the budgets required to fully implement plans. The lower-than-planned budgets have prevented public agencies from producing many of the outputs projected in land management plans, and from implementing the mitigation measures promised in NEPA documents.

To remedy this, the BLM needs to consider budget constraints when evaluating each management alternative as part of the NEPA process. This will require more detail as to where money will be spent, which programs will be fully funded and which ones will not. Planners should, for example, estimate the labor and capital costs of fully mitigating the environmental consequences that will result from implementing each management alternative. By ignoring budget constraints, the plan presents the public with an unrealistic picture of what will be accomplished given limited financial resources.

We are especially concerned with a potential lack of analysis of the costs to mitigate the environmental consequences of each alternative. Ignoring budget constraints is completely unrealistic and deceiving to the public, because planners have not considered the costs of implementing each alternative and the costs of mitigating the potential damage from each alternative. While the budget available to manage the planning area should be considered constant across alternatives, the costs to implement each management alternative are not equal. For example, an alternative resulting in resource damage will require more money for mitigation of said resource damage than a conservation alternative. It makes no sense for taxpayers to subsidize a more damaging and more costly alternative when a less damaging, less costly alternative is available. There is simply no justification for any assumption that funding will be sufficient to implement each alternative and that all resource damage will be fully mitigated – unless costs and budgets are fully analyzed.

Background and discussion

In a 1992 report to Congress, the U.S Office of Technology Assessment reviewed federal land management budgets and found that the funding received by public land management agencies had been significantly less than the budgets required to fully implement plans.[4] The lower-than-planned budgets prevented public agencies from producing many of the outputs and resource protections that were promised in land management plans. The budget shortfalls were not, however, passed down evenly across agency programs. Agency budgets historically have been biased toward resource extraction at the expense of environmental protection programs. Inadequate funding has resulted in the agencies failing to implement the environmental mitigation measures promised in NEPA documents.[5]

BLM's lack of attention to activities other than permitting oil and gas development was documented in a June 2002 report issued by the General Accounting Office (GAO) entitled: "Oil and Gas Development: Increased Permitting Activity Has Lessened BLM's Ability to Meet Its Environmental Protection Responsibilities." As indicated by the title, the GAO found that the increased volume of permits has

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[4] U.S. Congress, Office of Technology Assessment (1992). Forest Service Planning: Accommodating uses, producing outputs. and sustaining ecosystems. OTA-F-505, Washington, DC

[5] Morton, P. 1997. Sustaining recreation resources on the Southern Appalachian National Forests. Journal of Park and Recreation Administration. Vol. (15):4, pp6 1-78

resulted in more BLM staff resources devoted to issuing permits with less attention being paid to monitoring and enforcing compliance with environmental standards that apply to the activities conducted under the permits.

More recent evidence of unfunded mandates and broken promises comes from a May 2006 BLM document from the Pinedale Field Office titled "Commitments made in Decision Documents not yet achieved". The authors found that 580 requirements and commitments had been cumulatively made in recent decision documents – many of which had not been achieved. One of the more prominent commitments BLM made repeatedly in several decision documents was to track NOx emissions for southwest Wyoming. The authors of the document concluded that NOx monitoring had not been completed since 2000. The report details dozens of examples where funding was not allocated to successfully implement the plan and achieve the cumulative commitments made by the BLM in decision documents.

With history and recent experience acting as guidance, we believe it is very likely that the Casper Field Office will not have the funding necessary to achieve the cumulative oversight, monitoring and enforcement commitments made in this and recent decision documents.

A quick and incomplete review of the Casper RMP/EIS found many commitments made by the BLM. The questions that BLM must answer is simple: How much will all these commitments costs and how do the total costs of commitments compare with historic budget levels? Since historic budget levels are known, this analysis would not be speculative. Historical evidence suggests significant uncertainty about the ability of the BLM to fully implement the plan and keep the promises and commitments made. An analysis of costs and budgets is needed to help reduce this uncertainty.

The decision to evaluate and choose a preferred alternative must be based on knowledge that the preferred alternative can be fully implemented. To increase the knowledge base and to reduce uncertainty, decision makers must collect and analyze data on how the implementation cost of the preferred alterative compares with historic and projected funding levels – i.e. appropriations from Congress.

The Casper RMP/EIS cannot insure the legally required protection because planners have not analyzed and compared the costs of mitigation, monitoring and enforcement with the potential funding available to cover those costs. Ignoring budget constraints is an arbitrary and capricious decision by the BLM. It is also somewhat deceiving to the public and to the courts as it portrays a higher level of environmental protection than will actually occur.

Rather than presenting a proposed alternative that is unconstrained by reality and budgets, the agency must present the public and the courts with a more accurate picture of what can actually be accomplished given rational expectations of appropriations and budgets.

Legal Mandate

The BLM must consider the impact of budget constraints on its ability to fulfill the promises made in the Casper RMP/EIS with respect to protecting ecological and multiple use values. According to a Council of Environmental Quality memorandum on NEPA requirements [cited in NEPA Compliance Manual, 2nd Edition (1994)]: [6]

[6] Freeman, L.R.; March, F.; Spensley, J.W. 1994. NEPA Compliance Manual, 2nd Edition. Government Institutes, Inc., Rockville MD

"[T]o ensure that environmental effects of a proposed action are fairly assessed, the probability of the mitigation measure being implemented must also be discussed. Thus the EIS and the Record of Decision should indicate the likelihood that such measures will be adopted or enforced by the responsible agencies. (Section 1502.16(h), and 1505.2)"

The probability that a mitigation measure will be implemented (and that risks will decrease) is largely a function of budgets and funding levels. In order to discuss the probability of mitigation, the agency must examine data and compare the cost of proposed commitments with historic and projected budgets.

In order to fulfill NEPA's mandate and truly take a "hard look" at its actions, the government must do a full assessment of the environmental risks from proposed management. Examining the probability of mitigation measures being funded and implemented is a necessary part of analyzing environmental risks. Environmental risks tend to increase when mitigation measures are not funded and implemented. The relative risk associated with implementing each alternative is essential information for decision makers selecting a preferred alternative.

Recommendations for Conducting Socioeconomic Analysis.

We commend the Casper field office for using The Sonoran Institute's Economic Profile System to analyze the economic trends and conditions in the Planning area. The analysis of trends, rather than a static picture ofjobs, is a much more accurate and revealing method for determining the current and potential impacts that public land management decisions will have on the surrounding communities.

However, we feel that the analysis draws some erroneous conclusions from the data examined. Furthermore, the Draft lacks an analysis of the often important role that protected public lands plays in the economic prosperity of many rural western communities.

Throughout the discussion of the social and economic conditions the Draft EIS makes statements about the economic importance of extractive industries in the planning area. These statements are not supported by the data presented. In the last 30 years, the West has evolved from a region largely focused on extractive industries into a much more diverse area with a more diverse economy (Bennett and McBeth 1998, Johnson 2001). Recent research shows that most western counties are no longer "resource dependent," and have instead developed diversified economies based on recreation, tourism, knowledge-based industries and the service sector. A recent study by the Sonoran Institute examining the impact of public lands on economic well-being in eleven western states found that only three percent of western counties could be classified as resource-extraction dependent (Rasker et al. 2004). This trend is born out in the counties of the planning area as well, and must be recognized in the analysis and selection of alternatives in the Casper RMP. Public land management decisions all too often rely on a misconception of a resource-extraction-dependent rural West. Given the changing nature of the western economy, such assumptions exclude important non-extractive economic drivers and may even harm the region in the long run by ignoring the evolving nature of its economy.

As the economies of rural communities in the West diversify, the basis for making public land management decisions must also evolve. Merely counting jobs in resource extraction is not a sufficient way to measure the economic impact of public land management decisions. Management plans for public lands need to account for all aspects of the economic and social systems of these communities, including recreation, tourism and entrepreneurial businesses attracted to scenic locations, when evaluating alternatives.

There is a vast and growing body of research that indicates that the environmental amenities provided by public lands are an important economic driver in the rural West (see for example, Rudzitis and Johansen 1989; Johnson and Rasker 1993, 1995; Rasker 1994; Power 1995, 1996; Duffy-Deno 1998; Rudzitis 1999; Rudzitis, G. and R. Johnson. 2000, Rasker et al. 2004; Holmes and Hecox 2004). In a letter to the President and the Governors of the western states, economists from universities and other organizations throughout the United States pointed out that "The West's natural environment is, arguably, its greatest long-run economic strength" (Whitelaw et al. 2003).

The Draft lists the assumptions upon which the social and economic impact estimates were based. Among these is the assumption that employment opportunities are the driver of population changes. This assumption may not be entirely accurate. The western United States is growing at a rate faster than any other region (U.S. Census Bureau 2001), and, counter to the norm, population growth has preceded employment growth in the rural West (Vias 1999). Furthermore, counties with high levels of natural amenities are more likely to experience higher growth than those counties with fewer such amenities (McGranahan 1999). The BLM must assess the potential impacts of increasing oil and gas and other development on retirees and others who may have moved into the planning area for reasons other than employment opportunities.

Along with population growth comes demographic change. **As** Shumway and Otterstrom (2001) point out, "Population change represents more than a simple redistribution of people; it is an indicator and, in many instances an instigator, of a wide range of economic, social, cultural, political/policy, and environmental changes." **As** more people move from urban areas to rural communities they bring with them expectations about how local public lands ought to be managed. The Draft makes several references to the area's cultural, without acknowledging or examining the possibility that attitudes and values may change over the course of the planning horizon, and indeed that they may have changed. The values may in fact have changed due to the stated changes in population, both in terms of total numbers and a shift from rural to non-rural. Changing community values must be assessed and accounted for in the Final **EIS** for the Casper RMP.

Management plans for the public lands in the West must consider the increasing importance of industries and economic sectors that rely on these public lands, but not necessarily on the extraction of their natural resources. As the population of the entire country grows, the presence of undeveloped lands becomes more and more important. Indeed, as noted above, much recent research has concluded that the presence of protected public lands strengthen western rural economies by meeting growing needs for clean water, wildlife habitat and recreation opportunities.

We have attached a document entitled "Socio-Economic Framework for Public Land Management Planning: Indicators for the West's Economy," which describes the changing western economy and provides a detailed description of analyses that the BLM must include in order to fully assess the socioeconomic impacts of the alternatives in the Final RMP.

We also request that the BLM make a much more thorough examination of the socioeconomic costs associated with oil and gas development and mining. The Draft makes frequent mention of the importance of agriculture to the local economy and social structure. This sector is among the many non-oil and gas and non-mining industries that are likely to be negatively impacted by oil and gas development in the planning area. Areas where oil and gas drilling has escalated have experienced numerous negative impacts (Pederson Planning Consultants 2001, Pinedale Anticline Working Group, 2005).

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As mentioned in the Draft, many communities in the area have survived boom and bust cycles associated with oil and gas development. These cycles can have devastating impacts on the economic and social structure of a community (Freudenburg 1992, Freudenburg and Gramling 1994, Goldsmith 1992, Guilliford 1989, Smith 1986). Oil and gas development is also likely to imperil the regions potential to evolve into a more stable economy that relies on less variable and destructive uses of its surrounding public lands.

Many residents rely on non-labor income and thus can choose where they live. This is the single largest component of total personal income in the area. The presence of non-labor income in the economy also generates spillover impacts (Nelson 1999, Deller et al. 2001). Residents of the planning area may also experience a loss of property values associated with oil and gas development. This has happened, for example, in La Plata County, Colorado, where property values declined 22% due to oil and gas drilling in the county. This will impact local revenues in the planning area and must be accounted for in the analysis of the alternatives (BBC Research and Consulting 2001).

The BLM must make an assessment of the potential impact on other sectors of the economy associated with non-labor income in order to fulfill its obligation to take a hard look at the impacts of oil and gas development. We refer you to the attached document titled "The Economic and Social Impacts of Oil and Gas Development." This document focuses specifically on how BLM should evaluate the costs and benefits of conservation alternatives versus extraction alternatives within the area covered by the Casper RMP. As BLM considers the proposed alternatives, it must do a full accounting of the costs and benefits of that project.

Finally we would like to express our concern over the use of the IMPLAN model to predict economic impacts. While the IMPLAN model can be useful as a tool to develop static analyses of the regional economy, the agency and local communities must be aware of the shortcomings and poor track record of the model as a predictive tool.

In general, models like IMPLAN are grounded in economic base theory, which makes the incorrect assumption that an economy is static (i.e. it does not change). IMPLAN models do not consider the impacts of many important variables that affect regional growth in most rural communities, especially in the West. Amenities as high quality hunting, fishing and recreational opportunities, open space, scenic beauty, clean air and clean water, a sense of community, and overall high quality of life are not measured or accounted for in IMPLAN models. Many of these amenities are associated with attracting new migrants as well as retaining long-time residents. Richardson (1985), notes that 40 years of research on economic base models "has done nothing to increase confidence in them." In addition, he concluded that it would be hard to "resist the conclusion that economic base models should be buried, and without prospects for resurrection." Many others have also suggested that economic base theories be abandoned in favor of other, more comprehensive theories of regional growth and development (Krikelas, 1992; Rasker, 1994; Power, 1995 and 1996). Many of these economists recommend analysis of regional trends in total personal income as a better way to understand where the local economy came from and where it is headed.

Krikelas (1991) found only four studies out of 23 that provided any evidence in support of economic base theory as a long run theory of economic growth -- a dismal track record. Despite dire predictions, history is replete with cases of communities and areas that lost their export base and continued as successful economies with their social capital intact. The local-serving sectors of the economy were the persistent

ones, as new exports were substituted for the old. Tiebout (1956) also recognized the shortcomings of the economic base theory when he wrote, "Without the ability to develop residentiary activities, the cost of development of export activities will be prohibitive." Krikelas (1992) concludes that economic base theory has severe limitations. especially for economic planning and policy analysis. This is a conclusion that community leaders and land management officials and planners can no longer ignore, and one that should be incorporated into public land and community-level planning. As Haynes and Horne (1997) note:

> Where the economic base approach gets into trouble is when it is **used inappropriately as a tool for planning or predicting impacts** (emphasis added) of greater than one year in duration; a snapshot of current conditions tells little about the form a region's future economy may take.

Economists with both the Forest Service (Hoekstra, et. al 1990) and the Office of Technology Assessment (1992) concluded that while IMPLAN is useful for appraising the economic impacts of a management plan, the model is insufficient for evaluating the overall economic impacts for communities. And according to the OTA (1992), IMPLAN has an additional shortcoming for assessing community impacts: the economic data used to construct IMPLAN do not provide comparable details for all resource-based sectors of the economy. While economic data for oil and gas is classified as a separate manufacturing industry, recreation is scattered among a variety of industries generally classified in services and retail, with some in transportation. The ease of data acquisition for estimating oil and gas impacts combined with the difficulty of estimating the impacts of recreation and tourism underscores the potential bias favoring oil and gas development in IMPLAN modeling.

Our more specific concerns have to do with the technical assumptions used in most IMPLAN models. These questionable assumptions include: no changes in relative prices, no input substitution or technological change in the production processes, no labor mobility, no change in products or tastes, no regional migration, and no changes in state and local tax laws. The assumption of no labor mobility is particularly important for oil and gas drilling proposals, since it draws into question the issue of local versus non-local job creation. Workers are mobile, especially in the oil and gas industry as crews move from drill site to drill site. There is no guarantee that the oil and gas jobs projected by IMPLAN will be filled by local workers. And in fact, there is considerable evidence that workers in non-local crews fill most, if not all the direct jobs in oil and gas drilling.'

Another major assumption used by IMPLAN is the constant technology assumption. Most IMPLAN models, by failing to consider the downward impact of technology on job growth, will exaggerate the job potential from oil and gas drilling. Industries attempting to maximize profits seek to reduce production costs. One way to do this is to replace labor with technology resulting in fewer jobs. The downward trend in resource extraction jobs only becomes apparent if the agency completes a trend analysis showing changes in jobs and income over time.

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[7] For example: "Where Will the Workers Come From?" Casper (WY) Star Tribune, 6 October *2005*, and "Chinese Labor for Oil Drilling Eyed in Colo." United Press International, 11 July *2005* both discuss the origins of oil and gas workers in the Western U.S.

Laitner, et. al (1998) cite Bureau of Labor Statistics (BLS) data which indicate that in 1988, oil and gas drilling generated about 1.72jobs per million dollars of spending. By 1998 that number fell to 1.44jobs per million dollars. Further, BLS (cited by Laitner et al.) estimates that the number of oil-gas jobs will fall to 0.71 jobs per million dollars of spending by 2008. This indicates that the direct jobs estimated with a static model like IMPLAN model will be much more than the number actually created from drilling. As a result of this failure to account for technology improvements, input-output models are well known to predict higher multiplier effects than are actually experienced (Hoffman and Fortmann, 1996). **A** review of government data confirms this downward trend: since 1987 output per worker in the oil and gas industry has been increasing (Bureau of Labor Statistics, 2006). Investments in technology in the oil and gas industry have resulted in fewer and fewer workers required to drill each well and to produce natural gas and oil. The trends of technology replacing jobs in the oil and gas industry will continue.

Many residents of Western communities (both long-time and new) earn retirement and investment income. An analysis of economic trends will show that retirement and investment income is becoming increasingly important to rural economies of the West. While it is technically possible, most IMPLAN models completely fail to consider the important economic role of retirement and investment in the economy of a community or region. **A** more accurate, dynamic, and complimentary approach requires planners to examine regional trends in jobs and income.

It has been well documented that the current accelerated oil and gas development in the Rocky Mountain region has resulted in greater competition for skilled oil and gas workers. While most of these workers are not supplied from the local area, there may be some competition for workers which will result in several potential impacts in Platte, Natrona, Goshen, and Converse Counties. First, increased demand for local labor may result in shortages for employers outside the oil and gas industry as some workers move to oil and gas jobs. Second, coinpetition for workers may result in increased wage rates, which could burden local employers. Many of these employers are government entities with limited ability to increase wages in order to retain staff. A third potential impact of the proposed 3,000+ wells will be an increase in the population in these counties as workers following the rigs move to the area. This increased population will result in increased demand for housing (in turn raising housing prices) and increased demand for public services at a time when these local agencies may be experiencing staff shortages either through increased staffing needs going unmet or migration of labor to the oil and gas industry. The analysis of this proposal must include an examination of the changes in labor and government expenditures, among other costs, that will accrue to the surrounding communities. These impacts can be expected to be a large burden on the local communities if the full 3,000+ wells are implemented.

The analysis of **the** socio-economic impacts of the Casper RMP must be thorough and accurate in order to responsibly manage the public lands. We have included a brief document entitled "Socio-Economic Framework for Public Land Management Planning: Indicators for the West's Economy," which details our expectations for the baseline analysis of the region's economy as well as the analysis of the potential impacts of this level of drilling on the area.

We have also attached a scoping brief document entitled "The Economic and Social Impacts **of** Oil and Gas Development." This document focuses specifically on how BLM should evaluate the costs and benefits of conservation alternatives versus extraction alternatives within the area covered by the Casper Field Office. As BLM considers the proposed natural gas and coalbed methane development, it must do a full accounting of the costs and benefits of that project.

Recommendation: We request that BLM's socioeconomic analysis of the impacts under the Casper RMP follow the approaches set out in the scoping briefs "Socio-Economic Framework for Public Land

Management Planning: Indicators for the West's Economy" and "The Economic and Social Impacts of Oil and Gas Development," and incorporate the specific considerations detailed below.

BLM should utilize a Total Economic Valuation Framework for evaluating proposed oil and gas development projects.

In general, when looking at the economic implications of the proposed project, BLM should do a full accounting of the costs and benefits. To facilitate informed investment decisions about publicly owned wildlands, economic analysis must take into consideration both market and nonmarket benefits and costs (Loomis 1993). To account for the full array of market and nonmarket wildland benefits, economists have derived the total economic valuation framework (TEV). TEV is the appropriate measure to use generally when evaluating the benefits of conserving wildlands and wilderness character. Figure 1 summarizes the seven categories of wildland benefits (Morton 1999).

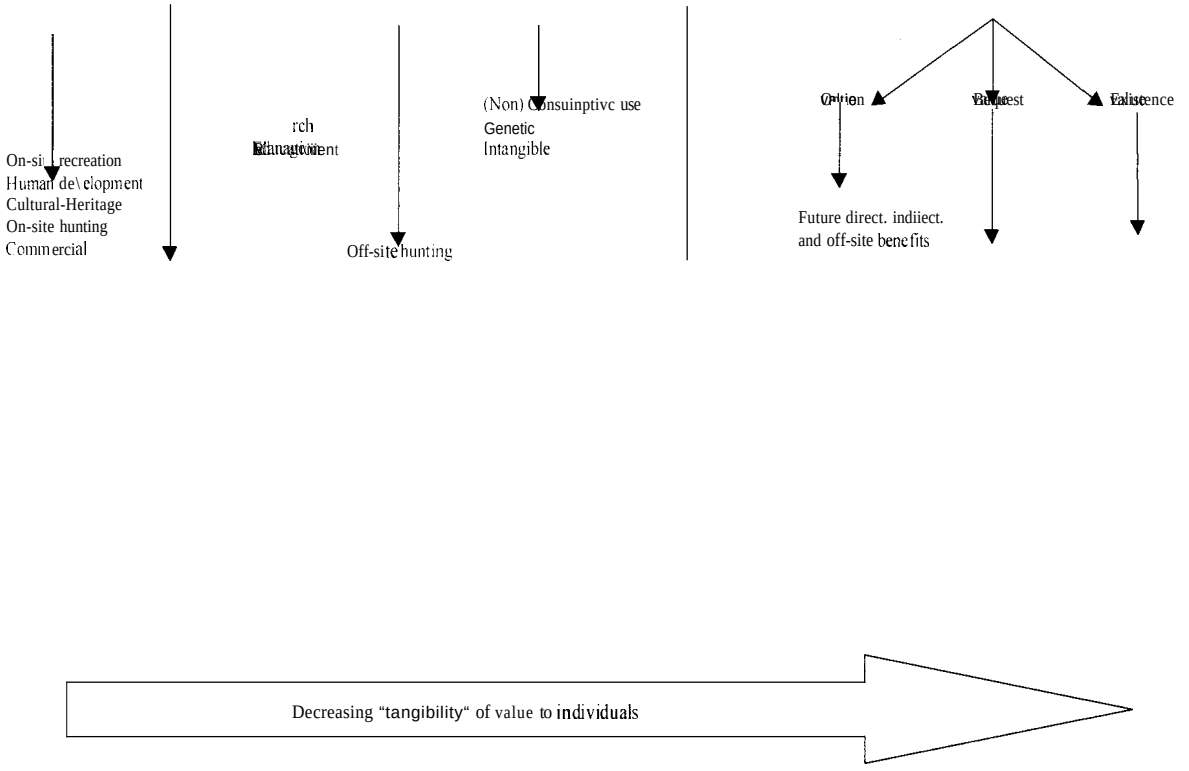

Figure 1. Total Economic Valuation Framework for Wilderness Quality Lands
Source: ***Morton*** *1999*

The total economic valuation concept provides an analytic framework for such an analysis. This framework includes non-market benefits (Randall and Stoll, 1983; Peterson and Sorg, 1987; Loomis and

Walsh, 1992). Under this approach, non-market benefits of a primitive and wild landscape may be substantial (Morton, 1999). Researchers have consistently found that passive use benefits of wildlands, including the benefits of simply knowing wilderness exists and being able to pass it on to future generations (known to economists as option, bequest and existence benefits), are greater than other wildland benefits. BLM planners must derive and fully utilize a total economic valuation framework when evaluating land management alternatives. It is the appropriate framework for evaluating management alternatives for public land.

The scope of the BLM analysis should extend beyond the surrounding area
All Americans own Federal public lands and the scope of the economic analysis should therefore look beyond the employment and income impacts on local communities to include all Americans. Taking a narrow "regional accounting stance" that only includes local counties will ignore the benefits and costs that accrue to Americans outside the region from management of public land.

While it is important to estimate local employment impacts, often the job gains of one community are offset by job losses in another community. There is no net gain to American society when allocation of public resources simply transfers economic activity from one location of the country to another (Loomis, 1993). For example, drilling in Wyoming and Colorado will displace drilling activity elsewhere in America, and there would be no net loss or gain of jobs from a national perspective. Because public lands are owned by all Americans, we recommend the BLM take a national accounting stance when estimating the benefits and costs of projects that will come under the jurisdiction of the Casper RMP.

BLM must recognize Wilderness characteristics and other natural qualities as a valuable resources that provide multiple uses for the public.
Multiple use of BLM and other public lands does not preclude wilderness designation or other protective designations for certain special areas. The concept of multiple use encompasses the entire public lands estate, not each and every individual unit. Some lands will be used for extracting resources, while others will produce the many benefits associated with wilderness and wildlands. It is illogical to call oil and gas development "multiple use." It is essentially a single use, since most other uses are not compatible with such development.

The BLM should recognize the multiple use aspects and the full extent and value of existing wilderness character as a resource within and near the planning area. BLM lands within the Casper Field Office contain pristine wildlands, including the sage grouse leks and a Citizens' Proposed Wilderness Area. The multiple benefits that derive from protecting wilderness quality lands include positive economic impacts to local communities. This RMP should prevent oil and gas development on all existing lands with wilderness character in a manner that protects against impairment and also ensures the existence of wilderness within the planning area for future generations.

A growing number of economists are recognizing that protecting the quality of the natural environment is key in attracting new residents and business and therefore the environment is the engine propelling the regional economy. A letter to President Bush from 100 economists concludes "The West's natural environment is, arguably, its greatest, long-run economic strength…A community's ability to retain and attract workers and firms now drives it prosperity. But if a community's natural environment is degraded, it has greater difficult retaining and attracting workers and firms" (Whitelaw 2003). Given these findings, we request that the BLM economists fully consider the indirect role of wildlands in attracting non-recreational businesses and retirees when considering the economic impacts of the proposed natural gas development project. Research supports these assertions that the amenities of the rural West attract business

and economic opportunities (Lorah, 2001; Rasker, 1994; Johnson and Rasker, 1993 and 1995; Rudzitis and Johansen, 1989 and 1991).

BLM has identified "wilderness characteristics" to include naturalness or providing opportunities for solitude or primitive recreation and provided for their continuing protection in land use planning. *See,* IM No. 2003-274,2003-275; **see** *also,* IM AZ-2005-007. FLPMA also envisions protection of a multitude of uses and values on the public lands. These values should also be identified and protected in this EIS. The planning area is located near substantial lands with wilderness character and encompasses lands with other values. The BLM should recognize the wide range of values associated with these lands and take the potential impacts to these characteristics into account when making decisions for the Casper RMP:

a. Scenic values – FLPMA specifically identifies "scenic values" as a resource of BLM lands for purposes of inventory and management (43 U.S.C. § 1711(a)), and the unspoiled landscapes of lands with wilderness characteristics generally provide spectacular viewing experiences. The scenic values of lands within the planning area will be severely compromised if destructive activities or other visual impairments are permitted. For example, air pollution from compressor stations include precursors to ozone, which when combined with the dust from truck traffic on roads can decrease visibility and hence scenic quality. Such impacts must be accounted for. It is also possible to model what the visual impacts to the landscape might be from drilling.

b. Recreation – FLPMA also identifies "outdoor recreation" as a valuable resource to be inventoried and managed by BLM (43 U.S.C. § 1711(a)). Lands with wilderness characteristics provide opportunities for primitive recreation, such as hiking, camping, hunting and wildlife viewing. The Casper Resource Area includes a wide range of recreation opportunities. Most, if not all primitive recreation experiences will be foreclosed or severely impacted if the naturalness and quiet of these lands are not preserved. Impacts to primitive recreation will accrue both from the noise from gas facilities and the presence of motor vehicles (those servicing the natural gas drilling operations, as well as the motorized recreation which is likely to take advantage of the gas development roads). The Preferred Alternative would allow that almost the entire planning area would be committed to full-field gas development, effectively precluding recreational opportunities.

c. Wildlife habitat and riparian areas – FLPMA acknowledges the value of wildlife habitat found in public lands and recognizes habitat as an important use (43 U.S.C. § 1702(c)). Due to their unspoiled state, lands with wilderness characteristics provide valuable habitat for wildlife, thereby supporting additional resources and uses of the public lands. **As** part of their habitat, many species are also dependent on riparian and other wetland habitats, especially during either seasonal migrations or seasons and years when surrounding habitats are dry and unproductive. Wilderness quality lands support biodiversity, watershed protection and overall healthy ecosystems. The Casper Field Office contains significant wildlife habitat in a region already burdened by oil and gas development. Oil and gas development has documented impacts on wildlife which extend beyond the immediate footprint of development. The network of well pads, roads and pipelines associated with such an enormous development will reduce and fragment the habitat over much of the project area.

We refer BLM to the following reports on this issue prepared by The Wilderness Society, enclosed and available on-line:

1) **Fragmenting our Lands: The Ecological Footprint from Oil and Gas Development** - http://www.wilderness.org/Library/Documents/upload/Energy-Footprint-Full-Report.pdf;

2) **Ecological Effects of a Transportation Network on Wildlife** - http://www.wilderness.org/Library/Documents/upload/Missouri-Breaks-Transportation-Effects-full-report-w-o-covers.pdf;
3) **Protecting Northern Arizona's National Monuments: The Challenges of Transportation Management"** - http://wwm.wilderness.org/Library/Documents/AZStripTransportation.cfm; and
4)"**Wildlife at a Crossroads: Energy Development in Western Wyoming."** – http://wwu.wilderness.org/Library/Documents/pinedale.cfm

The BLM must consider the value of the proposed development area for wildlife habitat, assess the potential impacts from this project and implement appropriate mitigation measures, as discussed in further detail in these reports.

d. Cultural resources – FLPMA also recognizes the importance of "historical values" as part of the resources of the public lands to be protected (43 U.S.C. § 1702(c)). The lack of intensive human access and activity on lands with wilderness characteristics helps to protect these resources.

e. Economic benefits – The recreation opportunities provided by wilderness quality lands also yield direct economic benefits to local communities. According to the U.S. Fish & Wildlife Service, in 2001, Wyoming and Colorado residents and non-residents spent $2.6 billion on wildlife recreation in the two states. (USFWS 2001, National Survey of Hunting, Fishing and Wildlife-associated Recreation - http://uww.census.gov/prod/www/abs/fishing.html). In addition, local communities that protect wildlands reap measurable benefits in terms of employment and personal income. A recent report by the Sonoran Institute (Rasker et al, 2004) found that: Protected lands have the greatest influence on economic growth in rural isolated counties that lack easy access to larger markets. From 1970 to 2000, real per capita income in isolated rural counties with protected land grew more than 60 percent faster than similar counties without any protected lands.

These findings confirm earlier research, showing that wilderness is in fact beneficial for local economies. Residents of counties with wilderness cite wilderness as an important reason why they moved to the county, and long-term residents cite it as a reason they stay. Recent research also indicate that many firms decide to locate or stay in the West because of scenic amenities and wildlife-based recreation, both of which are strongly supported by wilderness areas (Beyers and Lindahl 1996, Deller et al. 2001, Johnson and Rasker, 1993 and 1995, Rasker and Glick 1994, Low 2004, Morton 2000).

Other "non-market" economic values arise from the ability of wildlands to contribute to recreation and recreation-related jobs, scientific research, scenic viewsheds, biodiversity conservation, and watershed protection (Morton 1999, Loomis 2000, Pickton, and Sikorowski 2004). **All** of these economic benefits are dependent upon adequate protection of the wilderness characteristics of the lands.

f. Quality of life –Public wildlands help define the character of this area and are an important component of the quality of life for local residents and future generations. Their protection enables the customs and culture of this community to continue.

g. Balanced use – The vast majority of BLM lands are open to oil and gas development. FLPMA recognizes that "multiple use" of the public lands requires "a combination of balanced and diverse resource uses" that includes recreation, watershed, wildlife, fish, and natural scenic and historical values (43 U.S.C. § 1702(c)). FLPMA also requires BLM to prepare land use plans that may limit certain uses in some areas (43 U.S.C. § 1712). Many other multiple uses of public lands are compatible with protection

of wilderness characteristics – in fact, many are enhanced if not dependent on protection of wilderness qualities (such as primitive recreation and wildlife habitat). Protection of wilderness characteristics will benefit many of the other multiple uses of BLM lands, while other more exclusionary uses (such as oil and gas development) will still have adequate opportunities on other BLM lands.

A full accounting of all hidden costs of oil and gas drilling is needed

The hidden economic costs from oil and gas drilling are summarized in Table 1 and should be included as part of the economic analysis of the Casper RMP alternatives. While many of these costs are difficult to estimate, academic and federal agency economists have made great advances in developing methods to value non-market costs and benefits. Included in Table 1 are methods for estimating the economic costs, in order to make the point that these costs are quantifiable and should be included in the economic calculus. Many heretofore unquantifiable wildland benefits and costs are now quantifiable, and are available to agency officials responsible for developing the policies and procedures for guiding public land management. We therefore strongly encourage the BLM to internalize non-market costs into the economic analysis of the proposed project in order to balance the multiple uses and benefits derived from public land. Detailed explanations of these costs are included in the attached document referenced above titled "The Economic and Social Impacts of Oil and Gas Drilling" and in the document titled **"Drilling in the Rocky Mountains: How Much and at** What **Cost?"** also attached.

Table 1. Economic Costs of Mining and Oil and Gas Extraction

cost Category	Description of Potential Cost	Methods for Estimating Cost
Direct use	Decline in quality of recreation including hunting, fishing, hiking, biking, horseback riding	Travel cost method, contingent valuation method
Community	Air, water and noise pollution negatively impacts quality of life for area residents with potential decline in the number of retirees and households with non-labor income as their primary source, loss of an educated workforce negatively impacts non-recreation businesses. Decline in recreation visits and return visits negatively impacts recreation businesses.	Surveys of residents and businesses. Averting expenditure methods for estimating the costs of mitigating health and noise impacts. Change in recreation visitation, expenditures and business income. Documentation of migration patterns.
Science	Oil and gas extraction in roadless areas reduces the value of the area for study of natural ecosystems and as an experimental control for adaptive ecosystem management.	Change in management costs, loss of information from natural studies foregone.
Off-site	Air, water and noise pollution affect quality of downstream and downwind recreation activities. Drilling rigs in viewsheds reduce the quality of scenic landscapes, driving for pleasure and other recreation activities and negatively impacts adjacent property values. Groundwater discharged can negatively impact adjacent habitat, property, and crop yields, while depleting aquifers and wells.	Contingent valuation method, hedonic pricing analysis of property values, preventative expenditures, well replacement costs, restoration and environmental mitigation costs, direct impact analysis of the change in crop yields and revenues.
Biodiversity	Air, water and noise pollution can negatively impact fish and wildlife species. Ground water discharged	Replacement costs, restoration and environmental mitigation

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Table 1. Economic Costs of Mining and Oil and Gas Extraction

Cost Category	Description of Potential Cost	Methods for Estimating Cost
	changes hydrological regimes with negative impacts on riparian areas and species. Road and drill site construction displaces and fragments wildlife habitat.	costs.
Ecosystem services	Discharging ground water negatively impacts aquifer recharge and wetland filtration services. Road and drill site construction increase erosion causing a decline in watershed protection services.	Change in productivity, replacement costs, increased water treatment costs for cities, preventative expenditures.
Passive use	Roads, drilling and pipelines in roadless areas results in the decline in passive use benefits for natural environments.	Contingent valuation method.

Source: Testimony of Peter A. Morton, PhD. Resource Economist, Ecology and Economics Research Department, The Wilderness Society, before the Subcommittee on Forests and Public Land Management, Committee on Energy and Natural Resources, United States Senate, April 26, 2001.

Economically Recoverable vs. Technically Recoverable Oil and Gas.
As BLM develops its EIS for the Casper RMP, it should base its analysis on economically recoverable natural gas, not simply technically recoverable natural gas. Economically recoverable resources are that part of the technologically recoverable resources that can be recovered with a profit. To be considered economically recoverable, the market and non-market costs of gas recovery must be less than or equal to the gas price. When economic criteria are considered, the recoverable gas drops significantly (Attanasi, 1998: LaTourrette, 2002)

If economic factors are not considered, the potential gas will be overestimated as will the opportunity costs of all forms of environmental protection. If the gas is not economical to extract, there is no adverse impact on gas supply from protecting wilderness, wildlife, archeological sites, recreation sites and other public resources either through lease stipulations or outright bans on leasing. Further, an economic evaluation of the proposed project that relies on misleading economic information or fails to include all relevant costs in its economic analysis will violate NEPA because it does not provide decision-makers and the public a valid foundation on which to judge proposed projects.

The BLM should avoid IMPLAN or other input-output models that are grounded in Economic Base Theory when estimating jobs and income for each alternative.

The IMPLAN model is an economic model used by the Forest Service and the BLM to project jobs and income from proposed actions. While the IMPLAN model can be useful as a static analysis of the regional economy, communities must be aware of the shortcomings and poor track record of the model. A more accurate, dynamic, and complimentary approach examines regional trends in jobs and income. We recommend that the BLM use the EPS model developed by and available free from the Sonoran Institute (2004).

According to a Council of Environmental Quality memorandum on NEPA requirements [cited in NEPA Compliance Manual, 2nd Edition (Freeman et al 1994)]:

> [T]o ensure that environmental effects of a proposed action are fairly assessed, the probability of the mitigation measure being implemented must also be discussed. Thus the EIS and the Record of Decision should indicate the likelihood that such measures will be adopted or enforced by the responsible agencies. (Section 1502.16(h), and 1505.2)

The "probability of mitigation measures being implemented" is directly related to how much the mitigation will cost and how those costs relate to the expected budget available. As such the EIS should include an analysis of the costs of implementing each alternative, and the costs of the mitigation plans contained within each alternative. These costs should then **be** compared to the expected budget level to assess the probability of mitigation measures being fully implemented. Furthermore, the costs to communities from unmitigated environmental damage must be estimated and included in the benefit-cost analysis for the Casper RMP.

Toprovide socio-economic context, the BLM should examine historic trends in county income and employment.

In order to fully understand the local area and the role of public lands in the economy, an analysis of economic trends must be completed. A static analysis is incapable of revealing the overall importance of various industries over time or the likely role of these industries in the future. Completing an analysis of income and employment trends and the role of wildlands in those trends is especially relevant given the growing body of literature suggesting that the future diversification of rural economies is dependent on the ecological and amenity services provided by public lands in the west (Power 1996, Haynes and Horne 1997). These services (e.g. watershed protection, wildlife habitat, and scenic vistas) improve the quality of life, which in turn attracts new businesses and capital to rural communities.

Public lands in the West represent natural assets that provide communities with a comparative advantage over other rural areas in diversifying their economies. Public land management can contribute to decreasing dependence/specialization and diversifying local economies by de-emphasizing resource extraction and emphasizing management and budgets on providing high-quality recreation and conserving habitat for the region's biological resources.

Best Management Practices

BLM refers to a series of websites outlining Best Management Practices for oil and gas development.. We agree that many of these BMPs should be implemented, but as a mandatory standard, not a discretionary suggestion. BMPs that should be implemented throughout the Casper Field Office include:

- Directional drilling
- Drilling of multiple wells from a single wellpad
- Transportation planning to minimize the road network
- Remote well monitoring
- Piping of produced fluids to centralized tank batteries to reduce traffic
- Submersible pumps
- Belowground wellheads
- Bussing of workers
- Flareless completions

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- Burying of powerlines and pipelines beside existing roads
- Using two-track routes for access in lieu of constructed roads in every possible instance
- Reuse of old roads or well pads
- Interim reclamation of well locations and access roads as soon as the well is put into production
- Avoidance of facility placement on steep slopes, rigetops, or hill tops
- Storage of fluids with secondary containment to limit the impacts of spills
- On-site bioremediation of oil field wastes and spills
- Removal of trash, waste, or junk and other materials not currently in use
- Recontouring and revegetation of disturbed areas to blend with the surrounding landscape
- Reclamation of unneeded roads to the original contour
- Blending facilities into background scenery by repeating natural forms, lines, and colors.

In addition, the following Best Management Practices should also be applied to all oil and gas projects throughout the planning area (see BLM IM 2004-194):

- Installation of raptor perch avoidance
- Noise reduction techniques and designs
- Screening facilities from view
- Seasonal restriction on vehicle traffic

In addition, BLM should require use of pitless drilling to reduce wellpad size and contamination of wildlife at reserve pits. This method entails closed-loop systems that recycle drilling mud rather than dumping it into open pits. In addition to the elimination of toxic waste pits on the surface, this method reduces wellfield truck traffic by up to 75%, reduces water consumption by 80%, and is actually **8%** less costly than constructing and maintaining a reserve pit (Longwell and Hertzler 1997). This method has proven successful in Alaska (Phillips Petroleum 2002) and Colorado (Longwell and Hertzler 1997), and is planned for the Sakhalin I project in Russia (Sumrow 2002). Due to its environmental advantage, pitless drilling should be mandated as a standard requirement for drilling operations under the Casper RMP.

However, the placement of roads and drilling sites within *3* miles of sage grouse leks, crucial winter or calving range, prairie dog towns, mountain plover nesting areas, and citizens' proposed wilderness is never a "Best Management Practice," and in fact is a Worst Management Practice, regardless of the heroic measures that may be taken to limit the degree of the impacts. Thus, for example, clustering of well facilities inside crucial winter range is a Worst Management Practice; instead directional drilling should be employed to move roads and facilities outside crucial winter range to start with. The BLM's so-called "Best Management Practices" for big game crucial winter range and sage grouse habitat should never be needed if the agency adopts the actual Best Management Practice of keeping industrial facilities out of these sensitive habitats entirely.

PALEONOTOLOGICAL RESOURCES

According to the Draft EIS, some 50% of the planning area is underlain by strata with Probable Fossil Yield Classification of 4 or 5. In these area, there should be a requirement to clear all proposed roads, well sites, powerline and pipeline rights-of-way, seismograph source lines (if off-road vehicle traffic is to be allowed), and other sources of potential damage to fossil resources prior to the commencement of project activities. This requirement should be part of the standard mitigation package under the Casper RMP.

We recommend against the designation of a specific recreational fossil area designation (see DEIS at 3-89). There is no reason to designate such an area, as all BLM lands are open to non-vertebrate fossil collection for non-commercial purposes. Such a designation would serve only to concentrate use and impacts in a small area, leading to significant impacts on the environment.

WIND ENERGY

In general, we support the development of wind energy as an alternative to fossil fuels. However, as with oil and gas development, it must be done responsibly and in the right locations. Areas that should be withdrawn from wind energy development include:

- Lands within view of the South Fork of the Powder proposed wilderness, South Big Horn/ Hole in the Wall ACEC, scenic backcountry byways, and Oregon National Historic Trail. The BLM should conduct viewshed analyses of these features and present maps of visible areas in fulfillment of NEPA's baseline information requirement for the Casper RMP EIS.

- Lands in high-quality sage grouse habitat and within 5 miles of an active or inactive sage grouse lek.

- Lands within raptor migration corridors as identified by HawkWatch International.

Lands that should be prioritized for wind energy development include those areas of superb or outstanding potential that occur on isolated parcels of BLM lands with no public access, and which lie outside important viewsheds. BLM should identify priority sites for wind farm development through the Casper RMP and prioritize wind energy development ahead of fossil fuels development as a priority formally identified in the Casper RMP.

Water Quality

BLM notes that water produced in conjunction with oil and gas development currently causes changes to water quality and quantity in streams within the Field Office boundary. DEIS at *3-52*. These water discharges total hundreds of millions of barrels. *3-25* through *3-27*. Yet nowhere in the DEIS does BLM present, on a stream-by-stream basis, the alterations from natural flows in terms of quantity or quality that have been realized as a result of these outfalls. The Wyoming DEQ requires at least some monitoring of outfall and water channel quantity and quality, which is generally performed by the operator of the oil and gas field. Yet nowhere are these data summarized as a way to present baseline information on the current state of changes that have been wrought on natural stream flows. What are the changes in Class 1 and Class 2 streams? What fishes and other aquatic species have been affected so far? How have natural distributions of native fishes been altered (either expanded or contracted) by flow augmentation and/or water quality changes resulting for oil and gas outfalls?

Fire

The Draft EIS addresses the need to reduce fire in the Wildland-Urban Interface (WUI). DEIS at *3-32*. We concur with the need to focus both fuel reduction and fire suppression efforts in the WUI, and further note that the WUI needs to be rigorously defined. The WUI should be defined as lands within *0.25* miles of existing structures. Current definition of WUI in the Casper RMP DEIS is insufficient as it does not comport with the best available science.

GRAZING

Livestock grazing is **an** activity that must be managed to prevent damage to soils and vegetation. We support the implementation of BLM's Standards for Healthy Rangelands. BLM provides a table of stream

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miles and acres according to Properly Functioning Condition criteria for rangeland health. DEIS at 3-46. A map of these PFC distributions should also be provided to the public, without which it is difficult for the public to comment on which areas are in greatest need of attention. Stewardship of the land by grazing permitees is variable: Some permittees graze the land in a way that prevents damage to grasslands ecosystems, while others overgraze their allotments and engage in ecologically irresponsible activities like predator "control" and prairie dog poisoning. Overall, we wish to see the prevention of overgrazing on allotments throughout the Casper Field Office, and the uniform adoption of strong grazing ethics.

SPECIFIC PROVISIONS FOR INCORPORATION INTO THE CASPER RMP

We propose a balanced approach to management of the public lands and resources in the Casper Field Office. The final RMP for these lands should promote the best use of the lands and resources in the Area, with the overarching goal that all permitted activities will be compatible with maintaining healthy ecosystems. It must also prevent any undue or unnecessary degradation of public land values. In keeping with these goals, these recommendations provide that some areas with high wildlife, scenic, or recreational values are preserved and managed to support these fragile resources. Even so, the vast majority of these federal lands would remain available for energy development, logging, livestock grazing, and other uses.

Wildlife Habitat and Fisheries Management

1. Broad stretches of undeveloped landscape should be maintained in a well-distributed pattern throughout the planning area.

2. All management activities shall be done in a manner compatible with maintaining thriving populations of BLM Sensitive Species and other plants or wildlife classified as rare or declining.

3. Wild horse numbers, if present, should be managed at sustainable levels, taking into consideration impacts to wildlife, habitats, and rangelands.

4. The BLM shall protect habitat so as to maintain the viability of all native species widely distributed throughout the planning area.

5. All management activities should prevent soil erosion and compaction, and maintain or restore biological soil crusts over the long term.

Fire/Fuels Management

1. Natural fires shall be allowed to burn unless and until they directly threaten human lives and property.

2. Fuels reduction projects designed to reduce fire hazard shall be limited to areas within ¼ mile of existing buildings.

3. Prescribed fire will be the principal tool of fuels reduction, not mechanical treatments.

Areas of Critical Environmental Concern

1. Existing Areas of Critical Environmental Concern should be retained in the new Plan.

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2. The following areas will be designated as new Areas of Critical Environmental Concern: Black-tailed Prairie Dog ACEC. Cedar Ridge ACEC, South Big Horns/Red Wall ACEC, Alcova Fossil ACEC, Jackson Canyon ACEC, and Bates Hole ACEC.

3. Big game crucial habitats as delineated by WGFD should be leased only under No Surface Occupancy stipulations. Existing facilities on these lands should be closed during the winter season if they cannot be maintained without vehicle traffic and human presence during the critical season.

4. All ACECs will be withdrawn from locatable mineral entry and be classified as "unsuitable" for coal leasing.

4. Fluid minerals in all ACECs may be leased only under No Surface Occupancy stipulations.

Wilderness

1. All lands encompassed by citizens' wilderness inventories should be granted Wilderness Study Area status and managed to protect their wilderness qualities.

2. Citizens' proposed wilderness areas must be withdrawn from mineral leasing, coal leasing, traqnsmission and powerline rights-of-way, communication site consideration, and locatable mineral entry.

Land Ownership Adjustments

1. BLM should identify and acquire non-BLM lands and consolidate ownership to enhance its ability to manage important recreation opportunities and wildlife habitats such as migration corridors, crucial big game habitats as defined by WGFD, riparian areas, and wetlands.

2. All land swaps will be conducted with adequate public notice and involvement, with no net loss of public lands.

3. The RMP should determine which lands are currently legally accessible by motor vehicle, horse, or foot for public recreation, and which lands are rendered unavailable for public recreation due to private lands which hold no access easements. The RMP should address the problem of inaccessibility of public lands for public recreation, including acquisition of easements and appropriate land exchanges.

Oil and Gas Leasing and Development

Goal: Sensitive landscapes and habitats (defined below) must be spared from the impacts of oil and gas development. In lands that are not especially sensitive, major reforms are needed to prevent widespread degradation of the land, to minimize the overall impacts of the oil and gas industry, and to make oil and gas development as compatible as possible with other multiple-use resources, including fish and wildlife habitat, watershed values, recreation, and wilderness.

1. Pursuant to supplemental program guidance, the BLM shall determine which lands should be off-limits to oil and gas leasing, including at minimum:

   - The South Fork of the Powder citizens' proposed Wilderness Study Area;

- Existing and Proposed ACECs; and

- Lands in Visual Resource Management Classes I and 11.

2. BLM shall institute a program to suspend and/or trade to nullify currently existing leases in the above three categories of land.

3. No new leasing shall occur on crucial winter ranges, crucial winter relief ranges, crucial winter yearlong habitats, of elk calving ranges as defined by WGFD until BLM thoroughly evaluates the effectiveness of seasonal timing and No Surface Occupancy stipulations and mitigation measures.

4. In the case of split-estate lands, the surface owner shall be given written notification prior to the offering of underlying subsurface mineral rights at a lease sale.

5. BLM shall prepare site-specific environmental analysis consistent with the requirements of NEPA § 102(2)(C) (i.e., an EIS) for leasing decisions on split-estate lands (e.g., federal minerals underlying private surface). Accordingly, under this approach, the RMP decision would defer leasing decisions on split-estate lands subject to subsequent site-specific analysis (which would be triggered by industry nomination to lease).

6. BLM shall provide the record surface owner 45 day advance written notice of proposed leasing decision and opportunity to comment, including recommending specific lease stipulations.

7. Staged development shall be instituted on presently existing leases to achieve no net loss of crucial winter ranges, crucial winter yearlong ranges, severe winter relief ranges, and elk calving ranges as delineated by WGFD.

8. In cases where drilling is approved (subject to the limitations outlined below), directional drilling shall be the required to minimize environmental impacts, unless a less environmentally harmful alternative is available.

9. Areas may be leased only under a No Surface Occupancy Stipulation with appropriate buffers to guarantee protection of the special resources in question, and will be excluded from surface development. Waivers may be granted for surface disturbances and developments *if* they will be completely invisible by line-of-sight from the site in question. These include:

   a. Lands within 5 miles of the Oregon, Bridger, and Bozeman historic trails, Native American Trails, or a site eligible for the National Register of Historic Places.

   b. Lands within Native American religious or cultural sites as identified by the tribes, including Cedar Ridge.

10. Sensitive areas that will be leased under No Surface Occupancy stipulations and shall be withdrawn from surface disturbing activities on a year-round basis, with ***no waiver available:***

    - Lands where there is overlap between three or more types of wildlife crucial winter ranges, crucial winter relief areas, and elk calving areas as defined by WGFD,

    - Other Areas of Critical Environmental Concern as outlined in these comments,

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- areas within 1 mile of active raptor nests,
- areas within 3 miles of active sage grouse or 1 mile of sharp-tailed grouse leks,
- large prairie dog colonies and complexes, or those associated with BLM Sensitive Species such as the black-footed ferret, burrowing owl, mountain plover, or swift fox, plus a %-mile buffer zone around these colonies,
- critical habitats of Endangered and Threatened species, and
- areas within the 100-year floodplain of permanent or intermittent streams or within 500 feet of natural water sources or riparian vegetation.

11. Wilderness Study Areas, including new citizens' proposed wilderness additions, will be withdrawn from mineral leasing and other surface disturbing activities.

12. Oilfield exploration standards.

    a. Seismograph testing will take place without the construction of additional roads. Construction for the purposes of this policy shall include blading, grading, or the use of mechanical means such as hand tools.

    b. Shot-hole seismic exploration will be the preferred method for seismic exploration where sensitive archaeological resources are not threatened, but shall be limited to hand-laying of geophone lines and helicopter transport of drilling rigs in sensitive landscapes outlined in Section 2.

13. Exploration wells will be constructed within 100 feet of existing improved gravel roads, limited by the stipulations outlined above. If improved gravel roads are unavailable, previously constructed but unmaintained roadways may be upgraded, with the stipulation that the minimum length of roadway will be reconstructed and that these route shall be returned to their original condition upon termination of production.

    a. Off-road travel on steep or unstable soils or during wet weather is prohibited.

14. Oil and gas infill development.

    a. Wherever possible, infill production wells shall be sidetracked from existing wells or drilled from existing wellpads or from cluster pads immediately adjacent to improved gravel roads and subject to the limitations of Section 1

    b. Cluster pads shall be constructed at intervals that create the minimum practicable footprint.

    c. The construction of new roads will not be permitted for oilfield infill development unless exceptional difficulties are presented.

15. Full-field development of new fields.

a. Production wells shall be drilled from cluster pads immediately adjacent to existing improved gravel roads and subject to the limitations above; these cluster pads will be spaced at the widest possible spacing to minimize surface disturbance.
b. The construction of new roads shall not be permitted unless the maximum interspersion cannot be met under the provisions of Section 4(b), subject to the limitations of Section 1. If new roads are constructed, the siting of cluster pads away from existing improved gravel roads will be achieved by minimizing the length of new road construction, using existing unimproved roadways wherever they are available.

16. New oil and gas drilling activities shall be regulated under a Staged Development scenario:

a. There shall be no net loss of unroaded or undeveloped lands. Drilling will not be introduced into new unroaded or undeveloped areas until an equivalent acreage of formerly developed lands achieves undeveloped status.

17 State-of-the-art drilling technologies, including but not limited to pitless drilling techniques (using closed-loop circulation of drilling muds), shall be employed for all exploration and production wells unless there is a less environmentally harmful alternative.

18. Coalbed methane produced water may either be reinjected into aquifers of similar water quality or treated to remove pollutants prior to discharge. Produced water from coalbed methane wells shall not be discharged onto soil surfaces or into water bodies if it might affect sensitive wildlife species, water quality, or soil productivity.

19. The plan of operations shall include a reclamation plan which describes in detail the methods and practices that will be used to ensure complete and timely restoration of all lands affected by oil and gas activities to the condition that existed prior to surface disturbing activities. Unless otherwise provided in an approved surface use plan of operations, reclamation shall be conducted concurrently with other operations.

20. Disturbed lands should be returned to their natural condition immediately after the termination of development activities for oil and gas; bonds shall not be refunded until this requirement is met.

21. Revegetation activities should re-create the original distribution and species composition on plant on the site prior to disturbance.

22. The reseeding of disturbed sites shall use only native species of plants.

23. Topsoil shall be retained for all surface-disturbing activities, and shall be replaced during reclamation activities.

24. The obligation to complete reclamation will persist until the site is substantially returned to its natural condition.

Noxious Weeds

1. The BLM will work with other agencies to prevent the introduction of noxious weeds.

2. In order to retard the spread of noxious weeds, the following steps will be taken:

- Reduce the road construction associated with oil and gas development and other surface disturbance to the minimum practicable footprint.

- Reduce grazing pressures where overuse is promoting the spread of invasive species.

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- Require that any fill material used on the Resource Area be free of non-native seeds or other noxious weed material.

Coal and Locatable Minerals

1. Sensitive areas that will be classified "unsuitable" for coal leasing under SMCRA on a year-round basis, with ***no waiver available:***

   - Areas where there is overlap between three or more wildlife crucial winter ranges, crucial winter relief areas, and birthing areas,
   - Other Areas of Critical Environmental Concern as outlined in these comments,
   - areas within 1 mile of active raptor nests,
   - areas within *3* miles of active sage grouse or 1 mile of sharp-tailed grouse leks,
   - large prairie dog colonies and complexes, or those inhabited by BLM Sensitive Species such as black-footed ferret, burrowing owl, mountain plover, or swift fox,
   - critical habitats of Endangered and Threatened species, and
   - areas within the 100-year floodplain of permanent or intermittent streams or within 500 feet of natural water sources or riparian vegetation.

2. Sensitive areas that will be withdrawn from locatable minerals entry on a year-round basis, with ***no waiver available:***

   - wildlife crucial winter ranges, crucial winter relief areas, and birthing areas,
   - Other Areas of Critical Environmental Concern as outlined in the Western Heritage Alternative,
   - areas within 1 mile of active raptor nests,
   - areas within *3* miles of active sage grouse or 1 mile of sharp-tailed grouse leks,
   - large prairie dog colonies and complexes, or those inhabited by BLM Sensitive Species such as black-footed ferret, burrowing owl, mountain plover, or swift fox,
   - critical habitats of Endangered and Threatened species, and
   - areas within the 100-year floodplain of permanent or intermittent streams or within 500 feet of natural water sources or riparian vegetation.

Off-Road Vehicle Management

1. **All** motor vehicles should be limited to designated roads and trails throughout the planning area.

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2. Designated routes will be limited to those which minimize damage to soil, harassment of wildlife, and conflicts with other recreational users in accordance with Executive Orders # 11644 (1972) and 11989 (1977), and 43 C.F.R. § 8340 et seq.

Sensitive Plants Management

1. All current special management areas should be maintained.

2. The BLM should take measures to ensure preservation of the plant species of concern listed on the Wyoming Natural Diversity Database.

Soil, Water, **and** Air Management

Soils

1. The RMP should map the occurrence of Biological Soil Crusts throughout the planning area and evaluate current and future impacts to this important soil resource from livestock grazing, seismic exploration, and other types of development.

2. Develop and implement long-term monitoring protocols for the restoration of soil crust communities. Adapt and refine monitoring protocols, in particular the Biological Soil Crust Stability Index, for evaluation of existing BSC condition. When used in conjunction with corresponding measures of landscape stability, biotic integrity, and watershed function, the BSCSI can be used to help determine the relative health of grassland and sagebrush communities.

3. Identify, map and protect from human related disturbances any remaining areas (refugia) where BSC represent 50% or more of the total ground cover (These are unlikely to represent more than 0.1% of the CFO).

4. Place NSO restrictions on all areas with highly erodible soils.

Water Quantity

1. The RMP should provide that BLM will pursue whatever mechanisms are available to it under federal and state law to preserve minimum stream flows necessary for wildlife habitat, fisheries, and recreation. These mechanisms include conditions on the issuance of rights-of-way for water projects on BLM lands, reserved water rights, and state instream flow protections.

Water Quality

1. The RMP must ensure compliance with all federal and state water quality standards.

2. The RMP should detail the steps BLM intends to take to improve water quality in those stream segments that are not currently meeting state standards. Special attention is required for those stream segments on the state's 303(d) list. These steps should include, at a minimum, reducing the impact of livestock grazing on water quality by limiting livestock access to riparian areas; reducing the impact of timber operations on water quality by creating adequate buffer zones; restricting road construction and ORV use in riparian areas, and ensuring that produced water is either treated or re-injected.

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In addition, the Resource Area contains several stream segments that have been designated as Class 1 or Outstanding Waters. For these stream segments, the RMP must ensure that there is no deterioration in water quality.

Air Quality

1. BLM must ensure that all activities on BLM lands are in compliance with federal and state air quality standards and take steps to improve air quality where such standards are not being met.

2. Air quality impacts associated with oil and gas development should be strictly limited which might degrade current Class I Areas (and on lands proposed for wilderness designation), and any areas of non-attainment of current air quality standards.

Visual Resource Management

1. Lands within the viewsheds of National Trails, lands within the viewsheds of Scenic Byways, and lands proposed for wilderness designation must be managed as VRM Class I.

Wild and Scenic Rivers

1. All eligible stream segments will be nominated for protection under the Wild and Scenic Rivers Act.

Adaptive Management Strategy

1. Recognizing that the costs of monitoring and mitigating for private uses on the public lands often outstrip the agency's resources, the RMP will contain a schedule for re-evaluating the ability of BLM to achieve the non-commodity resource goals contained in the RMP. If those goals are not or cannot be met, the RMP will outline how BLM will adapt its management of the Resource Area in order to ensure preservation of wildlife, scenic, and recreational values.

Monitoring

1. The BLM shall undertake a systematic program of periodic monitoring of resources and attributes, including but not limited to grazing levels, biological soil crusts, sage grouse populations, burrowing owl populations, extent and occupancy of prairie dog colonies, and population trend of Sensitive Species.

Vegetation Treatments

1. Sagebrush reduction treatments shall not occur within 3 miles of a sage grouse lek, within 1 mile of a sharp-tailed grouse lek, or on sage grouse or sharp-tailed grouse winter habitats.

Forest Management

1. The new RMP should outline standards and guidelines for timber harvest that require harvest to be sustainable over time and compatible with other multiple uses such as wildlife, recreation, and watershed values.

2. Timber harvest rotations should reflect natural stand turnover before the advent of widespread logging.

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3. The RMP should ban clearcutting and seed-tree harvest in favor of group selection, individual tree selection, and three-stage shelterwood harvests to minimize additional forest fragmentation.

4. No new timber roads should be constructed in lands proposed for wilderness designation, lands where three or more wildlife migration corridors and crucial habitats coincide, and lands requiring NSO stipulations for leased minerals.

5. For timber sales, a minimum of 5 snags/acre of the largest diameter available will be retained to enhance wildlife habitat.

Historical and Cultural Resources

1. Cultural and paleontological resources should be preserved in place so that their full scientific and cultural values can be evaluated and maintained.

2. BLM should inventory the Resource Area in order to identify sites of cultural and paleontological resources.

3. BLM should engage the Native American community in identifying sites that should be given special protections, including ACEC designation.

4. Sites of known cultural or paleontological resources, such as the Morrison Formation, should be designated and protected as ACECs.

5. **All** permits, leases, contracts, rights-of-way or other agreements allowing private uses should require consultation and inventories prior to any surface disturbance to determine whether such resources are or may be present.

ROW Corridors and Renewable Energy Facilities

1. Utility corridors should be designated along existing rights-of-way or high-traffic gravel roads or highways.

2. The following areas shall be classified as "exclusion areas" for the purposes of siting ROW corridors and renewable energy facilities:

   wildlife crucial winter ranges, crucial winter relief areas, and birthing areas,

   · Other Areas of Critical Environmental Concern as outlined in these comments,

   areas within 1 mile of active raptor nests,

   · areas within 5 miles of active sage grouse or 3 miles of sharp-tailed grouse leks,

   lands within 1 mile of large prairie dog colonies and complexes, or those inhabited by BLM Sensitive Species such as black-footed ferret, burrowing owl, mountain plover, or swift fox, and

   · critical habitats of Endangered and Threatened species.

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3. Areas within the 100-year floodplain of permanent or intermittent streams or within 500 feet of natural water sources or riparian vegetation shall be classified as "avoidance areas" for the purposes of sighting ROW corridors.

4. Communications sites and antenna structures will not be built in or adjacent to:

- wildlife crucial winter ranges, crucial winter relief areas, and birthing areas,
- Other Areas of Critical Environmental Concern as outlined in the Western Heritage Alternative,
- areas within 1 mile of active raptor nests,

  areas within 5 miles of active sage grouse or 3 miles of sharp-tailed grouse leks,
- large prairie dog colonies and complexes, or those inhabited by BLM Sensitive Species such as black-footed ferret, burrowing owl, mountain plover, or swift fox, and
- critical habitats of Endangered and Threatened species.

Livestock Grazing Management

Overall, the BLM should manage allotments to avoid overgrazing and render livestock grazing compatible with other multiple-use values.

1. The RMP should include a reasoned determination as to which lands within the Resource Area should be grazed at all. The special values of lands in ACECs or other special management areas, lands that warrant the protection of NSO stipulations, lands with concentrations of biological soil crusts, or lands with plant or animal species of concern may dictate a determination that such lands are unsuitable for livestock grazing.

2. The RMP should include a three-year schedule for reviewing the condition of all allotments and riparian areas and swift rehabilitation of those that are not in compliance with these requirements. The RMP should adopt a similar schedule for ensuring the timely completion of evaluations required under the National Environmental Policy Act and the Endangered Species Act for grazing activities on the Resource Area.

3. The BLM should manage all allotments toward "good" to "excellent" range condition.

4. Sufficient forage should remain following livestock grazing to support native wildlife.

5. The new RMP should impose measures to minimize the transmission of diseases from livestock to native wildlife.

6. **All** fences shall meet WGFD standards with regard to construction standards.

7. Illegal fences should be brought into compliance or removed.

8. The construction of new fences that might potentially interfere with the migration or dispersal of wildlife should be avoided.

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9. The "Standards and Guidelines for General Application to All Components of the Rangeland Ecosystem," as well as "Standards and Guidelines for Unhealthy Ecosystems," currently in force on BLM lands, shall be formally adopted in full into the new RMP.

10. The BLM must ensure that grazing complies with the Fundamentals of Rangeland Health and other statewide requirements, and all riparian areas must be managed to comply with current "Properly Functioning Condition" requirements.

Conclusions

Thank you for the opportunity to comment on the proposed alternatives for the Casper RMP. The Preferred Alternative is near the extreme and of the spectrum for short- and long-term surface disturbance. See DEIS at 4-3. It poorly balances consumptive resource uses against the need to conserve wildlife, intact ecosystems, watersheds, wilderness, an recreation; and it utterly fails to require best management practices or scientifically sound mitigation measures to reduce or minimize environmental impacts. The BLM needs to strike a more balanced plan that affords equal weight to all multiple uses, instead of pursuing industrial and commercial uses of the public lands to the exclusion of other values. We urge you to adopt a more scientific, ecosystem-based approach to land management through the Casper RMP, and to incorporate the recommendations contained in these comments into the final Casper plan. We look forward to your response, and please provide us with all future NEPA documentation regarding this plan revision.

Sincerely yours,

Erik Molvar
Biodiversity Conservation Alliance

Signing on behalf of:

Liz Howell
Wyoming Wilderness Association
P.O. Box 6588
Sheridan, WY 82801
(307) 672-2751

Nada Culver
The Wilderness Society
1660 Wynkoop, Suite 850
Denver, CO 80202
(303) 650-5818

Steve Forrest
Senior Program Officer, Northern Great Plains Program
World Wildlife Fund
P.O. Box 7276
Bozeman, Montana 59771
(406) 582-7571

2005 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.

Prepared for:

Questar Exploration and Production Company
Independence Plaza
1050 17th St., Suite 500
Denver, CO 80265

TRC Mariah Associates Inc.
605 Skyline Road
Laramie, WY 82070

Bureau of Land Management
Pinedale Field Office
PO Box 768
Pinedale, WY 82941

Wyoming Game and Fish Department
Pinedale Regional Office
PO Box 850
Pinedale, WY 82941

Prepared by:

Hall Sawyer, Ryan Fields, Dale Strickland, and Lyman McDonald
Western Ecosystems Technology, Inc.
2003 Jim Avenue
Cheyenne, WY 82001

Attachment 1

Sawyer, H., R. Nielson, D. Strickland, and L. McDonald. 2005. 2005 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.

ACKNOWLEDGEMENTS

Phase II of the Sublette Mule Deer Study has been a cooperative effort among agencies and industry. This project was largely funded by Questar Exploration and Production Company (QEP) and subcontracted through TRC Mariah Associates Inc. (TRC). The Pinedale Field Office of the Bureau of Land Management (BLM) provided additional funding and the Wyoming Game and Fish Department (WGFD) provided logistical support, project assistance, and in-kind donations in the form of data collection. Many thanks to Ron Hogan (QEP), Jane Seiler (QEP), Steve Belinda (BLM), Karen Rogers (BLM), Craig Kling (TRC), Scott Smith (WGFD), Herb Haley (WGFD), Bernie Holz (WGFD), Scott Edberg (WGFD), Scott Werbelow (WGFD), Dan Stroud (WGFD), Dean Clause (WGFD), Dennis Almquist (WGFD), Brad Hovinga (WGFD), Doug McWhirter (WGFD), Fred Lindzey (retired), Jim Pope (Leading Edge Aviation), Wes Livingston (Leading Edge Aviation), and Gary Lust (Mountain Air). Thanks to John Amos (SkyTruth) for image acquisition and processing.

LIST OF ACRONYMS

BACI	Before-After Control-Impact
BLM	Bureau of Land Management
CR	County Road
DAU	Data Analysis Unit
EIS	Environmental Impact Statement
GIS	Geographic Information System
GPS	Global Positioning System
MCP	Minimum Convex Polygon
MWRC	Mesa Winter Range Complex
NEPA	National Environmental Policy Act
NGO	Non-Government Organization
PAPA	Pinedale Anticline Project Area
PFWRC	Pinedale Front Winter Range Complex
QEP	Questar Exploration and Production Company
ROD	Record of Decision
RSPF	Resource Selection Probability Function
TPB	Trapper's Point Bottleneck
TRC	TRC Mariah Associates, Inc.
USGS	United States Geological Survey
UW	University of Wyoming
VHF	Very High Frequency
WEST	Western EcoSystem Technology, Inc.
WGFD	Wyoming Game and Fish Department

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1.0 OVERVIEW

In 1998 the Wyoming Cooperative Fish and Wildlife Research Unit began the Sublette Mule Deer Study, a collaborative effort with industry, agencies, and private organizations intended to examine movement patterns and population characteristics of the Sublette mule deer herd in western Wyoming. Although a variety of agencies and non-government organizations (NGOs) contributed to the study, it was funded largely by industry (Ultra Petroleum). Concurrently, the Bureau of Land Management (BLM), in compliance with the National Environmental Policy Act (NEPA), initiated an Environmental Impact Statement (EIS) to assess natural gas development in the 300-mi^2 Pinedale Anticline Project Area (PAPA) (BLM 2000) (Figure 1.1). Because the PAPA provides important winter range to a large segment of the Sublette mule deer herd, there were concerns about the potential effects gas field development may have on the deer population.

The Sublette Mule Deer Study was originally designed to have two phases. The first phase of the study was intended to gather information needed by agencies to improve management of the Sublette deer herd, including the identification of seasonal ranges, determination of migration routes, and estimation of survival rates (Sawyer and Lindzey 2001). Additionally, these data were collected so that pre-development information on the mule deer population would be available if Phase II of the study materialized. Phase II was envisioned as a long-term study that would examine the potential impacts of energy development on mule deer, using treatment and control areas, with energy development as the treatment. The BLM completed the PAPA EIS and released their record of decision (ROD) in July of 2000 (BLM 2000). Phase I of the Sublette Mule Deer Study was completed in March of 2001 (Sawyer and Lindzey 2001). Following a 1-year pilot study funded by QEP, Phase II was initiated in December of 2002, as a Before-After/Control-Impact (BACI) study design (Green 1979, Morrison et al. 2001) that uses the PAPA as a treatment area and a portion of the Pinedale Front as the control area. Mule deer population characteristics (i.e., survival, reproduction, abundance) and habitat use in relation to development features will be measured in both areas, and over time, performance of mule deer in the PAPA will be compared to those in the control area, both before and after the treatment. This report summarizes the results from the 2005 study period.

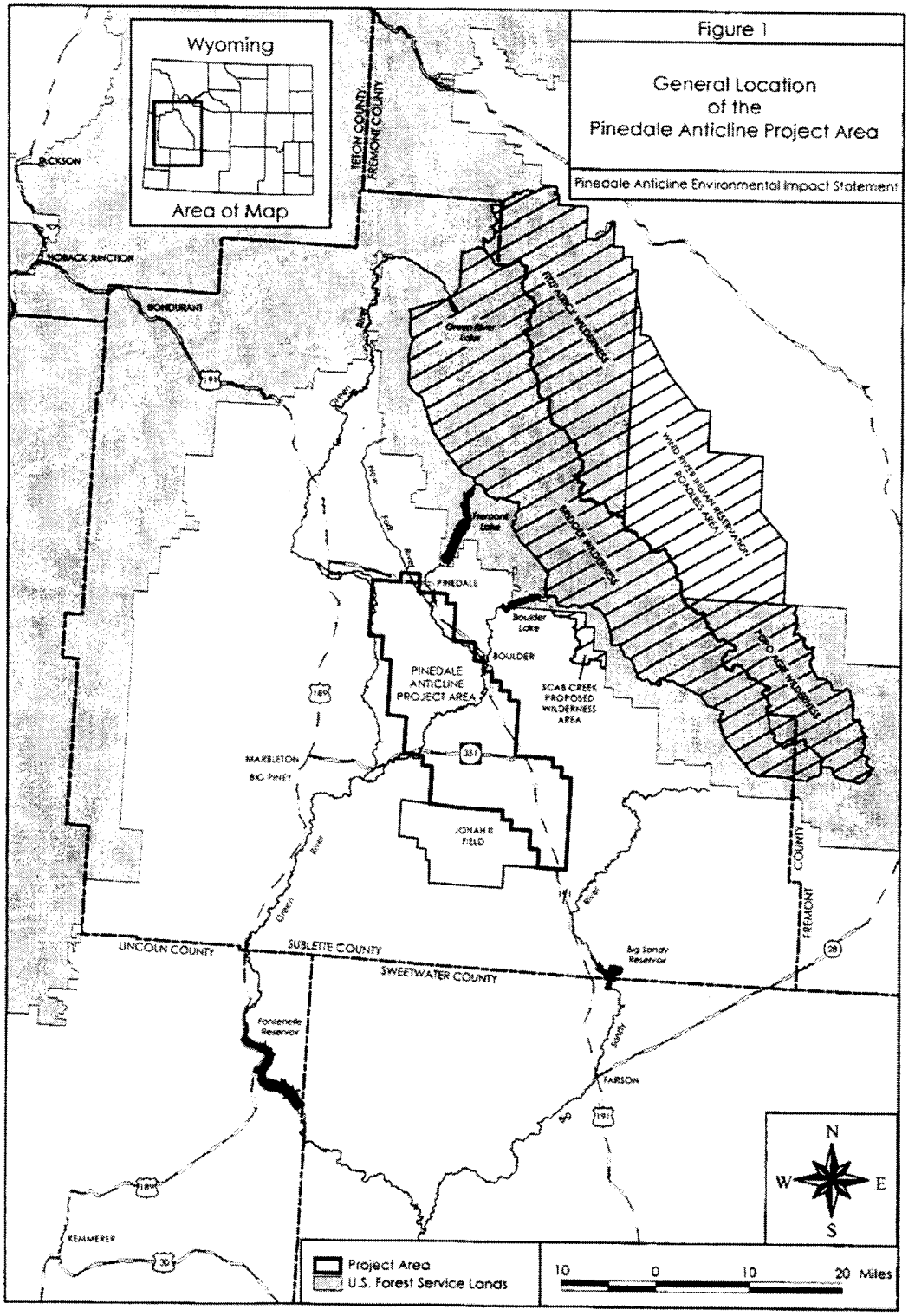

Figure 1.1 Location of Pinedale Anticline Project Area in western Wyoming (from BLM 2000).

2.0 SUBLETTE MULE DEER STUDY

2.1 INTRODUCTION

Western Wyoming is home to the largest, most diverse ungulate populations in the Rocky Mountain region. Maintenance of these populations and protection of their habitats are primary concerns among the public and state and federal agencies. Because of their large numbers and economic importance, mule deer continue to be a top priority for the Wyoming Game and Fish Department (WGFD). The Sublette mule deer herd unit includes 15 hunt areas (130, 138-142, 146, 150-156, and 162) and has a post-season population objective of 32,000 (WGFD 2002). Results from the Sublette Mule Deer Study (Sawyer and Lindzey 2001) indicate that these mule deer seasonally migrate 60-100 miles from winter range near Pinedale, Wyoming to summer in portions of the Salt River Range, Wyoming Range, Wind River Range, Gros Ventre Range, and Snake River Range. During the lengthy spring and fall migrations, mule deer spend a substantial amount of time, often 4-5 months out of the year, on mid-elevation transition ranges that connect summer and wintering areas. By late-fall, most mule deer annually converge in the Green River Basin to winter in one of two major complexes; the Mesa Winter Range Complex (the Mesa) and the Pinedale Front Winter Range Complex (the Pinedale Front) (Figure 2.1). Generally, the Mesa includes the PAPA and those wintering areas west of US 191, while the Pinedale Front includes those areas east of US 191 to the base of the Wind River Mountains.

Population parameters measured during the 3-year (1998-2000) Phase I study (WGFD 2002, Sawyer and Lindzey 2001) suggested the Sublette deer herd was a healthy and productive population prior to development of energy resources on the PAPA. Annual survival rates of radio-collared adult females (n=149) averaged 85% and were consistent with populations studied in other western states (Unsworth et al. 1999). Fawn:doe ratios, an indicator of reproductive success, were among the highest in the state, averaging >75 fawns per 100 does for the study period and approximately 70 fawns per 100 does over the last decade (WGFD 2002). Although the Sublette deer herd has been very productive in the past and recent studies have improved management, this deer herd is similar to others in the region in that habitat loss due to urban expansion and energy development continue to create major management concerns.

Natural gas production in Wyoming has steadily increased since the mid-1980s, particularly in the five counties that form the southwest quarter of the state: Sublette, Fremont, Lincoln, Uinta, and Sweetwater (BLM 2002). This area of the state contains some of the largest and most productive gas fields in the nation, including the Jonah, Continental Divide/Wamsutter, Fontenelle, Big Piney-LaBarge, Moxa Arch, Riley Ridge, Desolation Flats, and the Pinedale Anticline. Natural gas exploration, development, and production are at an all time high in Wyoming and expected to increase.

Because the PAPA encompasses the Mesa, which is used by thousands of mule deer, pronghorn, and sage grouse, development of this area may have adverse impacts on wildlife. Impacts to wildlife include direct habitat loss to infrastructure (i.e., roads, well pads, pipelines) construction and indirect habitat losses that may occur if deer use declines (i.e., avoidance or displacement) in areas near infrastructure. The best way to evaluate the impact(s) of energy development on wildlife populations is through long-term studies where pre-development data, such as, estimates of survival and reproduction are available. Because these studies are by necessity observational, determining cause and effect relationships is very difficult. Simply documenting a behavioral response (e.g.,

avoidance, acclimation, displacement) to a disturbance adds very little to our knowledge of the impact, if it cannot be linked to the survival or reproductive success of the species involved. And conversely, documenting a change in reproduction or survival does not add significantly to our understanding of the impact if the cause (e.g., weather, habitat loss, disease) of the change cannot be determined. And, because of the difficulty with designing and funding long-term studies, impacts of energy development on free-ranging ungulate populations are poorly understood and often debated. However, both direct and indirect habitat losses associated with energy development have the potential to affect ungulate population dynamics, particularly when disturbances are concentrated on winter ranges, where energetic costs are great and animals occur at high densities.

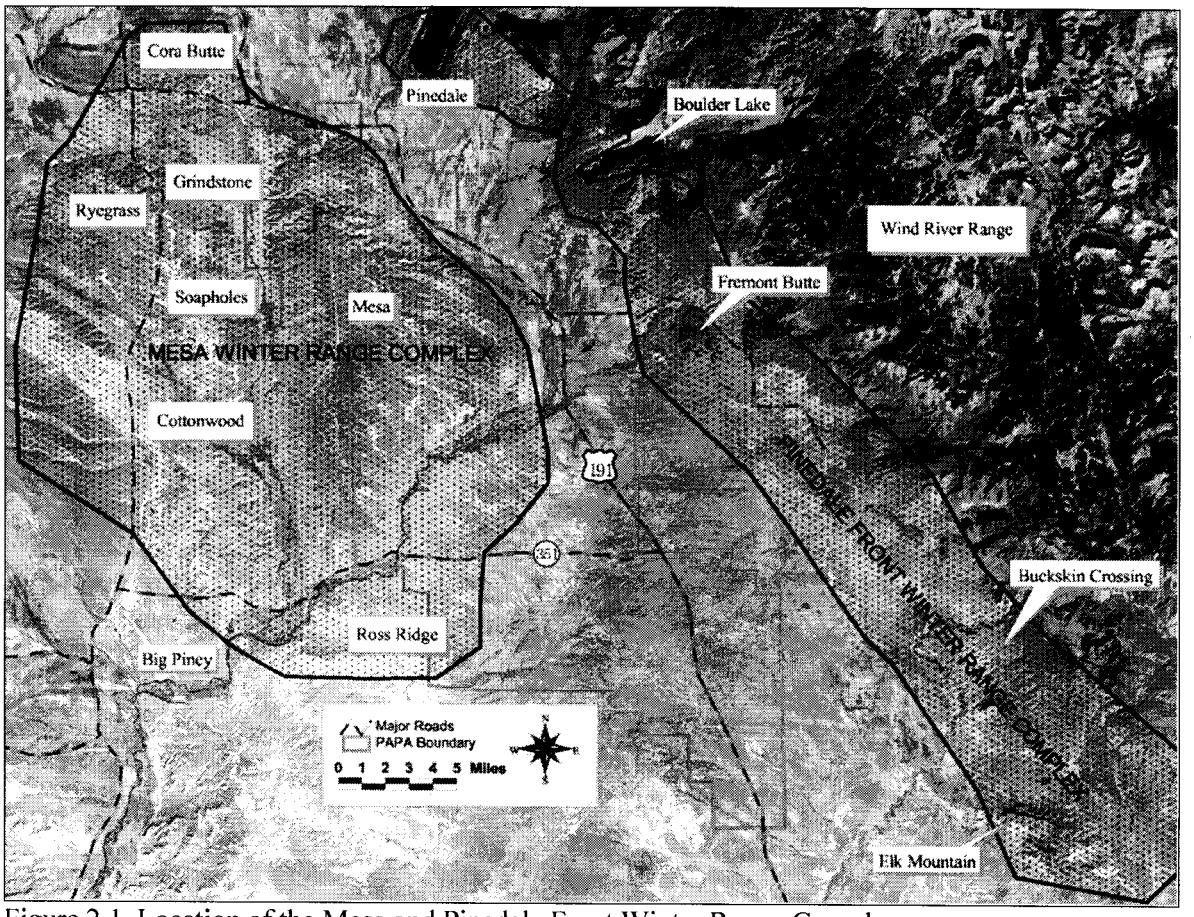

Figure 2.1 Location of the Mesa and Pinedale Front Winter Range Complexes.

The major shortcoming of efforts to evaluate the impact(s) of disturbances on wildlife populations is that they seldom are addressed in an experimental framework, but rather tend to be short-term and are almost always observational. Brief, post-development monitoring plans associated with regulatory work generally result in little or no information that allow agencies and industry to assess impacts on wildlife or identify new, and potentially more effective, mitigation measures. On the other hand, long-term studies are difficult to implement because they are expensive and require interagency and industry cooperation and commitment. Additionally, the acquisition of pre-development data on movement patterns and population characteristics, and identification of suitable control and treatment areas is extremely uncommon. The situation in the PAPA and upper

Green River Basin is unique because most of the necessary information is available to conduct a BACI study to suggest if, and if so, how natural gas development affects the PAPA mule deer population.

The basic idea with a BACI study design is that the potentially impacted (treatment) site is sampled both before and after the time of the disturbance (e.g., energy development), and one or more control sites that do not receive any disturbance are sampled at the same time (Manly 2001). The assumption is that any naturally occurring changes will be similar at the control and treatment sites, and in the absence of the treatment the parameters of interest will be similar for both areas, or at least the magnitude of the differences will be relatively constant from year to year. Thus, potential changes at the treatment site may be attributed to the disturbance. It is not critical that the control and treatment populations be identical, only that the subpopulations are independent and that both respond to the same environmental factors.

For this study, energy development on the Mesa is considered the treatment and a portion of the Pinedale Front serves as the control area. The Pinedale Front consists mostly of federal lands located along the southwest portion of the Wind River Range, where no energy development is anticipated. The Pinedale Front is a suitable control site because: 1) there is little or no exchange of deer between the Mesa and Pinedale Front, 2) the two deer subpopulations use separate winter ranges, but share common transition and summer ranges, so they have comparable foods available during parturition and arrive on winter ranges in similar condition, 3) although the two deer subpopulations occupy distinct winter ranges, they are in close proximity to one another (15-30 miles), so both are exposed to similar weather patterns and environmental conditions, 4) habitat characteristics on both winter ranges are similar and dominated by sagebrush communities, and 5) population characteristics of the two subpopulations have consistently tracked one another prior to development of the PAPA.

We believe four population parameters should be monitored to detect the potential impacts of energy development on mule deer, including: 1) adult doe survival, 2) over-winter fawn survival, 3) reproduction, and 4) abundance. As these parameters are measured in treatment and control areas, comparisons can be made, and over time, the potential impacts of energy development on mule deer may be assessed. If mule deer in the PAPA continue to function as well as before development and as well as those in the control area it would suggest that energy development has no adverse impacts on mule deer in the region. If however, mule deer survival or reproduction in the PAPA decreases, while the same parameters in the control area remain unchanged or increase, then energy development may be the cause of those declines. Again, this does not demonstrate a cause-effect relationship; rather it is simply one piece in a weight of evidence approach, where our study design examines several direct (e.g, survival, reproduction) and indirect (e.g., habitat use, displacement) parameters that are statistically analyzed and carefully interpreted.

Results from Phase I identified seasonal migration routes and distribution of deer in the Mesa and Pinedale Front (Sawyer and Lindzey 2001). Although mule deer migrations of >60 miles have been reported in parts of Idaho (Thomas and Irby 1990) and Montana (Mackie et al. 1998), mule deer on and adjacent to the PAPA are likely the most migratory deer in the western states, annually migrating 60-100 miles between winter and summer ranges. Because these deer are highly mobile and demonstrate strong fidelity to seasonal ranges, the potential for energy development, or other human disturbances, to disrupt migratory routes and/or winter distribution patterns exists. While changes in distribution or migratory patterns may not necessarily result in decreased deer survival or

reproduction, it is useful to include within the monitoring plan to: 1) document if migration routes remain intact, 2) document if deer continue using pre-development winter ranges, 3) provide industry and agencies with accurate, precise movement data for site-specific analyses (e.g., seasonal range designation or comparison of effects of multiple well pads versus single well pad), 4) identify mitigation opportunities on and off-site treatment and control areas (e.g., migration corridors, habitat improvements), and 5) allow for analyses that estimate and describe indirect habitat loss (e.g., avoidance of roads or well pads) or changes in habitat use.

Properly designed long-term monitoring and examination of adult survival, over-winter fawn survival, reproduction, abundance, and seasonal distribution/movement patterns will allow for population-level inferences concerning the potential impacts of energy development on mule deer.

2.2 STUDY AREA

The PAPA is located in west-central Wyoming in Sublette County, near the town of Pinedale (Figure 1.1). The PAPA is characterized by sagebrush communities and riparian habitats associated with the Green and New Fork Rivers. Elevations range from 6,800 to 7,800 feet. The PAPA consists primarily of federal lands (80%) and minerals (83%) administered by the BLM. The state of Wyoming owns 5% (15.2 mi^2) of the surface and another 15% (46.7 mi^2) is private. Aside from the abundant energy resources, the PAPA is an important area for agriculture and provides winter range for 4,000-6,000 mule deer, 2,000-3,000 pronghorn, and 3,000-4,000 sage grouse. While the project area is fairly large, most deer occur in the northern portion of the PAPA, an area locally known as "The Mesa", which includes approximately 100-mi^2. In July of 2000, the BLM approved the development of 700 producing well pads in the PAPA and recognized that this may require as many as 900 well pads to be constructed and drilled (BLM 2000). Additionally, 401 miles of pipeline and 276 miles of access roads were approved for development of energy resources on the PAPA.

2.3 METHODS

2.3.1 Deer Capture

Helicopter net-gunning was used to capture deer across winter ranges in treatment (Mesa) and control (Pinedale Front) areas. Captured deer were fitted with collars supporting either a GPS or VHF radio transmitter. Both types of collars were equipped with mortality sensors that change pulse rate if the collar remains stationary for more than 8 hours. The VHF collars (Advanced Telemetry Systems, Isanti, MN) were duty-cycled to transmit signals October 1 through May 31. The GPS collars (Telonics, Mesa, AZ) were store-on-board units capable of storing approximately 3,000 locations and programmed to obtain fixes every 2 hours during winter months (November-April) and every 25 hours during the remainder of the year. Additionally, each GPS collar was equipped with a remote release mechanism programmed to activate at a specified time, so that collars could be retrieved and data downloaded.

2.3.1 Winter Movement and Distribution Patterns

Data collected from GPS-collared deer accurately identified winter distribution, movement patterns, and migration routes of the marked deer on and adjacent to winter ranges. Because a portion (n=17) of GPS collars are to remain on the same deer for consecutive winters (2004-05

and 2005-06), some data for the 2004-05 winter will not be available until 2006.

2.3.3 Population Characteristics

2.3.3.1 Abundance and Density Estimates

Deer abundance and density were estimated in treatment (Mesa) and control (Pinedale Front) areas using aerial counts of deer in systematically sampled 1-mi^2 quadrat units. Winter distribution data collected from radio-collared deer in the study area between 1998 and 2003 was used to delineate 68-mi^2 and 70-mi^2 sampling frames for the treatment and control areas, respectively. Sampling frames were expected to contain high-densities of deer so stratification was unnecessary. We sampled 34 quadrats from each sampling frame, covering approximately 50% of the geographic area. Equations used to calculate abundance and density estimates were taken from Thompson et al. (1998). Standard 90% confidence intervals were calculated using a Z statistic.

The size of the sampling frame in the control area has changed over the course of the study (See Section 2.4.4.1). During the first year of surveys (2002) we identified a 35-mi^2 sampling frame that we believed represented the core winter range in the Pinedale Front. During 2003 we made some slight modifications to improve our sampling and used a similar 38-mi^2 sampling frame (Figure 2.2). However, during the 2003 surveys many of our marked deer moved out of the sampled area. At this time it became apparent that these deer utilize a much larger area than we originally thought. To accurately adjust the size and extent of our sampling frame we conducted a telemetry flight prior to the 2004 survey to adjust the size of our sampling frame based on locations of marked deer. The new sampling frame was 70-mi^2 (Figure 2.3), nearly double the size of the 2002 and 2003 frames and approximately the same size as the sampling frame for the treatment area.

Group size and vegetative cover may significantly influence visibility bias in ungulate helicopter surveys (Samuel et al. 1987). However, the treatment and control areas for this study consist of homogenous sagebrush stands with no tree cover. Additionally, telemetry data from Phase I indicated male and female deer did not winter in areas with different habitat characteristics, so potential group size variation resulting from sexual segregation should not influence counts. Further, when survey areas contain large concentrations of animals that are widely distributed, recognition of individual groups may be near impossible. Attempting to determine visibility correction factors for groups is likely not feasible in these situations (Samuel et al. 1987). Counts of animals within the sampled quadrats are assumed to provide valid indices on density and abundance. That is, if not all animals present were detected, we assume the same visibility bias in both treatment and control areas over time.

Counts were conducted from a piston-powered Bell helicopter flown approximately 100-150 feet above ground and at speeds of 20-40 knots. The northeast UTM coordinates for each quadrat were programmed into a GPS unit on the helicopter. Quadrat perimeters were then flown clockwise, such that the observer was positioned on the inside, while the pilot navigated. A real-time flight path was traced into the on-board GPS and once the perimeter was established the quadrat interiors were systematically searched. Observer and navigator collectively detected deer groups and determined whether groups were inside or outside quadrat boundaries. Deer detected inside and moving out were considered in the quadrat, while deer detected outside and moving in the quadrat were considered out. Half of the deer detected on perimeter boundaries were considered in the quadrat. For each quadrat, the observer recorded total number of deer, number of deer groups, and total

search time.

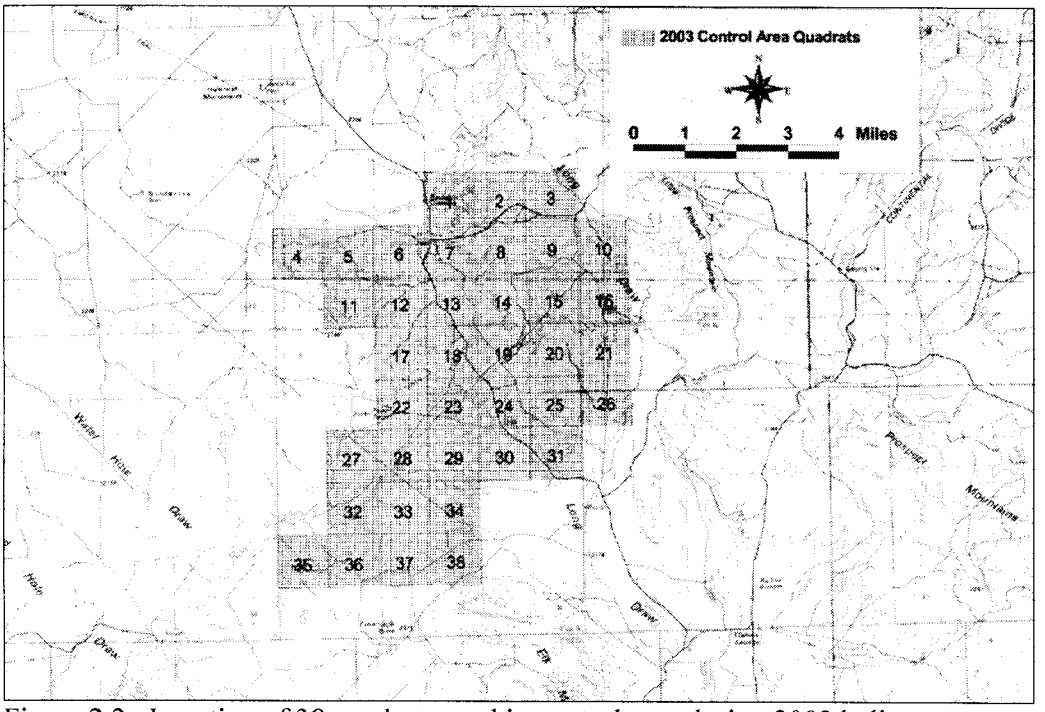

Figure 2.2 Location of 38 quadrats used in control area during 2003 helicopter surveys.

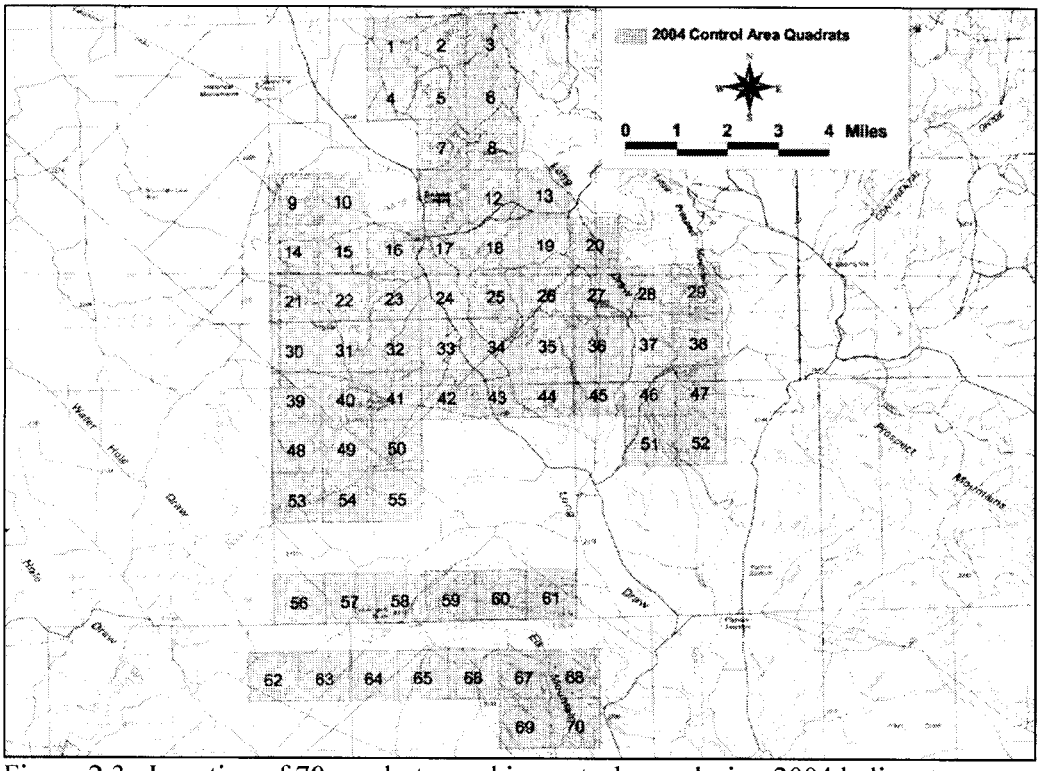

Figure 2.3 Location of 70 quadrats used in control area during 2004 helicopter surveys.

2.3.3.2 Reproduction

Doe:fawn ratios are commonly used as an index to herd productivity or reproduction. Doe:fawn ratios were calculated from composition data collected during the WGFD's annual helicopter surveys in December, consistent with the previous 10 years of WGFD data collection (WGFD 2002). Sample sizes were adequate to obtain desired levels of precision in ratio estimates (Czaplewski et al. 1983).

2.3.3.3 Adult Female Winter Survival

Adult doe survival was estimated from telemetry records using the Kaplan-Meier procedure (Kaplan and Meier 1985). We attempted to maintain a sample of 30 marked deer in both control and treatment areas. Marked deer were located at least once per month, December through May.

2.3.3.4 Over-winter Fawn Survival

Deer from both the Mesa and Pinedale Front congregate on the northern ends of their respective winter ranges every spring which allows large numbers (>1,000) of animals to be counted and classified. Ground-based composition surveys conducted in April were used to calculate post-winter adult:fawn ratios. These data were used in conjunction with adult survival rates and December adult:fawn ratios to estimate over-winter fawn survival, using the change-in-ratio estimator from White et al. (1996):

$\hat{S}_f = \hat{S}_a x \frac{B}{A}$, where A = count of December fawns/count of December adults

B = count of April fawns/count of April adults

$\hat{S}_a$ = estimate of adult survival

Adult survival rates were estimated from telemetry records, rather than carcass counts. The delta method (Seber 1982) was used to estimate variance.

2.3.4 Direct Habitat Loss

Satellite imagery and geographic information system (GIS) software were used to digitize road networks and well pads associated with natural gas development in the northern portion of the PAPA (i.e., The Mesa), from 2000 through 2003. Areas within the PAPA, but outside the Mesa were not considered. Landsat images were purchased from the United States Geological Survey (USGS) and processed by SkyTruth (Sheperdstown, West Virginia, USA). Images were generally obtained in early fall (i.e., September-October), after most annual construction activities (e.g., well pad and road building) were complete, but prior to snow accumulation. Pipelines and seismic tracks were not included in this analysis. Roads and well pads were digitized in ArcView®(ESRI, Redlands, California, USA). Length of road segments and size of well pads were calculated in ArcView®. Acreage estimates associated with road networks were based on an average road width of 30 ft. We recognize there is some error associated with the digitizing process, however it is expected to be minimal and the resulting digital GIS coverages

are considered the best available data. During the digitizing process we assumed full reclamation of well pads had not occurred, since the gas field is only 3 years old and successful reclamation (i.e., re-establishment of native plant species) of native shrub communities in arid environments is extremely difficult and unlikely to occur during a short time period.

2.3.5 Resource Selection

2.3.5.1 Study Area Delineation

We defined the study area by mapping 39,641 locations from 77 mule deer over a 6-year period (1998 to 2003), creating a minimum convex polygon (MCP), and then clipping the MCP to the boundary of the PAPA. This was consistent with McClean et al. (1998)'s recommendation that study-area level of habitat availability should be based on the distribution of radiocollared animals. Additionally, the MCP generated from GPS data was consistent with winter distribution patterns documented for this deer population using >60 VHF radio-collars, between 1998 and 2000 (Sawyer and Lindzey 2001).

2.3.5.2 Predictor Variables

We identified 5 variables as potentially important predictors of winter mule deer distribution, including: elevation, slope, aspect, road density, and distance to well pad. We did not include vegetation as a variable because the sagebrush-grassland was relatively homogeneous across the study area and difficult to divide into finer vegetation classes. Further, we believed differences in sagebrush characteristics could be largely explained by elevation, slope, and aspect. We used the SPATIAL ANALYST extension for ArcView® to calculate slope and aspect from a 26 x 26 m digital elevation model (USGS 1999). Grid cells with slopes > 2 degrees were assigned to 1 of 4 aspect categories; northeast, northwest, southeast, or southwest. Grid cells with slopes of ≤ 2 degrees were considered flat and assigned to a fifth category that was used as the reference (Neter et al. 1996) during habitat modeling. We obtained elevation, slope, and aspect values for each of the sampled units using the GET GRID extension for ArcView®. The sample units consisted of 4,500 circular units with 100-meter radii distributed across the study area. We annually digitized roads and well pads from LANDSAT® thematic satellite images acquired from the USGS and processed by SkyTruth. The LANDSAT® images were obtained every fall, prior to snow accumulation, but after most annual development activities were complete. We calculated road density by placing a circular buffer with a 0.5 km radius on the center of the sample unit and measuring the length of road within the buffer. We used the NEAREST NEIGHBOR extension for ArcView® to measure the distance from the center of each sampled unit to the edge of the nearest well pad. We did not distinguish between developing and producing well pads. We assumed habitat loss was similar among all well pads because development of the field was in its early stages (i.e., < 5 years) and there was no evidence of successful shrub reclamation. Additionally, there was no evidence that suggested the type of well pad was an accurate indicator of the amount of human activity (e.g., traffic) that occurred at each site. Without an accurate measure of human activity, we believed it was inappropriate to distinguish between producing and developing well pads.

2.3.5.3 Modeling Procedures

Our approach to modeling winter habitat use consisted of 4 basic steps: 1) estimate the relative

frequency of use (i.e., an empirical estimate of probability of use) for a large sample of habitat units for each radiocollared deer during each winter, 2) use the relative frequency as the response variable in a multiple regression analysis to model the probability of use for each deer as a function of predictor variables, 3) develop a population–level model from the individual deer models for each winter, and 4) map predictions of population–level models from each winter. Our analysis treated each winter period separately to allow mule deer habitat use and environmental characteristics (e.g., road density or number of well pads) to change through time. We treated radiocollared deer as the experimental unit to avoid pseudo–replication (i.e., spatial and temporal autocorrelation) and to accommodate population–level inference (Otis and White 1999, Johnson et al. 2000, Erickson et al. 2001).

We estimated relative frequency of use for each radiocollared deer using a simple technique that involved counting the number of deer locations in each of approximately 4,500 randomly sampled circular habitat units across the study area. We took a simple random sample with replacement for each winter to ensure independence of the habitat units (Thompson 1992:51). We chose circular habitat units that had a 100-meter radii; an area small enough to detect changes in animal movements, but large enough to ensure multiple locations could occur in each unit. Previous analyses suggested model coefficients were similar across a variety of unit sizes, including 50, 75, and 150-meter radii (R. Nielson, Western Ecosystems Technology, Inc., unpublished data). We measured predictor variables on of each of the sampled habitat units and conducted a Pearson's pairwise correlation analysis (PROC CORR; SAS Institute 2000) before modeling to identify multicollinearities and determine if any variables should be excluded from the modeling ($|r| > 0.60$).

The relative frequency of locations from a radiocollared deer found in each habitat unit was an empirical estimate of the probability of use by that deer and was used as a continuous response variable in a generalized linear model (GLM). We used an offset term (McCullagh and Nelder 1989) in the GLM to estimate probability of use for each radiocollared deer as a function of a linear combination of predictor variables, plus or minus an error term assumed to have a negative binomial distribution (McCullagh and Nelder 1989, White and Bennetts 1996). We preferred the negative binomial distribution over the more commonly used Poisson, because it allows for over–dispersion (White and Bennetts 1996).

We obtained a population–level model for each winter by first estimating coefficients for each radiocollared deer. We used PROC GENMOD (SAS Institute 2000) and the negative binomial distribution to fit the following GLM for each radiocollared deer during each winter period:

$$\ln(E[r_i]) = \ln(total) + \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p, \qquad (1)$$

which was equivalent to:

$$\ln(E[r_i / total]) = \ln(E[\text{Relative Frequency}_i]) = \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p, \qquad (2)$$

where r_i was the number of locations for a radiocollared deer within habitat unit i ($i = 1, 2, \ldots, 4500$), *total* was the total number of locations for the deer within the study area, β_o was an intercept term, $\beta_1,\ldots,\beta_p$ were unknown coefficients for habitat variables $X_1,\ldots,X_p$, and $E[.]$ denotes the expected value. We used the same offset term for all sampled habitat units of a given deer, thus the term ln(*total*) was absorbed into the estimate of β_o and ensured we were modeling relative frequency of use (e.g., 0, 0.003, 0.0034, ...) instead of integer counts (e.g., 0, 1, 2, ...). Because some locations for each deer were not within a sampled habitat unit, inclusion of the offset term in equation (1) was not equivalent to conditioning on the total number of observed locations (i.e.,

multinomial distribution). In fact, one could drop the offset term and simply scale the resulting estimates of frequency of use by the total number of observed locations to obtain predictions of relative frequency identical to those obtained by equation (1). This approach to modeling resource selection estimates the relative frequency or absolute probability of use as a function of predictor variables, so we refer to it as a resource selection probability function (RSPF) (Manly et al. 2002).

We assumed GLM coefficients for predictor variable k for each deer were a random sample from a normal distribution (Seber 1984, Littell et al. 1996), with the mean of the distribution representing the average or population–level effect of predictor variable k on probability of use. We estimated coefficients for the population–level RSPF for each winter using

$$\hat{\bar{\beta}}_k = \frac{1}{n}\sum_{j=1}^{n}\hat{\beta}_{kj}, \tag{3}$$

where $\hat{\beta}_{kj}$ was the estimate of coefficient k for individual j (j = 1,…,n). We estimated the variance of each population–level model coefficient using the variation between radiocollared deer and the equation

$$\mathrm{var}(\hat{\bar{\beta}}_k) = \frac{1}{n-1}\sum_{j=1}^{n}(\hat{\beta}_{kj} - \hat{\bar{\beta}}_k)^2. \tag{4}$$

This method of estimating population–level coefficients using equations (3) and (4) was used by Marzluff et al. (2004) and Glenn et al. (2004) for evaluating habitat selection of Stellar's jays and northern spotted owls, respectively. Population–level inferences using equations (3) and (4) are unaffected by potential autocorrelation because temporal autocorrelation between deer locations or spatial autocorrelation between habitat units do not bias model coefficients for the individual radiocollared deer models (McCullagh and Nelder 1989, Neter et al. 1996).

Standard criteria for model selection such as Akaike's Information Criterion (Burnham and Anderson 2002) might be appropriate for individual deer, but do not apply for building a model for population–level effects because the same model (i.e., predictor variables) is required for each deer within a winter. Therefore, we used a forward-stepwise model building procedure (Neter et al. 1996) to estimate population–level RSPFs for winters 2000–01, 2001–02, and 2002–03. The forward–stepwise model building process required fitting the same models to each deer within a winter and using equations (3) and (4) to estimate population–level model coefficients. We used a t–statistic to determine variable entry ($\alpha \leq 0.15$) and exit ($\alpha > 0.20$) (Hosmer and Lemshow 2000). We considered quadratic terms for road density, distance to nearest well pad, and slope during the model building process and, following convention, the linear form of each variable was included if the model contained a quadratic form.

We conducted stepwise model building for all winters except for the pre-development period that included winters 1998–1999 and 1999–2000. The limited number of locations recorded for radiocollared deer during this period precluded fitting individual models. Rather, we estimated a population–level model for the pre-development period by pooling location data across 45 deer that had a minimum of 10 locations. We took simple random samples of 30 locations from deer with >30 locations to ensure that approximately equal weight was given to each deer in the analysis. We fit a model containing slope, elevation, distance to roads, and aspect for the pre-development period. Distance to well pad was not included as a variable in the pre-development model because there were only 11 existing well pads on the Mesa prior to development and most

were >10 years old with little or no human activity associated with them. We used bootstrapping to estimate the standard errors and P values of the pre-development population–level model coefficients.

We mapped predictions of population–level RSPFs for each winter on 100 x 100-meter grids that covered the study area. We checked predictions to ensure all values were in the [0,1] interval, such that we were not extrapolating outside the range of the model data (Neter et al. 1996). The estimated probability of use for each grid cell was assigned a value of 1 to 4 based on the quartiles of the distribution of predictions for each map. We assigned grid cells with the highest 25% of predicted probabilities of use a value of 1 and classified them as high use areas, assigned grid cells in the 51 to 75 percentiles a value of 2 and classified them as medium-high use areas, assigned grid cells in the 26 to 50 percentiles a value of 3 and classified them as medium-low use areas, and assigned grid cells in the 0 to 25 percentiles a values of 4 and classified them as low use areas. We used contingency tables to identify changes in the 4 habitat use categories across the 4 winter periods.

2.4 RESULTS

2.4.1 Deer Capture

We captured and radio-collared 27 adult female deer on December 19, 2004. Deer capture (n=17) in the PAPA was restricted to those areas where deer congregate across the northern end of the PAPA in early winter, as they move onto the Mesa from Trapper's Point and/or the Ryegrass/Grindstone area. We assumed this represented a random sample of deer in the subpopulation because the deer were congregated on the north end, before they moved south to their respective winter ranges. For the same reason, deer capture (n=10) in the Pinedale Front was restricted to the Big Sandy area; bounded to the north and west by the Big Sandy River, east to the Prospects, and south to Elk Mountain. Of the 27 deer captured, 20 were equipped with GPS radio-collars and 7 equipped with traditional VHF radio-collars. All GPS collars were store-on-board units equipped with VHF transmitters on 12-hour duty cycles, 8-hour mortality sensors, and remote-release mechanisms programmed to drop collars on April 15, 2005 or April 15, 2006. The programming schedule for GPS collars was as follows:

- obtain 1 location every 2-3 hours December 20, 2004 – April 15, 2005
- obtain 1 location every 25 hours April 16, 2005 – October 31, 2005
- obtain 1 location every 2-3 hours November 01, 2005 – April 15, 2006

Consistent with previous years, our goal was to maintain a sample size of 30 deer in each area, including 10 GPS and 20 VHF radio-collars (Table 2.1).

Table 2.1 Number and type of radio-collars functioning in treatment and control areas during the 2004-05 winter.

Treatment Area (The Mesa)			**Control Area** (Pinedale Front)	
Deer ID	Collar Type		Deer ID	Collar Type
801	VHF		804	VHF
805[a]	VHF		807	VHF
806	VHF		8071	VHF
809	VHF		811	VHF
813	VHF		818	VHF
815	VHF		820	VHF
817	VHF		821	VHF
822	VHF		825	VHF
827	VHF		833	VHF
830	VHF		835*	VHF
837	GPS		836	VHF
838	GPS		850	VHF
839	GPS		853	VHF
841	GPS		860	GPS
842	VHF		861	GPS
843	GPS		864	GPS
844	GPS		867	GPS
845	VHF		869	GPS
847	GPS		870	GPS
848	GPS		872	GPS
849	VHF		876	GPS
852	VHF		877	GPS
853	VHF		878	GPS
854	VHF			
855	GPS			
8553	VHF			
858	GPS			
859	GPS			
862	GPS			
863	GPS			
865	GPS			
866	GPS			
868	GPS			
870[a]	VHF			
871	GPS			
873	GPS			
874	GPS			
876	GPS			
878	GPS			
884	GPS			
886	VHF			
887	GPS			
889[b]	GPS			
892	VHF			
905[a]	VHF			
989	VHF			
VHF = 22 GPS = 24 Total = 46			VHF = 13 GPS = 10 Total = 23	

[a] Radio-collars left over from Phase I (Sawyer and Lindzey 2001).
[b] Missing and not included in survival analysis

2.4.2 GPS Data Collection

We collected data from 17 GPS collars following the 2004-05 winter, including 16 that were released on April 15, 2005 and one (#8.74) that was recovered from a dead deer in early April. One collar (#8.89) that was supposed to be released in 2005 could not be located. Of the 17 collars obtained this year, 10 (#844, #855, #862, #864, #866, #867, #868, #870, #884, and #887) contained data for consecutive winters (2003-04 and 2004-05).

Of the 17 collars that were retrieved, all functioned properly and collected the expected number of locations. Consistent with GPS performance in previous years (Sawyer et al. 2004), success rates for GPS fix attempts were very high (99%) and locations precise (88% 3-D locations). A minimum of four satellites are needed to generate 3-D locations, which typically have less than 20-meter error (Di Orio et al. 2003).

2.4.3 Winter Movement and Distribution Patterns

2.4.3.1 Treatment Area (Mesa):

We mapped GPS locations collected from 10 deer that used the Mesa during the 2004-05 winter (Figure 2.4). Data from 8 additional deer were not mapped because their collars will not be recovered until April 15, 2006. Distribution and movement patterns were variable among deer, and generally, deer shifted areas of use through the winter and utilized a large portion of the Mesa.

Figure 2.5 includes locations (r = 3,657) from all 10 deer and illustrates the importance of BLM lands to this mule deer population. Boundaries between private and BLM lands generally correspond with habitat type and topography; with private lands consisting of flat river bottoms and agricultural areas, whereas BLM lands contain sagebrush hills in drier, more rugged terrain. Mule deer demonstrated a strong affinity to the sagebrush-dominated BLM lands.

Consistent with previous years, all deer traveled to the Cora Butte area via the Trapper's Point Bottleneck (TPB) (Sawyer and Lindzey 2001, Sawyer et al. 2004). Figure 2.5 clearly defines the TPB, located 7 miles west of Pinedale, near the junction of US 191, WYO 352, and CR 110. Sawyer and Lindzey (2001) defined bottlenecks as *"those areas along migration routes where topography, vegetation, development and/or other landscape features restrict animal movements to narrow or limited regions."* Bottlenecks create management concerns because the potential to disrupt or threaten established migratory routes are much greater in these areas. This naturally-occurring bottleneck is approximately 1 mile in width and length, restricted to the southwest by the Green River riparian complex and to the northeast by the New Fork/Duck Creek riparian complex. Sagebrush habitats north and south of US 191 are used extensively by mule deer during certain times of the year (Sawyer and Lindzey 2001). Mule deer use the narrow strip of sagebrush connecting the two areas to cross US 191. Development of small, fenced house lots adjacent to BLM lands has narrowed the effective width of the TPB to < ½ mile.

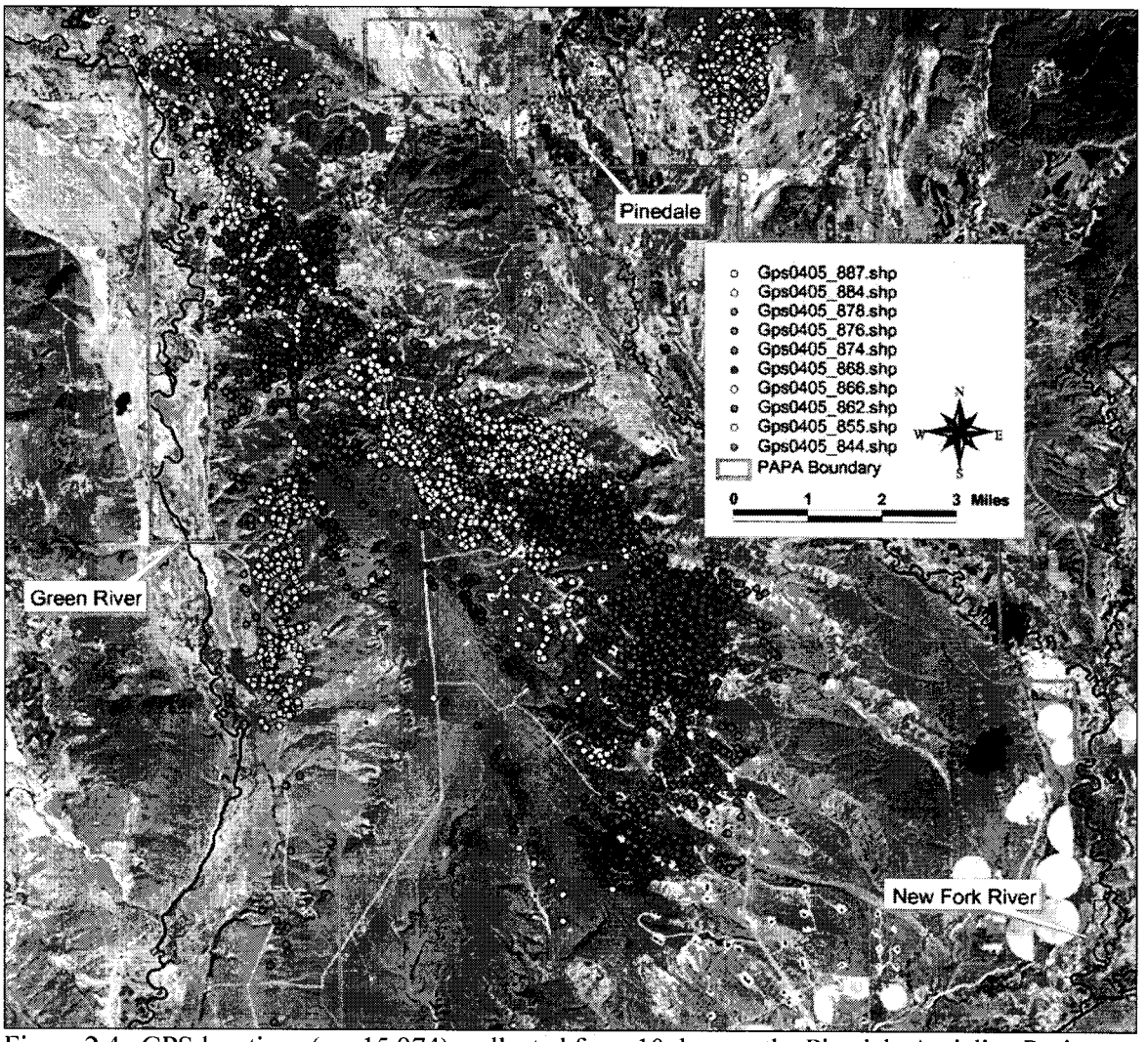

Figure 2.4. GPS locations (r = 15,974) collected from 10 deer on the Pinedale Anticline Project Area (PAPA), November 1, 2004 – April 15, 2005, overlaid on satellite image taken August 28, 2004.

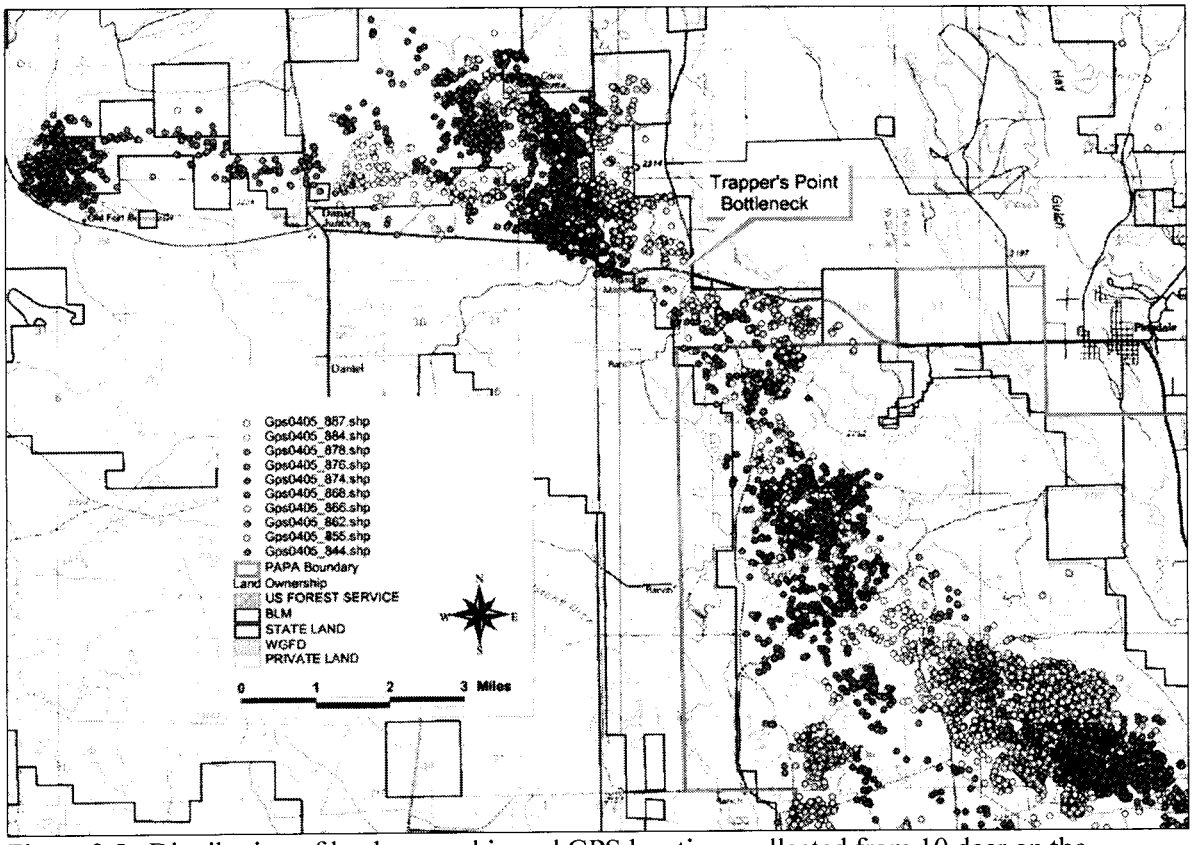

Figure 2.5. Distribution of land ownership and GPS locations collected from 10 deer on the Pinedale Anticline Project Area (PAPA), November 1, 2004 – April 15, 2005.

Several unusual movement events were documented from GPS collars recovered this spring. First, was Deer #862 (Figure 2.6) that was captured on the Mesa on December 18, 2003. Deer #862 moved around the Mesa for 3 weeks after capture, then left the project area and migrated 20-25 miles southwest. This deer spent the remaining winter months in a different winter range characterized by sagebrush draws and located near the Calpet Road, south of Big Piney. In the spring of 2004 this deer used the same migration route to move back through the western edge of the Mesa, through the TPB, and onto summer ranges. This deer returned in the fall of 2004 through the TPB, but did not move into the central portion of the Mesa, rather it moved quickly down the western edge and returned to the Big Piney winter range via the migration route it used the year before. Interestingly, in the spring of 2005, this deer used a different migration route between Big Piney and the Mesa. Deer #862 was the first GPS-collared deer to have left the Mesa and on moved on to a different winter range.

The second unusual movement was that of Deer #887 (Figure 2.7), captured on the Mesa on December 18, 2003. Deer #887 occupied the western breaks of the Mesa during the 2003-04 winter and migrated through the TPB in the spring of 2004 on its way to summer range. However, in the fall of 2004, this deer returned to the Mesa via the typical Pinedale Front migration route that runs along the base of the Wind River Range. And then in the spring of 2005, Deer #887 again migrated off the Mesa through the TPB. Of all the GPS-collared deer (>50) we've monitored on the Mesa in the last 5 years, Deer #887 was the first to and from summer ranges using both Trapper's Point and the Pinedale Front migration routes.

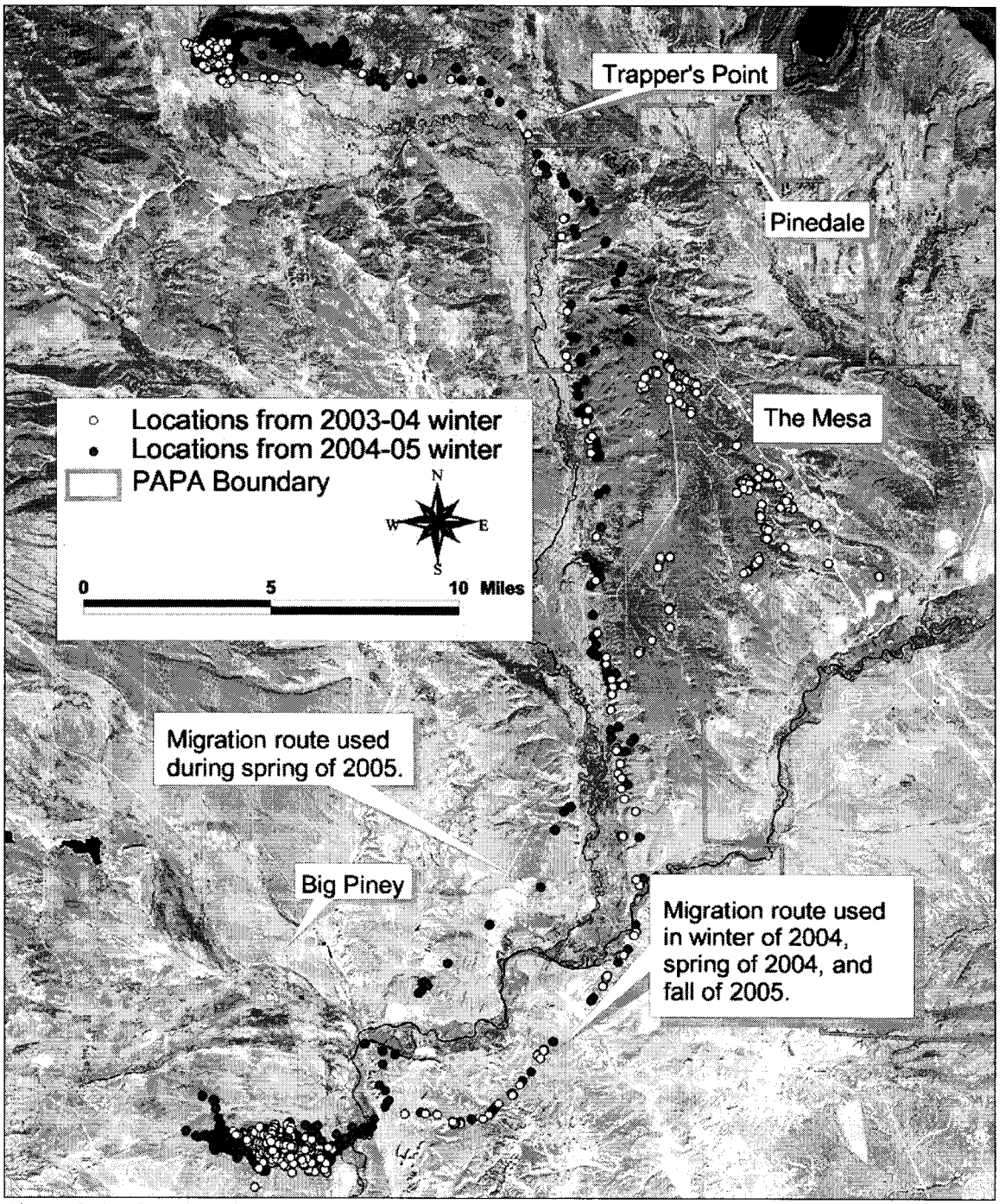

Figure 2.6 GPS locations (r = 2,253) of deer #862 in the Pinedale Anticline Project Area (PAPA), December 18, 2003 – April 15, 2004 (yellow) and November 1, 2004 – April 15, 2005 (blue).

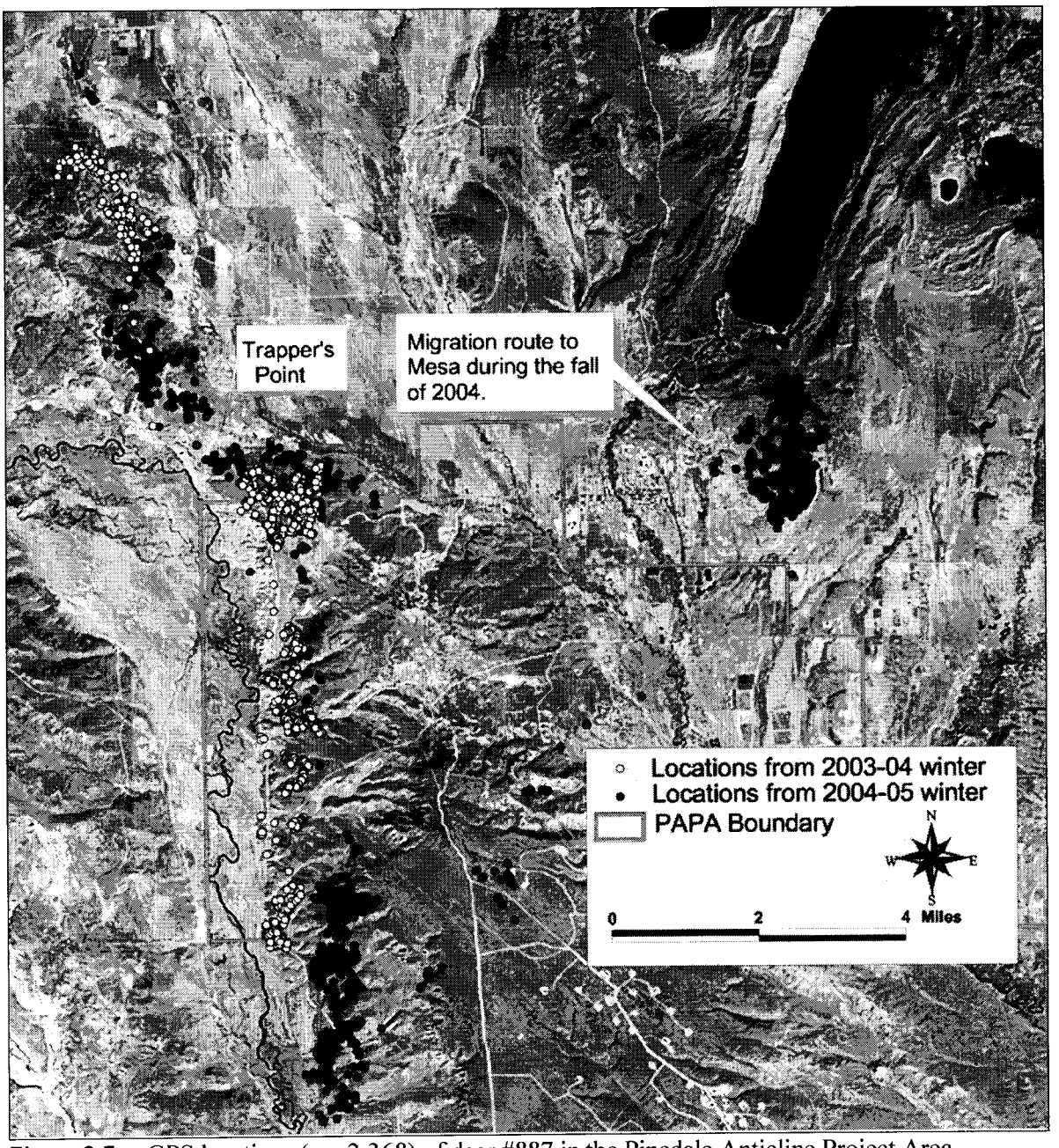

Figure 2.7 GPS locations (r = 2,368) of deer #887 in the Pinedale Anticline Project Area (PAPA), December 21, 2003 – April 15, 2004 (yellow) and November 1, 2004 – April 15, 2005 (blue).

2.4.3.2 Control Area (Pinedale Front):

We mapped GPS locations collected from 7 deer that used the Pinedale Front during the 2004-05 winter (Figure 2.8). Data from 3 additional deer were not mapped because their collars will not be recovered until April 15, 2006.

Consistent among deer was their mobility and tendency to shift areas of use through the winter, utilizing areas that exceeded 100-mi^2. And, similar to previous years (Sawyer et al. 2004), deer moved outside the core winter range area around Buckskin Crossing to peripheral areas, such as Elk Mountain, Little Sandy Creek, and areas along the west side of the Prospects. While distribution patterns of deer were variable across the winter range, the migratory routes to and from the winter range were nearly identical among deer (Figure 2.9).

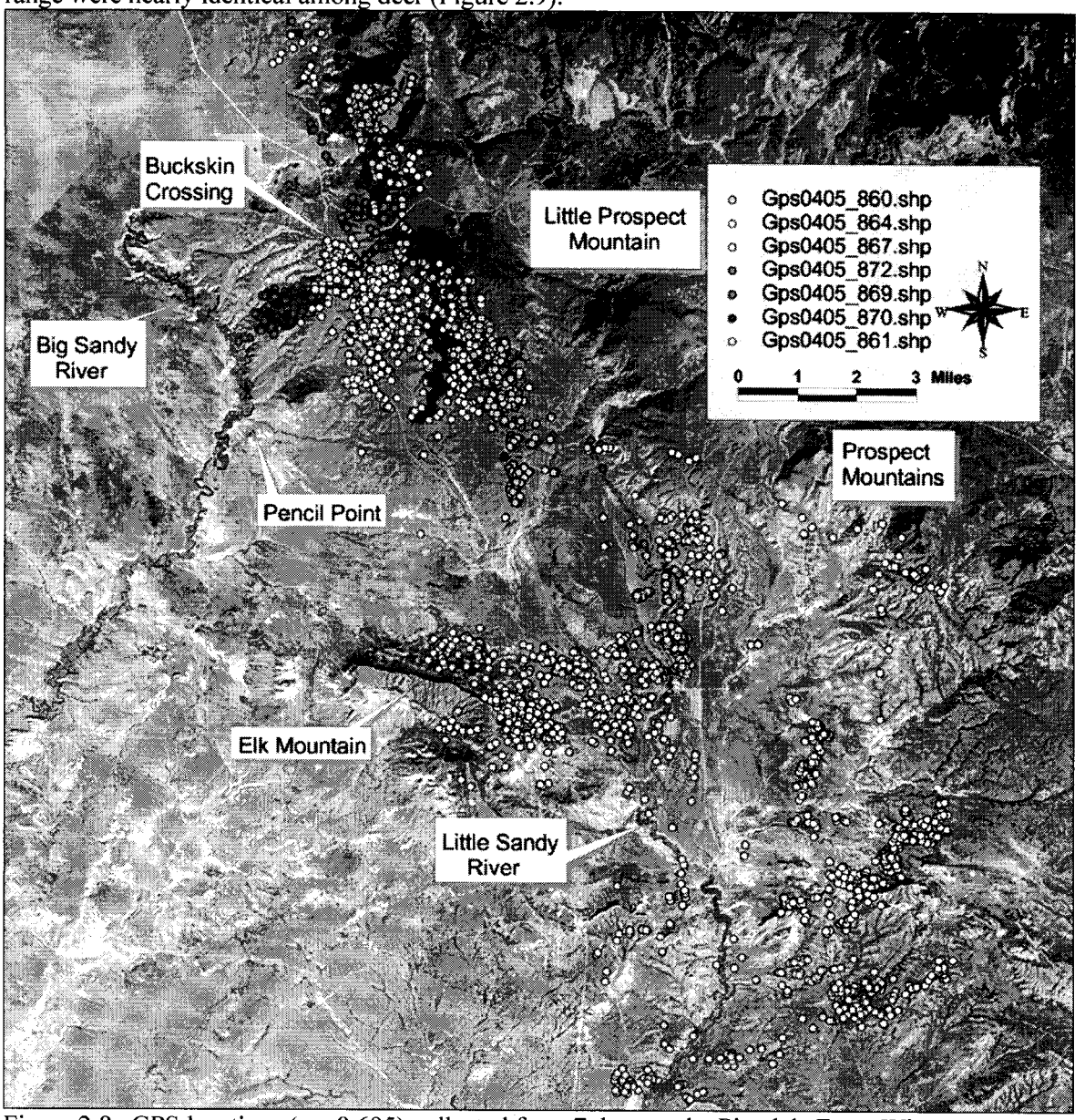

Figure 2.8. GPS locations (r = 8,695) collected from 7 deer on the Pinedale Front Winter Range Complex (PFWRC), November 1, 2004 – April 15, 2005.

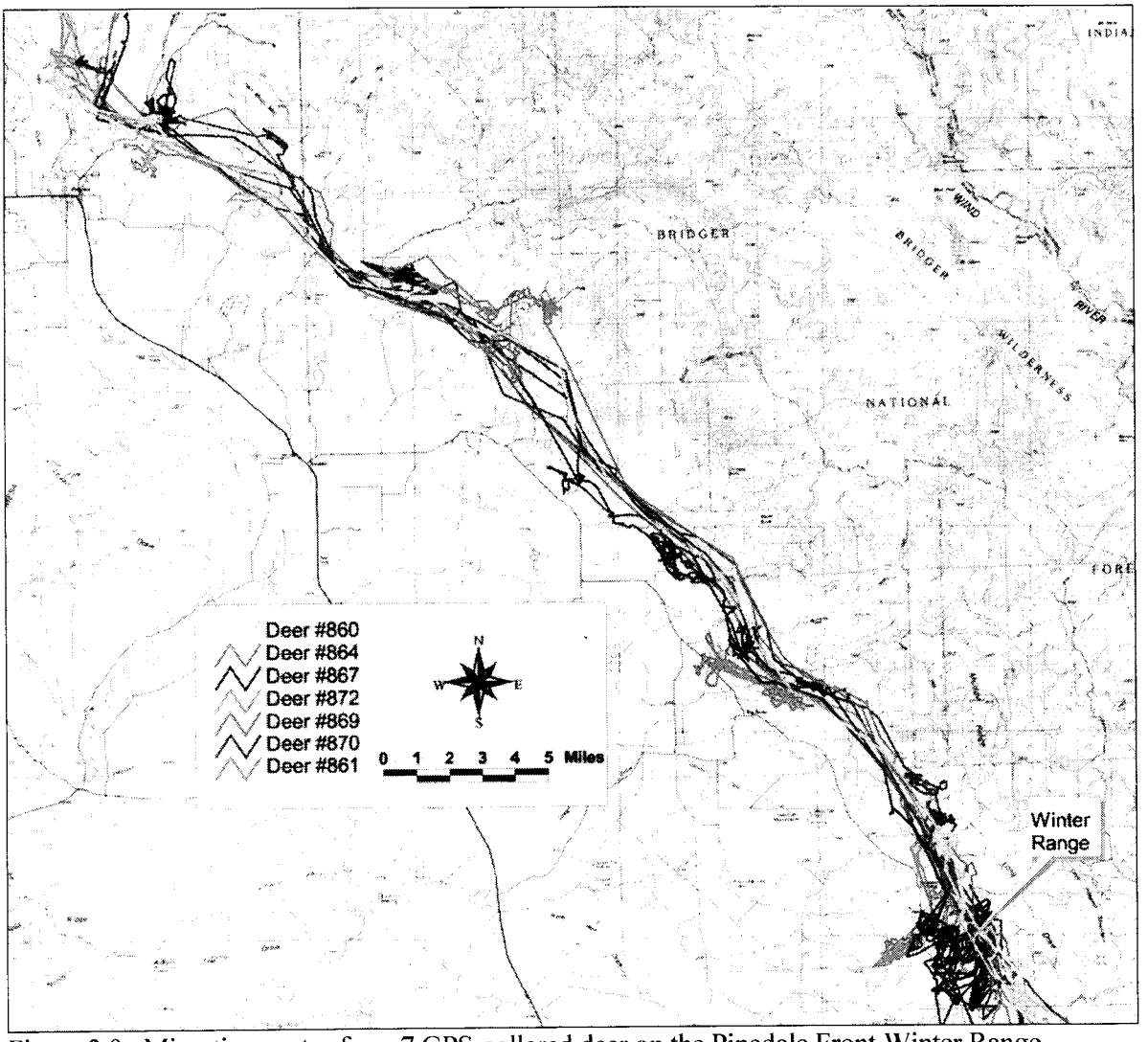

Figure 2.9. Migration routes from 7 GPS-collared deer on the Pinedale Front Winter Range Complex (PFWRC), November 1, 2004 – April 15, 2005.

Most deer began migrating north along the Pinedale Front in mid-March. Deer that winter along the Pinedale Front were known to migrate northerly along the Wind River Range to the New Fork Lake area before shifting their migration in a westerly route towards the Hoback Basin and adjacent mountain ranges (Sawyer and Lindzey 2001). Details of this migration route, in terms of size, width, specific location, and deer fidelity were unknown prior to GPS data collected over the last 3 years. Consistent with the last 2 years, all 7 GPS-collared deer migrated along a distinct 50-mile movement corridor located at the base of the Wind River Range. While deer sometimes remained in one area for a number of days, they appeared to follow a well-defined route that narrowed to ¼-mile in some areas (i.e., Boulder Lake, Fremont Lake), but rarely exceeded 1-2 miles in width (Figure 2.9).

The migration route leads deer north from the Buckskin Crossing area, across the Big Sandy River, then northerly across the sagebrush flats below Sheep Creek and Muddy Creek. Deer then moved into slightly rougher terrain among the boulders and sagebrush draws east of CR 353,

south of the East Fork, and west of Irish Canyon. Deer then moved northerly, crossing the East Fork and Pocket Creek approximately 2-3 miles east of CR 353. Once across Pocket Creek, deer contoured through the sagebrush slopes and aspen pockets, northerly through Cottonwood Creek and Silver Creek. From Silver Creek, deer continued northwesterly across Lovett and Scab Creek. Deer continued to contour across the sagebrush slopes below Soda Lake, towards the outlet of Boulder Lake. Deer crossed Boulder Creek near the outlet of Boulder Lake, and then moved north to Fall Creek, apparently to avoid an agricultural area between Fall Creek and Pole Creek. Deer crossed Fall Creek just below the confluence of Meadow Creek, and then moved northwesterly toward the outlet of Fremont Lake. Deer crossed Pine Creek at the Fremont Lake Bottleneck, as described by Sawyer and Lindzey (2001), and continued north along the Willow Creek Road and Fremont Ridge. Deer moved within ½-mile either side of the Willow Lake Road from Soda Lake to the outlet of Willow Lake.

2.4.4 Population Characteristics

2.4.4.1 Abundance and Density Estimates

Helicopter flights were conducted on February 23-24, 2005 to count deer in selected 1-mi^2 quadrats of both treatment and control areas. Average flight time per quadrat was 10 minutes. Estimated deer abundance ($\hat{N}$) in the treatment area was 2,818 ± 536 and deer density ($\hat{D}$) was 41 ± 8 deer/mi^2 (Table 2.2, Figure 2.10). Deer abundance and density in the treatment area were lower than previous years. Estimated deer abundance ($\hat{N}$) in the control area was 4,281 ± 723 and deer density ($\hat{D}$) was 61 ± 10 deer/mi^2 (Table 2.3, Figure 2.11). Abundance and density estimates for the control area were significantly higher than last year, but have been variable since 2002. Because the sampling frame in the control area did not reflect the area utilized by our marked population prior to 2004, abundance and density estimates are expected to be biased high during 2002 and biased low during 2003.

We used the abundance estimates from 2002 through 2005 to fit weighted least-squares regression lines (Figures 2.10 and 2.11) and test whether or not the lines (i.e., trend) had slopes that differed from zero. The regression equation for the treatment area was: Y = 5335 – 845(yr[a]). The line from this equation had an R^2 of 98.5% and a slope that was significantly different from zero (t = -12.67, P = 0.006), indicating a declining deer population through the course of study. The negative slope and associated coefficient indicates deer abundance decreased at an average rate of 845 animals per year between 2002 and 2005, resulting in a 4-year 46% reduction. The regression equation for the control area was: Y = 1685 + 582(yr). The line from this equation had an R^2 of 26.6% and a slope that was not significantly different from zero (t = 0.85, P = 0.484), indicating that the estimated positive trend was not statistically significant. A comparative test between the trend lines from the control and treatment areas, indicated the trends (i.e., slopes) were not statistically different at a 90% confidence level (t = -1.989, P = 0.117, df =4), but would be considered different at a confidence level ≤ 88%.

[a] yr = year of study (i.e., 0, 1, 2, 3)

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Table 2.2 Summary statistics for abundance and density estimates in the treatment area, February 2002 - 2005.

Summary Statistics	**Treatment Area** (The Mesa)			
Year	***2002***	***2003***	***2004***	***2005***
Total Quadrats (U)	68	66	68	68
Quadrats Sampled (u)	18	32	34	34
Deer Counted (N)	1,384	2,267	1,782	1,409
Density Estimate ($\hat{D}$)	***77***	***71***	***52***	***41***
Variance ($V\hat{a}r(\hat{D})$)	146	87	34	23
Standard Error ($SE(\hat{D})$)	12.07	9.30	5.82	4.79
90% Confidence Interval	(57, 97)	(56, 86)	(42, 62)	(33, 49)
Abundance Estimate($\hat{N}$)	***5,228***	***4,676***	***3,564***	***2,818***
Variance ($V\hat{a}r(\hat{N})$)	673863	377132	156318	106246
Standard Error ($SE(\hat{N})$)	821	614	395	326
90% Confidence Interval	(3,878 - 6,578)	(3,666 - 5,686)	(2,914 - 4,214)	(2,282 - 3,354)
Coefficient of Variation ($CV(\hat{N})$)	16%	13%	11%	12%

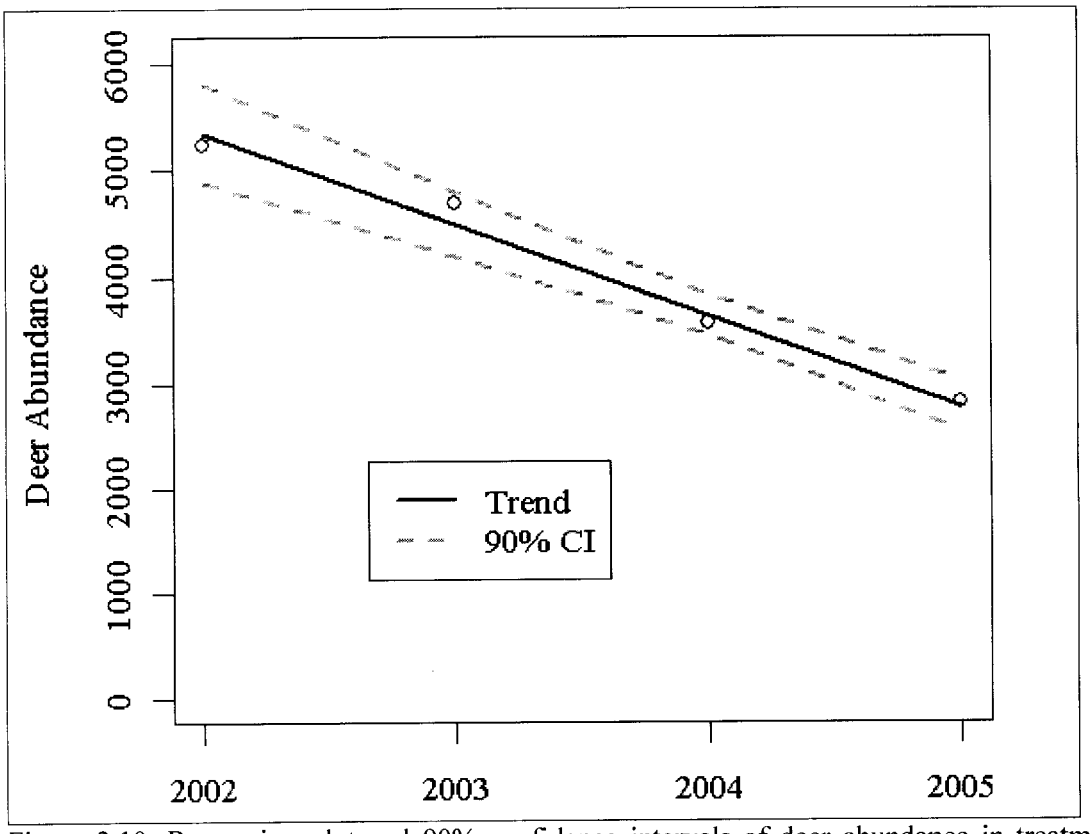

Figure 2.10. Regression plot and 90% confidence intervals of deer abundance in treatment area (Mesa), February 2002 – 2005.

Table 2.3 Summary statistics for abundance and density estimates in the control area, February 2002 - 2005.

Summary Statistics	**Control Area** (Pinedale Front)			
Year	***2002***[a]	***2003***[b]	***2004***	***2005***
Total Quadrats (U)	35	38	70	70
Quadrats Sampled (u)	7	18	34	33
Deer Counted (N)	810	849	1,171	2,018
Density Estimate ($\hat{D}$)	***116***	***47***	***34***	***61***
Variance ($\hat{Var}(\hat{D})$)	406	64	22	39
Standard Error ($SE(\hat{D})$)	20.14	8.01	4.70	6.28
90% Confidence Interval	(83, 149)	(31, 63)	(26, 42)	(51, 71)
Abundance Estimate($\hat{N}$)	***4,050***	***1,792***	***2,411***	***4,281***
Variance ($\hat{Var}(\hat{N})$)	496,752	92,661	108,347	193,294
Standard Error ($SE(\hat{N})$)	705	304	329	440
90% Confidence Interval	(2,891 - 5,209)	(1,291 - 2,293)	(1,870 - 2,952)	(3,558 - 5,004)
Coefficient of Variation ($CV(\hat{N})$)	17%	17%	14%	10%

[a] Abundance and density estimates expected to be high.
[b] Abundance and density estimates expected to be low.

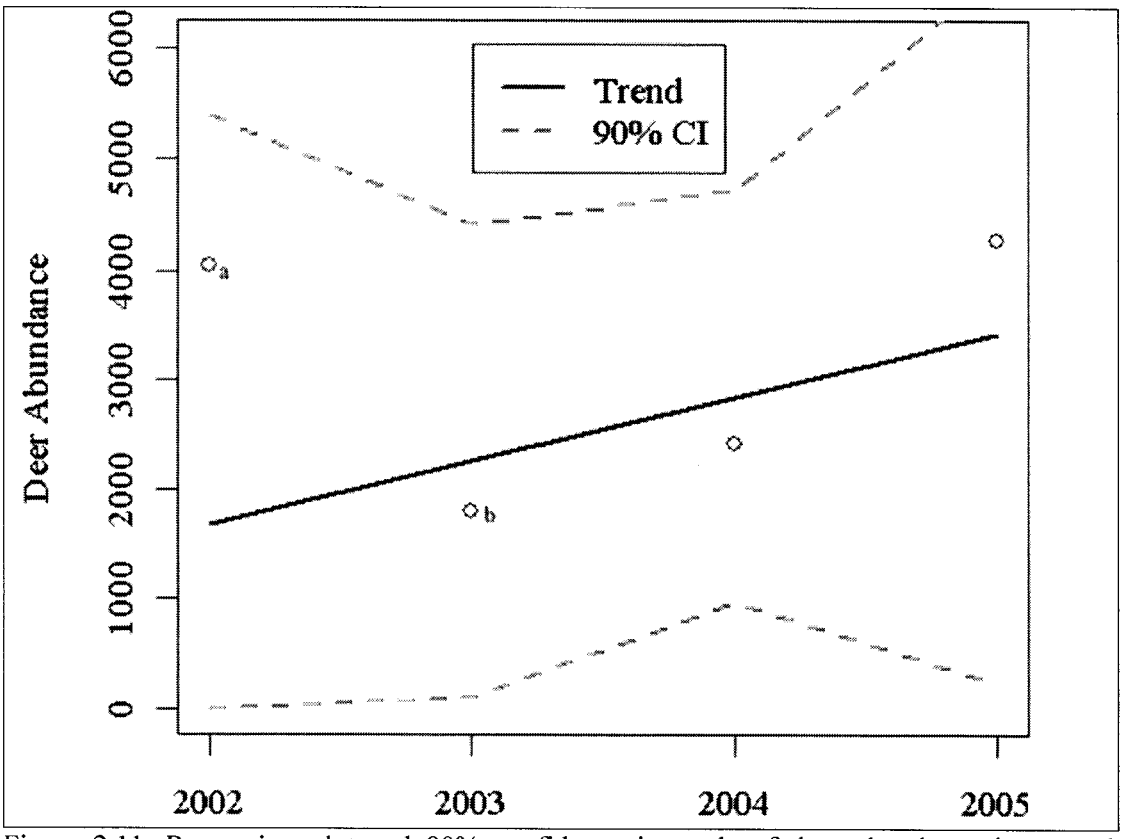

Figure 2.11. Regression plot and 90% confidence intervals of deer abundance in control area (Pinedale Front), February 2002 – 2005.

2.4.4.2 Reproduction

Year	Treatment fawn:doe December	Control fawn:doe December
Pre-Development Phase		
1992-93	62	61
1993-94	47	51
1994-95	61	72
1995-96	56	63
1996-97	73	75
1997-98	92	81
1998-99	67	76
1999-00	85	76
Average	**68**	**69**
Development Phase		
2000-01	85	81
2001-02	69	71
2002-03	64	65
2003-04	78	78
2004-05	68	69
Average	**73**	**73**

The WGFD conducted helicopter composition (buck:doe:fawn) surveys to collect pre-winter (December) information on the sex (i.e., buck or doe) and age (i.e., fawn or adult) structure of the population. A total of 8,622 deer were classified in December of 2004, including 3,345 on the Mesa Winter Range Complex and 5,277 on the Pinedale Front Winter Range Complex (S. Smith, WGFD, unpublished data). Estimated fawn:doe ratios were 68:100 for the Mesa and 69:100 in the Pinedale Front (Table 2.4). Both areas have displayed similar trends in reproduction (fawn:doe ratios) prior to and since the PAPA ROD in 2000 (Figure 2.12).

Table 2.4 (Left)
Mule deer fawn:doe ratios measured for treatment (Mesa) and control (Pinedale Front) areas by Wyoming Game and Fish Department, 1992-2005.

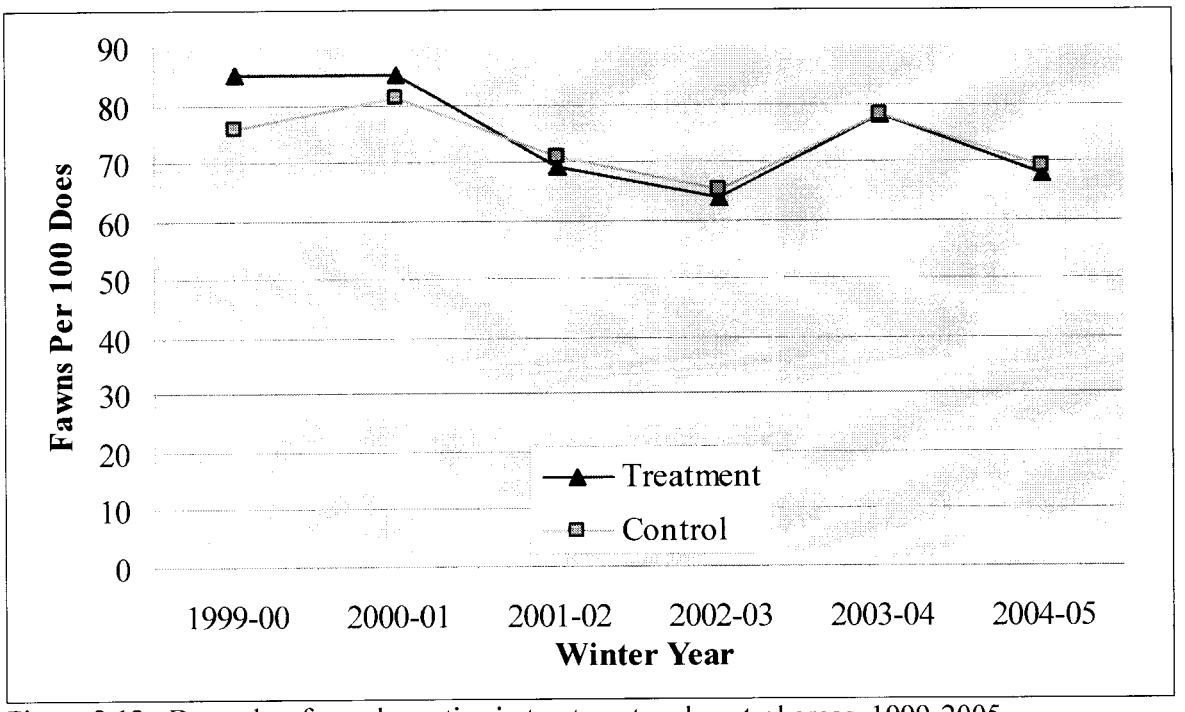

Figure 2.12 December fawn:doe ratios in treatment and control areas, 1999-2005.

2.4.4.3 Over-winter Fawn Survival

The WGFD conducted ground-based composition (adult:fawn) surveys to estimate post-winter fawn:adult ratios during April of 2005 (S. Smith, WGFD, unpublished data). A total of 2,252 and 2,024 deer were counted in the Pinedale Front and Mesa winter ranges, respectively (Tables 2.5-2.6). Estimates of over-winter fawn survival were 0.79 and 0.64 in the Pinedale Front and Mesa, respectively (Tables 2.5-2.6). Except for the relatively severe 2003-04 winter (Photo 2.1), over-winter fawn survival has generally been lower in the treatment area (Mesa) compared to the control (Pinedale Front), since the PAPA ROD in 2000 (Figure 2.13).

Table 2.5 Mule deer count data and calculations for over-winter fawn survival in the control (Pinedale Front), 1999-2005.

Year	December Adults	December Fawns	April Adults	April Fawns	A*	B**	$\hat{S}_a$	$\hat{S}_f$
1999-00	2,698	1,517	959	494	0.56	0.52	0.83	0.76
2000-01	2,853	1,769	955	478	0.62	0.50	0.85	0.69
2001-02	4,593	2,455	790	300	0.53	0.38	0.85	0.60
2002-03	3,565	1,813	704	254	0.51	0.36	0.96	0.68
2003-04	3,977	2,463	1771	441	0.62	0.25	0.82	0.33
2004-05	3,394	1,883	1565	687	0.55	0.44	1.0	0.79

* A = count of December fawns/count of December adults
** B = count of April fawns/count of April adults

Table 2.6 Mule deer count data and calculations for over-winter fawn survival in the treatment (Mesa), 1999-2005.

Year	December Adults	December Fawns	April Adults	April Fawns	A	B	$\hat{S}_a$	$\hat{S}_f$
1999-00	2,550	1,547	1,390	764	0.61	0.55	0.82	0.74
2000-01	2,420	1,458	1,685	707	0.60	0.42	0.85	0.59
2001-02	2,546	1,275	1,366	460	0.50	0.34	0.85	0.57
2002-03	1,864	914	1,489	470	0.49	0.32	0.88	0.57
2003-04	2,063	1,201	1,215	319	0.58	0.26	0.79	0.36
2004-05	2,162	1,183	1,477	547	0.55	0.37	0.95	0.64

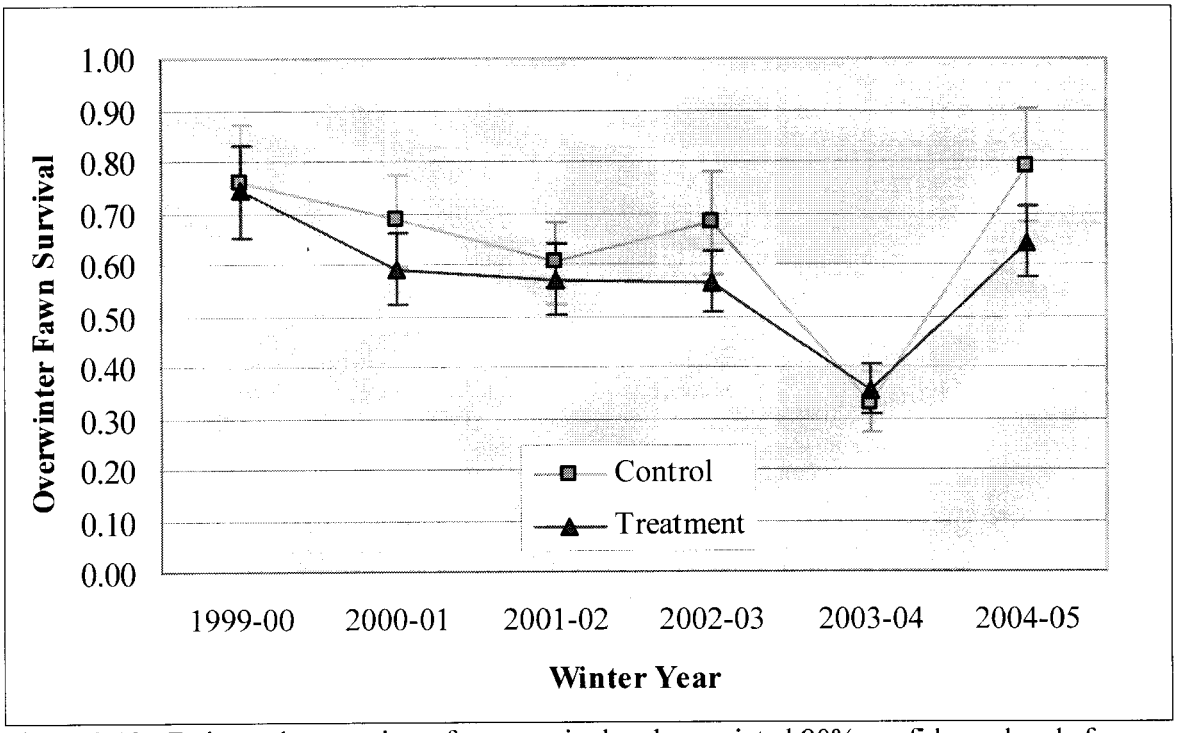

Figure 2.13 Estimated over-winter fawn survival and associated 90% confidence bands for treatment and control areas, 1999-2005.

2.4.4.4 Adult Winter Survival

Winter (December 15 – April 15) survival rates were estimated using the telemetry records of 67 radio-collared adult female deer, including 45 in the treatment and 22 in the control area. Two radiocollared deer (#874, #505) died in the treatment and none in the control. Both deer that died in the treatment were in poor body condition and starvation appeared to be the cause of death. Winter survival rates were 0.95 and 1.00 for the treatment and control areas, respectively (Table 2.7, Figure 2.14). It is worth noting that one deer (#804) from the control died in early November 2004, however she was not included in this survival analysis because her death occurred outside the December 15 – April 15 period that we used to estimate winter survival. Because standard methods cannot be used to compute a standard error or confidence interval for a proportion equal to 1.0, we used a one-sided binomial hypothesis test (Lehmann 1986:93) to estimate the standard error in Table 2.5. The estimated standard error (0.07) is larger than estimates from previous years and should be considered conservative. The high adult survival rates corresponded with a relatively mild winter, compared with 2003-04 (Photos 2.1 and 2.2).

Table 2.7 Winter (2004-05) survival rates and summary statistics for adult female radio-collared deer in treatment and control areas.

Study Area	Time Period	N_1	N_2	$\hat{S}$	90% CI	SE
Pinedale Anticline (Treatment)	December 15, 2004 - April 15, 2005	45	2	0.95	0.91 to 0.99	0.03
Pinedale Front (Control)	December 15, 2004 - April 15, 2005	22	0	1.0	0.91 to 1.0	0.07

N_1=number of available collars, N_2=number of deaths, $\hat{S}$ =survival estimate, CI=confidence interval

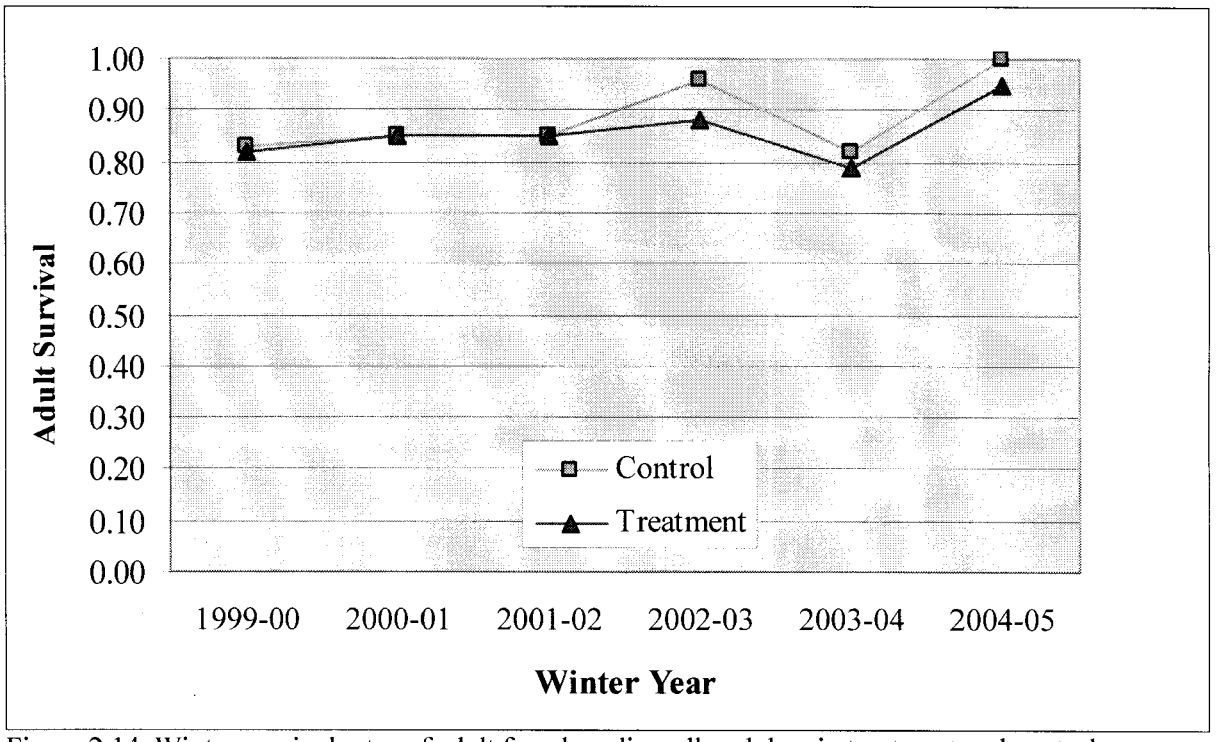

Figure 2.14 Winter survival rates of adult female radio-collared deer in treatment and control areas, 1999-2005.

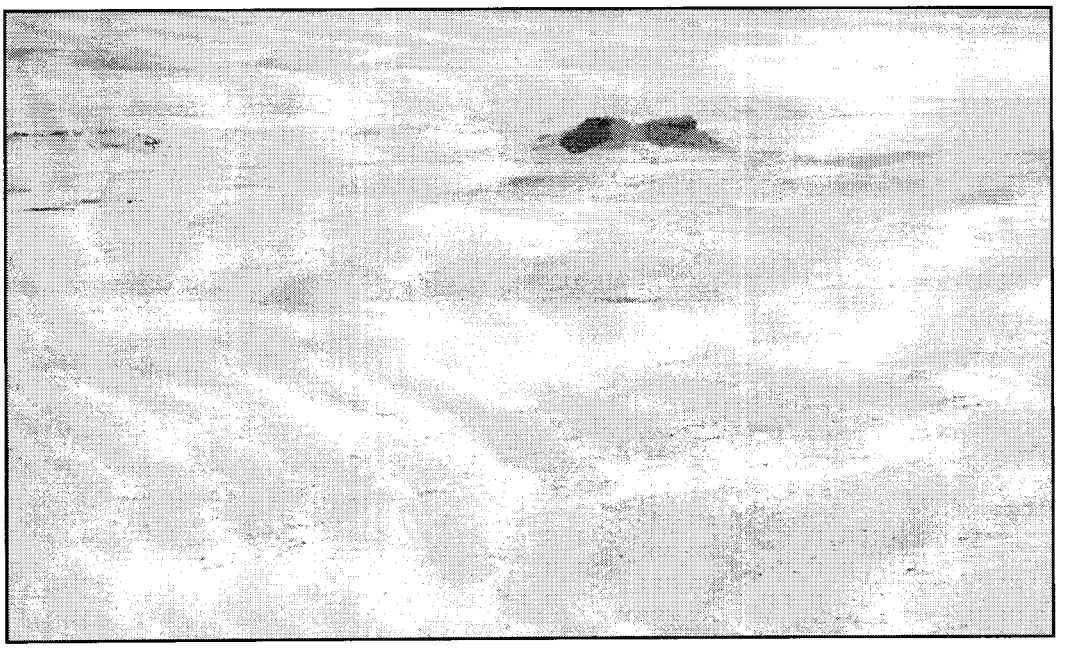

Photo 2.1 Snow conditions on Mesa during February 2004 (view south towards Two Buttes).

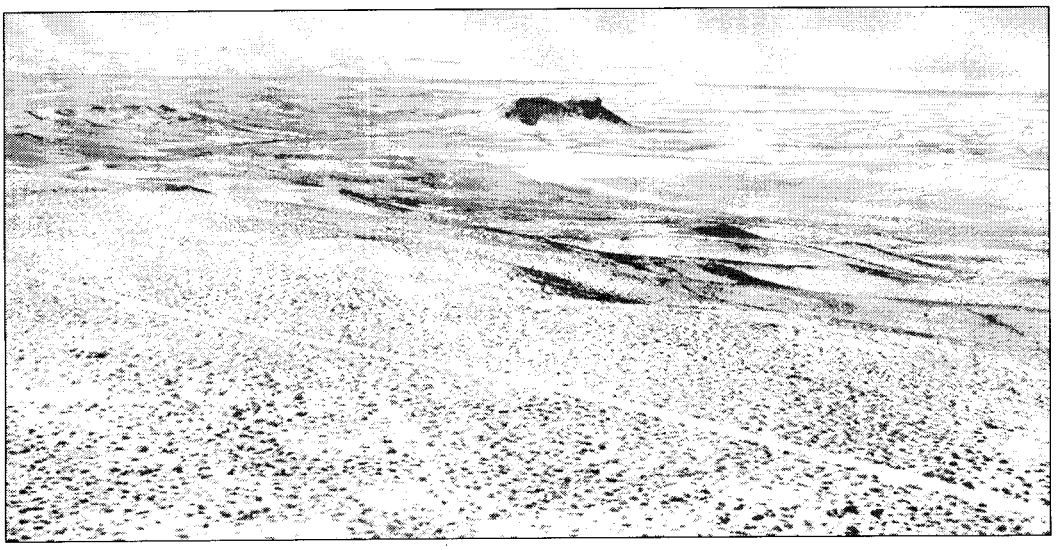

Photo 2.2. Snow conditions on Mesa during February 2005 (view south towards Two Buttes).

2.4.5 Direct Habitat Loss

2.4.5.1 Pre-Development

Prior to development, The Mesa portion of the PAPA was relatively undisturbed, with very few improved roads and approximately a dozen existing well pads (Figure 2.15).

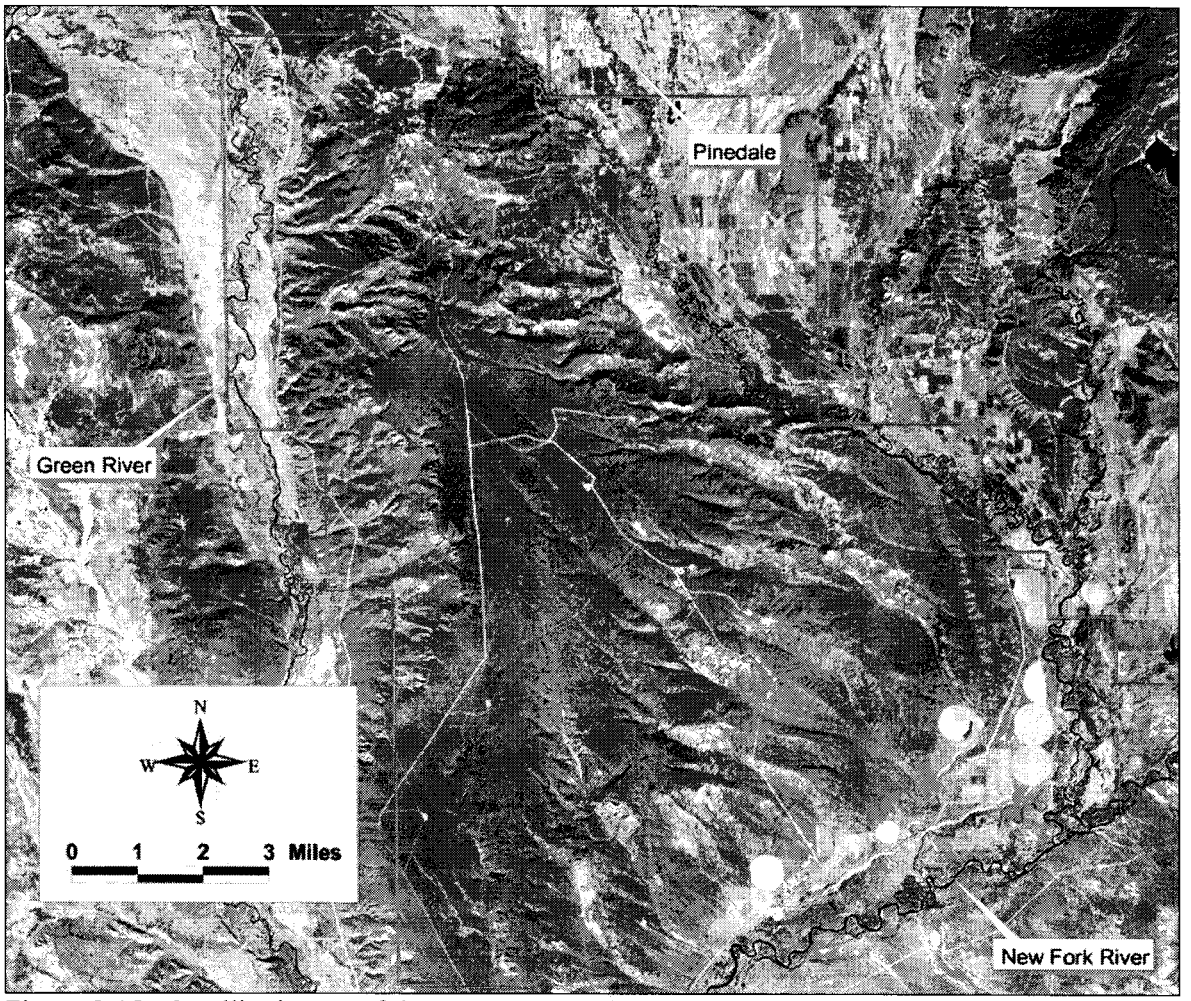

Figure 2.15 Satellite image of the Mesa on October 1999, prior to development of the Pinedale Anticline Project Area (PAPA).

2.4.5.2 Year 1 of Development

The BLM's ROD for the PAPA was released in July, 2000. Accordingly, natural gas development was minimal during this year. Approximately 11 miles of new roads and 39 acres of well pads were constructed on the Mesa during 2000 (Table 2.8). Approximately 51% of total surface disturbance was associated with road building, while the other 49% was attributed to well pad construction (Table 2.8).

2.4.5.3 Year 2 of Development

2001 marked the first full calendar year of gas field development in the PAPA. Most development occurred along the central portion of the Mesa, adjacent to Lovatt Draw (Figure 2.16). Based on satellite imagery, approximately 13 miles of new roads and 113 acres of well pads were constructed on the Mesa during the first nine months 2001 (Table 2.8). Approximately 30% of total surface disturbance was associated with road building, while the other 70% was attributed to well pad construction (Table 2.8).

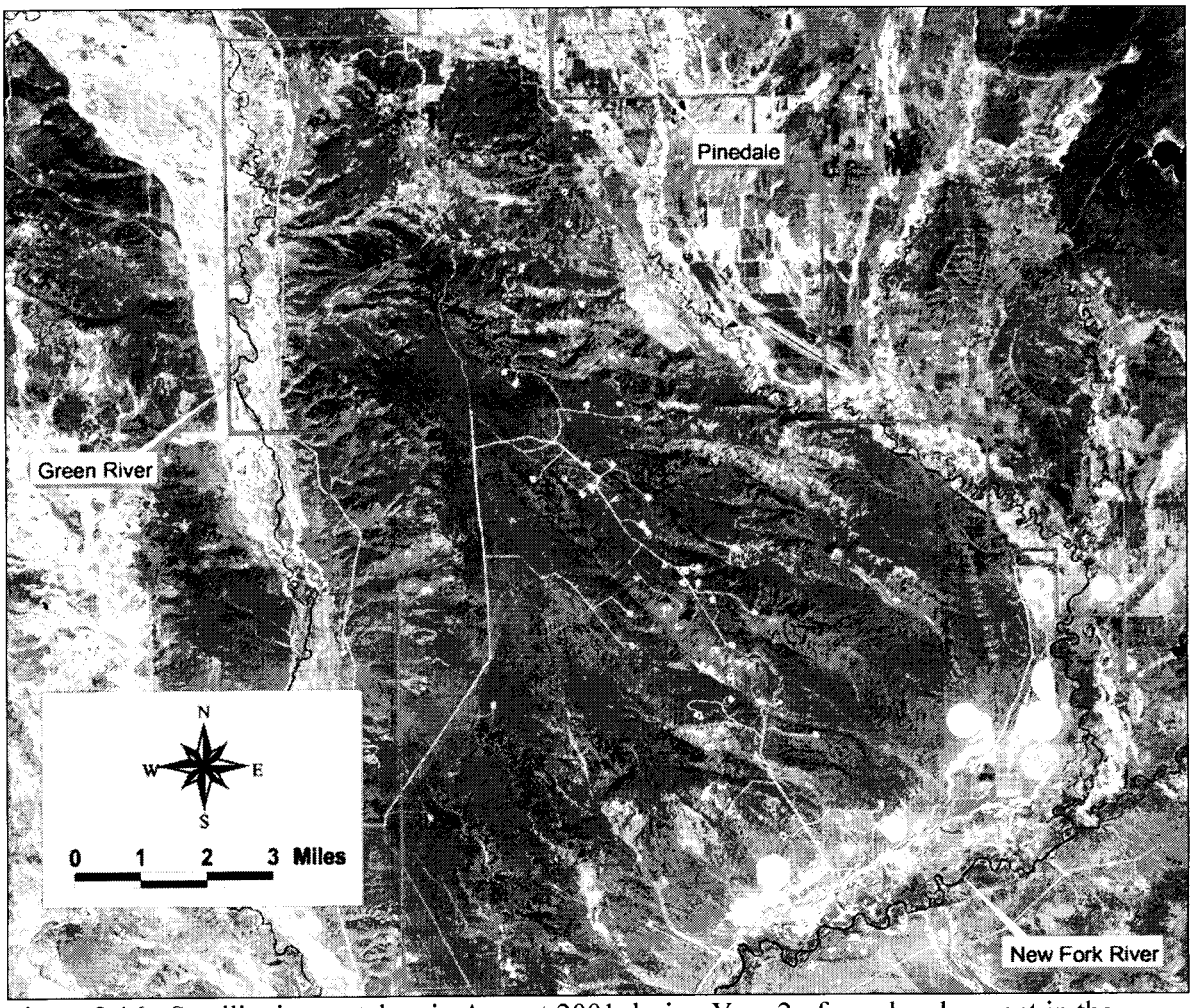

Figure 2.16 Satellite image taken in August 2001 during Year 2 of gas development in the Pinedale Anticline Project Area (PAPA).

2.4.5.4 Year 3 of Development

Similar to 2001, most development in 2002 occurred along the central portion of the Mesa, adjacent to Lovatt Draw, from the Paradise Road northwest to Stewart Point (Figure 2.17). Drilling activity was also evident on the northern Mesa, east of Stewart Point. Based on satellite imagery, approximately 18 miles of new roads and 201 acres of well pads were constructed on the Mesa between August 2001 and October 2002 (Table 2.8). Approximately 25% of total surface disturbance was associated with road building, while the other 75% was attributed to well pad construction (Table 2.8).

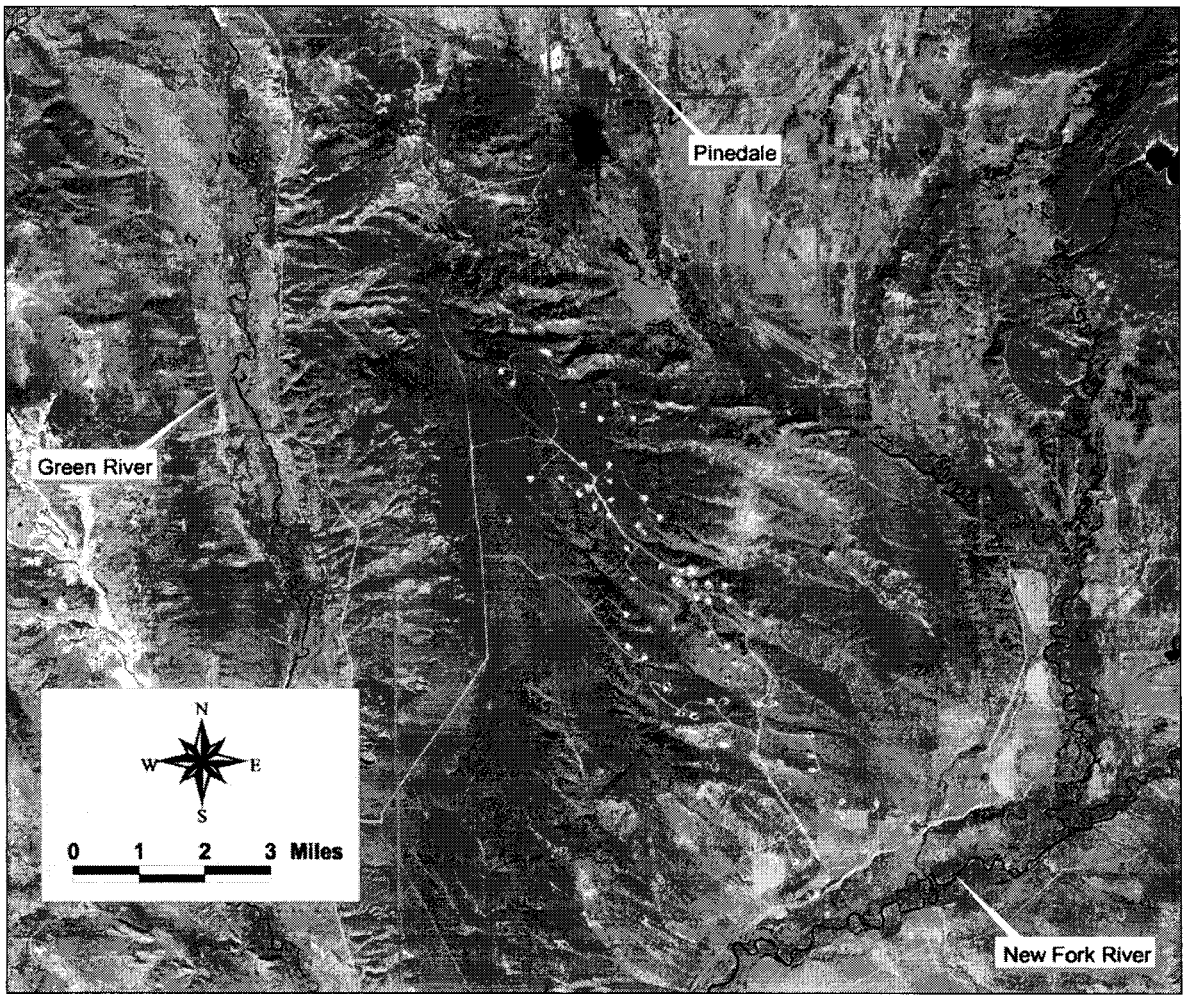

Figure 2.17 Satellite image taken in October 2002 during Year 3 of gas development in the Pinedale Anticline Project Area (PAPA).

2.4.5.5 Year 4 of Development

Similar to 2001 and 2002, most gas development in 2003 occurred along the central portion of the Mesa, adjacent to Lovatt Draw, from the Paradise Road northwest to Stewart Point (Figure 2.18). Drilling activity was also evident on the northern Mesa, east of Stewart Point. Based on satellite imagery, approximately 14 miles of new roads and 237 acres of well pads were constructed on the Mesa between October 2002 and September 2003 (Table 2.8). Approximately 18% of total surface disturbance was associated with road building, while the other 82% was attributed to well pad construction (Table 2.8).

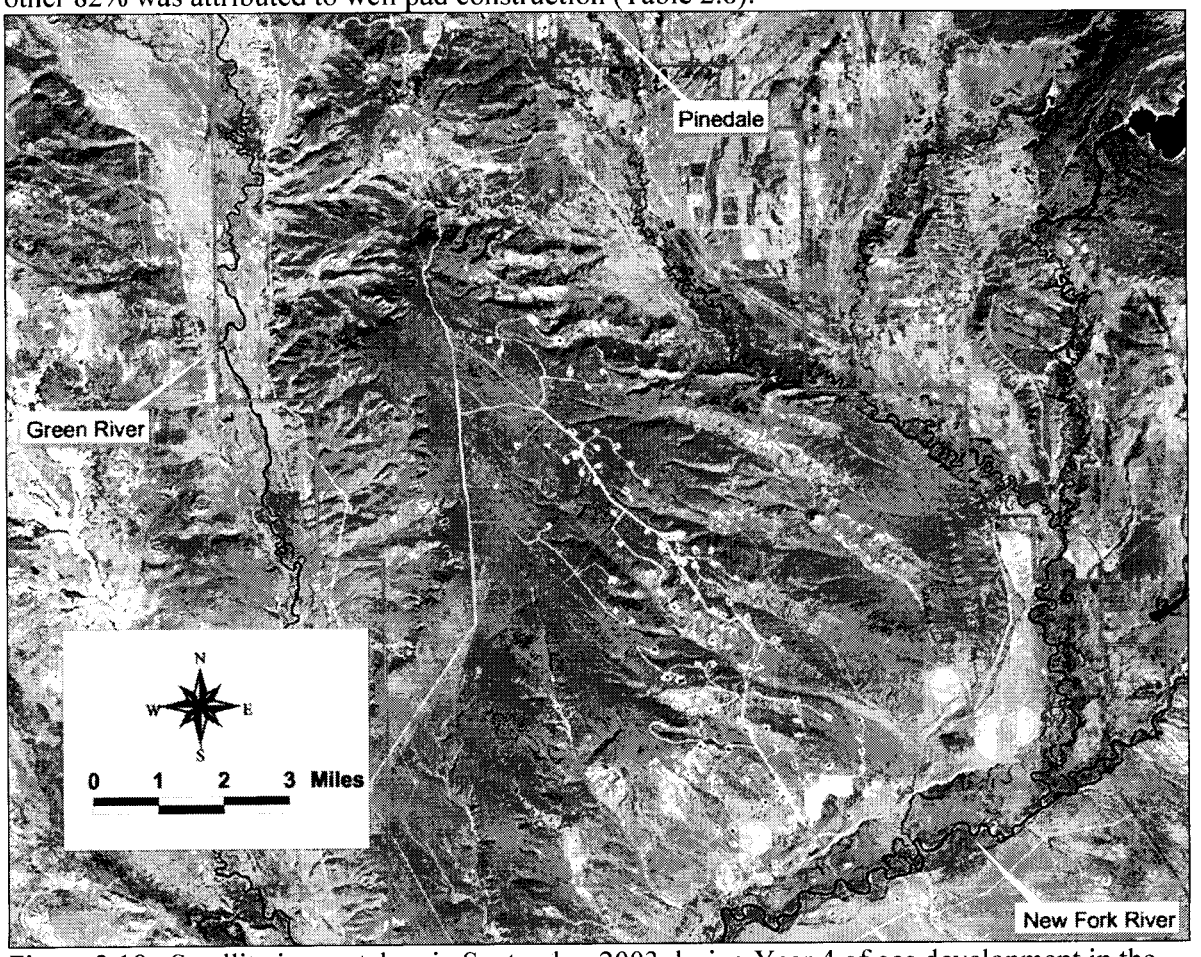

Figure 2.18 Satellite image taken in September 2003 during Year 4 of gas development in the Pinedale Anticline Project Area (PAPA).

2.4.5.5 Year 5 of Development

Similar to 2001-2003, most gas development in 2004 occurred along the central portion of the Mesa, adjacent to Lovatt Draw, from the Paradise Road northwest to Stewart Point (Figure 2.19). Drilling activity was also evident on the northern Mesa, east of Stewart Point. Based on satellite imagery, approximately 3 miles of new roads and 221 acres of well pads were constructed on the Mesa between September 2003 and August 2004 (Table 2.8). Approximately 5% of total surface disturbance was associated with road building, while the other 95% was attributed to well pad construction (Table 2.8).

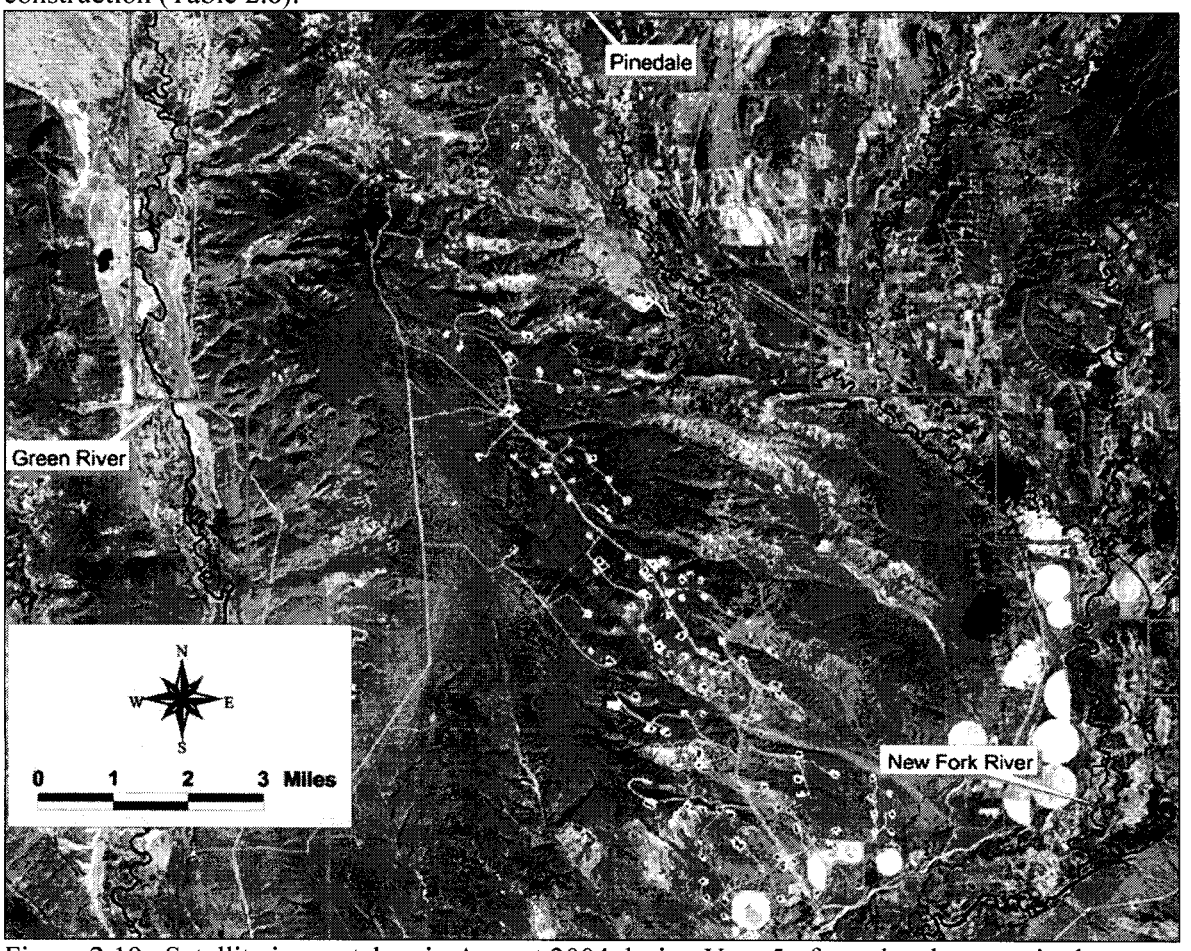

Figure 2.19 Satellite image taken in August 2004 during Year 5 of gas development in the Pinedale Anticline Project Area (PAPA).

Table 2.8 Summary of annual and cumulative direct habitat loss (i.e., surface disturbance) associated with road networks and well pads on the Mesa, 2000-2004.

Year	Roads (mi)	Roads (acres)[a]	Well Pads (acres)	Total (acres)	% Roads	% Well Pads
2000	11.4	41	39	80	51%	49%
2001	13.1	48	113	161	30%	70%
2002	18.1	66	201	267	25%	75%
2003	13.9	51	237	288	18%	82%
2004	3.2	12	221	233	5%	95%
Total	59.7	218	811	1,029	21%	79%

[a] Based on an average road width of 30 feet.

2.4.6 Resource Selection

Population-level models (Table 2.9) and predictive maps (Figures 2.20-2.24) were estimated for five winter periods: Pre-Development (Winters 1998-99 and 1999-00), Year 1 of Development (Winter 2000-01), Year 2 of Development (Winter 2001-02), Year 3 of Development (Winter 2002-03), and Year 4 of Development (Winter 2003-04).

2.4.6.1 Pre-Development: Winters 1998-99 and 1999-00

The population–level RSPF was estimated from 953 VHF deer locations collected from 45 adult female mule deer during the winters (1 December to 15 April) of 1998–99 and 1999–00 (Table 2.9). Units with the highest probability of use (Figure 2.20) had an average elevation of 2,265 m, an average slope of 5 degrees, and an average road density of 0.14 km/km^2. Aspects with the highest probability of use were northwest and southwest.

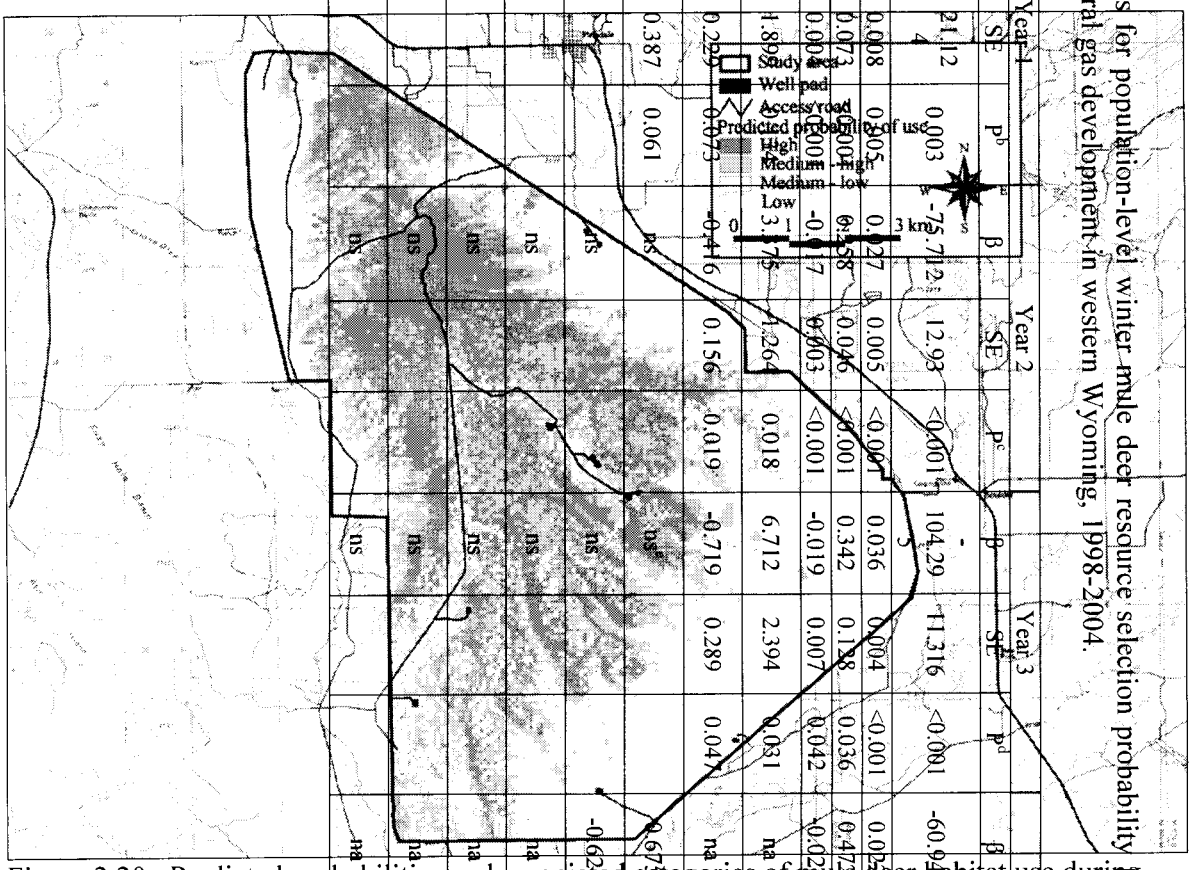

Figure 2.20. Predicted probabilities and associated categories of mule deer habitat use during 1998-99 and 1999-2000 winters, prior to natural gas field development in western Wyoming.

Table 2.9. Habitat variables and coefficients for population-level winter mule deer resource selection probability functions (RSPF) before and during 4 years of natural gas development in western Wyoming, 1998-2004.

Variable	Pre-Development			Year 1			Year 2			Year 3			Year 4		
	β	SE	P^b	β	SE	P^c	β	SE	P^d	β	SE	P^d	β	SE	P^d
Intercept	-12.929	6.637	<0.001	-75.712	21.112	0.003	12.93	<0.001	104.29	-11.316	<0.001	-60.9	13.117	<0.001	
Elevation	0.005	0.001	<0.001	0.027	0.008	0.005	0.005	<0.001	0.036	0.004	<0.001	0.02	0.006	0.003	
Slope	0.068	0.010	<0.001	0.058	0.073	0.002	0.046	<0.001	0.342	0.138	0.036	0.472	0.078	<0.001	
Slope^2	-0.004	0.001	<0.001	-0.017	0.003	0.001	-0.003	<0.001	-0.019	0.007	0.042	-0.02	0.005	<0.001	
Well distance			na	1.264	1.829	na	0.018		6.712	2.394	0.031	na			
Well distance^2	-0.465	0.156	na	-0.416	0.073	0.225	-0.019	-0.719	0.289	0.041	na				
Road density	0.024	0.387	ns	0.061	0.387	ns		ns		ns		0.67	0.615	0.299	
Road density^2	-0.224		ns			ns		ns		ns		-0.62	0.128	<0.001	
Aspect = NE	0.013		ns			ns		ns		ns		na			
Aspect = NW	0.038		ns			ns		ns		ns		na			
Aspect = SE	0.222		ns			ns		ns		ns		na			
Aspect = SW	0.024		ns			ns		ns		ns		na			

2.4.6.2 Year 1 of Development: Winter 2000-01

Individual models were estimated for 10 radiocollared deer during the winter (1 January to 15 April) of 2000–01. Eight of the ten deer had positive coefficients for elevation and negative coefficients for road density, indicating selection for higher elevations and low road densities. Based on the relationship between the linear and quadratic terms for slope and distance to well pad variables, all 10 deer selected for moderate slopes and 7 of 10 deer selected areas away from well pads.

The population–level RSPF was estimated from 18,706 GPS locations collected from 10 radiocollared deer during the winter of 2000–01 (Table 2.9). The RSPF included elevation, slope, road density, and distance to well pad (Table 2.9). Deer selected for areas with higher elevations, moderate slopes, low road densities, and away from well pads. Habitat units with the highest probability of use (Figure 2.21) had an average elevation of 2,266 m, slope of 5 degrees, road density of 0.16 km/km^2, and were 2.7 km away from the nearest well pad. Predictive maps indicate probability of deer use was lowest in areas close to well pads and access roads (Figure 2.21). Shifts in deer distribution between pre-development and Year 1 of development were evident through the changes in the 4 deer use categories (Table 2.10). Of the habitat units classified as high deer use prior to development, only 60% were classified as high deer use during Year 1 of development. Of the areas classified as low deer use prior to development, 58% remained classified as low deer use during Year 1 of development.

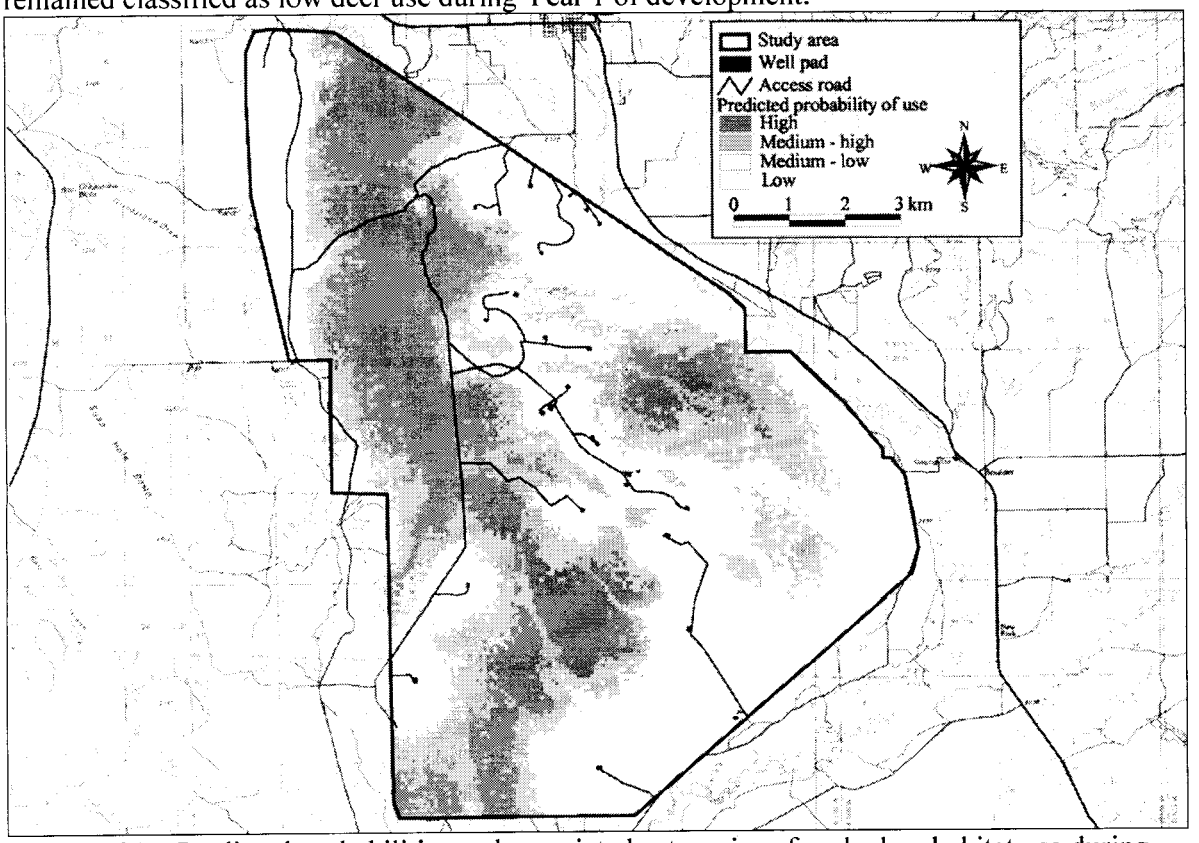

Figure 2.21. Predicted probabilities and associated categories of mule deer habitat use during Year 1 (winter of 2000-01) of natural gas development in western Wyoming.

2.4.6.3 Year 2 of Development: Winter 2001-02

Individual models were developed for 15 radiocollared deer during the winter (4 January to 15 April) of 2001–02. Fourteen of the 15 deer had positive coefficients for elevation, indicating selection of higher elevations. Based on the relationship between the linear and quadratic terms for slope and distance to well pad variables, all 15 deer selected for moderate slopes and 12 of 15 deer selected areas away from well pads.

The population–level RSPF was estimated from 14,851 GPS locations collected from 15 radiocollared deer during the winter of 2001–02 (Table 2.9). The RSPF included elevation, slope, and distance to well pad (Table 2.9). Deer selected for areas with higher elevations, moderate slopes, and away from well pads. Habitat units with the highest probability of use (Figure 2.22) had an average elevation of 2,255 m, slope of 5 degrees, and were 3.1 km away from the nearest well pad. Predictive maps indicate probability of deer use was lowest in areas close to well pads (Figure 2.22). Shifts in deer distribution between pre-development, Year 1, and Year 2 of development were evident through the changes in the 4 deer use categories (Table 2.10). Of the habitat units classified as high deer use prior to development, only 49% were classified as high deer use during Year 2 of development. Of the areas classified as low deer use prior to development, 48% remained classified as low deer use during Year 2 of development.

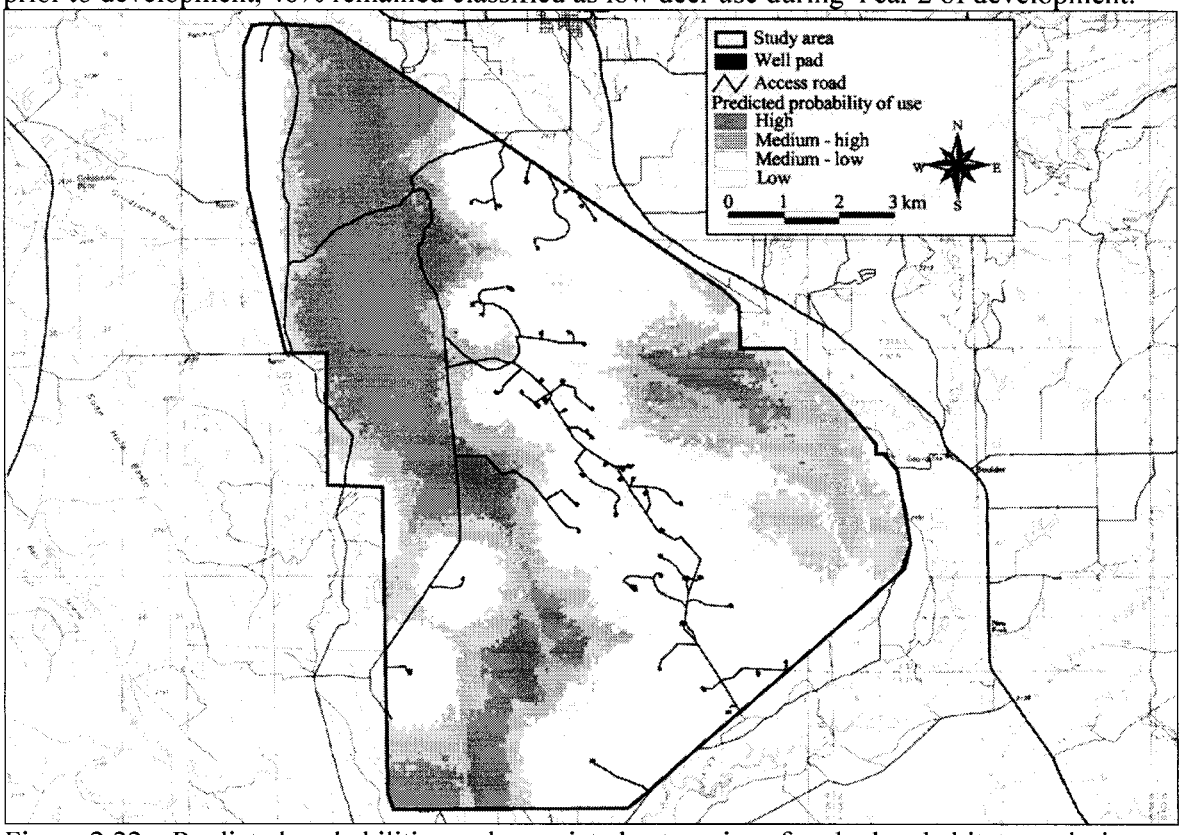

Figure 2.22. Predicted probabilities and associated categories of mule deer habitat use during Year 2 (winter of 2001-02) of natural gas development in western Wyoming.

2.4.6.4 Year 3 of Development: Winter 2002-03

Individual models were developed for 7 radiocollared deer during the winter (20 December to 15 April) of 2002–03. All 7 deer had positive coefficients for elevation, indicating selection of higher elevations. Based on the relationship between the linear and quadratic terms for slope and distance to well pad variables, 6 of 7 deer selected for moderate slopes and 6 of 7 deer selected areas away from well pads.

The population–level RSPF was estimated from 5,131 GPS locations collected from 7 radiocollared deer during the winter of 2002–03 (Table 2.9). Our target sample of 10 marked animals was not met because 3 deer died early in the season. The RSPF included elevation, slope, and distance to well pad (Table 2.9). Deer selected areas with high elevations, moderate slopes, and away from well pads. Habitat units with the highest probability of use (Figure 2.23) had an average elevation of 2,233 m, slope of 5 degrees, and were 3.7 km away from the nearest well pad. Predictive maps indicate probability of deer use was lowest in areas close to well pads (Figure 2.23). Shifts in deer distribution between pre-development, Year 1, Year 2, and Year 3 of development were evident through the changes in the 4 deer use categories (Table 2.10). Of the habitat units classified as high deer use prior to development, only 37% were classified as high deer use during Year 3 of development. Of the areas classified as low deer use prior to development, 41% remained classified as low deer use during Year 3 of development.

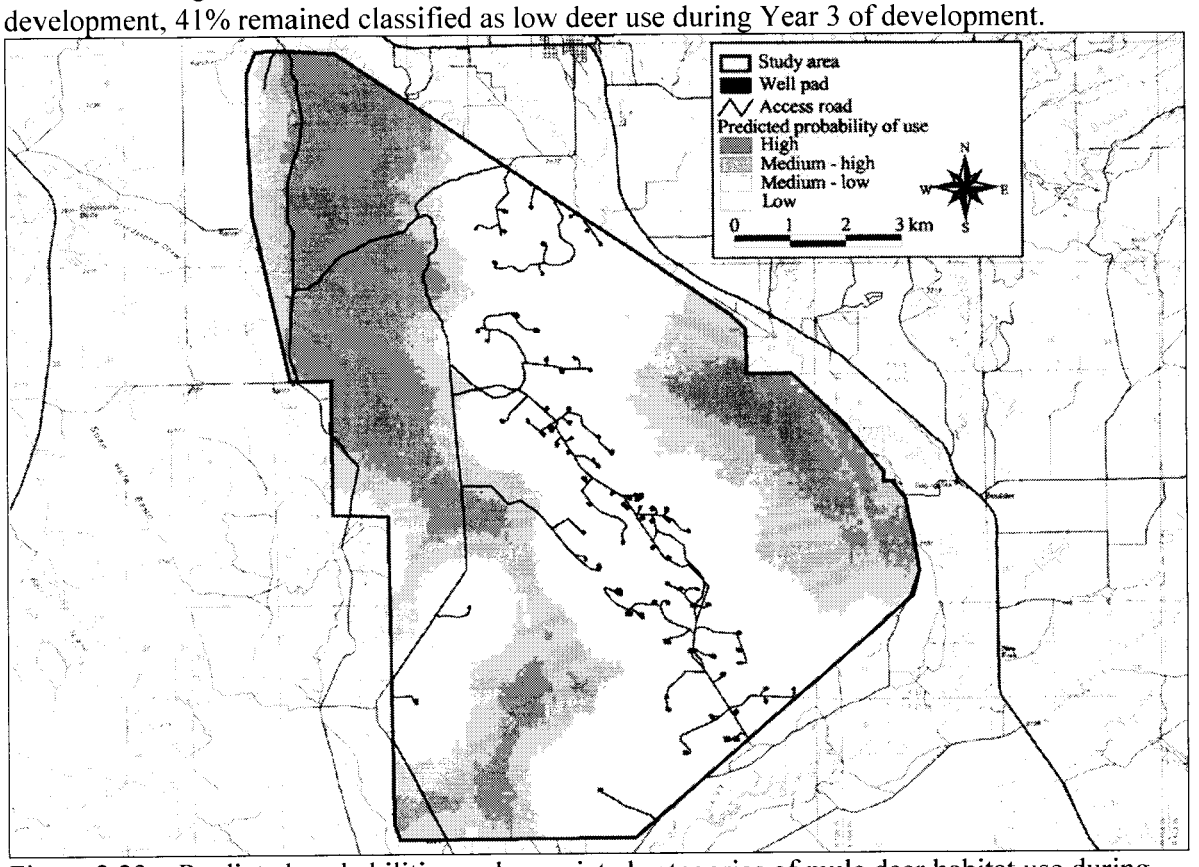

Figure 2.23. Predicted probabilities and associated categories of mule deer habitat use during Year 3 (winter of 2002-03) of natural gas development in western Wyoming.

2.4.6.5 Year 4 of Development: Winter 2003-04

Individual models were estimated for 11 radiocollared deer during the winter (20 December to 15 April) of 2003–04. Nine of eleven deer had positive coefficients for elevation, indicating selection for higher elevations. Based on the relationship between the linear and quadratic terms for slope and road density variables, 10 deer selected for moderate slopes and all 11 deer selected areas with low road density.

The population–level RSPF was estimated from 12,207 GPS locations collected from 11 radiocollared deer during the winter of 2003–04 (Table 2.9). The RSPF included elevation, slope, and road density (Table 2.9). Deer selected for areas with higher elevations, moderate slopes, and low road densities. Habitat units with the highest probability of use (Figure 2.24) had an average elevation of 2,276 m, slope of 8 degrees, and road density < 1.2 km/km^2. Predictive maps indicate probability of deer use was lowest in areas with high road densities and areas along the peripheral of the study area (Figure 2.24). Aside from the areas with high road densities, the probability of deer use between pre-development and Year 4 of development was more similar than during Years 1-3 of development, as evidenced through the changes in the 4 deer use categories (Table 2.10). Of the habitat units classified as high deer use prior to development, 71% were classified as high deer use during Year 4 of development. And, of the areas classified as low deer use prior to development, 77% remained classified as low deer use during Year 4 of development.

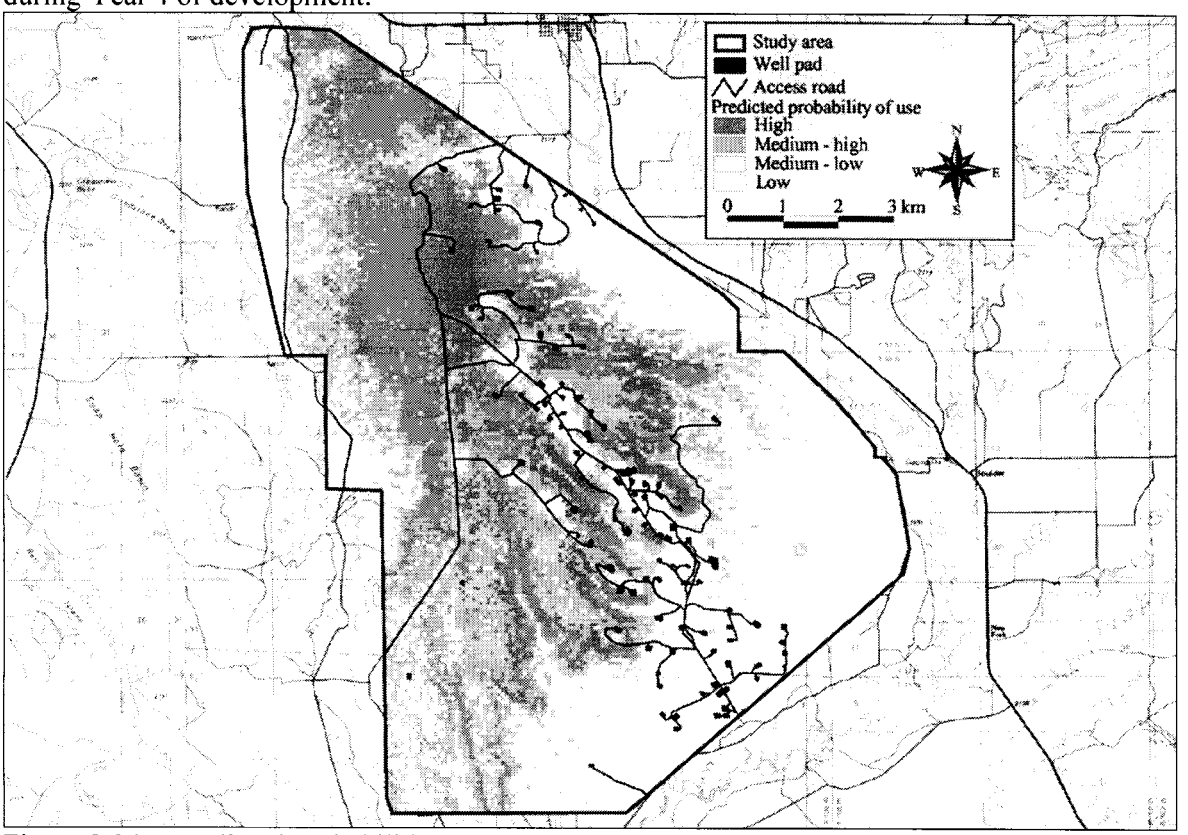

Figure 2.24. Predicted probabilities and associated categories of mule deer habitat use during Year 4 (winter of 2003-04) of natural gas development in western Wyoming.

Table 2.10 Percent change in the 4 pre-development deer use categories through 4 years of natural gas development in western Wyoming.

Pre-development category[a]	Year of development	High	Medium-High	Medium-Low	Low
High	Year 1	60%	23%	13%	4%
	Year 2	49%	19%	23%	9%
	Year 3	37%	22%	27%	14%
	Year 4	71%	23%	3%	2%
Medium-High	Year 1	31%	36%	22%	11%
	Year 2	34%	23%	25%	18%
	Year 3	27%	22%	28%	22%
	Year 4	25%	49%	22%	4%
Medium-Low	Year 1	9%	34%	31%	26%
	Year 2	16%	35%	25%	25%
	Year 3	25%	27%	25%	23%
	Year 4	4%	26%	53%	17%
Low	Year 1	0%	7%	34%	58%
	Year 2	1%	23%	27%	48%
	Year 3	11%	29%	20%	41%
	Year 4	0%	2%	22%	77%

[a] Category rows may not sum to exactly 100% because of rounding error

2.5 DISCUSSION

Currently, we collect 25,000 to 30,000 locations per year from 20 GPS-collared deer and approximately 400 locations from 40 VHF radio-collared deer. In previous years, the GPS collection schedule has been restricted to the winter (1 November – 15 April) however, beginning in 2005 we deployed new collars that will collect GPS locations on a year-around basis. These data will add to our knowledge of migration routes and seasonal distribution patterns of the Sublette mule deer herd. We plan to continue equipping deer with GPS collars for consecutive years. Although data analysis is delayed a full year when GPS collars operate on the same deer for two consecutive years, acquiring movement and distribution information from the same animal over a period of years provides useful year-to-year comparisons. For example, during the 2002-03 winter we were able to demonstrate that deer on the Mesa wintered farther north than in previous years. And, during the harsh 2003-04 winter we were able to document weather-related shifts in distribution. And, for the last several years we were able to illustrate the strong annual fidelity that deer have for the 50-mile migration route along the Pinedale Front. Additionally, as levels of development continue to increase in the PAPA, it will be important to monitor the same deer for consecutive years to determine whether emigration to other winter ranges is occurring.

Basic distribution maps generated from GPS data illustrated winter distribution patterns of deer in the control (Pinedale Front) and treatment (Mesa) areas, demonstrated the importance of BLM lands, and continued to refine information on migration routes and seasonal ranges. Deer in the treatment area continued to utilize the TPB as a migratory route between winter and spring/fall transition ranges. Deer movements through the TPB were quick (< 2 hours), as evident by the distance between locations, but the TPB continued to function effectively during 2004 and 2005. Agencies, industry, NGO's, and the public recognize the value of maintaining this movement corridor for the Sublette deer herd. Land-use decisions in and adjacent to the TPB should consider the migration routes and seasonal ranges of the Sublette deer herd.

Consistent with previous years, deer distribution and movement patterns in the control area were variable during the 2004-05 winter. The core winter range around Buckskin Crossing was heavily used, but deer shifted areas of use (10–15 miles) in all directions; south to Elk Mountain, southeast along the Big Sandy, easterly to the Little Sandy and Prospects, and northerly to Muddy Mountain. The ability to alter their rates of movements, to change their pathways, and occupy a variety of winter habitats as needed are behaviors that likely allow these deer to best exploit winter ranges. However, the unpredictable movement patterns made calculation of abundance and density estimates difficult, as the size of the sampling frame progressively increased from 2002 through 2004 to encompass the range of our marked deer. Because the sampling frame did not reflect the area utilized by our marked population prior to 2004, abundance and density estimates are expected to be biased high during 2002, and biased low during 2003.

Although winter distribution patterns varied among deer in the control area, the migration route to northerly transition and summer ranges was surprisingly consistent. All GPS-collared deer captured in the Pinedale Front migrated along a distinct movement corridor located at the base of the Wind River Range. Deer followed a well-defined route that narrowed to ¼-mile in some areas (i.e., Boulder Lake, Fremont Lake), but rarely exceeded 1-2 miles in width. GPS data

collected from individual deer for consecutive winters showed a strong affinity for this migration corridor during both spring and fall migrations. Deer that winter in the Pinedale Front were known to migrate northerly along the Wind River Range to the New Fork Lake area, before shifting their migration in a westerly direction towards the Hoback Basin and adjacent mountain ranges (Sawyer and Lindzey 2001). However, details of this migration route, in terms of size, width, specific location, and deer fidelity were unknown prior to GPS data collected over the last three years. Although these deer may migrate 100 miles between winter and summer ranges (Sawyer and Lindzey 2001), our GPS collars have not previously collected locations May through October, and therefore did not record the entire migration route(s). Deer management in the Sublette DAU is complicated by the long-distance migrations that occur through a variety of habitats and across a mix of land ownership. Knowledge of this migration route should provide agencies with the necessary information to maintain deer movements through the Pinedale Front, adjust harvest strategies accordingly, and prioritize habitat enhancement projects. Because several thousand mule deer rely on this migration corridor to access their seasonal ranges, maintenance of the corridor should be a priority for agencies, industry, and conservation groups.

In addition to basic distribution and movement maps, GPS data can be used to conduct more rigorous scientific analyses, such as estimation of resource selection models (Manly et al. 2002). Resource selection, as described by Manly et al. (2002), is a rapidly advancing methodology for analyzing, modeling, and interpreting wildlife field studies. Resource selection analyses have broad applications, and in the case of this study, were used to determine how mule deer use their habitats in relation to various habitat features, including well pads and road networks associated with energy development. Our basic approach to resource selection treats the GPS-collared deer as the experimental unit and estimates a population-level model (i.e., resource selection probability function [RSPF]), so inference can be made to the entire population of mule deer on the Mesa.

Sample size, in this case the number of collared mule deer, is an important consideration for statistical procedures that rely on simple random sampling to obtain population-level inference. We recognize the number of marked animals in our analysis may appear low, but we believe our sample adequately represents the Mesa deer population because of our *a priori* knowledge of deer movement and distribution patterns. Sawyer and Lindzey (2001) studied the movement and distribution patterns of this mule deer population for three years (1998-2000) prior to gas field development. Their results indicated that most deer congregate in the northern portion of the study area during early winter, before moving on to their respective winter ranges. Our sampling design incorporated this knowledge by obtaining a random sample of deer for collaring while they were congregated on the northern portion of the study area. Thus, while our sample sizes may be less than preferred, we believe our sampling strategy and model-building process adequately represents the PAPA deer population. We believe larger sample sizes should reveal the same relationships between the probability of mule deer habitat use and environmental conditions, but with higher precision.

Prior to this study, descriptions of how mule deer respond to gas development were generally based on anecdotal field observations. Two of the major shortcomings with anecdotal field observations are; 1) animals being observed may not be representative of the population, and, 2) animals may move to other areas when not being observed. Our resource selection analysis

accounts for the first shortcoming by obtaining a random sample of mule deer and treating the animal as the experimental unit. The random sample results in each animal having the same probability of capture and is more likely to be representative of the population than simply making observations of the most visible animals. Treating the marked animal as the experimental unit also ensures that all animals are weighted equally in the analysis. For example, some deer may use habitats in close proximity to roads and well pads, while others may use habitats away from roads and well pads. But, because all deer are treated equally, no one deer will influence model results more than another. Our analysis accounts for the second shortcoming by using GPS data that is collected every 2 hours for the entire winter, irrespective of time of day or weather conditions. This type of data collection provides accurate and unbiased documentation of animal movements through the entire winter period.

We view our resource selection analysis as an objective means to document mule deer behavioral response to natural gas development and quantify indirect habitat losses through time. Although indirect impacts associated with human activity or development have been documented in elk (Lyon 1983, Morrison et al. 1995, Rowland et al. 2000), data that suggest similar behavior in mule deer (Rost and Bailey 1979, Freddy et al. 1986, Yarmaloy et al. 1988, Merrill et al. 1994, Taylor and Knight 2003) are limited and largely observational in nature. Specific knowledge of how, or if mule deer respond to natural gas development does not exist in the literature. The resource selection analysis presented in this report is the only multi-year study that examines the effects of natural gas development on mule deer. Although this study is proposed to run several more years, results to date suggest that winter habitat selection and distribution patterns of mule deer have been affected by well pad development. Changes in habitat selection by mule deer appeared to be immediate (i.e., Year 1 of development) and through 3 years of development, we found no evidence they acclimated or habituated to well pads. Rather, mule deer had progressively higher probability of use in areas farther away from well pads as development progressed; preferring areas 2.7, 3.1, and 3.7 km away from well pads in Years 1, 2, and 3, respectively.

Population–level models and associated predictive maps were useful tools for illustrating changes in habitat selection patterns through time. We recognize the 4 levels of habitat use were subjectively defined and could vary depending on study objectives. Nonetheless, we believe models and associated predictive maps provide a useful framework for quantifying indirect habitat losses by measuring the changes (e.g., percent or area) in habitat use categories through time. Predictive maps suggest that some areas categorized as high use prior to development, changed to low use as development progressed, and other areas initially categorized as low use changed to high use. For example, following Year 1 of development 17% of units classified as high use before development had changed to medium–low or low use, and by Year 3 of development, 41% of those areas classified as high use before development had changed to medium–low or low use. Conversely, by Year 3 of development, 40% of low use areas had changed to medium–high or high use areas. Assuming habitats with high probability of use prior to development were more suitable than habitats with lower probability of use, these results suggest natural gas development on the Mesa displaced mule deer to less suitable habitats.

Interestingly, the model from Year 4 did not contain the distance to well pad variable and mule deer habitat selection was not influenced by proximity of well pads. Without the influence of

well pads, the predictive map looked remarkably similar to pre-development distribution patterns. This distribution pattern probably reflects the heavy snow conditions during Year 4 (2003-04); the most severe winter since this study began in 1998. The heavy snow conditions likely reduced the options and available habitat to deer such that they reverted to their traditional (i.e., pre-development) or available habitats, which were located in areas now covered by or in close proximity to well pads. Given the mild winter in Year 5 (i.e., winter 2004-05), we expect the Year 5 model to include the distance to well pad variable and the predictive map should look similar to those from Years 1 through 3. The analysis from Year 5 is expected to be complete in the summer of 2006.

A single well pad typically disturbs 3 to 4 acres of habitat; however, areas with the highest probability of deer use were 2.7, 3.1, and 3.7 km away from well pads during the first 3 years of development respectively. There are two potential concerns with the apparent avoidance of well pads by mule deer during Years 1 through 3 of development. 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., reduced survival, reduced reproduction, or emigration). 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).

We continue to monitor four population parameters to detect changes in the treatment and control areas, including: 1) recruitment, 2) adult doe survival, 3) over-winter fawn survival, and 4) abundance. Recruitment (i.e., doe:fawn ratios) in the treatment and control areas has been essentially the same since development began. Estimates of over-winter adult survival have been lower in the treatment area for 3 of the 5 years since development began, and over-winter fawn survival has been lower 4 of 5 years. The only year over-winter fawn survival was not lower in the treatment was in the harsh winter of 2003-04, when we would expect high fawn mortality in both treatment and control areas. While these individual point estimates of over-winter adult and fawn survival were not statistically different between treatment and control areas, the long-term trends suggest deer in the treatment may not be performing as well as deer in the control.

Of particular concern is the decreasing abundance estimates in the treatment area, dropping from 5,228 in 2002 to 2,818 in 2005. This 4-year, 46% reduction in deer abundance is disconcerting because there is no concurrent evidence of a population decline in the control area. At this point in time we cannot detect any positive or negative trends in the control area, but abundance in the treatment area has significantly declined since 2002. Following the severe winter and associated high mortality rates in 2003-04, we expected deer abundance to increase the following year in both treatment and control areas, given the exceptionally mild 2004-05 winter. While an increase was evident in the control area, abundance continued to decline in the treatment area.

Population change is generally a function of four components, including; births, deaths,

immigration, and emigration. Ideally, we could explain how each of these components has contributed to the population decline in the treatment area. However, our population monitoring was designed to make comparisons between treatment and control areas, rather than model population dynamics (White 2000). But, based on the population parameters we have measured, we believe reduced over-winter fawn survival, lower adult survival, and emigration are likely responsible for the population changes on the Mesa. The first GPS-collared deer to emigrate from the Mesa and occupy a new, distinct winter range was documented during the 2003-04 winter (see Section 2.4.3). While this behavior was only documented in one of eleven GPS-collared deer that winter, it may have represented 9% of the population, or approximately 320 deer (i.e., 9% of 3,564).

Long-term monitoring programs will continue to provide the best opportunities for detecting changes in population parameters and to verify the magnitude of these apparent impacts of development on mule deer performance. As we continue to measure population parameters and examine habitat selection in treatment and control areas, comparisons can be made, and over time, the impacts of energy development on mule deer will be better understood. For this study, the number of captured deer or counted deer may refine the precision of the measurement (e.g., survival, reproduction), but the strength of this monitoring plan and robustness of the conclusions will be determined by the number of years it is implemented. Future monitoring should be modified to incorporate any changes in development plans, such as winter drilling. Assuming winter drilling occurs on federal lands beginning in the 2005-06 winter, we plan to evaluate how different levels of human activity (e.g., traffic) at developing and producing well pads influence mule deer distribution. Understanding mule deer response to different levels of human activity and types of well pads would allow mitigation measures to be evaluated and improved.

2.6 SUMMARY AND MANAGEMENT IMPLICATIONS

The objective of this monitoring effort is to evaluate potential impacts of natural gas development on mule deer in terms of: 1) direct habitat loss, 2) changes in habitat selection, and 3) population performance.

- **Direct Habitat Losses:** Satellite imagery was used to estimate direct habitat losses (i.e., surface disturbance) for the Mesa portion of the PAPA. Through August 2004, approximately 1,029 acres had been disturbed, of which 79% was due to well pad construction and 21% to access roads. Each year development has progressed, well pads account for relatively more direct habitat loss than access roads. Pipelines and seismic tracks *were not* included in the estimates of direct habitat loss.

- **Habitat Selection Patterns:** During Years 1 through 3 of gas development, habitat selection models and predictive maps suggested mule deer were less likely to occupy habitats in close proximity to well pads than those farther away. Changes in habitat selection appeared to be immediate (i.e., Year 1 of development) and no evidence of well pad acclimation occurred through the first 3 years of development, rather deer selected areas farther from well pads as development progressed. The lower levels of deer use within 2.7 to 3.7 km of well pads suggested indirect habitat losses may be substantially larger than direct habitat losses. Additionally, some areas classified as high deer use prior to development changed to areas of low use following development. If areas classified as high use before development were those preferred by deer, then observed shifts in their distribution were towards less preferred and presumably less suitable habitats. During Year 4 of development and following a substantial reduction in deer abundance, habitat selection patterns of deer were influenced by road density, but not proximity of well pads. This may be an artifact of the unusually severe winter during Year 4, where movement options and available habitat for deer were limited. Results from Year 5 should help clarify trends in habitat selection.

- **Population Performance:** We monitored four population characteristics to compare population performance in the treatment (Mesa) and control (Pinedale Front) areas, including: 1) recruitment, 2) over-winter adult doe survival, 3) over-winter fawn survival, and 4) abundance. Recruitment (i.e., doe:fawn ratios) in the treatment and control areas has been essentially the same since development began. Point estimates of over-winter adult survival have been slightly lower in the treatment area for 3 of the 5 years since development began, and over-winter fawn survival has been slightly lower 4 of 5 years. The only year over-winter fawn survival was not lower in the treatment was in the harsh winter of 2003-04, when we would expect high fawn mortality in both treatment and control areas. While these point estimates of over-winter adult and fawn survival were not statistically different between treatment and control areas, the long-term trends in these vital rates suggest deer in the treatment area may not be performing demographically as well as deer in the control area. Additionally, a portion of the deer normally wintering on the Mesa emigrated to a new, distinct winter range during the 2003-04 winter. The combination of changes in births, deaths, and emigration resulted in an estimated 46% reduction in deer abundance over four years, although we are unable to estimate the relative contribution of these factors to the decline. There is no evidence of a similar decline in abundance in the control area.

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Possible management implications include:

- Monitoring shifts in distribution, or habitat use, or population parameters allows mitigation measures aimed at reducing impacts to be evaluated and timely, site-specific strategies to be developed. The current mitigation measure is focused on seasonal timing restrictions, where drilling activity is limited to non-winter months. This type of mitigation is common across federal lands and intended to reduce human activity and presumably the associated stress to big game during the winter months, typically 15 November to 30 April. Major shifts in the distribution of mule deer on the Mesa occurred during Years 1 through 3 of development even though drilling on federal lands was largely restricted to non-winter months. Estimates of deer abundance on the Mesa have significantly declined since development began. To date, our findings suggest seasonal timing restrictions may not be achieving desired results.

- In deep-gas fields like the PAPA where well densities range from 4 to 16 pads per section, the number of producing well pads and associated human activity may negate the potential effectiveness of timing restrictions on drilling activities as a means to reduce disturbance to wintering deer. Reducing disturbance to wintering mule deer may require restrictions or approaches that minimize the level of human activity during both production and development phases of wells. Directional drilling technology offers promising new methods for reducing surface disturbance and human activity. Limiting public access and road management strategies may also be a necessary part of mitigation plans.

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Invited Article

Winter Habitat Selection of Mule Deer Before and During Development of a Natural Gas Field

HALL SAWYER,[1] *Western Ecosystems Technology, Inc., Cheyenne, WY 82001, USA*
RYAN M. NIELSON, *Western Ecosystems Technology, Inc., Cheyenne, WY 82001, USA*
FRED LINDZEY, *United States Geological Survey (USGS), Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, WY 82071, USA*
LYMAN L. McDONALD, *Western Ecosystems Technology, Inc., Cheyenne, WY 82001, USA*

Abstract

*Increased levels of natural gas exploration, development, and production across the Intermountain West have created a variety of concerns for mule deer (*Odocoileus hemionus*) populations, including direct habitat loss to road and well-pad construction and indirect habitat losses that may occur if deer use declines near roads or well pads. We examined winter habitat selection patterns of adult female mule deer before and during the first 3 years of development in a natural gas field in western Wyoming. We used global positioning system (GPS) locations collected from a sample of adult female mule deer to model relative frequency or probability of use as a function of habitat variables. Model coefficients and predictive maps suggested mule deer were less likely to occupy areas in close proximity to well pads than those farther away. Changes in habitat selection appeared to be immediate (i.e., year 1 of development), and no evidence of well-pad acclimation occurred through the course of the study; rather, mule deer selected areas farther from well pads as development progressed. Lower predicted probabilities of use within 2.7 to 3.7 km of well pads suggested indirect habitat losses may be substantially larger than direct habitat losses. Additionally, some areas classified as high probability of use by mule deer before gas field development changed to areas of low use following development, and others originally classified as low probability of use were used more frequently as the field developed. If areas with high probability of use before development were those preferred by the deer, observed shifts in their distribution as development progressed were toward less-preferred and presumably less-suitable habitats.* (JOURNAL OF WILDLIFE MANAGEMENT 70(2):396–403; 2006)

Key words

generalized linear model (GLM), Global Positioning System (GPS), habitat selection, mule deer, natural gas development, negative binomial, Odocoileus hemionus, *resource selection probability function (RSPF), Wyoming.*

Natural gas development on public lands in Wyoming has steadily increased since 1984 (Bureau of Land Management 2002) and created much concern over potential impacts to wildlife. Public lands with high gas potential often coincide with regions of Wyoming that support large mule deer (*Odocoileus hemionus*) populations, such as the Green River Basin (Bureau of Land Management 2000*a*), Great Divide Basin (Bureau of Land Management 2000*b*), and Powder River Basin (Bureau of Land Management 2003). Impacts of natural gas development on mule deer may include the direct loss (i.e., surface disturbance) of habitat to well pad, access road, and pipeline construction. Additional indirect habitat losses may occur if increased human activity (e.g., traffic, noise) associated with infrastructure cause mule deer to be displaced or alter their habitat use patterns. Although it is relatively easy to quantify the direct habitat losses that result from conversion of native vegetation to infrastructure, it is much more difficult to document indirect habitat losses. Nonetheless, because indirect impacts can affect a substantially larger area than direct impacts, understanding them may be a key component to maintaining mule deer seasonal ranges and populations in regions with high levels of natural gas development. Accordingly, there is a need among land management and wildlife agencies to better understand how natural gas development can lead to indirect habitat loss to ensure informed land-use decisions are made, reasonable and effective mitigation measures identified, and appropriate monitoring programs implemented. Our objective was to determine whether natural gas development affected the habitat selection patterns and, thus, distribution of wintering mule deer in western Wyoming.

[1] *E-mail: hsawyer@west-inc.com*

Study Area

Beginning in 2000, the Bureau of Land Management (BLM) approved the construction of 700 producing well pads, 645 km of pipeline, and 444 km of roads to develop a natural gas field in the Pinedale Anticline Project Area (PAPA; Bureau of Land Management 2000*a*). The PAPA contains one of the largest and highest density (19 to 30 deer/km^2) mule deer winter ranges in Wyoming (S. Smith, Wyoming Game and Fish Department, Cheyenne, Wyo., USA, unpublished data). The PAPA is located in the upper Green River Basin of western Wyoming, approximately 5 km southwest of Pinedale. The PAPA consists primarily of federal lands (80%) and minerals administered by the BLM (83%). The state of Wyoming owns 5% (39 km^2) of the surface and another 15% (121 km^2) is private (Bureau of Land Management 2000*a*). The study area contains abundant deep gas reserves, supports a variety of agricultural uses, and provides winter range for 4,000 to 5,000 migratory mule deer that summer in portions of 4 different mountain ranges 80 to 200 km away (Sawyer and Lindzey 2001). Although the PAPA covers 799 km^2, most mule deer wintered in the northern one-third, an area locally known as the Mesa. The Mesa is 260 km^2 in size, bounded by the Green River on the west and the New Fork River on the north, south, and east, and vegetated primarily by Wyoming big sagebrush (*Artemisia tridentata*) and sagebrush–grassland communities. Elevation ranges from 2,070 to 2,400 m. Our study was restricted to the Mesa portion of the PAPA.

Attachment 2

Methods

Capture

We captured adult (≥1 year) female mule deer using helicopter net-gunning in the northern portion of the PAPA where deer congregated in early winter before moving to their individual winter ranges throughout the Mesa (Sawyer and Lindzey 2001). We believed attempting to randomly capture deer in this area during early winter provided the best opportunity to achieve a representative sample from the wintering population. In years before development (winters 1998–1999 and 1999–2000), we fitted deer with standard, very high frequency (VHF) radio collars (Advanced Telemetry Systems, Isanti, Minnesota). We located radio-collared deer from the ground or air every 7 to 10 days during the 1998–1999 and 1999–2000 winters (1 Dec to 31 Mar). During years of gas field development (winters 2000–2001, 2001–2002, and 2002–2003), we fitted deer with store-on-board global positioning system (GPS) radio collars (Telonics, Inc., Mesa, Arizona) equipped with VHF transmitters and remote-release mechanisms programmed to release at specified dates and times. We fitted GPS radio collars to a sample of different deer each winter; however, 3 deer had collars that collected GPS locations for both the 2001–2002 and 2002–2003 winters. We programmed GPS radio collars to attempt location fixes every 1 or 2 hrs, depending on model type. We did not differentially correct GPS locations because 3-dimensional fixes typically have <20 m error (Di Orio et al. 2003), and previous work in the study area indicated 99% fix-rate success with 80% of successful fixes 3-dimensional locations (Sawyer et al. 2002). Potential fix-rate bias was not a concern because of the high fix-rate success of the GPS collars.

Modeling Procedures

Defining availability.—We defined the study area by mapping 39,641 locations from 77 mule deer over a 6-year period (1998 to 2003), creating a minimum convex polygon (MCP), and then clipping the MCP to the boundary of the PAPA. This was consistent with the McClean et al. (1998) recommendation that the study-area level of habitat availability should be based on the distribution of radio-collared animals.

Habitat variables.—We identified 5 variables as potentially important predictors of winter mule deer distribution, including elevation, slope, aspect, road density, and distance to well pad. We did not include vegetation as a variable because the sagebrush–grassland was relatively homogeneous across the study area and difficult to divide into finer vegetation classes. Further, we believed differences in sagebrush characteristics could be largely explained by elevation, slope, and aspect. We used the SPATIAL ANALYST extension for ArcView (Environmental Systems Research Institute, Redlands, California) to calculate slope and aspect from a 26 × 26-m digital elevation model (U.S. Geologic Survey 1999). Grid cells with slopes >2 degrees were assigned to 1 of 4 aspect categories: northeast, northwest, southeast, or southwest. Grid cells with slopes of ≤2 degrees were considered flat and assigned to a fifth category that was used as the reference (Neter et al. 1996) during habitat modeling. We obtained elevation, slope, and aspect values for each of the sampled units using the GET GRID extension for ArcView. The sample units consisted of approximately 4,500 circular units with 100-m radii distributed across the study area. We annually digitized roads and well pads from LANDSAT thematic satellite images acquired from the U.S. Geologic Survey and processed by SkyTruth (Sheperdstown, West Virginia). The LANDSAT images were obtained every fall, before snow accumulation, but after most annual development activities were complete. We calculated road density by placing a circular buffer with a 0.5-km radius on the center of the sample unit and measuring the length of road within the buffer. We used the NEAREST NEIGHBOR extension for ArcView to measure the distance from the center of each sampled unit to the edge of the nearest well pad. We did not distinguish between developing and producing well pads. We assumed habitat loss was similar among all well pads because development of the field was in its early stages (i.e., <5 years), and there was no evidence of successful shrub reclamation. Additionally, there was no evidence that suggested the type of well pad was an accurate indicator of the amount of human activity (e.g., traffic) that occurred at each site. Without an accurate measure of human activity, we believed it was inappropriate to distinguish between producing and developing well pads.

Statistical analyses.—Our approach to modeling winter habitat use consisted of 4 basic steps: 1) estimate the relative frequency of use (i.e., an empirical estimate of probability of use) for a large sample of habitat units for each radiocollared deer, during each winter; 2) use the relative frequency as the response variable in a multiple regression analysis to model the probability of use for each deer as a function of predictor variables; 3) develop a population-level model from the individual deer models, for each winter; and 4) map predictions of population-level models from each winter. Our analysis treated each winter period separately to allow mule deer habitat use and environmental characteristics (e.g., road density or number of well pads) to change through time. We treated radiocollared deer as the experimental unit to avoid pseudo-replication (i.e., spatial and temporal autocorrelation) and to accommodate population-level inference (Otis and White 1999, Johnson et al. 2000, Erickson et al. 2001).

We estimated relative frequency of use for each radio-collared deer using a simple technique that involved counting the number of deer locations in each of approximately 4,500 randomly sampled, circular habitat units across the study area. We took a simple random sample with replacement for each winter to ensure independence of the habitat units (Thompson 1992:51). We chose circular habitat units that had a 100-m radii; an area small enough to detect changes in animal movements but large enough to ensure multiple locations could occur in each unit. Previous analyses suggested model coefficients were similar across a variety of unit sizes, including 50, 75, and 150-m radii (R. Nielson, Western Ecosystems Technology, Inc., Cheyenne, Wyo., USA, unpublished data). We measured predictor variables on each of the sampled habitat units and conducted a Pearson's pairwise correlation analysis (PROC CORR; SAS 2000) before modeling to identify multicolinearities and to determine whether any variables should be excluded from the modeling ($|r| > 0.60$).

The relative frequency of locations from a radio-collared deer found in each habitat unit was an empirical estimate of the probability of use by that deer and was used as a continuous response variable in a generalized linear model (GLM). We used

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an offset term (McCullagh and Nelder 1989) in the GLM to estimate probability of use for each radiocollared deer as a function of a linear combination of predictor variables, plus or minus an error term assumed to have a negative binomial distribution (McCullagh and Nelder 1989, White and Bennetts 1996). We preferred the negative binomial distribution over the more commonly used Poisson because it allows for overdispersion (White and Bennetts 1996).

We obtained a population-level model for each winter by first estimating coefficients for each radiocollared deer. We used PROC GENMOD (SAS 2000) and the negative binomial distribution to fit the following GLM for each radiocollared deer during each winter period:

$$\ln[E(r_i)] = \ln(total) + \beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p, \quad (1)$$

which is equivalent to

$$\ln[E(r_i/total)] = \ln[E(\text{Relative frequency}_i)]$$
$$= \beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p \quad (2)$$

where r_i is the number of locations for a radio-collared deer within habitat unit i ($i = 1, 2, \ldots, 4{,}500$), *total* is the total number of locations for the deer within the study area, β_0 was an intercept term, $\beta_1, \ldots, \beta_p$ are unknown coefficients for habitat variables $X_1, \ldots, X_p$, and $E(.)$ denotes the expected value. We used the same offset term for all sampled habitat units of a given deer, thus the term $\ln(total)$ was absorbed into the estimate of β_0 and ensured we were modeling relative frequency of use (e.g., 0, 0.003, 0.0034, ...) instead of integer counts (e.g., 0, 1, 2, ...). Because some locations for each deer were not within a sampled habitat unit, inclusion of the offset term in Eq. (1) was not equivalent to conditioning on the total number of observed locations (i.e., multinomial distribution). In fact, one could drop the offset term and simply scale the resulting estimates of frequency of use by the total number of observed locations to obtain predictions of relative frequency identical to those obtained by Eq. (1). This approach to modeling resource selection estimates the relative frequency or absolute probability of use as a function of predictor variables, so we refer to it as a resource selection probability function (RSPF; Manly et al. 2002).

We assumed GLM coefficients for predictor variable k, for each deer, were a random sample from a normal distribution (Seber 1984, Littell et al. 1996), with the mean of the distribution representing the average or population-level effect of predictor variable k on probability of use. We estimated coefficients for the population-level RSPF for each winter using

$$\hat{\bar{\beta}}_k = \frac{1}{n}\sum_{j=1}^{n} \hat{\beta}_{kj}, \quad (3)$$

Where $\hat{\beta}_{kj}$ was the estimate of coefficient k for individual j ($j = 1, \ldots, n$). We estimated the variance of each population-level model coefficient using the variation between radiocollared deer and the equation

$$\text{var}(\hat{\bar{\beta}}_k) = \frac{1}{n-1}\sum_{j=1}^{n} (\hat{\beta}_{kj} - \bar{\beta}_k)^2. \quad (4)$$

This method of estimating population-level coefficients using Eqs. (3) and (4) was used by Marzluff et al. (2004) and Glenn et al. (2004) for evaluating habitat selection of Steller's jays (*Cyanocitta stelleri*) and northern spotted owls (*Strix occidentalis caurina*), respectively. Population-level inferences using Eqs. (3) and (4) are unaffected by potential autocorrelation because temporal autocorrelation between deer locations or spatial autocorrelation between habitat units do not bias model coefficients for the individual radiocollared deer models (McCullagh and Nelder 1989, Neter et al. 1996).

Standard criteria for model selection such as Akaike's Information Criterion (Burnham and Anderson 2002) might be appropriate for individual deer but do not apply for building a model for population-level effects because the same model (i.e., predictor variables) is required for each deer within a winter. Therefore, we used a forward-stepwise model-building procedure (Neter et al. 1996) to estimate population-level RSPFs for winters 2000–2001, 2001–2002, and 2002–2003. The forward-stepwise model-building process required fitting the same models to each deer within a winter and using Eqs. (3) and (4) to estimate population-level model coefficients. We used a t-statistic to determine variable entry ($\alpha \leq 0.15$) and exit ($\alpha > 0.20$; Hosmer and Lemeshow 2000). We considered quadratic terms for road density, distance to nearest well pad, and slope during the model-building process and following convention, the linear form of each variable was included if the model contained a quadratic form.

We conducted stepwise model building for all winters except for the predevelopment period that included winters 1998–1999 and 1999–2000. The limited number of locations recorded for radiocollared deer during that period precluded fitting individual models. Rather, we estimated a population-level model for the predevelopment period by pooling location data across 45 deer that had a minimum of 10 locations. We took simple random samples of 30 locations from deer with >30 locations to ensure that approximately equal weight was given to each deer in the analysis. We fit a model containing slope, elevation, distance to roads, and aspect for the predevelopment period. Distance to well pad was not included as a variable in the predevelopment model because there were only 11 existing well pads on the Mesa before development, and most were >10 years old, with little or no human activity associated with them. We used bootstrapping to estimate the standard errors and P values of the predevelopment population-level model coefficients.

We mapped predictions of population-level RSPFs for each winter on 104 × 104-m grids that covered the study area. We checked predictions to ensure all values were in the [0,1] interval, such that we were not extrapolating outside the range of the model data (Neter et al. 1996). The estimated probability of use for each grid cell was assigned a value of 1 to 4 based on the quartiles of the distribution of predictions for each map. We assigned grid cells with the highest 25% of predicted probabilities of use a value of 1 and classified them as high-use areas, assigned grid cells in the 51 to 75 percentiles a value of 2 and classified them as medium- to high-use areas, assigned grid cells in the 26 to 50 percentiles a value of 3 and classified them as medium- to low-use areas, and assigned grid cells in the 0 to 25 percentiles a values of 4 and classified them as low-use areas. We used contingency tables to identify changes in the 4 habitat-use categories across the 4 winter periods.

Results

Predevelopment: Winters 1998–1999 and 1999–2000

The population-level RSPF was estimated from 953 VHF deer locations collected from 45 adult female mule deer during the winters (1 Dec to 15 Apr) of 1998–1999 and 1999–2000 (Table 1). Units with the highest probability of use (Fig. 1) had an average elevation of 2,275 m, an average slope of 5 degrees, and an average road density of 0.14 km/km^2. Aspects with the highest probability of use were northwest and southwest.

Year 1 of Development: Winter 2000–2001

Individual models were estimated for 10 radiocollared deer during the winter (1 Jan to 15 Apr) of 2000–2001. Eight of the 10 deer had positive coefficients for elevation and negative coefficients for road density, indicating selection for higher elevations and low road densities. Based on the relationship between the linear and quadratic terms for slope and distance-to-well-pad variables, all 10 deer selected for moderate slopes, and 7 of 10 deer selected areas away from well pads.

The population-level RSPF was estimated from 18,706 GPS locations collected from 10 radiocollared deer during the winter of 2000–2001 (Table 1). The RSPF included elevation, slope, road density, and distance to well pad (Table 1). Deer selected for areas with higher elevations, moderate slopes, low road densities, and away from well pads. Habitat units with the highest probability of use (Fig. 2) had an average elevation of 2,266 m, slope of 5 degrees, road density of 0.16 km/km^2, and were 2.7 km away from the nearest well pad. Predictive maps indicate probability of deer use was lowest in areas close to well pads and access roads (Fig. 2). Shifts in deer distribution between predevelopment and year 1 of development were evident through the changes in the 4 deer use categories (Table 2). Of the habitat units classified as high deer use before development, only 60% were classified as high deer use during year 1 of development (Table 2). Of the areas classified as low deer use before development, 58% remained classified as low deer use during year 1 of development (Table 2).

Year 2 of Development: Winter 2001–2002

Individual models were developed for 15 radiocollared deer during the winter (4 Jan to 15 Apr) of 2001–2002. Fourteen of the 15 deer had positive coefficients for elevation, indicating selection of higher elevations. Based on the relationship between the linear and quadratic terms for slope and distance-to-well-pad variables, all 15 deer selected for moderate slopes, and 12 of 15 deer selected areas away from well pads.

The population-level RSPF was estimated from 14,851 GPS locations collected from 15 radiocollared deer during the winter of 2001–2002 (Table 1). The RSPF included elevation, slope, and distance to well pad (Table 1). Deer selected for areas with higher elevations, moderate slopes, and away from well pads. Habitat units with the highest probability of use (Fig. 3) had an average elevation of 2,255 m, slope of 5 degrees, and were 3.1 km away from the nearest well pad. Predictive maps indicate probability of deer use was lowest in areas close to well pads (Fig. 3). Shifts in deer distribution between predevelopment, year 1, and year 2 of development were evident through the changes in the 4 deer-use categories (Table 2). Of the habitat units classified as high deer use before development, only 49% were classified as high deer use during year 2 of development (Table 2). Of the areas classified as low deer use before development, 48% remained classified as low deer use during year 2 of development (Table 2).

Year 3 of Development: Winter 2002–2003

Individual models were developed for 7 radiocollared deer during the winter (20 Dec to 15 Apr) of 2002–2003. All 7 deer had positive coefficients for elevation, indicating selection of higher elevations. Based on the relationship between the linear and quadratic terms for slope and distance-to-well-pad variables, 6 of 7 deer selected for moderate slopes, and 6 of 7 deer selected areas away from well pads.

The population-level RSPF was estimated from 4,904 GPS locations collected from 7 radiocollared deer during the winter of 2002–2003 (Table 1). Our target sample of 10 marked animals was not met because 3 deer died early in the season. The RSPF included elevation, slope, and distance to well pad (Table 1). Deer selected areas with high elevations, moderate slopes, and away from well pads. Habitat units with the highest probability of use (Fig. 4) had an average elevation of 2,233 m, slope of 5 degrees, and were 3.7 km away from the nearest well pad. Predictive maps indicate probability of deer use was lowest in areas close to well

Table 1. Coefficients for population-level winter mule deer resource selection probability functions (RSPF) before and during 3 years of natural gas development in western Wyo., USA, 1998–2003.

	Predevelopment			Year 1			Year 2			Year 3		
	β	SE	*P*	β	SE	*P*	β	SE	*P*	β	SE	*P*
Intercept	−29.649	6.637	<0.001	−84.560	21.124	0.003	−75.712	12.931	<0.001	−104.295	11.316	<0.001
Elevation	0.009	0.001	<0.001	0.031	0.008	0.005	0.027	0.005	<0.001	0.036	0.004	<0.001
Slope	0.098	0.010	<0.001	0.391	0.073	<0.001	0.258	0.046	<0.001	0.342	0.128	0.036
Slope^2	−0.004	0.001	<0.001	−0.022	0.004	<0.001	−0.017	0.003	<0.001	−0.019	0.007	0.042
Well distance	na[a]			3.129	1.899	0.134	3.375	1.264	0.018	6.712	2.394	0.031
Well distance^2	na			−0.465	0.229	0.073	−0.416	0.156	0.019	−0.719	0.289	0.047
Road density	−0.249	0.027	<0.001	−0.827	0.387	0.061	ns[b]			ns		
Aspect = NE	0.012	0.051	0.818	ns			ns			ns		
Aspect = NW	0.399	0.025	<0.001	ns			ns			ns		
Aspect = SE	−0.301	0.022	<0.001	ns			ns			ns		
Aspect = SW	0.194	0.028	<0.001	ns			ns			ns		

[a] Not applicable.
[b] Not significant.

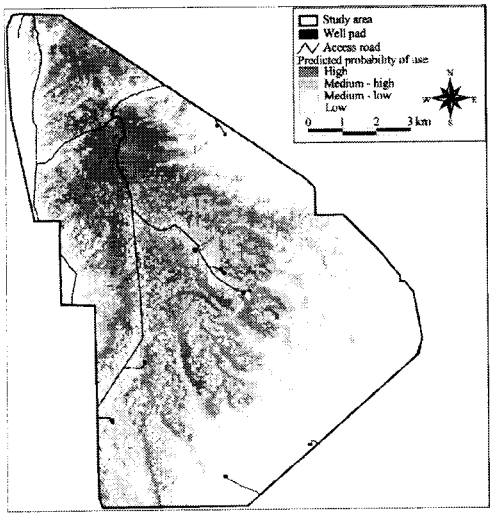

Figure 1. Predicted probabilities and associated categories of mule deer habitat use during 1998–1999 and 1999–2000 winters, before natural gas field development in western Wyo., USA.

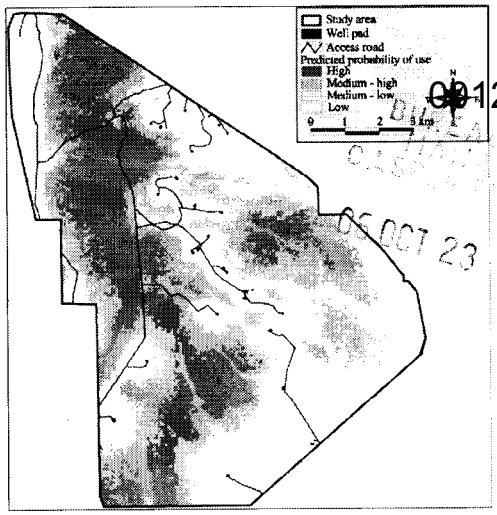

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Figure 2. Predicted probabilities and associated categories of mule deer habitat use during year 1 (winter of 2000–2001) of natural gas development in western Wyo., USA.

pads (Fig. 4). Shifts in deer distribution between predevelopment, year 1, year 2, and year 3 of development were evident through the changes in the 4 deer-use categories (Table 2). Of the habitat units classified as high deer use before development, only 37% were classified as high deer use during year 3 of development (Table 2). Of the areas classified as low deer use before development, 41% remained classified as low deer use during year 3 of development (Table 2).

Discussion

Our statistical analysis differs from the typical methods used in the study of habitat selection (Manly et al. 2002) in several important ways. First, our sample size was the number of radiocollared deer during each winter, and our objective was to make statistical inferences to the corresponding population in the study area. Thus, we assumed that our radiocollared deer represented a simple random sample from the population each winter. Second, our response variable was an empirical estimate of the probability of use of a habitat unit, or the volume under an animal's utilization distribution surface. And third, we used a stepwise model-building procedure to develop a population-level model from individual deer models, where the average of the coefficients across deer comprised the population-level model for each winter period.

We recognize that other techniques may be used to estimate population-level models. Random-coefficients or hierarchical models (Littell et al. 1996) can estimate individual and population-level coefficients; however, model convergence can be problematic. To date, we believe the most appropriate method to obtain a population-level model is to fit a GLM with negative binomial errors to each radiocollared deer and average the coefficients. Seber (1984:486) describes this estimator and notes that identical population-level coefficients can be obtained if one averages the relative frequency of use in each of the sampled habitat units and fits a single model. We prefer to estimate individual models because the variation among individuals is often of biological interest.

We would have preferred the use of GPS radio collars during all years of this study because they can systematically collect thousands of accurate deer locations, regardless of weather conditions or time of day. Although the VHF radio collar locations used for the predevelopment model were collected at irregular intervals and during daylight hours, we believe the resulting model provides a reasonable comparison to models estimated during years of development with GPS radio collar locations. Hayes and Krausman (1993) suggested diurnal use of habitats by female mule deer were representative of overall patterns of habitat use, except in areas with high levels of human disturbance. Because human activity was exceptionally low on the Mesa before development, we believe the 953 VHF locations collected from 45 radiocollared deer accurately reflect overall deer use during that time period.

We view our resource selection analysis as an objective means to document mule deer response to natural gas development and quantify indirect habitat losses through time. Although indirect impacts associated with human activity or development have been documented in elk (*Cervus elaphus*; Lyon 1983, Morrison et al. 1995, Rowland et al. 2000), data that suggest similar behavior in mule deer (Rost and Bailey 1979, Yarmaloy et al. 1988, Merrill et al. 1994) are limited and largely observational in nature. Specific knowledge of how, or whether, mule deer respond to natural gas development does not exist in the literature. Our results suggest winter habitat selection and distribution patterns of mule deer were affected by well pad development. Changes in habitat selection by mule deer appeared to be immediate (i.e., year 1 of development), and through 3 years of development, we found no evidence they acclimated or habituated to well pads. Rather, mule deer had progressively higher probability of use in areas farther away from well pads as development progressed. The nonlinear relationship between probability of deer use and distance to well pad indicates deer selected areas away from well pads, but only up to a certain distance. We believe this reflects the ability of mule

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Associate Editors: Strickland and McDonald.

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Table 2. Percent change in the 4 predevelopment deer-use categories through 3 years (2001–2003) of natural gas development in western Wyo., USA.

Predevelopment category[a]	Year of development	Deer use category: High	Medium–high	Medium–low	Low
High	Year 1	60%	23%	13%	4%
	Year 2	49%	19%	23%	9%
	Year 3	37%	22%	27%	14%
Medium–high	Year 1	31%	36%	22%	11%
	Year 2	34%	23%	25%	18%
	Year 3	27%	22%	28%	22%
Medium–low	Year 1	9%	34%	31%	26%
	Year 2	16%	35%	25%	25%
	Year 3	25%	27%	25%	23%
Low	Year 1	0%	7%	34%	58%
	Year 2	1%	23%	27%	48%
	Year 3	11%	29%	20%	41%

[a] Category rows may not sum to exactly 100% because of rounding error.

deer to avoid localized disturbances and habitat perturbations without completely abandoning their home ranges.

Population-level RSPFs and associated predictive maps were useful tools for illustrating changes in habitat selection patterns through time. We recognize the 4 levels of habitat use were subjectively defined and could vary depending on study objectives or species information. Nonetheless, we believe RSPFs and associated predictive maps can provide a useful framework for quantifying indirect habitat losses by measuring the changes (e.g., percentage or area) in habitat use categories through time. Predictive maps suggest that some areas categorized as high use before development, changed to low use as development progressed, and other areas initially categorized as low use changed to high use. For example, following year 1 of development, 17% of units classified as high use before development had changed to medium–low or low use, and by year 3 of development, 41% of those areas classified as high use before development had changed to medium–low or low use. Conversely, by year 3 of development, 40% of low-use areas had changed to medium–high or high-use areas. Assuming habitats with high probability of use before development were more suitable than habitats with lower probability of use, these results suggest natural gas development on the Mesa displaced mule deer to less-suitable habitats.

Winter severity and forage availability can influence the distribution patterns of mule deer (Garrott et al. 1987, Brown 1992). However, winter conditions on the Mesa were considered relatively mild during the course of this study (1998–2003) and were unlikely to have precluded deer from using their entire winter range. Gilbert et al. (1970) reported snow depths >61 cm were required to preclude use of an area by mule deer. With the exception of isolated drifts, snow depths were <61 cm across the Mesa during all years of study. If the observed changes in deer distribution were due to severe winter conditions, we would expect deer use to shift to areas with lower elevations and south-facing slopes. Instead, deer always selected for high elevations, and aspect was never a significant predictor variable during years of development, further suggesting the observed shifts in deer distribution

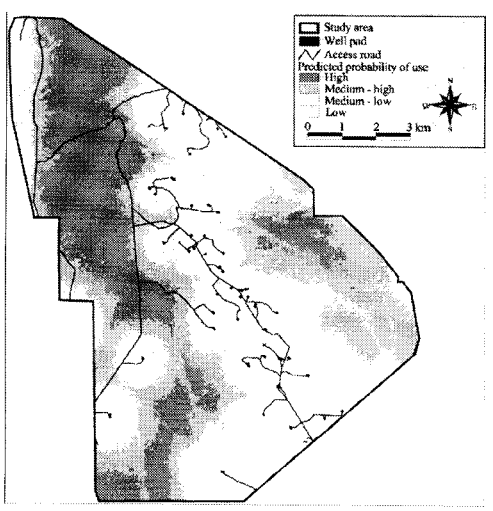

Figure 3. Predicted probabilities and associated categories of mule deer habitat use during year 2 (winter of 2001–2002) of natural gas development in western Wyo., USA.

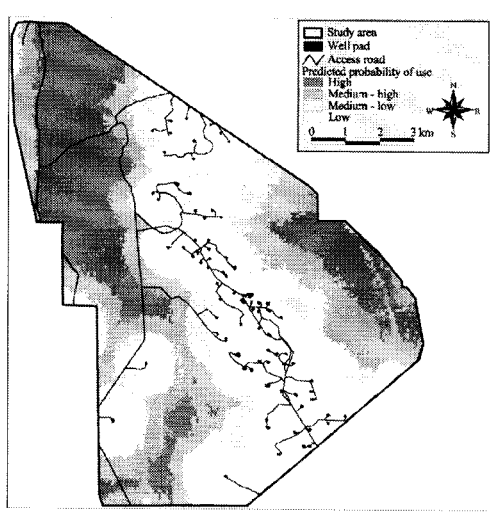

Figure 4. Predicted probabilities and associated categories of mule deer habitat use during year 3 (winter of 2002–2003) of natural gas development in western Wyo., USA.

were due to increased well-pad development and associated human activity rather than winter conditions.

A single well pad typically disturbs 3 to 4 acres of habitat; however, areas with the highest probability of deer use were 2.7, 3.1, and 3.7 km away from well pads during the first 3 years of development, respectively. 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 overwinter mortality (White et al. 1987, Hobbs 1989).

Monitoring shifts in distribution or habitat use allows for mitigation measures aimed at reducing impacts to be evaluated and for timely, site-specific strategies to be developed. The current mitigation measure is focused on seasonal-timing restrictions, where drilling activity is limited to nonwinter months. This type of mitigation is common across federal lands and intended to reduce human activity and, presumably, the associated stress to big game during the winter months, typically 15 November to 30 April. Major shifts in the distribution of mule deer on the Mesa occurred even though drilling on federal lands was largely restricted to nonwinter months. Our findings suggest current mitigation measures may not be achieving desired results. Winter-timing restrictions are only imposed on leases that occur in areas designated as crucial winter range, and then, only through the development phase of the well. Consequently, variable levels of human activity may occur throughout the field during winter as producing wells are serviced, and despite the recognition of the uniqueness of crucial winter range, roads may cross or abut these areas, exposing them to human disturbances as well.

Management Implications

In deep-gas fields like the PAPA, where well densities range from 4 to 16 pads per section (2.58 km^2), the number of producing well pads and associated human activity may negate the potential effectiveness of timing restrictions on drilling activities as a means of reducing disturbance to wintering deer. Mitigation measures designed to minimize disturbance to wintering mule deer in natural gas fields should consider all human activity across the entire project area and not be restricted to the development of wells or to crucial winter ranges. Reducing disturbance to wintering mule deer may require restrictions or approaches that limit the level of human activity during both production and development phases of the wells. Directional drilling technology offers promising new methods for reducing surface disturbance and human activity. Limiting public access and developing road management strategies may also be a necessary part of mitigation plans. Future research and monitoring efforts should evaluate how different levels of human activity (e.g., traffic or noise) at developing and producing well pads influence mule deer distribution. Understanding mule deer response to different levels of human activity and types of well pads would allow mitigation measures to be properly evaluated and improved.

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. This relationship, however, needs to be documented. Accordingly, we recommend appropriate population parameters (i.e., adult female survival, overwinter fawn survival, recruitment) be monitored in areas with large-scale gas development so that changes in reproduction or survival can be detected. The major shortcoming of efforts to evaluate the impacts of disturbances on wildlife populations is that they seldom are addressed in an experimental framework but, rather, tend to be short-term and observational. Brief, postdevelopment monitoring plans associated with regulatory work generally result in little or no information that allow agencies and industry to assess impacts on wildlife or to improve mitigation measures. We encourage long-term (>5 years) studies that identify habitat-selection patterns and that measure population characteristics in control and treatment areas before and during gas-development projects that occur in sensitive mule deer ranges.

Acknowledgments

We thank D. McWhirter, S. Smith, B. Holz, H. Haley, D. Almquist, B. Hovinga, S. Edberg, D. Clause, and S. Werbelow of the Wyoming Game and Fish Department (WGFD); S. Anderson of the Wyoming Cooperative Fish and Wildlife Research Unit; P. Guernsey of TRC Mariah Associates, Inc.; and S. Belinda of the BLM for providing field, office, and logistical support. Discussions with D. Thomas, J. Millspaugh, C. Nations, T. McDonald, and G. White helped refine the statistical methods. Comments from L. Carpenter, R. Sparrowe, and J. Brown improved the manuscript. Our research was funded by Ultra Petroleum, Questar Exploration and Production Company, the BLM, and the WGFD.

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A Blueprint for Sage-grouse Conservation and Recovery

Prepared by

Clait E. Braun, Ph.D.

Grouse Inc.
Tucson, Arizona

May 2006

Attachment 3

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Abstract: The distribution of greater sage-grouse (*Centrocercus urophasianus*) has declined by at least 44% while overall abundance has decreased by up to 93% from presumed historic levels. These decreases are the result of habitat loss, fragmentation, and degradation. Federal and state public land management agencies currently are responsible for about 70% of the remaining sagebrush (*Artemisia* spp.) steppe, with the Bureau of Land Management and U.S. Forest Service managing most of these lands for multiple uses. The goals of strategies outlined here are to improve sagebrush habitats to increase greater sage-grouse abundance by at least 33% by 2015, and overall distribution of greater sage-grouse by at least 20% by 2030. The abundance goal is achievable following recommendations presented in this document while the distribution goal will be more difficult to obtain. Federal land management agencies are key to achieving both goals, as they are responsible for managing public lands, which support most of the remaining populations of greater sage-grouse. Improved vegetation management to restore degraded habitat (from domestic livestock grazing and development, such as from mining and gas/oil extraction) followed by reduction of habitat fragmentation has the greatest potential for maintaining and enhancing viable populations of greater sage-grouse. While the habitat management strategies and recommendations in this report focus on greater sage-grouse, they are also applicable to Gunnison sage-grouse (*Centrocercus minimus*).

Introduction

Sage-grouse (*Centrocercus urophasianus, C. minimus)* are dependent upon sagebrush (*Artemisia* spp.) and were historically widespread and at least locally abundant (Patterson 1952, Schroeder et al. 2004). Concern about the decrease in the abundance of sage-grouse is not only recent (Connelly and Braun 1997, Braun 1998, Connelly et al. 2004) but also long-term (Hornaday 1916, Patterson 1952). Sagebrush was also historically widely distributed in western North America (Küchler 1964, Vale 1975, Miller and Eddleman 2001, Schroeder et al. 2004). In the United States, about 70% of the remaining sagebrush steppe and distribution of sage-grouse is on public land, with most (~50% of all publicly owned sagebrush steppe) managed by the U. S. Department of Interior, Bureau of Land Management (BLM) (Connelly et al. 2004). Thus, the BLM and the U.S. Forest Service (USFS) (U.S. Department of Agriculture) have the greatest potential to positively impact sage-grouse abundance and distribution provided effective policies and conservation actions are implemented that will benefit sagebrush steppe habitats. Overall, the "responsibility for maintaining sagebrush habitats and [sage-grouse] populations rests squarely on public land management agencies because most [of the] species' [home] range [is] owned publicly and managed by state or federal agencies" (Knick et al. 2003:627, Connelly et al. 2004).

Statement of Problem

The abundance and distribution of greater sage-grouse (*Centrocercus urophasianus*) have declined. Sage-grouse historically occupied at least 1,247,004 km² in western North America of which at least 1,200,483 km² were occupied by greater sage-grouse (Schroeder et al. 2004). Greater sage-grouse now occupy about 668,412 km² of

their estimated historical distribution and have been extirpated from 1 state (Nebraska) and 1 Canadian province (British Columbia) (Braun 1998). There are no data on historical numbers (pre-European settlement) but estimates range from at least 2 to 10 million birds (C. E. Braun, illustrated presentation to the Western Association of Fish and Wildlife Agencies, Jackson Hole, Wyoming, July 1998). Braun (1998) further presented estimated breeding population levels by state and province based on counts of male sage-grouse in spring 1998 as reported by state and provincial biologists. The total was presented as ~142,000 sage grouse (Braun 1998:141). This suggests a decrease of ~93% in overall abundance if the minimum historical estimate of 2 million sage grouse is used. Braun (1998) generally classified reasons for the apparent decrease in sage-grouse abundance as the result of habitat loss, habitat fragmentation, and habitat degradation. More recently, Connelly et al. (2004:13-4) indicated that of 41 populations defined for their analysis, 5 populations have been extirpated or have numbers too small to monitor, and 14 additional populations face a high risk of extinction. The vast majority of remaining sage-grouse are in only 8 populations. Additionally, Connelly et al. (2004: 6-67) reported that an examination of all trend data from the 1940s to 2003 "suggest a substantial decline in the overall sage-grouse population in North America." Sage-grouse populations declined at an overall rate of 2.0% per year from 1965 to 2003 (Connelly et al. 2004). These authors (2004:6-71) concluded, "Continued loss and degradation of habitat and other factors…do not provide causes for optimism."

Goals

With respect to conservation of sage-grouse and the species' habitats as well as other sagebrush obligate species, the overall goal of management of public lands should be to (1) maintain the present abundance and distribution of greater sage-grouse and (2) enhance the population viability of the species through habitat management that results in increased abundance and distribution. While it is necessary to understand past changes in abundance and distribution of greater sage-grouse, it is also important to understand the present status of the species and to work towards a goal of no net loss of sagebrush steppe presently or potentially useful to sage-grouse, no further loss of populations or subpopulations, and enhancement of sage-grouse numbers by one-third (33%) and overall distribution by one-fifth (20%) (from ~668,412 km^2 to 835,000 km^2). The abundance goal can likely be achieved by 2015 while the enhanced distribution goal is longer term (2030). Both desired increases (33% in abundance, 20% in distribution) were selected (by C. E. Braun) because they should be achievable, detectable, and measurable using current technology. A 20% increase in distribution was selected, as it should be detectable. Smaller increases in distribution are not likely to be detectable or measurable.

Habitat Needs Overview

The habitat needs of greater sage-grouse are reasonably well understood based on knowledge of what has been described as "used" by sage-grouse (extensive literature summarized in Braun et al. 1977, Connelly et al. 2000*b*, Braun et al. 2005). The basic seasonal periods relating to sage-grouse habitat needs have been described as winter (early to mid-December to early to mid-March), spring (early to mid-March to early to

mid-June), summer (early to mid-June to late September), and fall (late September to early to mid-December) depending upon elevation and weather conditions (Braun et al. 2005). A summary (Braun et al. 2005) of the existing literature is attached as an appendix.

Management of Development

Development of sagebrush steppe could include agricultural uses (usually permanent loss), which includes converting sagebrush habitats to cropland, placement of ranch/farm buildings, or the replacement of native sagebrush habitats with seeded pasture lands. Development may also refer to permanent conversion of sagebrush habitats to urban, suburban, and exurban uses (housing), and related infrastructure. "Development" as used in this section refers primarily to energy development, which includes mining (coal, gold, trona, and other mineral deposits) and extraction of natural gas (including coal bed methane) and oil. The following are minimum recommendations for development in sage-grouse habitats as it has been documented that some populations of greater sage-grouse require larger areas for breeding, brood-rearing, winter-use, and security depending upon whether they are migratory or non-migratory (Connelly et al. 2000*b*).

Noise

Sage-grouse are known to select display sites (leks) that are highly visible and which have good acoustic properties (Patterson 1952, Connelly et al. 2000*b*, Lyon 2000, Braun et al. 2002). Sage-grouse numbers on leks within 1.6 km (1 mile) of coal bed methane (CBM) compressor stations in Campbell County, Wyoming, were consistently lower than on leks not affected by this disturbance (Braun et al. 2002). Holloran and Anderson (2005) reported that lek activity by sage-grouse decreased downwind of drilling activities, suggesting that noise had measurable negative impacts on sage-grouse. Roads also generate noise and Connelly et al. (2004) indicated there were no active sage-grouse leks within 2 km of Interstate 80 (I-80) across southern Wyoming and only 9 leks were known to occur between 2 and 4 km of I-80. Lyon and Anderson (2003) reported that oil and gas development influenced the rate of nest initiation of sage-grouse in excess of 3 km of construction activities. Clearly, the amount and (likely) frequency of noise associated with development has major negative effects on greater sage-grouse.

Consequently, all drilling activities for gas and oil development should be prohibited within 5.5 km (3.3 miles) of active leks and their associated nesting areas (Holloran 2005). Further, all existing and new compressor stations should add noise abatement devices (mufflers) to reduce audible noise within 5.5 km of active leks. The actual level of noise (measured in decibels) that would not negatively affect greater sage-grouse breeding and nesting activities is presently unknown.

Physical Disturbance

Greater sage-grouse are known to be negatively impacted by activities associated with mining, and oil and gas development (Remington and Braun 1991, Aldridge 1998, Lyon and Anderson 2003, Holloran and Anderson 2005). Besides the actual physical disturbance to the landscape caused by mining and oil and gas development activities, the

impacts of roads are also negative for sage-grouse (Connelly et al. 2004). There are numerous examples of active leks being abandoned once road use associated with mining and gas/oil development increased in close proximity (< 1 km) to leks and nesting habitat (Braun 1986).

All surface activity should be prohibited within 5.5 km (Holloran and Anderson 2004, 2005) of active sage-grouse leks. No surface occupancy is preferred to simply limiting use of areas to specific periods, as the latter does not appear to benefit sage-grouse. Roads should not be placed within 5.5 km (3.3 miles) of active leks. If roads are present, they should be seasonally closed during the sage-grouse breeding season from 1 March to 20 June.

Management of Fire

Prescribed Fire

Fire has been demonstrated to be negative for greater sage-grouse (Hulet 1983; Connelly et al. 2000*a*, *b*; Nelle et al. 2000) as it destroys winter and nesting habitats. Use of fire has been promoted by public land management agencies (both BLM and USFS) to reduce sagebrush cover and increase forbs. However, the only presumed value of this practice is to improve brood-use areas or remove encroaching conifers. The problems with use of prescribed fire relate to control of the fire (escapement is frequent), what is actually burned versus what was desired to be burned, and size of the planned burn. Too often, what is burned is nesting or winter-use areas and burned areas are too large (> 20 ha).

Prescribed fire should not be used in areas where invasion of cheatgrass (*Bromus tectorum*) or other exotic species is likely. Burned areas should be smaller than 20 ha in size and no more than 20% of the landscape (128 ac per section [640 ac]) should be burned over a 30-year interval in taller sagebrush types. Burning should not be permitted in low sagebrush habitat types (i.e., *Artemisia arbuscula, A. longiloba, A. nova*). Burning that benefits sage-grouse will most likely be that which affects brood habitat. There should be a demonstrated need for additional brood habitat before use of prescribed fire is considered. The goal is to not exceed 20% fire coverage (128 ac per section [640 ac]) over a 30-year period regardless of the total area planned to be burned. Reseeding should not be necessary for prescribed burns, as areas should be sufficiently small so that surrounding sagebrush habitat can reseed the areas naturally.

Wild Fire

All wild fires should be vigorously suppressed except in areas where juniper (*Juniperus* spp.) or pinyon pine (*Pinus edulis*) has invaded (>20 trees/ha). Most wild fires are negative for sage-grouse in the short-term. If wild fires occur, grazing by domestic livestock should be immediately suspended and should not be reinstated for a minimum of 3 years. The present 2-year rest period from grazing that is often prescribed on public lands following wild fires is not based on data. Replicated studies are needed across the gradient of moisture regimes and habitat types to learn if 3 years or more are adequate for ecosystem renewal following wild fire. Most areas burned by wild fire do not require reseeding, as disking and other forms of site preparation can be harmful to site restoration. These are practices that promote livestock grazing, not habitat restoration. If

reseeding must be done to reduce soil erosion, it should occur in linear strips perpendicular to the prevailing wind except on steeper (>30%) slopes. Strips should be planted with dryland alfalfa, biennial sweet clover, native bunch grasses, and sagebrush seed in a ratio of 1 strip (10 m width) per 50 m. Areas closest to a potential fire source (roads or railroads) should be planted with a 20-m wide strip of fire resistant vegetation.

Management of Grazing

Sound grazing management in sagebrush steppe should promote light use of herbaceous forage while having a neutral or positive impact on plant vigor. Further, proper livestock grazing should maintain or enhance desirable plant communities, improve vegetation palatability, increase native plant diversity, and promote residual vegetative cover. Extreme caution should be exercised in grazing sagebrush steppe until scientific evidence is obtained through replicated studies that demonstrate grazing improves, restores, or maintains the ecosystem. It is questionable if grazing of sagebrush-dominated rangelands that produce less than 448 kg per ha (400 lbs/ac) per year of herbaceous forage should be permitted. Domestic livestock grazing should not be permitted of any sagebrush steppe habitats that produce less than 224 kg per ha (200 lbs/ac) of herbaceous vegetation per year if successful sage-grouse nesting and brood rearing is an objective. Unfortunately, there are no replicated long-term studies of the effects of stocking rates for cattle in sagebrush grasslands (Holechek et al. 1999:12).

Livestock

Grazing by domestic cattle can negatively impact nesting success of ground-nesting birds (Walsberg 2005). Several studies have demonstrated that greater sage-grouse nest success is higher where grass height and density is greater than at random sites (Wakkinen 1990, Gregg 1991). Thus, livestock grazing that reduces herbaceous cover in sagebrush steppe may negatively affect nest success of sage-grouse. Sites used by sage-grouse broods are characterized by higher plant species richness (Dunn and Braun 1986, Klott and Lindzey 1990, and others) with strong grass and forb components (Sveum et al. 1998). Excessive livestock use may damage these important areas.

Livestock stocking rates are most important in affecting forage use and residual herbaceous cover followed by timing of grazing and length of the grazing season. The most common prescription used by public land management agencies on public lands is that of 'moderate use'. Holechek et al. (1999:12) equated 'moderate use' to removal of an average of 43% (their Table 2) of the primary forage species. These authors found that moderate use resulted in rangeland deterioration in semi-arid grasslands. Holechek et al. (1999:15) recommended that no more than 30-35% use of annual herbaceous production would be necessary for improvement in rangeland vegetation versus the common recommendation of 50% use by the Natural Resources Conservation Service.

My recommendation, if livestock grazing is permitted on public rangelands, is to not exceed 25-30% utilization of herbaceous forage each year. Grazing should not be allowed until after 20 June and all livestock should be removed by 1 August with a goal of leaving at least 70% of the herbaceous production each year to form residual cover to benefit sage-grouse nesting the following spring. Twice-over grazing systems, where livestock pass through an area twice in a grazing season, should be avoided, and full

rotation of each subdivision of an allotment or at least on a pasture basis should occur once every 4 years. Winter grazing is generally less negative for herbaceous vegetation and sage-grouse than grazing during the growing season. Care should be used in calculating stocking rates to ensure that no more than 25-30% forage utilization is achieved. Winter grazing should not be initiated until plant growth has ceased for the year and should generally occur in the 15 November to 1 March interval. Larger pastures with fewer fences are better than smaller pastures. Water and salt should be placed near fences or fence corners, as these areas (fences and fence corners) tend to 'naturally' attract livestock. The goal should be to reduce livestock impacts in the centers of pastures or allotments. Because fences are generally negative for sage-grouse (Connelly et al. 2004), placement of water and salt near fences can be used to concentrate livestock impacts in areas removed from the more valuable habitats for sage-grouse.

Wildlife

Native wildlife, primarily elk (*Cervus elaphus*), but also deer (*Odocoileus* spp.), pronghorn (*Antilocapra americana*), and hares (*Lepus* spp.), graze sagebrush steppe. Except in limited situations, such as within fenced pastures (to benefit domestic sheep which may prevent pronghorn movement), severe winter conditions, or unique situations (especially with hares), grazing by native wildlife species of particular sites is non-repetitive (unlike with domestic livestock). Hunting regulations by state and provincial agencies should keep populations of game animals within herd objectives. Management of elk can be difficult in achieving adequate harvests. State and provincial wildlife agencies should rigorously seek to manage elk within stated herd objectives or to reduce their numbers when sage-grouse habitat objectives are at risk. In areas where herd objectives cannot be met through legal hunting, reintroduction of native large predators should be considered.

'Wild' horses and burros also occupy some public lands and can cause habitat deterioration in areas important to sage-grouse. Efforts should be made to reduce or eliminate undocumented or permitted horses and burros on public lands important to sage-grouse where habitat deterioration is occurring.

Management of Habitat Fragmentation

Fragmentation of habitats useful for greater sage-grouse is not of recent origin, but only recently has it been accorded proper recognition (Braun 1998, Connelly et al. 2004). There are many factors that can fragment habitats from conversion of habitat type (agriculture adjacent to sagebrush steppe), to fences, power lines, roads, reservoirs, wild fire, and prescribed burns. Essentially, any land use, development, or treatment that subdivides blocks of intact sagebrush causes fragmentation. Management of sagebrush steppe should focus on maintaining large (>1 cadastral section [2.59 km^2 or 1 mi^2]) blocks of sagebrush steppe and preferably in excess of 20 cadastral sections [51.8 km^2 or 20 mi^2] in size. These blocks should conserve habitat at the landscape scale with at least 1 large block per Township (36 cadastral sections [93.2 km^2 or 36 mi^2]) throughout the sagebrush steppe. This recommendation is based on personal observations as well on published literature (Toepfer et al. 1990).

Continuity among habitat patches is desirable. Dispersal corridors should be preserved between and among blocks of habitats useful to greater sage-grouse. These corridors should be at least 1.6 km (1 mi) in width to reduce predator concentrations. Corridors should not contain roads, power lines, oil and gas developments, fences, or buildings.

Management of Invasive Plant Species

Invasive plant species are becoming more widespread throughout public lands as a result of disturbance from livestock grazing, livestock feeding operations, roads, development, and other land uses. While there are numerous invasive species that may occur across the sagebrush steppe, those most important over large areas include cheatgrass, juniper and pinyon pine (both native species), as well as other exotic species. Control or elimination of exotic species should have the highest priority.

Cheatgrass

Livestock management practices, fire, plowing/chaining, various types of development, and other practices have facilitated the spread of cheatgrass. Cheatgrass is palatable to livestock for only a short period during early growth in spring. It is a highly proficient seed producer and cannot be easily controlled by disking, plowing, grazing, or herbicides during the growing period or when mature. However, several pre-emergent herbicides have been demonstrated to reduce germination of cheatgrass (Connelly et al. 2000*b*). Reseeding cheatgrass-dominated areas with dryland alfalfa and native bunch grasses in strips (20 m width with every other strip being alfalfa/bunch grasses/biennial sweet clover/sagebrush) would appear to be effective in reducing cheatgrass abundance and may be more economical than use of herbicides.

Pinyon/Juniper

Management of pinyon pine or juniper invasion can be achieved through cutting and burning (either or both) individual trees as well as use of prescribed fire over larger landscapes. Treatment of individual trees is most effective (but more expensive), as the live sagebrush and grass/forb understory is not burned (Commons et al. 1999).

Management of Rangeland Seedings

Hundreds of thousands of hectares of former sagebrush steppe have been seeded with non-native forage species following plowing (to benefit livestock) or wild fire. Much of this area was reseeded with crested wheatgrass (*Agropyron cristatum*). Unfortunately, crested wheatgrass is of little use to sage-grouse as it provides poor cover and no food value. Sage-grouse seasonally consume forbs, insects, and sagebrush and do not eat grass seeds or leaves. Further, crested wheatgrass is a prolific seed producer with the ability to remain dominant on the landscape for periods exceeding 40 years. Crested wheatgrass is preferred forage for livestock and wild ungulates, especially during the growing period. It is capable of withstanding substantial grazing pressure and, once established, crested wheatgrass is difficult to replace with native bunchgrasses and sagebrush (due to competition and lack of seed sources).

Benign neglect has allowed portions (primarily the edges) of many seedings on public lands to revert in part to sage-grouse habitat. This is the result of sagebrush regeneration from seeds of live sagebrush in adjacent areas. Sage-grouse use these areas as density of sagebrush seedlings and canopy cover increases. Unfortunately, forb abundance in most crested wheatgrass seedings is very low (<3-5% cover) and sage-grouse use is mostly confined to foraging on young sagebrush plants. Crested wheatgrass seedings with less than 5% sagebrush canopy cover should be disked and reseeded in strips perpendicular to the prevailing wind to aid restoration of native habitats. Strips should be no more than 20 m in width in a ratio of 1 strip every 100 m. Strips should be planted with a mixture of dryland alfalfa, biennial sweet clover, native bunch grasses, and taller sagebrush (either mountain big sagebrush [*Artemisia tridentata vaseyana*] or Wyoming big sagebrush [*A. t. wyomingensis*] depending upon the site).

Biological control of crested wheatgrass seedings through manipulation of grazing intensity is possible but is negative to overall rangeland health as it results in severe overgrazing of all areas including adjacent native sagebrush steppe. This practice should not be promoted, as it will fail to control or eliminate crested wheatgrass. Chemical control of crested wheatgrass seedings also has little chance of success because of the abundant but dormant seed in the upper levels of the soil profile that are not affected by herbicides. Mechanical control through plowing or disking of the entire seeding followed by reseeding with desirable plant species also has little merit as it is expensive and exposes large expanses to wind erosion and exotic weeds. Plowing or disking (with or without reseeding) also has little chance of success because of the abundant amount of crested wheatgrass seed in the upper soil profile. Thus, the best scenario is to disk strips into crested wheatgrass seedings horizontal to the prevailing wind and replant desired vegetation (in strips) while protecting all larger sagebrush plants that may be present to serve as seed sources. Additional strips should be disked and reseeded at 3-5 year intervals depending upon site and results from the initial strips (adaptive management).

Management of Roads

Roads are known to reduce the value of potential breeding habitats for greater sage-grouse (Connelly et al. 2004), cause lek abandonment (Braun 1986), and lead to death (from collisions). Road densities are increasing within occupied sage-grouse habitats. A recent study in the Upper Green River Valley, Wyoming found that all remaining greater sage-grouse leks were within 5 km (3.1 miles) of a road and that 95% of the Jonah gas field had road densities greater than 3.2 km per 2.59 km^2 (2 miles/mile^2) (Thomson et al. 2005). Distinction should be made among primary roads (usually paved), secondary roads (mostly gravel), and trails (usually dirt, commonly expressed as 2-tracks). Primary roads are most negative for greater sage-grouse because of vehicle frequency, speed, and noise. Secondary roads can also be very negative depending again upon vehicle frequency, speed, and noise. Generally, trails are used seasonally and receive light vehicle use. Consequently, they are least problematic for sage-grouse.

Public land management agencies should have transportation plans for each forest, district, and resource area. Both permanent and seasonal road/trail closures are appropriate to reduce disturbance to sage-grouse during breeding activities and winter.

Most trails within occupied sage-grouse habitat should be closed during the breeding period and winter. Some secondary roads within 5 km of active leks should be closed during the 1 March-20 June period as well as during winter (December-February). All secondary roads and trails that traverse important sage-grouse areas should be reviewed and considered for permanent closure and revegetation.

Off-road vehicles (ORVs) should be prohibited except on designated trails and roads where sage-grouse use does not occur.

Management of Structures

Greater sage-grouse did not evolve with structures. Sage-grouse commonly collide with fences, and power lines have been demonstrated to be negative as they may result in collisions resulting in injury to or death of birds (Connelly et al. 2004). Structures can also provide perch locations for raptors, especially golden eagles (*Aquila chrysaetos*), which prey upon sage-grouse during all seasons of the year, and corvids that prey on nests. Prior to the advent of human-made structures, raptors and corvids in sagebrush steppe used elevated natural sites from which to hunt. The addition of power line poles, fences, hay equipment and stacks, and abandoned buildings have greatly expanded the number of suitable perches for raptors in a landscape that is mostly devoid of trees (Connelly et al. 2004). Historically, there were large expanses of suitable habitat for sage-grouse with few elevated perch sites.

Utility companies should be required to fit all potential perch sites (poles, towers) for golden eagles with devices to deter perching (including power poles associated with oil and gas development). All unused power poles (and towers) should be removed and consideration should be given to elimination (and removal) of unnecessary power lines that traverse sage-grouse habitats. Existing power lines should be placed in corridors that follow road systems, especially those that are paved, to minimize impacts on the landscape. First priority for fitting power poles with raptor guards and or for removal of power lines should be given to areas within 5.5 km (3.3 miles) of active leks (at least line of sight). Second priority should be given to known sage-grouse winter-use areas, especially along windswept ridges and near large expanses of sagebrush that are not typically covered by snow in winter. Raptor predation during summer and early fall is usually a local problem and more a product of habitat quality (i.e., sage-grouse are limited to few areas of suitable habitat) than at other times of the year.

Metal fence posts are preferable to wooden posts for fencing as the former better discourage raptors from using them as perches. Fencing within 2 km of active leks should be discouraged as sage-grouse are more likely to collide with them as they fly to and from leks, frequently at low levels and in low light. Fences designed to prevent domestic sheep from escaping pastures should be eliminated as walking sage-grouse frequently will follow and not readily fly over them. Fences in sage-grouse areas should be of no more than 3-strands of wire with both the top and bottom wires being barbless. All unnecessary fences should be removed (wire and posts). If fences known to result in sage-grouse mortality cannot be removed, the top wire should be marked with permanent visual flagging.

Management of Vegetation

Native sagebrush steppe vegetation should be given highest priority for management. Management should revolve around proper livestock grazing practices and not use of chemical or mechanical treatments. Grazing should be managed to ensure that sagebrush-dominated rangelands have the opportunity to recover from past management practices. The goal is to have healthy, self-sustaining native vegetation in which sagebrush comprises 10 to 25% of the vegetative canopy cover, grasses comprise 30-40%, and forbs comprise 15 to 20% of the ground cover. Holechek et al. (1999:15) indicate that livestock grazing, if the intent is to improve rangeland vegetative condition, should remove no more than 30-35% of the annual herbaceous growth. Some areas may require complete removal of livestock grazing for 3-5 years before grazing at lower stocking rates can resume. Improved management of grazing is the least expensive practice to restore degraded sagebrush steppe and should have the highest priority.

Chemicals such as 2,4-D and tebuthiuron have been widely used in attempts to eliminate or reduce sagebrush to increase livestock forage on public rangelands (Braun 1987, 1998). Use of 2,4-D has mostly been phased out for a variety of human health and environmental reasons (Braun 1998). Tebuthiuron is now favored for controlling sagebrush, especially to 'thin' sagebrush stands. Unfortunately, the effectiveness of this chemical is site dependent and is greatly affected by soil characteristics (Braun 1998) and continued livestock grazing. Application rates are critical and use of high rates or any chemical use on inappropriate soils can lead to total kill of sagebrush and forbs. For this reason, use of chemicals to 'thin' or control sagebrush is usually inappropriate for winter and breeding habitat.

Mechanical methods to manage sagebrush date to the 1930's and have involved brush beating, disking, chaining, and railing (Pechanic et al. 1954). These methods are relatively expensive and have mostly been used on small scales. They have the advantage of being able to be tailored to specific sites and will not 'escape' or 'drift' when compared to fire or use of chemicals. Of the available mechanical methods, use of brush beating is most appropriate as the desired results in terms of vegetation can reasonably be predicted. Brush beating or any other type of mechanical method to manage sagebrush should only be considered for 'better' range sites where vegetation response can be expected. These are normally areas where sagebrush canopy cover is >30%. Brush beating should be done in strips (usually 10-20 m in width) not to exceed one-quarter (25%) of the width of untreated strips. Strips should conform to the terrain and should not be straight lines but should be perpendicular to the prevailing wind. The design should result in a mosaic of sagebrush types with no more than 20-30% of the area being treated every 10-15 years (depending upon site). The goal is to set back sagebrush height (causing resprouting) and not death of all sagebrush plants. This can be accomplished by adjustment of the height of the mower blades. More recent advances such as the 'Dixie Harrow' and 'Lawson Aerator' may have merit but more scientific analysis of the results of using these devices is needed. Management of livestock grazing (reduction in or elimination of use for at least 2 years) is normally needed following brush beating or any mechanical treatment.

Use of fire to manage sagebrush steppe vegetation is usually inappropriate as it is difficult to control and frequently burns primarily winter and nesting habitats (Connelly et al. 2000*a*). Fire should generally be avoided or, at the least, restricted to small (<20 ha) sites where a lack of brood habitat has been documented to limit increases in sage-grouse populations.

Management of Water

Greater sage-grouse have been documented to use open water, especially during dry seasons. They readily eat snow in winter and forage during summer and fall on succulent vegetation in mesic sites. This vegetation may be adjacent to agricultural areas, riparian habitats, or where water is allowed to flow over land at springs and ponds. The need for so-called wildlife "guzzlers" is questionable, as studies have failed to demonstrate increases in sage-grouse density in areas with guzzlers (Connelly and Doughty 1989). Surface water flow in summer is important as it promotes growth of succulent forbs, which are attractive to greater sage-grouse. Pipes and tanks (for livestock) have no value for sage-grouse unless water is available at ground level or is allowed to spill onto the ground. There should be no emphasis placed on improving water distribution for livestock as this negatively affects sage-grouse habitats in most cases outside of ponds. All seeps and springs, and associated mesic sites should be fenced to exclude large grazing animals including domestic sheep, cattle, horses, and burros.

Livestock grazing has also impacted water tables by increasing sagebrush density and increasing soil erosion by reducing surface litter that slows runoff. Techniques useful to increasing water table levels include reduction of livestock grazing, sagebrush mowing, filling eroded drainages with (certified weed-free) straw bales, and creating check dams. These techniques are also useful in creating brood habitat for sage-grouse.

Where Should Management Focus Be Placed?

Areas with existing sage-grouse populations should have the highest priority for conservation. The best scenario for improved sage-grouse abundance and distribution is to conserve habitats with existing populations and then work outward from those core areas to improve habitats in more peripheral areas. GIS (Geographic Information Systems) derived maps of present vegetation and soil potential should be used with overlays of past and planned treatments to prevent too much area from being treated in a 10-15+ year period. The goal should be to increase sage-grouse abundance and distribution. Increases in abundance will be easier to achieve.

Areas contiguous to existing populations which do not presently have sage-grouse or which have very small populations (100-300 birds) should have second priority for management. Review of GIS maps of vegetation and soil potential will frequently identify factors that are depressing sage-grouse populations when compared to similar maps where sage-grouse still persist in some number. Treatments to improve abundance and distribution of populations will vary from area to area. Grazing practices and development are the most obvious factors depressing sage-grouse populations followed by fragmentation caused by vegetation treatments, including fire.

How Should Success Be Measured?

Changes in abundance of greater sage-grouse are best measured by monitoring the number of active leks in a discrete area (leks/10 km^2) over a 3-5 year period. Total number of males counted in a given area over a 3-5 year period can also be used. Changes in estimated nest success and percent young based on wing surveys of hunter-harvested birds (where appropriate) may also provide useful data (Autenrieth et al. 1982, Connelly et al. 2003). Changes in the proportion of young to adult (and yearling) hens in the harvest can also be used to detect improvement in sage-grouse production.

Changes in distribution of greater sage-grouse can be derived from intensive searches for active leks in areas (based on GIS derived maps of potential habitat) where sage-grouse were not present in the previous 3-5 years. Random transects to assess seasonal changes in distribution of sage-grouse fecal pellets can also be used to assess changes in distribution. Even presence or absence line transect counts of either sage-grouse or their sign (pellets) can be useful. These surveys should be made at 3-5 year intervals.

Changes in vegetation such as % bare ground, % forb coverage, % grass coverage, % sagebrush cover, as well as height of residual herbaceous material can be used to assess changes in vegetative composition and quality of habitats. However, vegetation surveys are labor intensive, costly, and may be affected by weather conditions, rodents, insects, and grazing animals. It is highly unlikely that short-term changes can be detected without standardized plots, which are marked and uniformly evaluated. This is not likely to be done on a consistent basis over large areas of western North America. It will be difficult to measure success in vegetation improvement except over time in very localized sites.

Conclusions

Habitat conservation strategies to improve the abundance and distribution of greater sage-grouse have not been scientifically tested because of the reluctance of public land management agencies to invest in replicated management experiments over sufficiently large areas to be able to detect responses. However, sufficient information is available to make management recommendations given that negative responses of sage-grouse (decreases in abundance and distribution) are measurable. Habitat loss is certainly measurable as are fragmentation and degradation of habitats. The most notable changes in the sagebrush steppe since European settlement are associated with repetitive grazing by domestic livestock and developments (no matter how 'development' is defined). It is logical to expect improvement in sage-grouse abundance, at the least, with changes in policies, regulations, and practices involving grazing of domestic livestock and development. Both of these factors are managed by the key public land management agencies (BLM and USFS) that together control in excess of 60% of the remaining sagebrush steppe occupied by greater sage-grouse. Improvement in distribution will be more difficult as restoration of useful sagebrush habitats in areas that have been burned or plowed and seeded to exotic grasses will be exceedingly slow.

Management practices that significantly reduce wild fire, reduce grazing intensity and forage utilization, and reduce or eliminate the spread of introduced annuals have the

best chance to positively impact abundance of greater sage-grouse. They will be the least expensive to implement. Development practices such as gas and oil exploration and production including surface infrastructure, which are obviously negatively affecting sage-grouse abundance and distribution, will be more expensive to change, but collectively changes in these practices could equal the gains expected to result from changes in livestock grazing practices.

Sufficient knowledge is available to begin implementing recommended practices that will positively affect greater sage-grouse. The key is to develop public support and the resolve within federal agencies to make the necessary changes.

Recommendations

-First priority for habitat management should be areas where larger sage-grouse populations are still present. Management practices chosen should maintain the present abundance and distribution of sage-grouse.

-The second priority for habitat management is for areas where sage-grouse populations are small (<300 birds or 100 males counted on a 3-year moving average). Management practices should enhance sage-grouse abundance and distribution.

-A third priority should be to improve habitats in areas adjacent to existing populations.

-Sagebrush steppe management should focus on maintaining large (>1 cadastral section and preferably >20 cadastral sections in size) blocks of sagebrush habitat per Township (36 cadastral sections).

-No surface occupancy should be allowed within 5.5 km of all active sage-grouse leks.

-No roads should be constructed within 5.5 km of active sage-grouse leks.

-Existing roads within 5.5 km of active sage-grouse leks should have seasonal closures (1 March-20 June).

-Prescribed fires should be no larger than 20 ha with no more that 40% of each cadastral section being burned over a 15-year period.

-Wild fires in sagebrush steppe should be vigorously suppressed except in areas with >20 invasive conifer trees per ha.

-Livestock grazing should be deferred for 3 years following fires for recovery of herbaceous native vegetation.

-Livestock grazing should not remove more than 25-30% of the annual growth of herbaceous vegetation with grazing delayed until after 20 June. True rest rotation systems should be used and winter grazing is preferred.

-Where wildlife (deer and elk) herd objectives cannot be achieved through legal hunting, reintroduction and expansion of populations of large predators should be encouraged.

-Rangeland seedings of exotic grasses should be converted using reseeded strips of native bunchgrasses, adapted subspecies or species of sagebrush, and dryland alfalfa.

-Power lines should be placed only into existing road/utility corridors.
-Power poles and other existing human structures should either be removed, if not used, or fitted with raptor-deterrence devices.
-Fences in sage-grouse use areas should be no more than 3 strands with the top and bottom wires being barbless. Unused fences should be removed.
-Use of chemicals to 'manage' sagebrush should not be permitted. If sagebrush is to be managed to reduce density or to enhance vigor, mechanical methods are preferred.
-Sage-grouse have not been shown to need open water. However, water should be allowed to flow (seep) over the ground to encourage growth of succulent forbs.
-Active leks per unit of area and total number of male sage-grouse counted at proscribed (4 counts per breeding period spaced at 7-10 day intervals) should be used as the measure of success of management treatments followed by changes in % bare ground, % forb coverage, % grass cover, % sagebrush canopy cover, and height of residual herbaceous vegetation.
-Sage-grouse pellet transects should be used to measure expansion of birds into vacant or former habitat.

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About The Author

Clait E. Braun has worked with sage-grouse as a researcher (1973-99) and consultant (2000-06), and has been a leader in publishing research and management articles on sage-grouse. Dr. Braun is a Certified Wildlife Biologist and has either worked in or extensively visited all states and provinces with current populations of sage-grouse. He retired from the Colorado Division of Wildlife where he was responsible for sage-grouse research from 1973 into 1999 and now operates Grouse Inc. providing professional guidance and reviews on sage-grouse and their habitats. This 'Blueprint' represents his professional experience and selected literature based on 30+ years of work with sage-grouse.

Appendix

Seasonal Habitat Requirements for Sage-grouse:

Spring, Summer, Fall, and Winter[1]

(Citation: Braun, C. E., J. W. Connelly, and M. A. Schroeder. 2005. Pages 38-42 *in* N. L. Shaw, M. Pellant, and S. B. Monsen, compilers. Sage-grouse habitat restoration symposium proceedings, 4-7 June 2001, Boise, Idaho, USA. U. S. Department of Agriculture, Forest Service, RMRS-P-38.)

[1]The contents of this 'Blueprint' document have not been reviewed or approved by either of the 2 coauthors of the published paper referenced in the Appendix.

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Seasonal Habitat Requirements for Sage-Grouse: Spring, Summer, Fall, and Winter

Clait E. Braun
John W. Connelly
Michael A. Schroeder

Abstract—Sage-grouse (*Centrocercus minimus, C. urophasianus*) are dependent upon live sagebrush (*Artemisia* spp.) for all life processes across their entire range. This paper describes habitats used by sage-grouse as documented in the scientific literature. The leaves of sagebrush are eaten by sage-grouse throughout the entire year and comprise 99 percent of their winter diets. Spring (late March through May) habitats are those with intermixed areas of taller (40 to 80 cm) sagebrush with canopy cover of 15 to 25 percent and taller (>18 cm) grass/forb cover of at least 15 percent. Sites used for display have shorter vegetation, frequently few or only short sagebrush plants, but with taller, more robust sagebrush within 100 to 200 m that is used for escape cover. Nesting cover mimics that used overall during spring but with clumps of tall (>50 cm), dense (about 25 percent) live sagebrush and abundant forbs (>10 to 12 percent cover). Early brood rearing areas are those within 200 m (initial 3 to 7 days posthatch) to 1 km (up to 3 to 4 weeks posthatch) of nest sites. Forbs and taller (>18 cm) grasses are important for broods; forbs provide succulent foods, grasses provide hiding cover, and the grass/forb mixture supports insects used by chicks. Summer use areas are those with abundant succulent forbs with live, taller (>40 cm), and robust (10 to 25 percent canopy cover) sagebrush useful for cover. These areas continue to be used into fall when sage-grouse move to higher benches/ridges where they forage on remaining succulent forbs such as buckwheat (*Eriogonum* spp.) and switch to more use of sagebrush leaves. Winter (early December to mid-March) use areas are often on windswept ridges, and south to southwest aspect slopes as well as draws with tall, robust live sagebrush. Height (25 to 35 cm) of sagebrush above the surface of the snow in areas used in winter is important, as is canopy cover (10 to 30 percent). Management of habitats used by sage-grouse should initially focus on maintaining all present use areas. Practices to enhance sagebrush habitats to benefit sage-grouse are reviewed, as is the need to annually monitor sage-grouse numbers along with systematic monitoring of the health of sagebrush ecosystems.

Clait E. Braun is retired from the Colorado Division of Wildlife and operates Grouse, Inc., 5572 North Ventana Vista Road, Tucson, AZ 85750 U.S.A., FAX: (520) 529-0365; e-mail: sg-wtp@juno.com. John W. Connelly is Research Biologist, Idaho Department of Fish and Game, 1345 Barton Road, Pocatello, ID 83204 U.S.A.; e-mail: JCsagegrouse@aol.com. Michael A. Schroeder is Upland Bird Research Biologist, Washington Department of Fish and Wildlife, P.O. Box 1077, Bridgeport, WA 98813 U.S.A.; e-mail: schromas@dfw.wa.gov

In: Shaw, Nancy L.; Pellant, Mike; Monsen, Stephen B., comps. 2005. Sage-grouse habitat restoration symposium proceedings; 2001 June 4–7; Boise, ID. Proceedings RMRS-P-38. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Introduction

Sage-grouse (*Centrocercus minimus, C. urophasianus*) historically occurred in at least 16 States and three Canadian Provinces (Aldrich 1963; American Ornithologists' Union 1957; Johnsgard 1973). They have been extirpated in five States and one Canadian Province (Braun 1998; Connelly and Braun 1997) and their overall distribution has become discontinuous (fig. 1). The changes in sage-grouse distribution have been attributed to loss, fragmentation, and degradation of habitats (Braun 1995, 1998; Connelly and Braun 1997), and it is probable that at least one-half of the original occupied area can no longer support sage-grouse (Braun 1998). Because of the reduced amount of available habitat, sage-grouse abundance has also markedly decreased with reported declines of 10 to 51 percent (Connelly and Braun 1997) and as much as 45 to 82 percent since 1980 (Braun 1998). The known decreases in distribution and abundance have led to concern about stability of sage-grouse populations and the health of sagebrush ecosystems upon which they depend. Petitions to list sage-grouse under the Federal Endangered Species Act have been filed for northern sage-grouse (*C. urophasianus*) and for Gunnison sage-grouse (*C. minimus*).

Sage-grouse are dependent upon ecosystems with vast and relatively continuous expanses of live, robust, taller sagebrushes (*Artemisia* spp.) with a strong grass and forb component. This dependency upon sagebrush, especially the subspecies of big sagebrush (*A. tridentata vaseyana, A. t. wyomingensis, A. t. tridentata*), low sagebrush (*A. arbuscula*), black sagebrush (A. *nova*), silver sagebrush (*A. cana*), and three-tip sagebrush (*A. tripartita*), as well as a variety of less apparent and abundant species, has been well documented (Patterson 1952; reviews by Braun and others 1977 and Connelly and others 2000a). Since the early 1960s, the sage-grouse/sagebrush relationship has focused attention by Western States and Provinces on the need to maintain healthy sagebrush-steppe communities over large expanses. Guidelines for maintenance of sage-grouse habitats were developed from the scientific literature (Braun and others 1977, completely revised by Connelly and others 2000a) and promoted by the Western States Sage-Grouse Technical Committee. The purpose of this paper is to present an overview of the habitat needs of sage-grouse based on the scientific literature, identify the issues that affect maintainance of useful habitats for sage-grouse, and discuss management strategies to maintain, enhance, and restore habitats

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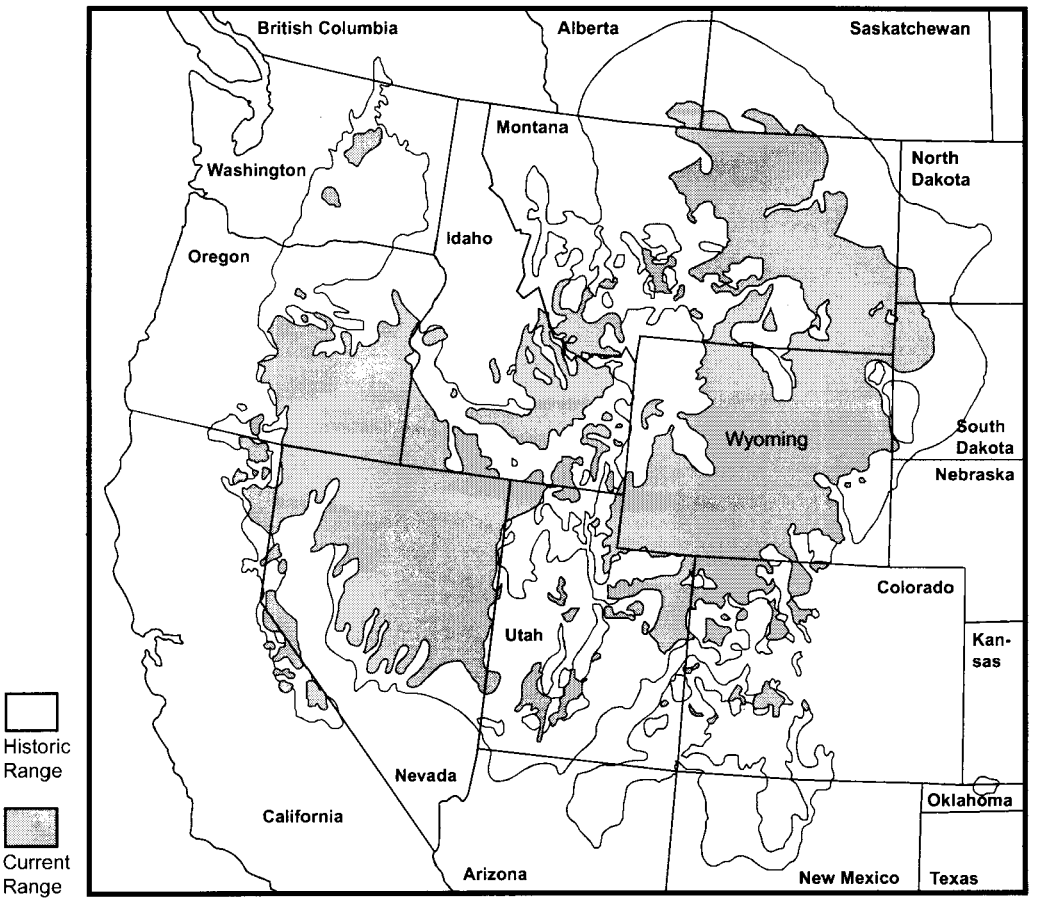

Figure 1—Historic and current distribution of sage-grouse (map prepared by M. A. Schroeder).

for sage-grouse. This paper draws extensively on the published *Guidelines to Manage Sage Grouse Populations and Their Habitats* (Connelly and others 2000a).

Habitat Overview

Spring

Timing of spring breeding activities of sage-grouse is dependent on elevation and amount of persistent snow cover. Attendance at leks may start in early to mid-March or, at higher elevations, in early April. Males may attend and display at leks until late May but most display and mating activities are greatly reduced by mid-May. Amount and depth of snow cover greatly influence sage-grouse breeding activities; thus, snow-free areas are important components of spring habitat. Habitats used by sage-grouse during the breeding period are those associated with foraging, leks, escape, and nesting. Depending upon moisture regimes, height of sagebrush in used habitats varies from 30 to 80 cm with canopy cover from 15 to 25 percent (Connelly and others 2000a). Lek sites typically have low amounts of sagebrush and appear relatively bare, but they may have extensive cover of low grasses and forbs. Taller, robust live sagebrush used as escape cover is normally within 100 to 200 m of active leks. The average distance from a nest to the nearest lek varies from 1.1 to 6.2 km, and the actual size of the breeding habitat appears largely dependent on the migratory characteristics of the sage-grouse population as well as distribution of sagebrush cover with respect to lek location (Connelly and others 2000a). Habitats selected for nesting are those with abundant (15 to 30 percent canopy cover) live, taller (30 to 80 cm) sagebrush plants within a community with >15 percent ground cover of taller (40 to 80 cm) grasses and forbs (Connelly and others 2000a). Early brood-rearing habitats (fig. 2) are normally those within 100 m to 1 km of nesting sites, especially areas with high plant species richness, moisture, and taller grasses and forbs (Connelly and others 2000a). Adult sage-grouse, while still foraging extensively on leaves of live sagebrush, eat leaves and flower parts of forbs during spring, as do chicks (Apa 1998; Drut and others 1994; Dunn and Braun 1986; Klott and Lindzey 1990).

Summer

Habitats used by sage-grouse in summer (early to mid-June to mid to late September) are those that provide

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Figure 2—Sage-grouse brood hen in good quality Wyoming big sagebrush habitat, North Park, Colorado (photograph by C. E. Braun).

adequate forage, especially succulent forbs, and cover useful for escape. These habitats may include those used for agriculture, especially for native and cultivated hay production, edges of bean and potato fields, as well as more typical sagebrush uplands and moist drainages. Taller (>40 cm) and robust (10 to 25 percent canopy cover) sagebrush is needed for loafing and escape cover as well as a source of food. Grass and forb ground cover can exceed 60 percent (hayfields). Provided moisture is available through water catchments or from succulent foliage, sage-grouse may be widely dispersed over a variety of habitats during this period (Connelly and others 2000a). As late summer approaches, there is movement from lower sites to benches and ridges (fig. 3) where sage-grouse forage extensively on leaves of sagebrush.

Fall

Fall (late September into early December) is a time of change for sage-grouse from being in groups of hens with chicks or males and unsuccessful brood hens to separation into larger flocks frequently segregated by gender. Some birds may continue to use lower riparian or hayfield habitats, but there is movement onto higher, frequently north-aspect slopes where succulent native forbs, such as buckwheats, provide green forage. Use of sagebrush leaves for food becomes more common as does use of extensive stands (>20 percent canopy cover) of taller (>25 cm), live sagebrush (Connelly and others 2000a). Movements can be slow but there is a general shift toward traditional winter use areas (Connelly and others 1988).

Winter

Flocks of sage-grouse are somewhat nomadic in early winter but may remain within chosen areas for periods of several weeks or more depending upon extent of snow cover and depth (Beck 1977; Hupp and Braun 1989b). Sagebrush height (>20 cm, but usually >30 cm, above the surface of the snow) is important as is the robust (>10 to 30 percent canopy cover) structure of live sagebrush (Connelly and others 2000a). Sage-grouse use a variety of sites in winter including windswept ridges with open (10 to 20 percent canopy cover) (fig. 4) stands of sagebrush to draws with dense (>25 percent canopy cover) stands. Quality of the snow can be important because sage-grouse are known to use snow roosts and burrows (Back and others 1987). Aspect is also important with south and southwest slopes most used in hilly terrain (Hupp and Braun 1989b). Leaves of live, vigorous sagebrush plants provide >99 percent of the foods eaten during the winter period (early December until early to mid-March) (Patterson 1952; Remington and Braun 1985; Wallestad and others 1975). Generally, winter is a time of body mass gain (Beck and Braun 1978), although severe winter conditions over prolonged intervals can reduce the amount of area available for foraging and cover (Beck 1977) and thus affect body condition (Hupp and Braun 1989a). Overall movement during winter may be extensive and home ranges can be large (Connelly and others 2000a). As winter wanes, flocks of sage-grouse move toward breeding areas that may be immediately adjacent to or far distant from winter use areas (Connelly and others 2000a).

Figure 3—Radio-tracking sage-grouse in high-elevation summer range with a stand of mountain big sagebrush in the background (photograph by J. W. Connelly).

Figure 4—Sage-grouse winter range in Wyoming big sagebrush habitat in North Park, Colorado (photograph by C. E. Braun).

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Issues

Decreases in distribution and abundance of sage-grouse have been ascribed to a complexity of factors (Braun 1987, 1998; Connelly and Braun 1997). The three major causes, (1) habitat loss (mostly permanent), (2) fragmentation (frequently permanent but reversible at times), and (3) degradation (usually can be corrected), are generally accepted but the latter two are poorly recognized and understood. Examples of permanent habitat loss include conversion of sagebrush rangelands to agricultural crops, town and subdivision developments, placement of power plants or surface mines, and reservoir construction. Fragmentation of habitats occurs with power lines, paved and other high-speed road development (including maintenance and improvement of farm roads), habitat-type conversion projects, fire, or any permanent development that reduces the size of existing habitat patches. Less understood are the impacts of fences, seasonal use trails, oil and gas wells with surface pipelines, noise, and so on. Some of these impacts can be resolved and sage-grouse will reoccupy some formerly disturbed areas (Braun 1987).

Distribution of habitat types useful to sage-grouse is also important, as these species are habitat specialists using a variety of areas within a larger landscape mosaic. Thus, not only is the quantity of sagebrush habitats important, but also the juxtaposition and quality of those habitats. All sagebrush habitats are not equal in their acceptability to sage-grouse, and location of areas used may affect sage-grouse distribution. Size of habitat patches is important and larger (>30 km^2) is better than smaller, although the spatial relationships of habitats for sage-grouse are not well understood. Sage-grouse use a mosaic of habitats that is normally present in sagebrush-steppe because of differences in soils, moisture, topography, aspect, insect defoliation, wildfires, and other factors. Sagebrush naturally regenerates as overmature plants die and seedlings become established. Use of the term "decadent" for sagebrush is generally inappropriate because it implies that sagebrush communities are not dynamic with a variety of age classes from seedlings to overmature. Since most sagebrush communities are resilient and represent a continuum of age classes within a mosaic of habitats, creation of "edge" to benefit sage-grouse is rarely needed. Because of human activities, the presence of too much edge (especially in straight lines) is more common than too little edge and results in degradation of sage-grouse habitats.

Sagebrush ecosystems have been managed through a variety of treatments from domestic livestock grazing, mechanical and chemical clearing or thinning, to use of prescribed fire (Braun 1998). Fire was a natural event in more mesic sagebrush communities but was infrequent as demonstrated by the lack of resprouting of big sagebrush, black sagebrush, and low sagebrush. Fire was more common in areas with three-tip sagebrush and silver sagebrush because both species resprout. Recent research suggests there is little gain in forage production of grasses and forbs after fire, because it can take longer than 30 years to return to preburn conditions (Wambolt and others 2001).

Treatments of sagebrush communities have primarily been conducted to benefit another treatment (livestock grazing). Use of some treatments has led to plantings of exotic grasses, invasion of areas by exotic plants, conifer invasion of sagebrush habitats, and increased fire frequency. Many, if not most, of these treatments have been applied to improve rangelands for domestic livestock but have had negative impacts on sagebrush communities and animals dependent on them (Braun and others 1976). Further, successive treatments have been applied to landscapes with little understanding of the cumulative effects that may impact both sagebrush-dependent animals, such as sage-grouse, and the overall health of the plant community. The impacts of natural events such as periodic drought are further exacerbated by human treatments of sagebrush communities. All of these issues emphasize the need for active protection of habitats presently used by sage-grouse as well as restoration of habitats that formerly supported sage-grouse populations.

Sage-Grouse Habitat Management Strategies

The objectives of habitat management to benefit sage-grouse, in order of importance, should be (1) to protect and maintain existing occupied habitats, (2) enhance existing occupied habitats, (3) restore degraded habitats that still receive some sage-grouse use, and (4) rehabilitate significantly altered habitats that no longer support sage-grouse. Strategies to accomplish these objectives should include:

- Vigorous suppression of wildfire.
- Reconsideration of any use of prescribed fire.
- Proper livestock management (including reconsideration of time of grazing, stocking rates, season of use, and frequency of use).
- Use of nitrogen fertilizer, except in areas infested by annual weeds.
- Mechanical chopping of sagebrush.
- Fence type and placement.
- Water management.
- Rehabilitation and restoration techniques discussed in these proceedings.

At times, manipulation of some occupied sage-grouse habitat may be necessary to enhance the overall quality of a seasonal range. An example would be removing or reducing some sagebrush canopy cover in known breeding habitat to enhance a depleted understory. Removal of 57 percent of sagebrush cover resulted in a significant decline in a sage-grouse breeding population (Connelly and others 2000b) and degradation of early brood-rearing habitat (Fischer and others 1996). More recently, a wildfire that removed about 30 percent of the sagebrush cover in a breeding habitat resulted in a 60 percent decline in sage-grouse nest success (Connelly, unpublished data, 1998). Because of this information and the fact that wildfires, drought, and insect infestations cannot be predicted, any sagebrush removal efforts should affect a relatively small portion of the occupied habitat. Connelly and others (2000a) suggested that >80 percent of breeding and winter habitat with vegetative characteristics necessary for productive sage-grouse habitat should remain intact to adequately provide for the needs of sage-grouse. However, an even greater percentage should be protected if sage-grouse populations are declining or the population status is unknown. All proposed habitat

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manipulations should carefully consider the current condition of habitat, status of the sage-grouse population, and likely outcome of the vegetation treatment, including recovery time necessary for the area to again provide adequate habitat for sage-grouse nesting and early brood rearing.

Acknowledgments

We thank S. B. Monsen for inviting our participation in the symposium that led to these proceedings. We further thank all managers and researchers who have contributed to the scientific literature and our understanding of sage-grouse and their use of habitats. Much of our knowledge was gained through research supported through Colorado (CEB), Idaho (JWC), and Washington (MAS) Federal Aid to Wildlife Restoration Projects. This is a contribution from the Western States/Provinces Sage and Columbian Sharp-Tailed Grouse Technical Committee.

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Fernleaf biscuitroot

15 March 2005

COMMENTS ON SAGE-GROUSE ISSUES
DRAFT ENVIRONMENTAL IMPACT STATEMENT
FOR THE RAWLINS
RESOURCE MANAGEMENT PLAN

PREPARED BY

Clait E. Braun
GROUSE INC.
Tucson, AZ
520-529-0365
sg-wtp@juno.com

Attachment 4

Overview

The following are my comments on the Draft Environmental Impact Statement (DEIS) for the Rawlins Resource Management Plan (RMP). I focused on sage-grouse issues, because this is my area of expertise.

The Draft EIS inadequately presents what in known about greater sage-grouse in the area covered by the RMP. The number of active sage-grouse leks is likely under represented, and few data are presented on brood and winter use areas. The best science available is not used as the BLM continues to use a 0.25-mile buffer for No Surface Occupancy (NSO) for areas around active sage-grouse leks. This distance is the same as for Historic Trails. The DEIS indicates that all sage-grouse use areas are acceptable for leasing for energy development. More livestock grazing is recommended and the Best Management Practices include: additional fencing, more water pipelines, use of Tebuthiuron to reduce live sagebrush, prescribed fire, reduced pasture size, and short duration grazing all of which will reduce the suitability of habitats for sage-grouse. Management of sagebrush habitats to benefit sage-grouse is not considered. There is no mention of what will be done in the section on Monitoring and Evaluation if sage-grouse populations continue to decline. The BLM combines Alternatives 1-3 into their preferred Alternative (# 4) and fails to give adequate consideration to Alternative 3 (protection of resources). Overall, the DEIS fails to take a "hard look" at all of the direct, indirect, and cumulative environmental consequences of the development that will result from their preferred Alternative. The DEIS does not meet the conditions of professional integrity concerning sage-grouse issues as required by the National Environmental Policy Act.

The BLM is encouraged to review the provisions of the Western Heritage Alternative (available at www.voiceforthewild.org/greatdivide) prepared by the Biodiversity Conservation Alliance of Laramie, Wyoming. This Alternative provides a balanced approach, using ecosystem management principles, and more thoroughly discusses all possible factors affecting sage-grouse and the impacts of these factors. The provisions (pages 96-106), specifically those concerning sage-grouse, are based on the published literature and have scientific merit versus the 4 alternatives presented by the BLM in the Rawlins Resource Management Plan DEIS, which are not scientifically credible.

The literature cited in the DEIS on sage-grouse is not adequate nor current as Braun et al. (2002) is not cited on the impacts of oil and gas activities on sage-grouse, Rowland (2004) is not cited on effects of habitat management practices, Schroeder et al. (2004) is not cited on overall distribution of sage-grouse and sagebrush habitats, and there is no citation of the Conservation Assessment on greater sage-grouse prepared by Connelly et al. (2004) for the Western Association of Fish and Wildlife Agencies.

Background

Sage-grouse (*Centrocercus* spp.) have been demonstrated to be dependent upon sagebrush (*Artemisia* spp.) steppe habitats throughout all of their life processes (Patterson 1952). An overview of the life history of sage-grouse and their habitat is presented in the Appendix. The distribution and abundance of sage-grouse have decreased throughout their formerly occupied range (Connelly and Braun 1997, Braun 1998, Schroeder et al. 1999, Connelly et al. 2004, Schroeder et al. 2004). The actual size of the overall decrease is unknown but most likely exceeds 50% in total area occupied and 80% in abundance (Braun 1998). Sage-grouse have been extirpated in 4-5 states and one Canadian province and have been listed as endangered in Canada. Six petitions were filed in the United States, covering all populations, to list sage-grouse as threatened or endangered under the Endangered Species Act of 1973. The U. S. Fish and Wildlife Service has responded (12 January 2005) to all of these petitions with the finding of "not warranted." However, the Gunnison sage-grouse (*C. minimus*) has been assigned candidate species status, sage-grouse populations (*C. urophasianus phaios*?) in Washington State have been identified as meriting "warranted but precluded" status, and a petition for listing a distinct population segment of sage-grouse in California and Nevada has been denied. Further, the Wyoming Game and Fish Department has recognized the problems with sage-grouse in Wyoming and, through a statewide working group, prepared and released for review a draft "Wyoming Greater Sage-grouse Conservation Plan" dated November 2002.

Much of the present distribution of sage-grouse is on publicly owned lands administered by the Bureau of Land Management (BLM) and the U. S. Forest Service (USFS). Management of wildlife on public lands is the responsibility of the respective state wildlife agency while management of wildlife habitat on public lands is the responsibility of the land management agency (usually BLM or USFS). Further, multiple use is most frequently prescribed for public lands administered by the BLM and USFS. Multiple uses typically include recreation, watershed, wildlife production and harvest, livestock production, and mineral exploration and development (including oil and gas production).

Energy production on public lands is not recent (Braun et al. 2002) and there has been exploration and development of typical sources such as coal, oil, and, gas dating to the 1880's. While past interest has seemed to be cyclic, depending upon demand, the recent interest in gas, and especially development of gas from coal bed methane and "tight sands" gas deposits, seems to be almost unprecedented. Many areas proposed for gas production in the western United States have been among the most productive for sagebrush-dependent wildlife, especially sage-grouse. Thus, increased development of energy resources in sagebrush steppe habitats has the potential to negatively affect sage-grouse.

The Rawlins Resource Area includes portions of Albany, Carbon, Laramie, and Sweetwater counties in south central Wyoming in an area known to be

productive for wildlife and especially sage-grouse (Patterson 1952). Wyoming, in general, has the strongest sage-grouse population in the world. Fragmentation of the habitats upon which this population depends will slowly unravel the entire presently linked sage-grouse population in Wyoming. This has already happened in most other states with disastrous results and has already started in Wyoming -- most noticeably at the periphery of the historical distribution. Once this continuity becomes fragmented, the overall distribution fabric is lost and sage-grouse populations will become disjointed and subject to greatly reduced abundance as well as local extirpation.

Analysis of the Rawlins Resource Area Sage-grouse Data

Local information about sage-grouse use areas is sparser in the Rawlins BLM Resource Area than in other areas of Wyoming (especially the Farson Area, Sweetwater County and near Pinedale, Sublette County -- Heath et al. 1997, Lyon 2000). Most of the available data that have been mapped are those on location of leks. There is only general knowledge about sage-grouse seasonal habitat use areas outside of the lek locations. These general data are not sufficiently precise for meaningful use, especially for winter and nesting habitat. What follows is an assessment of existing sage-grouse data for the Rawlins-Great Divide area -- and recommendations for monitoring -- for the four key habitat types used by sage-grouse (winter use areas, leks, nesting habitat, and brood rearing areas):

1. *Winter*—General maps showing the location of sage-grouse winter use areas in the Rawlins Resource Area currently are inadequate. Focus should immediately be placed on locating and mapping sage-grouse winter-use areas throughout the RMP area. This should have the highest priority, as over winter survival is critical to population maintenance. Maps should be prepared for both "average" or "normal" winters and severe winters which happen every 7-10 years. Once these areas are located and mapped; they should be described using standard measures for live sagebrush canopy cover, height, etc. following the approach of Connelly et al. (2000). Once identified, these areas should receive special attention (for example, designation as "Areas of Critical Environmental Concern") to reduce or prevent disturbance during winter, wild fire, and management activities that make them less useful to sage-grouse. Special attention should be given to any disturbance that reduces amount of live sagebrush, leaf surface, canopy cover, and height.

2. *Leks*--The available data on leks suggest that not all active lek sites have been located and the status (active, inactive [< 2 years, > 2years]) of each site mapped is poorly known. Further, there are gaps (some leks are not counted every year) in the count data and number of counts/lek in a given year vary. The available long-term trend in numbers of cocks appears to be down but the problems identified make data analysis difficult. Since active sage-grouse leks are relatively easy to locate during late March and April, standard surveys of all areas within the Rawlins Resource Area should be conducted in April 2005 and continuing at 3-year

intervals. All known lek sites should be checked for activity in spring 2005. Those classified as active should be counted (number of cocks) 3-4 times each spring at 7-10 day intervals starting in late March- early April, depending upon weather conditions, and continuing into early May. Those classified as inactive should be checked in late April/early May every 2-3 years to ascertain any change in status. UTM (or GIS) coordinates for all lek sites should be taken and plotted on base maps.

3. *Nesting*—Adequate data on areas used for sage-grouse nesting in the Rawlins Resource Area does not exist outside of unpublished, preliminary reports. Because sage-grouse have been shown to nest at a variety of distances from active leks and use a variety of micro sites for nest placement, it is difficult to identify all nesting areas. Thus, the Connelly et al. (2000) Guidelines should be followed to offer some protection to habitats useful for nesting at distances up to 3 miles from active leks. Since most actual nesting occurs within this distance (Braun et al. 1977) (with some nests at much greater distances), it is most reasonable to depict nesting habitat as all sagebrush areas with > 10% live canopy cover of sagebrush (primarily *A. tridentata vaseyana, A. t. wyomingensis, A. tripartita, A. nova,* and *A. cana* depending upon location) and a healthy understory of native grasses and forbs. Since active lek sites can be located, identifying concentric areas within a 3-mile radius around each lek site that will include most nesting sites is presently the only reasonable method to map potential nesting areas.

4. *Brood-rearing*--Broods, upon hatching, use areas close to the locations of successful nests and progressively move towards moist areas upon desiccation of vegetation in the uplands. Review of the available data suggests only general knowledge of where broods have been observed. These data appear to not have been mapped in relation to known sources of water (at ground level) or at riparian sites along streams, springs, etc. This should be done so that additional management consideration can be given to these areas. Management that should be in place includes movement of livestock to avoid degradation of plant communities in moist sites and riparian areas, and fencing to allow livestock access to water only in sites where erosion and plant community degradation would not be expected or could be controlled. Early brood survival is believed to be a problem throughout Wyoming (WGFD Draft Greater Sage Grouse Conservation Plan). Early brood survival is most affected by insect and succulent forb availability within secure (good hiding cover provided by grasses and forbs) habitats (Connelly et al. 2000). Late brood rearing habitat is primarily in close proximity (< 1 mile) of sites with moisture and succulent forbs adjacent to escape cover provided by live sagebrush (Connelly et al. 2000).

Rawlins Resource Area Sage-grouse Population and Habitat Trends

The data presently available are too limited to conclusively demonstrate the health of the sage-grouse population(s) and trends in quality of the available habitats. The overall trend in number of sage-grouse counted in spring is down. The

DEIS should have presented data on trends in numbers of active sage-grouse leks, counts of males on leks, and production data such as chicks per hen which would have allowed a thorough analysis. In the absence of these data, an adequate analysis of the direct and cumulative impacts of the four proposed alternatives is not possible. However, these available data (Wyoming Game and Fish Department) are relatively short term. In addition to the already substantial coal, oil, and gas development impacts, there are the additive effects of livestock grazing, power line and road placement, ranch building placement, and management treatments of sagebrush steppe areas to improve forage for livestock. All of these factors (and many more) have cumulative effects on ecosystem health and trends in numbers of all animals that are dependent upon the sagebrush steppe. Teasing apart the specific impacts is not possible without replicated studies. What is clear is that continuing practices presently in place will not improve conditions for or knowledge about local populations of sage-grouse. They will only lead to continued decline in health of the sagebrush habitat and in the distribution (the area of useful habitat is decreasing) and abundance of sage-grouse.

Long-term monitoring efforts (20-30 years at the minimum) and research studies to tease apart impacts of energy development and other multiple use activities are critically needed in the Rawlins Resource Area. These efforts should focus on public lands (and include immediately adjacent private and State lands) and be funded by Federal land management agencies and the oil and gas industry. Monitoring and evaluation is briefly mentioned (Appendix 17) but no mention is made of what procedures will be followed if sage-grouse populations decline. The cumulative effects of all human-induced practices in the sagebrush steppe on sage-grouse population health as measured by numbers of active leks, trends in numbers of males counted, and chicks per hen need to be fully evaluated and studied.

Understanding Sage-grouse Populations and Minimum Viable Population Size

Sage-grouse are specialists at using widely spaced resources scattered over large (hundreds of miles) expanses. All populations studied make seasonal movements from winter to breeding/nesting areas and then to late brood rearing and fall use sites. Movements can be as short as 5-10 miles to in excess of 60-80 miles. Thus, it can be argued that all populations are migratory with only the distance moved differing. This is true for most grouse species. Data presented by Lyon (2000) demonstrate that some sage-grouse in western Wyoming make substantial seasonal movements (as long as 60 miles).

The present data in the scientific literature are equivocal about the size of a minimum viable population for most wildlife species and estimates range from 500 to 5,000 breeding individuals (Franklin 1980, Soule 1980). All sage-grouse do not breed every year (for example, only a few dominant males are responsible for most matings and some females do not lay eggs as yearlings). Consequently, effective spring population size (i.e., those individuals actually breeding) is smaller than the total number of individual sage-grouse in a population. For sage-grouse, it is

doubtful that 500 individuals in spring would represent a population that would persist > 50 years. However, positive habitat management could reasonably be expected to provide adequate habitats to sustain a population for > 50 years provided all necessary habitat components were available over a contiguous area of not less than 50 mi^2, given a population density of 10 birds/mi^2 or at least 100 mi^2 given a population density of 5 birds/mi^2. Healthy, apparently sustainable populations, with some emigration and immigration, of > 3,000 total estimated individuals in the spring population are known to occupy "closed" areas (Jackson County, Colorado) of about 400 mi^2 of sagebrush steppe and associated riparian areas.

Scientific study has not identified a minimum viable population size or specific habitat size requirement for any population of sage-grouse. Further, habitat quality varies greatly depending upon soil factors, aspect, elevation, moisture, temperatures, management prescriptions, past and present uses, etc. Thus, there is no one definition or description of habitat quality that fits all situations as it is known that some sage-grouse populations persist in extremely degraded and marginal appearing habitats. It is also hypothesized that such populations are at great risk of extirpation as populations in similar habitat conditions have completely disappeared. Therefore, because of the difficulties in determining minimum viable population size and defining key habitat parameters for sage-grouse, it is imperative that a conservative approach is taken towards management of activities that could compromise sage-grouse habitat and fragment local populations. A reasonable conservative approach would be to adopt the Connelly et al. (2000) guidelines in terms of distances around active leks for no surface occupancy, residual cover to encourage nest success, etc.

Habitat Quality and Predation

Problems with defining minimum viable population size or describing habitat quality are compounded with the addition of consideration of the effects of predation (presently being studied in the Rawlins Resource Area). Highways, roads, and power lines, for example, degrade habitat quality by increasing fragmentation, noise, and dust while attracting generalist predators and making search (by predators) of more linear areas and smaller habitat patches easier. Further, data on number and type of predators prior to apparent changes in habitat quality are not available nor are past or present predation rates in designed studies with treatments and controls. In general, predation events on birds are believed (reviewed by Cote and Sutherland 1997) to be affected by habitat quality, no matter how it is defined. It is logical that prey animals are more secure in undisturbed habitats that have low fragmentation and better shrub structure coupled with a diverse understory of grasses and forbs. Adding structures such as buildings, power lines, fences, and creating smaller, less diverse patches of habitats within the sagebrush steppe intuitively benefits potential predators of sage-grouse. Replicated studies with treatments and controls have not been conducted because of the difficulty in finding study areas of sufficient size, control of all treatments, and the reluctance of

agencies and private interests to make available dedicated resources (including money and land). Management studies should be immediately implemented that focus on possible predation impacts as affected by fragmentation and livestock grazing impacts.

Assumptions/Analyses for Rawlins Resource Area Sage-grouse Management

Review of existing documents for the Rawlins Resource Area indicates the BLM has consistently ignored sage-grouse needs and the scientific literature upon which developed guidelines (Braun et al. 1977, Connelly et al. 2000) to maintain sage-grouse populations are based. Most seriously, the BLM has chosen a 0.25-mile distance from active leks for avoidance of or restrictions on development even though the scientific literature indicates there should be no manipulation of sagebrush habitats within 3 miles of active leks (Connelly et al. 2000). *The 0.25-mile restriction seems to have been created to justify existing practices and is not based on any reputable science.* The BLM's own analysis (see Pinedale Anticline Project Draft EIS 1999: 5-34 as an example) reports that, "of leks with at least one well within a 0.25-mile radius, four times as many are inactive than active" and that "more than three times as many leks with at least one oil or gas well within a 0.50-mile radius are inactive". Oil and gas well site development as well as development of roads, power lines, etc. all cause manipulation of habitat and reduction in area useable to sage-grouse. Further, BLM documents (Atlantic Rim Coalbed Methane Projects, Cow Creek Pod) indicate, "exceptions [for any restrictions] may be granted if the activity will occur in unsuitable [nesting = breeding] habitat". This language continues to be used in the DEIS for the Rawlins Resource Area without any scientific explanation of why habitats may be "unsuitable" (for sage-grouse).

As part of its mitigation guidelines and standard practices for surface disturbing activities, Wyoming BLM has imposed a restriction on activity within 2 miles of leks during the 8:00 PM to 8:00 AM interval from 1 March through 15 May which has been extended through 15 July (to benefit nesting females and broods) within 2 miles from leks (Rawlins DEIS). These dates provide minimal mitigation during the breeding and nesting periods as there is little monitoring of adherence to these restrictions and those in place can be modified. In actual practice, there is little protection from physical disturbance of habitats useful to sage-grouse nesting outside of the artificial 0.25-mile radius from active leks. Most critically, there is no recognition of the importance of sage-grouse winter use habitat and only minimal stipulations to help protect these habitats (only "within *identified* winter habitat"). The BLM also fails to adequately address the cumulative effects on sage-grouse of all treatments (not limited to oil and gas developments).

Nowhere is there mention of the possible negative effects of seismic activities. It appears the BLM has avoided recognition of short-term effects of trails, crushing of vegetation, and direct and indirect impacts to sage-grouse from use of large vehicles involved in this activity. Unfortunately, there apparently have been no studies on the immediate impacts of seismic activities. Until demonstrated otherwise,

seismic activities should be considered as factors that are negative for sagebrush habitats as they provide trails for increased predator access, they fragment habitats useful to sage-grouse, they decrease live sagebrush and forbs needed by sage-grouse, and could potentially disrupt breeding activities and nesting activities. BLM should require the oil and gas industry to fund well-designed scientific research on the effects of seismic activities on sage-grouse and their habitats.

Mitigation Measures To Protect Sage-grouse

Present mitigation measures to protect sage-grouse and their habitats in the existing Rawlins Resource Area DEIS are minimal (Appendix # 1) and have little scientific basis. The BLM should endorse and follow the "*Guidelines to manage sage grouse populations and their habitats*" (Connelly et al. 2000). Consideration should also be given to following the concluding comments of Braun et al. (2002) that strongly recommend that it is the responsibility of the oil and gas industry to demonstrate their activities have no negative impacts initially, short-term, or over the long-term. Effective mitigation practices, in addition to those in the *Guidelines* (Connelly et al. 2000), include permanent and seasonal road closures, burial and or modification of power lines, removal or modifications of fences and other structures, fertilization of sage-grouse winter ranges with nitrogen, and reduction or complete permanent elimination of other uses such as livestock grazing, especially on areas where oil and gas production is permitted. Mitigation should also consider those impacts that can be reasonably expected including cumulative (with other factors) effects. Full mitigation would require increasing the number (on a per unit basis) of sage-grouse in non-affected areas to equal the reduction in numbers of sage-grouse in affected areas. Research on developing methodology to enhance sagebrush habitats (to support higher densities of sage-grouse) should also be productive.

To further mitigate the impacts from the significant oil and gas developments that are being planned for the Rawlins Resource Area, the BLM should also designate, as part of the RMP revision process, multiple Areas of Critical Environmental Concern (ACECs) to protect at least 90% of sage-grouse winter use areas. The boundaries of these areas should follow the results of Recommendation # 1 (Winter) on page 4. These areas will be critical to maintaining population persistence over time.

Sage-grouse Monitoring Requirements

Assessment of the long-term effects of any use or disturbance, especially oil and gas or other energy-related development, on sage-grouse and the health of the sagebrush steppe should be based on collection and analysis of population information in spring, collection and analysis of harvest information, and numbers of birds counted in selected winter habitat. Sage-grouse population statistics collected in spring are those related to number of active leks per unit of area and total number of cocks counted on a sample of randomly selected, statistically defensible accessible leks. Harvest data collection should focus on analysis of wings

for changes in ratios of chicks/hen and males to females in both adult (including yearlings if not separable) and chick age classes. Once winter use areas are identified, standardized line transects should be established and annually sampled (using aircraft) following current sampling theory to estimate number of birds present. Sampling should occur immediately following fresh snowfall or during maximum snow accumulation. Changes in vegetation "quality" should be monitored at 3-5 year intervals at a statistically valid sampling rate along permanent 0.6-mile belt transects. Measurements desired include live sagebrush canopy cover, sagebrush height, and ground cover of native grasses and forbs. (This should also include measurement of residual grass height.) Modeling of the potential effects of environmental events such as drought (measured by the Palmer Drought Index) and severe winters (length of period of snow cover, depth of snow, temperature) should also be pursued. The Appendix (# 17) on Monitoring and Evaluation is notably deficient in reassuring anyone that scientific protocols will be used and the results will be properly evaluated.

It would also be desirable to establish concurrent long-term monitoring in areas of coal bed methane gas development in Campbell County and also within the Wind River Front area where there is currently no oil and gas development (the area is presently prohibited from new leasing) to compare with the data collected in the Rawlins Resource Area.

Long-term Effects On Rawlins Resource Area Sage-grouse Populations

The importance of sustained, long-term monitoring cannot be overstated. It is clear that oil and gas development will negatively affect sage-grouse populations (Braun et al. 2002) and only the magnitude of the impacts is unknown. The oil and gas industry should fund the monitoring and long-term research needed throughout the life of the project and the Rawlins RMP should make this a specific requirement in any new oil and gas development projects. This critical monitoring should continue until sage-grouse populations return to pre-disturbance levels, which could exceed 30 years. Cause and effect studies using an active adaptive management approach (Walters 1986) are necessary to fully understand the implications of oil and gas development on sage-grouse. The industry has the responsibility to demonstrate their activities have no negative impacts initially, short-term, or over the long-term on the distribution and abundance of sage-grouse in areas explored and developed for oil and gas production.

The DEIS for the Rawlins Resource Management Plan fails to mention the Comments on Sage-grouse Scoping Issues that I earlier submitted (14 February 2003). This suggests a general lack of responsiveness to professional review and detailed comments. There was no attempt to incorporate even minimal suggestions on identification and protection of winter habitats, brood habitats, or consideration of scientifically defensible buffers for NSO around active leks. The discussion of Monitoring in the DEIS is minimal and consideration of mitigating impacts on sage-

grouse is essentially non-existent. Thus, most of my comments on scoping issues are repeated in this document.

Conclusions

None of the 4 Alternatives adequately describe or analyze the expected impacts on sage-grouse distribution and abundance within the Rawlins Resource Area as a result of any specific Alternative or the preferred Alternative. My professional judgment is that all Alternatives (including the No Action Alternative) will fail to slow or cause the present declines in sage-grouse populations to stabilize. Alternatives 2 and 4 will increase the declines in distribution and abundance of sage-grouse in the Rawlins Resource Area. All of the proposed mitigation measures (Appendix # 1, page 3) for sage-grouse are totally inadequate. Further, all of those identified can be excepted, waived, or modified by the "Authorized Officer (Appendix # 1, page 3, # 2, a, b, and c). Even if the few listed (Appendix 1, page 3) were implemented, they would have little positive impact on sage-grouse populations.

Key Recommendations for the DEIS for the Rawlins Resource Management Plan

Mitigation Measures

1. The BLM should adopt a policy of no surface disturbance within 3 miles of occupied leks as data clearly show negative impacts to sage-grouse at the present distance of 0.25 miles. Further, adequate data are available to demonstrate that most female sage-grouse nest within 3 miles of active leks. *This is the minimum needed to maintain sage-grouse populations.*

2. All areas used by sage-grouse during both average or "normal" and severe winters should be located, mapped, and given special protection from wild fire, manipulation of sagebrush, and human-induced disturbance. *This is the minimum needed to maintain sage-grouse populations.* At least 90% of these newly mapped areas should be designated as a network of ACECs.

3. Adherence to time of use for restriction of activities from 6:00 PM through 9:00 AM during the breeding and nesting periods should be strictly monitored and enforced. *This is the minimum needed to maintain sage-grouse populations.*

4. Management of mid to late summer brood-rearing areas should encourage forb regrowth while maintaining at least a 6 inch residual grass height with taller (> 24 inches in height), live sagebrush of > 15 % canopy cover in close (< 200 yds) proximity for use as escape cover. *This is the minimum needed to maintain sage-grouse populations.*

5. Mitigation should be emphasized for all activities known to negatively impact

sage-grouse. Mitigation measures could include, but are not limited to: burial or modification of power lines, off set drilling, road closures and time restrictions, removal of livestock grazing, nitrogen fertilization of winter and nesting areas, removal or modification of existing fences, etc. Full mitigation would be to replace the exact number of sage-grouse impacted by development activities by increasing the number per unit of area that the remaining areas can support to equal the number displaced. *This is the minimum needed to maintain sage-grouse populations.*

Monitoring Requirements

1. Standardized line transects in identified winter use areas should be established and annually sampled (using aircraft) following current sampling theory to estimate changes in numbers of birds present. Sampling should immediately follow fresh snowfall or during maximum snow accumulation.

2. Standard surveys of all areas to locate active leks should be conducted in spring 2005 and continue at 3-year intervals. This will provide data on lek extinction and recruitment. *This is the minimum needed to monitor sage-grouse populations.*

3. All potential mid to late summer brood-rearing areas should be mapped based on moisture and green forb availability during the late June through late August interval. Management of mid to late summer brood-rearing areas should encourage forb regrowth while maintaining at least a 6-inch residual grass height with taller (> 24 inches in height), live sagebrush of > 15% canopy cover in close (< 200 yds) proximity for use as escape cover.

4. Leks classified as active should be counted (number of cocks present) 3-4 times each spring at 7-10 day intervals starting in late March-early April and continuing into mid May. Those leks classified as inactive should be checked in late April/early May every 2-3 years to ascertain change in status. *This is the minimum needed to monitor sage-grouse populations.*

5. The vegetation in areas used by sage-grouse during both average and severe winters should be described as to live sagebrush canopy cover, height, etc.

6. Harvest data based on examination of sage-grouse wings collected from hunters should continue on a well-defined population basis. Statistics needed to measure responses of sage-grouse are those relating to nest success, chicks per hen, and age/gender composition. *This is the minimum needed to monitor sage-grouse populations.*

7. Research should be initiated to learn if monitoring of insect abundance and forb growth will reliably predict sage-grouse chick survival.

Analysis and Other Management Issues

1. Habitat guidelines published by Connelly et al. (2000) should be incorporated into preparation of a "desired future condition" to be achieved to improve nest success and early chick sage-grouse survival. *This is the minimum needed to enhance sage-grouse populations.*

2. Replicated long-term studies are urgently needed to understand the effects of grazing practices and habitat fragmentation on predator numbers and predation rates on sage-grouse. These studies must involve treatments and controls on a landscape basis.

3. Nesting areas, since they are difficult to locate at a population or subpopulation scale, should be defined as all area within 3 miles of active leks. This will provide a minimum amount of protection. *This is the minimum needed to maintain sage-grouse populations.*

4. Early chick survival has been identified as a problem in Wyoming. Enhancing the forb and grass component in nesting areas (which are also early brood rearing sites) should be a priority.

5. The cumulative impacts of all human-induced activities within a given, describable sage-grouse population unit should be studied over a period sufficiently long (20-30 years) to be able to predict actual long- and short-term effects. When industry is involved in causing the impacts, they should be expected to fully support, financially, all studies as they have the burden to demonstrate their activities are not negative to sage-grouse.

6. Well-designed research on the immediate and short-term effects of seismic activities on sage-grouse and their habitats should be funded and undertaken.

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Thank you for the opportunity to comment, and please respond to the issues raised in these comments through the NEPA process.

Sincerely yours,

Clait E. Braun

Clait E. Braun

APPENDIX

An Overview of Sage-grouse Life History and Habitat Use

Sage-grouse are sagebrush dependent species and evolved to use sagebrush steppe on a landscape scale. Thus, they may use as little as 10% (all habitat that might be available) in severe winters (Beck 1977) to as much as 70% + during late summer and fall. Winter use sites are those with large expanses of sagebrush available above the snow, frequently in drainages, large flats along ridge tops, and on west and southwest exposures (Hupp and Braun 1989). Winter food is the leaves of sagebrush of a variety of species from low sagebrush (*A. arbuscula*), silver sagebrush (*A. cana*), black sagebrush (*A. nova*), three-tip sagebrush (*A. tripartita*), to a variety of subspecies of big sagebrush (*A. tridentata*). Taller and denser sagebrush cover is important during this period (Connelly et al. 2000).

Breeding areas may be adjacent to or far removed from winter use sites. Areas chosen for breeding are those that are open within the sagebrush type with

wide visibility and few impediments to hearing acuity. Sage-grouse display areas have low vegetation but with taller live sagebrush within 100-200 yards. Thus, escape and loafing cover is keenly important during the breeding season. Most importantly, sites chosen for use for display are in areas where movement of females searching for nesting sites is common. Nesting may occur as close as within 100 yards of an active lek with most nests being within 3 miles of the lek of mating. However, movements of 20 to 60 miles from lek of capture to actual nest sites have been reported (Connelly et al. 2000, Lyon 2000). During the breeding and pre-nesting period, newly growing green forbs become an important part of the diet for all sage-grouse, but especially for females. Live canopy cover of sagebrush and a diversity of herbaceous plants with taller residual cover are exceedingly important during the nesting period (Connelly et al. 2000).

Nesting areas used by sage-grouse are generally in sagebrush uplands with a live canopy cover of 15 to 25%. Taller and bushy live sagebrush plants are preferred for nest sites. These sites frequently are in larger patches of sagebrush and nests generally are placed under the tallest live sagebrush bush. Upon hatching sage-grouse move their chicks into more open habitats with live sagebrush where forbs are plentiful and grasses provide cover and increased insect availability. Live sagebrush canopy cover can be as little as 10-15% in early brood rearing areas (Connelly et al. 2000). As broods mature, movements become longer and hens with chicks move to wet meadow or riparian areas within the sagebrush type. Taller, more robust sagebrush continues to be important for loafing and escape cover. In the absence of succulent forbs in uplands, hen sage-grouse quickly move their broods to moist or wet areas, if available. If these movements are long or fast, chick survival suffers. Maintaining healthy sagebrush uplands is important to chick survival and apparent nest success.

During late brood rearing, movements of broods as well as those of unsuccessful hens and males may be relatively short depending upon moisture and availability of forbs. With advent of fall, broods combine into larger flocks with older birds of both genders. Movements into sagebrush uplands, especially areas with late forb green up, become pronounced, as do distances involved. This continues into late fall and early winter when snow initiates movement to winter ranges. Foraging on sagebrush leaves continues for adults throughout the summer, fall, and winter even though substantial amounts of forbs are taken when available. Chick sage-grouse start using sagebrush leaves in late July and early August when their diets become similar to those of adults.

Kenneth R Kreckel's Comments on the Rawlins Resource Management Plan Draft Environmental Impact Statement Focusing on Oil and Gas Operations

Recommendation

The Great Divide Draft Environmental Impact Statement fails to take into account modern drilling practices which can significantly reduce surface impacts attributed to oil and gas operations. Specifically, a more enhanced use of directional drilling and multi-well drill pads should be mandated. Although these topics are mentioned under Appendix 15 Fluid Minerals Best Management Practices, no specific provision for their use is provided.

One simple step is to vastly increase the surface spacing which is allowed for all new oil and gas developments :

> All new oil and gas fields, including CBNG, be developed utilizing the widest practical surface spacing. As an example, I will examine the use of a 640 acre surface spacing [1 mile] in detail. This is appropriate for a wide range of subsurface spacings. [In some situations, much greater spacings are possible. I will address them separately.]

This recommendation will reduce surface impacts dramatically. Moreover, because of advances in technology, it's cost, both to producing companies, and federal royalties will be minimal. In the following pages, I will show the recommendation is:

1. Technically feasible--the oil and gas industry is capable of easily reaching, and producing from, subsurface targets drilled at locations spaced at 640 acres for every reasonable subsurface spacing.

2. The cost of such a program is minimal, and sustainable by the industry.

3. Well economics will not unduly suffer. Wells in the Rawlins Management Plan will not be rendered "uneconomic".

It is further recommended:

> That the provisions of the Western Heritage Alternative, in regards to oil and gas activities, be adopted. An increased use of directional drilling will allow many of the areas closed to drilling under this alternative be drained from surface facilities on adjacent leases. I will examine drilling reaches of one, two and three miles in this regard. In addition, I will examine development situations where a nine section [3 mile spacing] will be more appropriate.

Attachment 5

Qualifications

I am a professional geo-scientist with over thirty years experience in the exploration for, and development of, oil and gas reserves in North America and Europe. During much of that time I managed the exploration and development efforts of Marathon Oil Company in various producing basins, including many years in the Rocky Mountain region. I have worked the Mesaverde in many basins of the Rockies. Of particular note is my eight years as Exploitation Manager of Marathon's Southern region, where I led the company's participation in hundreds of wells, many in tight gas sand formations similar to the objectives within the Rawlins area. I drilled over fifty horizontal wells, many more directional wells, and have expert knowledge on the use of deviated and horizontal wells. I have personal experience with the drilling of many wells that meet or exceed the offsets advocated within, including several with 6 to 7000' displacements, and an extended reach well with a 7000' displacement at 5000' depth.

During the past four years I have been consulting in the Rocky Mountain Region. Much of this work has been the evaluation of drilling ventures and the analysis of Draft Environmental Statements. For additional details on my background, please refer to the attached resume.

Details of Spacing Recommendation

The following table summarizes the parameters involved if a surface spacing of 640 acres were adopted. Note the categories of wells are identical to that used in the DEIS[1]. For the range of depths in each category, I've calculated the relevant angles and displacements required:

RAWLINS DEIS SPACING AND DIRECTIONAL WELL OPTIONS

	Sub-surface Spacing	Surface Spacing	Wells per pad	Pads per section	Depth [ft]	Horizontal displacement [ft]	Angle [deg] from surface	Angle [deg] from under 2500' casing
CBM-Shallow	80	640	8	1	500	1476	71	
	80	640	8	1	5000	1476	16	
CBM-Deep	160	640	4	1	5000	1867	20	37
	160	640	4	1	7000	1867	15	23
Intermediate	40	640	16	1	7000	2800	22	32
	160	640	8	1	7000	1867	15	23
	320	640	2	1	7000	1320	11	16
Intermediate	40	640	16	1	12000	2800	13	16
	160	640	8	1	12000	1867	9	11
	320	640	2	1	12000	1320	6	8
	640	2560	4	0.25	12000	3734	17	21
Deep	640	2560	4	0.25	15000	3734	14	17

[note: All angles are measured degrees from vertical. The column on angles from 2500' casing is illustrative. Actual surface casing may be less.]

For typical gas wells of intermediate depths, we can see that the angles involved increase from 6 to a maximum of just 37 degrees. Total horizontal displacements from surface, or under surface casing, range from 1300' to 3800' approximately. These angles and displacements are rather modest, and, as will be illustrated in the following paragraphs, easily achieved. Indeed, there are fields currently under development utilizing such directional parameters. One development under consideration by the BLM at the Wheeler to Webster Geographic Area in Colorado provides for 38 new surface locations plus the use of 21 existing well pads for a total of 160 new bottom hole locations for natural gas wells. The majority of the well pads will have multiple well bores at each location that would result in the drilling of 118 directional wells and 42 vertical wells. .Within Wyoming, Questar's development at the Pinedale Anticline [see below] is an excellent illustration of the use of these parameters. As for multi-well pads, nowhere do they exceed 16 per pad, a number which likewise is being utilized by companies presently operating in Wyoming.

Please note that for the deepest wells, with subsurface spacing of 640 acres, I calculated a 2560 acre surface spacing [one pad per four sections] draining each 640 subsurface area.

The CBM development will likely require a horizontal approach [see section on Coalbed Methane]. The Hartshorne CBM in Oklahoma is being developed with horizontal parameters very similar to these.

But are drilling angles of 6 to 37 degrees feasible? Are multi-well pads of 16 wells practical?. If so, are these possible from an economic standpoint? The following will demonstrate that the answer to all these questions is yes.

Industry routinely drills directional wells of this magnitude, and is capable of much more.

The drilling of directional wells is now commonplace in the oil and gas industry. In 2004, directional wells accounted for nearly 40% of the total wells drilled in the United States [see Figure 1] and has been increasing by a factor of 2% per year. Assuming that rate of growth continues, the next twenty years will see directional wells becoming the dominant form of drilling[2] Angles of approximately 90 degrees [horizontal wells] accounted for a third of the total.[2]

These numbers are appropriate for Wyoming as well. In a study of deep gas wells for 1997-2001 in the Rocky Mountains, the Department of Energy found directional wells accounted for 30 of 79 wells drilled, or 38%.[15]

In terms of horizontal displacement, that is, how far a wellbore can reach laterally away from its surface location, incredible distances have been achieved. Routinely achievable horizontal displacements have rapidly climbed from 400 to over 8,000 feet.[3] In directional drilling, it is now common for the horizontal displacement of the bottom hole location to be twice the vertical

depth of the well. [4] [This contrasts my recommendation calling for horizontal displacements of much less, usually a third of their vertical depths.]

Extended reach technology has allowed operators reach targets up to 35,000 feet horizontal displacement. [5] At Wytch Farm, wells drilled from surface locations onshore have set records:

> This record extended-reach well, M-11, at the BP Exploration Operating Co. Ltd. Wytch Farm development in southern England, has a horizontal displacement of 10,114 m [33,182 ft] at a true vertical depth (TVD) of only 1605 m [5266 ft]. Well M-11 is the second extended-reach record well at Wytch Farm. [6]

Recently, industry capabilities in directional drilling were summarized. Figure 2 plots the total depth of wells versus their horizontal displacement--essentially how far laterally a well can reach relative to its vertical depth. Individual wells are plotted as black dots. Note these data are wells actually drilled. The red lines separate the more extreme wells, that is, wells with horizontal displacements that are multiples of their vertical depth. The curved purple line divides the technology required, distinguishing standard technology from advanced extended reach technology. Basically, the difficulty of drilling increases to the right of the graph.

All of the wells recommended within the 640 ac spacing plot within the green ellipse. Please note the following:

> 1. The recommended wells are within the 'standard' capabilities of the industry and are nowhere near any of the extreme wells. Indeed, they barely depart from vertical wells.
>
> 2. The capabilities of the drilling industry are impressive. Existing extended reach advanced technologies could allow the development of reserves under NSO leases from locations one, two, three or more miles away. [see Sections on Longer Reach wells and Three Mile Surface Spacing below]
>
> 3. It can be deduced that the directional wells recommended in this report can be rather easily achieved. They can in no way be regarded as experimental, special case, or even unusual.

Industry has demonstrated the ability to drill from multi-well pads in situations analogous to the Rawlins Management Plan area.

The drilling of multiple wells from a single pad is an accepted and routine practice in the oil and gas industry. Examples from the offshore abound. Onshore, one example, which illustrates the potential of the approach, comes from the North Slope:

> In Northern Alaska, for example, companies go to extraordinary lengths to reduce the footprint of their presence. They employ highly sophisticated directional

> drilling to tap the resources of huge oil fields while confining disturbance of the surface to a minimum. The Alpine field on Alaska's North Slope provides an excellent illustration. From two drilling pads it produces from formations beneath 40,000 acres of land, estimated to contain some 429 million barrels of gross recoverable oil reserves. The pads and interconnecting road occupy only 94 acres—or two tenths of one percent of the field area. Plans are to eventually drill some 112 horizontal wells from the two drilling sites. There is no permanent road to this zero-discharge facility. Equipment and drilling supplies are delivered via temporary ice roads that leave no impact on the tundra.[7]

However, the technology has been employed much closer to the subject area. One such example is the Pinedale Anticline in western Wyoming. Here one operator, Questar, has utilized well pads comprising up to 20 subsurface wells to develop gas reserves within the Lance and Mesaverde, at depths of 9,000-14000'. [8] Horizontal displacements average 2100'. [8] Note that the target formations, depths, and horizontal displacements are comparable to that of the intermediate and deep gas wells in this report. [see Figure 3]

Keith Rattie, CEO of Questar, in an interview published in the Wall Street Transcript, May 2004, states:

> But we think there' a better way — a win-win for the environment, the community, and Questar. Last year we introduced pad drilling at Pinedale, the only operator thus far to do so. (A conventional single well 'pad' is the surface location, typically two to four acres that must be cleared before the drilling rig moves in.) Instead of conventional development ' one vertical well per pad ' we demonstrated that we can directionally drill up to 16 wells from a single larger pad of 13-14 acres. Pad drilling eliminates 15 out of 16 pads. [9]

The use of multi-well pads in this instance reduced the number of surface locations from 150 to 61 and the resulting surface disturbance from 1474 to 533 acres. But the benefits are not only confined to just these. Mr. Rattie adds:

> With pad drilling, we also need fewer roads and fewer gathering lines, production separators and other surface facilities. [9]

Another example, a horizontal development in Michigan using multi-well pads, reports a similar experience:

> Grouping of horizontals within "pads" takes less space, reducing environmental impact, and surface facilities cost less. For example, required length of the gathering system with pods is 65% less than with vertical well development.[10]

Thus additional reductions in surface impacts are realized, as are some economies through a lesser requirement for facilities.

While the Pinedale anticline is an extremely rich field, the technology employed need not be restricted only to fields of such magnitude. The Michigan example above, is certainly not an abnormally prolific development. Under the section on economics, I will show it can be applied to Wyoming cases as well.

Analogous in many ways to multi-well pads is the use of multilateral wells. This is the drilling of several directional wellbores, or sidetracks, out of a single wellbore. As in the case of multi-well pads, the drilling of multiple laterals is a well established technology in use in many situations, especially horizontal plays. The technology is applicable to the type of gas plays present in Rawlins Management area, as there are no barriers to commingling the production from multiple wellbores, and the geology is suitable. Since either technology will result in the reduction the number of surface locations, I will treat them as equivalent. It is best left to the operator to substitute one technology for the other.

Quantifying the cost of the directional multi-well approach.

Thus the industry has a proven capability to drill directionally from multi-well pads. As previously stated, the industry has used directional technology in 40% of its US wells. However, the technology is more costly, and the drilling of a directional well does entail a 'cost premium'. But what is this premium, and how does it relate to drilling in the Rawlins Plan area?

The history of horizontal wells, the more extreme subset of directional drilling, can provide a starting point.

> By 1990, the cost premium associated with horizontal wells had shrunk from the 300-percent level experienced with some early experimental wells to an annual average of 17 percent. Also, the industry' *Joint Association Survey on 1990 Drilling Costs* reported that average horizontal drilling cost per foot was $88.16 as compared to $75.40 for wells not drilled horizontally, a 17-percent cost premium. [3]

This was the situation in 1990. Since then, directional costs have come down even further.

But it is more instructive to examine the previously mentioned Questar's experience at Pinedale. Questar's published well costs indicate a 12.5% cost premium associated with its 16 well pad directional program. However, they also report cost savings that offset this premium:

1. Reduction in production personnel's time due to several wells concentrated in one location

2. Large reduction in truck traffic due to economies of scale with bulk deliveries.

3. Consolidation of production equipment. [11]

They report no specific amount of savings from these sources. For the purpose of my analysis, I will use a conservative figure of 15% for the net additional costs, which is a rough average of published sources and the Questar number. Actual costs, especially taking into account unrealized savings [some of which are listed above], will likely be less.

So the cost premium is rather low, but is it still enough to render potential wells uneconomic? The following section will address the economics of this recommendation.

The recommended use of directional drilling and multi-well pads is economically feasible.

Using economics for a typical well, we can illustrate the effect of the recommended program. Although producing companies usually consider their economic data to be proprietary, one operator, Williams, has published their economics for typical wells in various plays.[12] Their example from the Piceance Basin in Colorado is the nearest equivalent to gas plays in southern Wyoming. These wells produce from the Mesaverde, the same gas bearing formation in Wyoming, and at depths in the intermediate gas well category in Rawlins DEIS [7-9000']. The trapping mechanism is basin centered gas from tight gas sands, as in Wyoming. Net reserves are approximately 1 BCF. A summary of these economics can be found in Figure 4. Of particular note are the development costs of $0.89 per mcf and the resulting net cash margin of $3.08

A comparison of these economics and the equivalent economics for a directional well can be found in Figure 5. To calculate these results, we can take the average cost premium of 15% and increase the total well costs to $1,094,563, or on a per mcf basis, a development cost of $1.02. This represents an increase of $0.13 per mcf, reducing the net cash margin to $2.95. For informational purposes, I've updated the numbers using 2005 prices in the $6.20 per mcf range.

Thus for an average gas well within the area of the Rawlins DEIS, the 'cost premium' can be estimated at $0.13 per mcf. To put this $0.13 decrease in profitability in perspective, one can consider the following:

1. Swings in the NYMEX price of gas over the past several years have been on the order of $2.00 per mcf [see Figure 6].[13] Our cost premium of a mere $0.13 pales by comparison.

2. It is essentially equivalent to the existing disparity in royalties. Federal royalties of 12.5% represent a bargain. State royalties are 16.67%. Fee royalties are typically even higher. For a modest 1 BCF well in our example, the 4.17% difference between state and federal royalties allows the producer additional net reserves of 41,700 mcf. Using the $2.95 cash margin above, this yields the producer an additional $123,015, reducing the per mcf development cost by $0.115. With royalty costs factored in, it costs about the same to drill a directional well on federal land as a conventional well on private land.

3. Rise in the price of natural gas has been an order of magnitude greater [see Figure 7].[13] Over the past five years, the price of natural gas *at the well head* has more than doubled, from the $2.00 per mcf range to over $5.00. A mere glance at this graph indicates that the long term outlook for natural gas prices is to continue to increase. With a high degree of certainty, this price will be far greater during the twenty year time frame envisioned on the DEIS, easily absorbing any directional well cost premium.

4. The cost of directional drilling will continue to decrease [see 'Future' section below]. Again referring to Figure 1, we can see the long term trend for directional wells in the US is upward. Economies of scale as well as accumulated experience will pressure costs downward. The cost premium I have used in this report is probably estimated too high now, and is certainly too high in the future..

5. Industry has been utilizing the multi-well pad approach in a variety of circumstances Obviously in the cases cited above, and others, the cost premium did not render the development uneconomic.

6. The oil and gas industry can afford it. Over the past five years, oil companies' cash flow has nearly doubled, to $138 billion in 2003, while exploration and production spending increased by perhaps 10%, to $68 billion.[14] In 2003, oil companies spent as much money repurchasing their stock than exploring.[14] In 2004, profits for the top ten oil companies jumped again by 30%.[16]

Coalbed Methane

The 640 acre surface spacings for Coalbed Methane will likely require the use of horizontal wells. Horizontal techniques have been demonstrated to be effective in the development of CBM reserves in numerous basins. The case of the Hartshorne coal in Oklahoma is instructive. Vertical completions in this thin coal typically range from 256 to 3756' deep and yield average initial rates of 10 to 120 thousand cubic feet per day [mcf]. Since 1997, horizontal drilling has been used extensively. Between 1998 and 2002, six operators have drilled 110 horizontal wells. Laterals drilled reached up to 5300' at true vertical depths [TVD] of 752' to 3031'. Initial production from half of these wells have done twice the average of the vertical wells, between 200 to 400 mcf per day. Seven came in at well over a million cubic feet per day. The highest IP, 1152 mcfd, came from a horizontal lateral at 1604'.[20] The improvement in initial production is because

> "higher initial gas rates are possible in a horizontal well than in a single-bed vertical well by drilling at a high angle (perpendicular to oblique) to the face cleat to drain a larger area."[21]

In this play, Williams Exploration and Production reports that their "superior economics are due to their horizontal drilling and completion techniques." Net cash of $2.92 per mcf are reported from wells drilled to an average depth of 2000'. A success rate of 94% was reported by the operator.[22]

In the San Juan Basin, another Rocky Mountain Basin with geology similar to the Wyoming basins, horizontal wells have been shown to have great potential. With a proven track record in other CBM producing basins, one operator, CDX, has brought their technology to the San Juan Basin. One example is the CDX Penrose 1R well, located in sec 8, 32N 6W. Three laterals totaling 9463' were completed in the Fruitland [CBM]. Peak production of 2.36 million cubic feet per day was reached in January, 2004. In April, production was still 2.19 million cubic feet.[23]

Contrast these numbers to average figures for vertical wells. Williams reports an average peak production of 687 thousand cubic feet per day for typical vertical Fruitland wells.[22] When compared with the per lateral peak production in the Penrose well of 786 thousand cubic feet, it is clear that horizontal wells can achieve a much higher initial production rate. In this case, each of three laterals from a single well pad is producing more than a single vertical well. As CDX states in their reports, it may be possible to replace up to 16 vertical wells with laterals drilled from a single pad.

The following are sample economics for a 640 ac case:

Vertical Well Cost: $700,000 [4 wells: $2,800,000]
Vertical Well Average Recovery: 30%

Horizontal Well Cost: $2,600,000 [higher due to additional lateral length]
Horizontal Well Recovery: 60%

Vertical Well Return: $4,500,000
Horizontal Well Return: $6,100,000

Note the high cost of CDX horizontal wells is due to their proprietary technology which results in higher recoveries.

Future Trends

Since the DEIS focuses on long time frames, the outlook for future drilling economics should be examined.

We have already seen that the use of directional drilling will continue to expand, but what of costs? A study of US Oil and Gas drilling costs, undertaken by the Gas Research Institute, focusing on:

> historical trends and a look into the new millennium (GRI-98/0137), concludes that, with "smart drilling," producers will meet the expected growth in consumption with drilling levels and expenditures that remain well below historic highs. Advances in drilling technologies have increased (and will continue to increase) efficiencies, resulting in lower overall costs. These gains mean rates will reflect the benefits/costs of advanced technology in most cases. However, new technologies could produce higher day rates for certain rigs, which provide offsetting benefits by requiring fewer drilling days. GRI forecasts that drilling efficiency (annual footage per active onshore rig) will improve at an average 1.5% per year, consistent with the past three decades. [17]

As for costs of production, a look at the past several years can shed some light on trends. A study by the US Energy Information Agency found that operating costs have remained flat over the past quarter century, while gas prices have risen and fallen and risen again to their present levels. [18]

Concerning technologies that allow more gas to be produced from fewer wells, such as the use of multi-well pads, multi-laterals, and other technologies, an industry group, the Natural Gas Supply Association, found the following:

- 22,000 fewer wells are needed on an annual basis to develop the same amount of oil and gas reserves as were developed in 1985.
- Had technology remained constant since 1985, it would take two wells to produce the same amount of oil and natural gas as one 1985 well. However, advances in technology mean that one well today can produce two times as much as a single 1985 well.
- The drilling footprint of well pads has decreased by as much as 70 percent due to advanced drilling technology, which is extremely useful for drilling in sensitive areas.
- By using modular drilling rigs and slimhole drilling, the size and weight of drilling rigs can be reduced by up to 75 percent over traditional drilling rigs, reducing their surface impact.
- Had technology, and thus drilling footprints, remained at 1985 levels, today's drilling footprints would take up an additional 17,000 acres of land. [19]

These trends, established over the past twenty year period, are expected to continue over the next two decades. It is hoped the full impact of these technologies can be brought to the Rawlins Management Plan.

Further Action

It is further recommended that BLM adopt the oil and gas provisions of the Western Heritage Alternative. This would logically allow larger areas of NSO leases, etc. The following sections examine directional well options related to this alternative.

Three Mile [5760 acre] Surface Spacings

Surface spacings greater than 640 acres are not only possible, but may be more appropriate for many development situations. Fields requiring a 160, 320 or 640 acre subsurface spacing, consisting of deep and intermediate gas wells, can be developed with well pads placed at three mile intervals. Each pad will drain a nine section area [5760 ac.] utilizing 9 to 36 wells. This situation is summarized on the following table:

	Sub-surface Spacing	Surface Spacing	Wells per pad	Pads per section	Depth [ft]	Horizontal displacement [ft]	Angle [deg] from surface	Angle [deg] from under 2500' casing
CBM-Deep	160	5760	36	0.12	5000	9334	62	75
	160	5760	36	0.12	7000	9334	53	64
Intermediate	160	5760	36	0.12	7000	9334	53	64
	320	5760	18	0.12	7000	8452	50	62
Intermediate	160	5760	36	0.12	12000	9334	38	44
	320	5760	18	0.12	12000	8452	35	42
	640	5760	9	0.12	12000	7467	32	38
Deep	640	5760	9	0.12	15000	7467	26	31

The angles and displacements involved are not particularly extreme. Referring to Figure 9, one can see they plot within the standard technology area, indicating the conclusions drawn concerning the 640 acre spacings are valid for this nine section spacing as well.

While the technology and costs are similar to the 640 acre case, the reduction in acreage disturbed would be much greater. A reduction of well pads from one every section to one every nine sections would result in a direct reduction of 88%, with a corresponding savings in roads, pipelines, etc.

Longer Reach Wells

Directional wells enable a producer to drill under sensitive areas from surface locations that are one, two, or even three miles away. But how feasible are these longer reach wells in Wyoming?

The following table summarizes the situation for these various offsets, using the depths typical for Wyoming wells that are used in the DEIS:

	Well Reach [miles]	Depth [ft]	Horizontal displace ment [ft]	Angle [deg] from surface	Angle [deg] from under 2500' casing
Intermediate	1	7000	5280	37	50
	2	7000	10560	56	67
	3	7000	15840	66	74
Intermediate	1	12000	5280	24	29
	2	12000	10560	41	48
	3	12000	15840	53	59
Deep	1	15000	5280	19	23
	2	15000	10560	35	40
	3	15000	15840	47	52

We can see that the angles involved are still relatively modest, but how do they compare to industry capabilities? I've plotted these various options on the graph of extended reach wells [see Figure 10]. From this graph we can conclude the following:

> All the wells plot within the capability of the drilling industry. None of them plot near the more extreme cases to the right of the graph.
>
> The majority of the wells can, like the wells under the 640 ac spacing example, be drilled using standard technologies.
>
> Only in two cases do these directional wells cross the line from Standard to Advanced Technology. It can be concluded that wells of three mile displacement, although technically feasible, may require more costly advanced techniques.

So all of these longer offset wells can be considered. Although additional costs, over the 15% cost premium cited in this report for directional wells may be required in some cases, there are no inherent problems in considering all of these drilling options as mitigation to protect sensitive areas while still allowing the underlying gas to be produced.

Resulting Impact to Surface Disturbance

A more widespread use of directional drilling and multi-well pads will result in a dramatic reduction in disturbance to the surface, and hence a correspondingly large reduction in total impacts. Using Table A33-5, Surface Disturbance from Coalbed Natural Gas and Gas Wells as a starting point, I have calculated new surface disturbance figures. The following assumptions were made:

1. The number of new development wells are estimated at 50% and 75% of the total number of wells estimated by the BLM. The balance of the wells are assumed to be either exploratory or located in mature areas.

2. The reduction in surface impacts by going to a 640 acre surface spacing is calculated at approximately 75%. This is an average figure based on acreage reductions for the various combinations of subsurface and surface spacings recommended in this report. Details of these calculations can be found on Figure 8. [for the 5760 ac case, I used a 95% estimate]

The results are as follows:

COMPARISON OF SURFACE DISTURBANCE BETWEEN DEIS AND THIS RECOMMENDATION

	Alternative 1 No Action	Alternative 2 Development Emphasis	Alternative 3 Conservation Emphasis	Alternative 4 Future Preferred
Gross Disturbance [ac.] under DEIS	61895	63649	56505	57819
Disturbance if 50% Wells at 640 ac Spacing	38684	39781	35316	36137
Disturbance if 75% Wells at 640 ac Spacing	27079	27846	24721	25296
Disturbance if 50%at 5760ac, 25%at 640ac	20890	21482	19070	19514

Thus the full utilization of directional drilling from multi-well pads will result in a huge reduction in surface impacts. These reductions are on the order of 50 to 60 square miles!

Summary

I have presented a methodology for achieving a significant reduction in surface impacts within the Rawlins Management Area utilizing oil and gas wells drilled directionally from multi-well pads. These recommendations are rather easily achieved from a technical perspective and are sound from an economic standpoint. However I recognize there are impediments to their adoption:

1. Industry will not embrace this view on its own simply because it is more costly Fundamentally, corporations exist to provide the maximum possible profit to their shareholders. The lowest cost option will nearly always be adopted.

2. Current operators are a mix of midsize and undercapitalized companies. Many of these do not have the expertise available to the majors and are reluctant to attempt new ideas.

3. Drilling engineers are conservative and risk averse.

4. Companies live in the short-term, where the next quarterly report, today's stock price, and the year end reserve bookings are paramount.

For these reasons, the responsibility for the adoption of these measures falls to the BLM. Although this will require a measure of courage, the following points should be kept in mind:

1. The goal of the present administration to maximize production of our domestic oil and gas resources is not at odds with my recommendations. My recommendations only address the method.

2. Producing companies, if they do not have the required expertise, will readily find it with industry vendors and contractors.

3. If the BLM imposes strong, but feasible, benchmarks, industry will meet them. In my personal experience, oil company engineers consistently met the challenge of stringent drilling requirements, from the successful drilling of 1 mile laterals at 12,000' depths in the Austin Chalk to the drilling of the North Fork well in the Shoshone National Forest exclusively by helicopter.

4. Many technological advances were adopted only after an initial period of skepticism. At one time, horizontal drilling, multi-lateral wells and 3D seismic were all thought to be impractical or too costly. All are now utilized routinely. If the full use of directional drilling from multi-well pads is demanded, I am convinced it will soon become in the industry standard in Wyoming. Learning curves will be conquered and costs will go down.

5. BLM's role is to balance the concerns of the various stakeholders in our federal lands, and ensure the responsible use of our resources. The recommendations in this report represent an excellent compromise among the various factions, and in fact, is a "win-win".

If there are any questions, I can be reached at the following:

Kenneth Kreckel
3670 Placid Drive
Casper, WY 82604

Phone: 307 235 3505

E-mail: kreckel1@yahoo.com

Submitted by: _____

Date: 3-4-2003

Figure 1. Number of directional wells drilled in the Untied States as a percentage of total wells. Note there is a doubling over the past fifteen years.

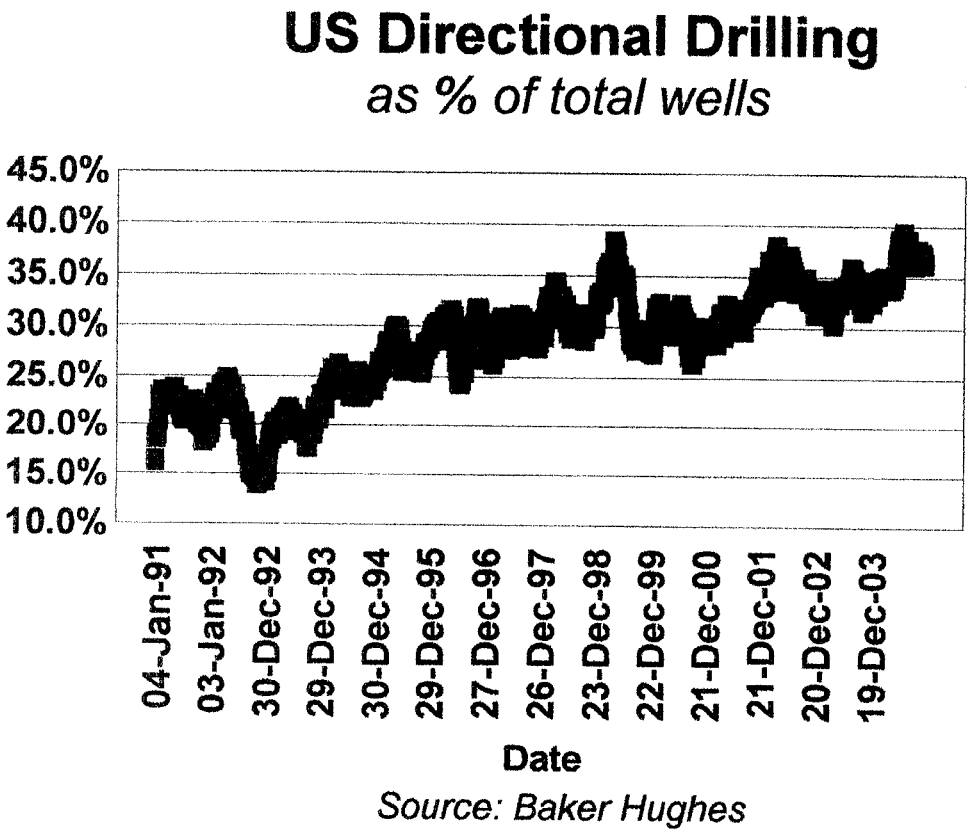
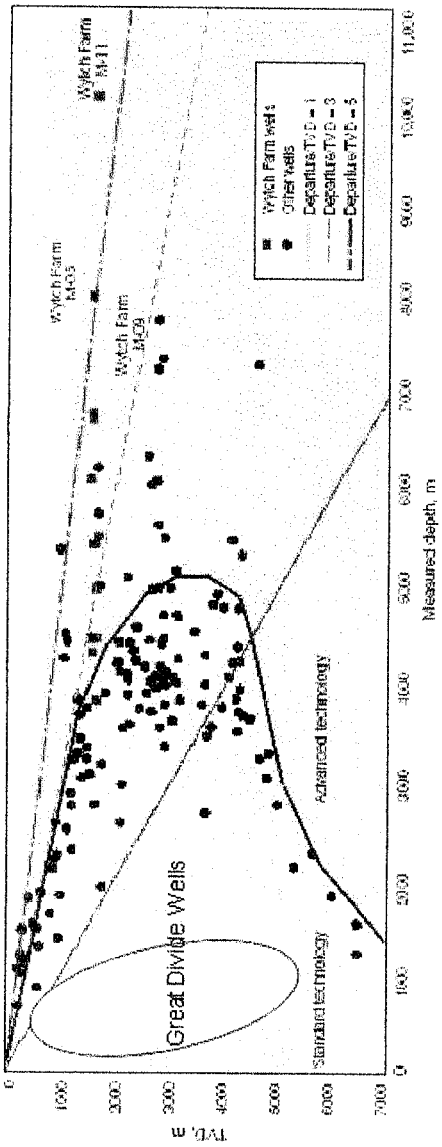
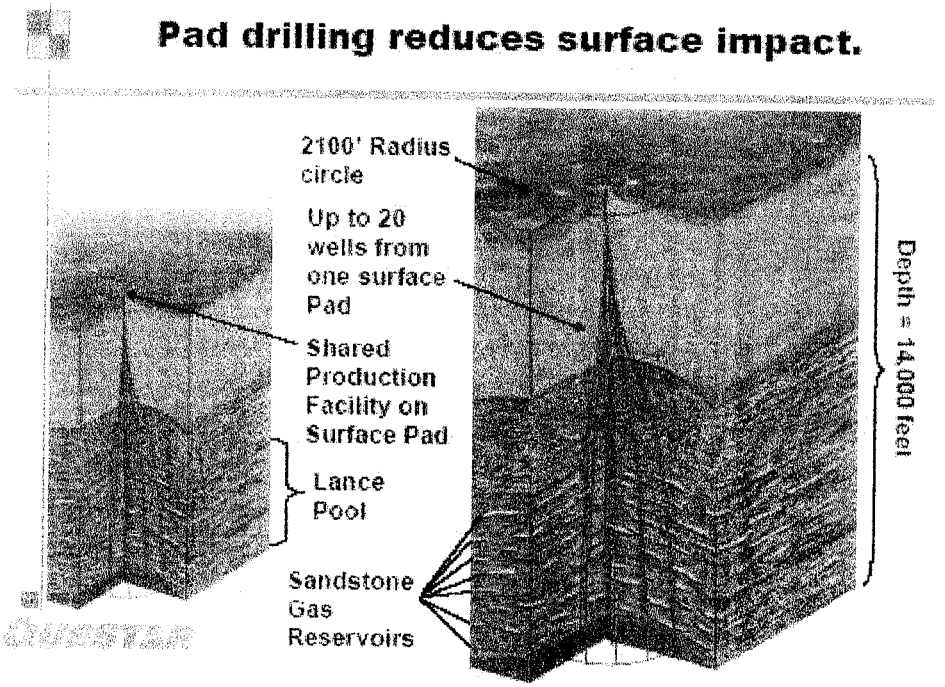


Figure 2



Industry comparison of extended-reach wells. What was once considered the envelope of extended-reach drilling now merely indicates the difference between standard and advanced technology. That envelope continuously enlarges as companies push technology to the limit.

Figure 3. From Questar literature, illustrating their directional well multi-pad approach at Pinedale. Note this example, from western Wyoming, is a gas development from the same formations as that envisioned in the Rawlins Management Plan.



Exploration & Production
Piceance Economics

Williams

Typical Well (Mesaverde)

Finding Costs	
Drill & Complete	$ 951,794
Total Well Cost, $	$ 951,794
Net Reserves, Mcf	1,072,548
Finding & Development Cost	$0.89

Illustrative Economics	
POV NYMEX Gas Price ($/Mmbtu)	$4.89
Basis Adjustment	-0.72
Rocky Mountain Gas Price (per MMbtu)	$4.17
BTU Adjustment - 1080 MMbtu/Mcf	-0.35
Transportation/Gathering/Compression	-0.09
Net Realized Gas Price - Mcf	$4.41
Production taxes - 7%	-0.29
Lifting Costs - $650/well/month	-0.15
Net Cash Flow - Mcf	$3.97
Finding & Development Cost	-0.89
Net Cash Margin	$3.08
After-Tax IRR	49%

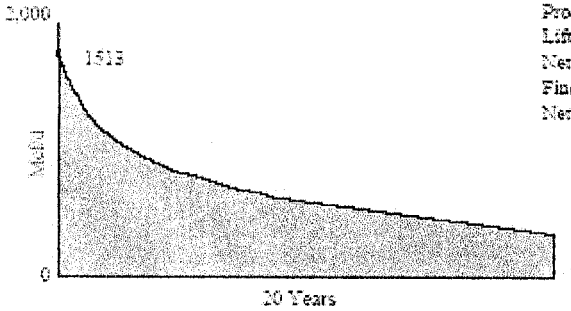


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Figure 4 Illustrative well economics from Williams' Piceance Basin gas play. This play is nearly identical to typical gas plays within the Rawlins Management Plan.

	2002 Vertical well	2002 Directional Well	2005 Directional Well
Total Well Cost, $	$951,794	$1,070,768	$1,070,768
Net Reserves, Mcf	1072548	1072548	1072548
NYMEX Gas Price (MMbtu)$	$4.89	$4.89	$6.20
Basis Adjustment	$0.72	$0.72	$0.72
Rocky Mountain Gas Price (per MMbtu)$	$4.17	$4.17	$5.48
BTU Adjustment -1080 MMbtu/Mcf+	$0.33	$0.33	$0.33
Transportation/Gathering/Compression	$0.09	$0.09	$0.09
Net Realized Gas Price -Mcf$	$4.41	$4.41	$5.72
Production taxes -7%-	$0.29	$0.29	$0.40
Lifting Costs -$650/well/month-	$0.15	$0.15	$0.15
Net Cash Flow - $/mcf	$3.97	$3.97	$5.17
Finding & Development Cost-	$0.89	$1.02	$1.02
Net Cash Margin $/mcf	$3.08	$2.95	$4.15

Figure 5. Comparison of the Williams economics in Figure 4 with a directional well costing 15% more. This results in a negative difference of only $0.13 per mcf. A look at the situation in 2005 is included to show the impact of higher product prices.

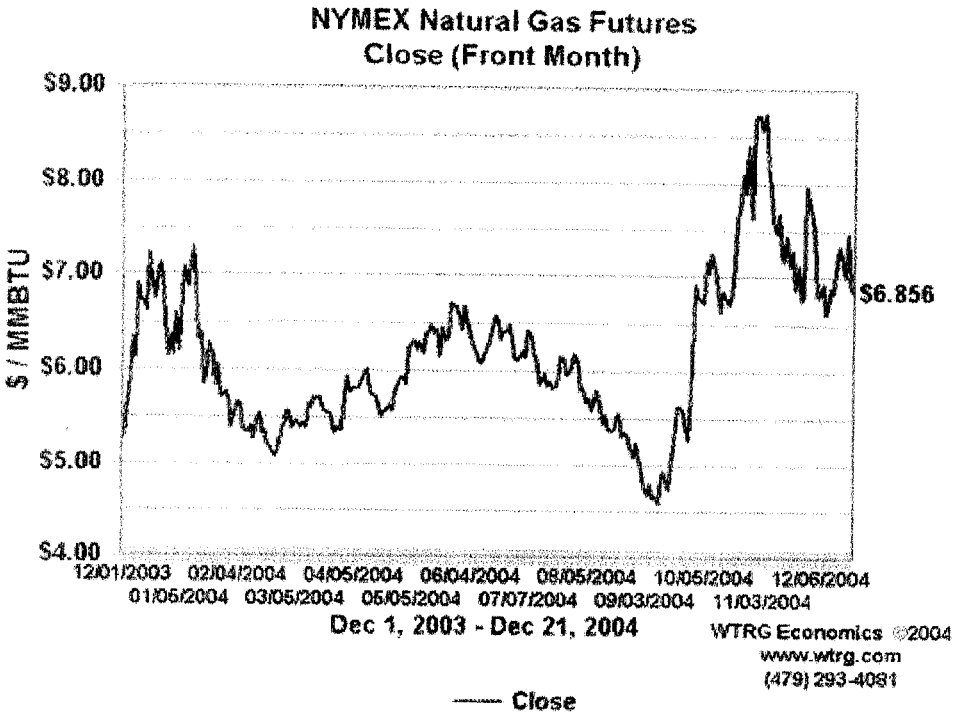

Figure 6. NYMEX gas prices over 2004. Swings of over $2 per mcf were experienced. Contrast this with the minor impact of $0.13 per mcf associated with directional wells.

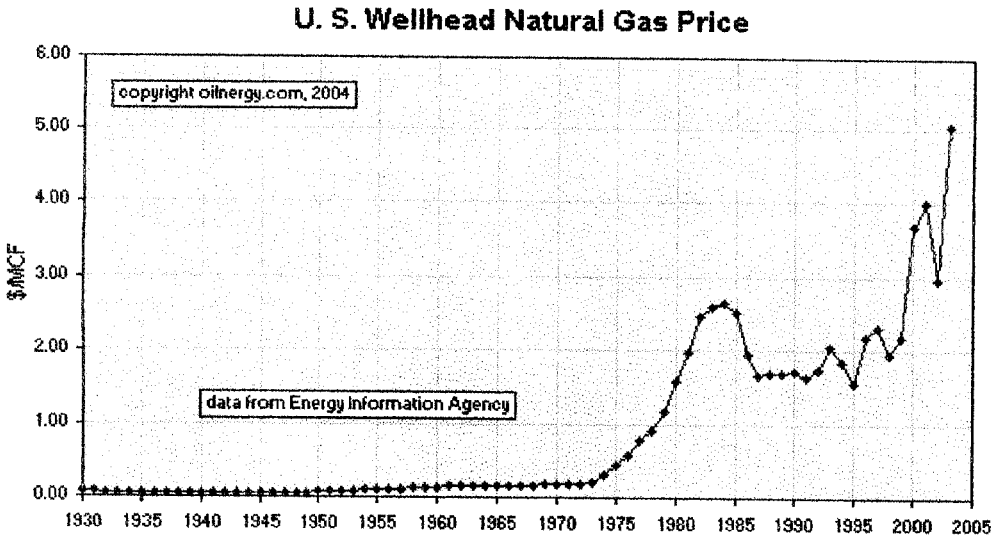

Figure 7. Average price of natural gas at the wellhead since 1930. Note the long term increase in price. The prime driver for the recent rise in Rocky Mountain drilling can be seen in the increase since the 1990's.

SUMMARY OF ACRES DISTURBED UNDER CURRENT AND RECOMMENDED SURFACE SPACINGS

		Drilling Well Pad	Prod Well Pad	Drill Roads	Prod Roads	New Pipelines	Acres Distrubed per Well	Subsurface Spacing	Surface Spacing	Wells per section	Acres Disturbed per Section	Per cent Reduction in Acres Disturbed
	CBM-Shallow	1.25	0.01	1.8	0.9	0.7	4.66	80	80	8	37.28	
		1.25	0.01	1.8	0.9	0.7	4.66	80	80	8	37.28	
CURRENT	CBM-Deep	2.5	0.5	2.5	1.6	0.7	7.8	160	160	4	31.2	
		2.5	0.5	2.5	1.6	0.7	7.8	160	160	4	31.2	
DEIS	Intermediate	2.5	0.8	2.5	1.6	1.5	8.9	40	40	16	142.4	
		2.5	0.8	2.5	1.6	1.5	8.9	160	160	8	71.2	
		2.5	0.8	2.5	1.6	1.5	8.9	320	320	2	17.8	
	Deep	4	1.4	7.6	4.7	4.5	22.2	640	640	1	22.2	
	CBM-Shallow	4	0.01	1.8	0.9	0.7	7.41	80	640	1	7.41	80%
		4	0.01	1.8	0.9	0.7	7.41	80	640	1	7.41	80%
RECOMMENDED	CBM-Deep	4	0.5	2.5	1.6	0.7	9.3	160	640	1	9.3	70%
		4	0.5	2.5	1.6	0.7	9.3	160	640	1	9.3	70%
	Intermediate	10	0.8	2.5	1.6	1.5	16.4	40	640	1	16.4	88%
		6	0.8	2.5	1.6	1.5	12.4	160	640	1	12.4	83%
		4	0.8	2.5	1.6	1.5	10.4	320	640	1	10.4	42%
	Deep	10	1.4	7.6	4.7	4.5	28.2	640	2560	0.25	7.05	68%
											Average Reduction is Acres Disturbed	73%

Figure 8. Calculation of the surface disturbance under the recommended 640 acre surface spacing with that assumed in the Rawlins DEIS. The major differences are the size and numbers of drilling pads.

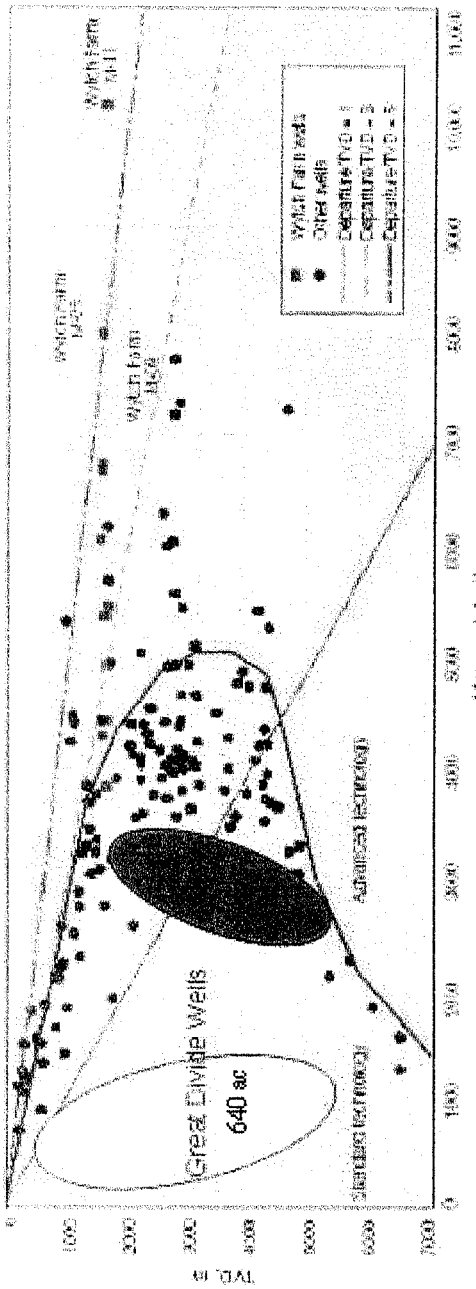

Figure 9

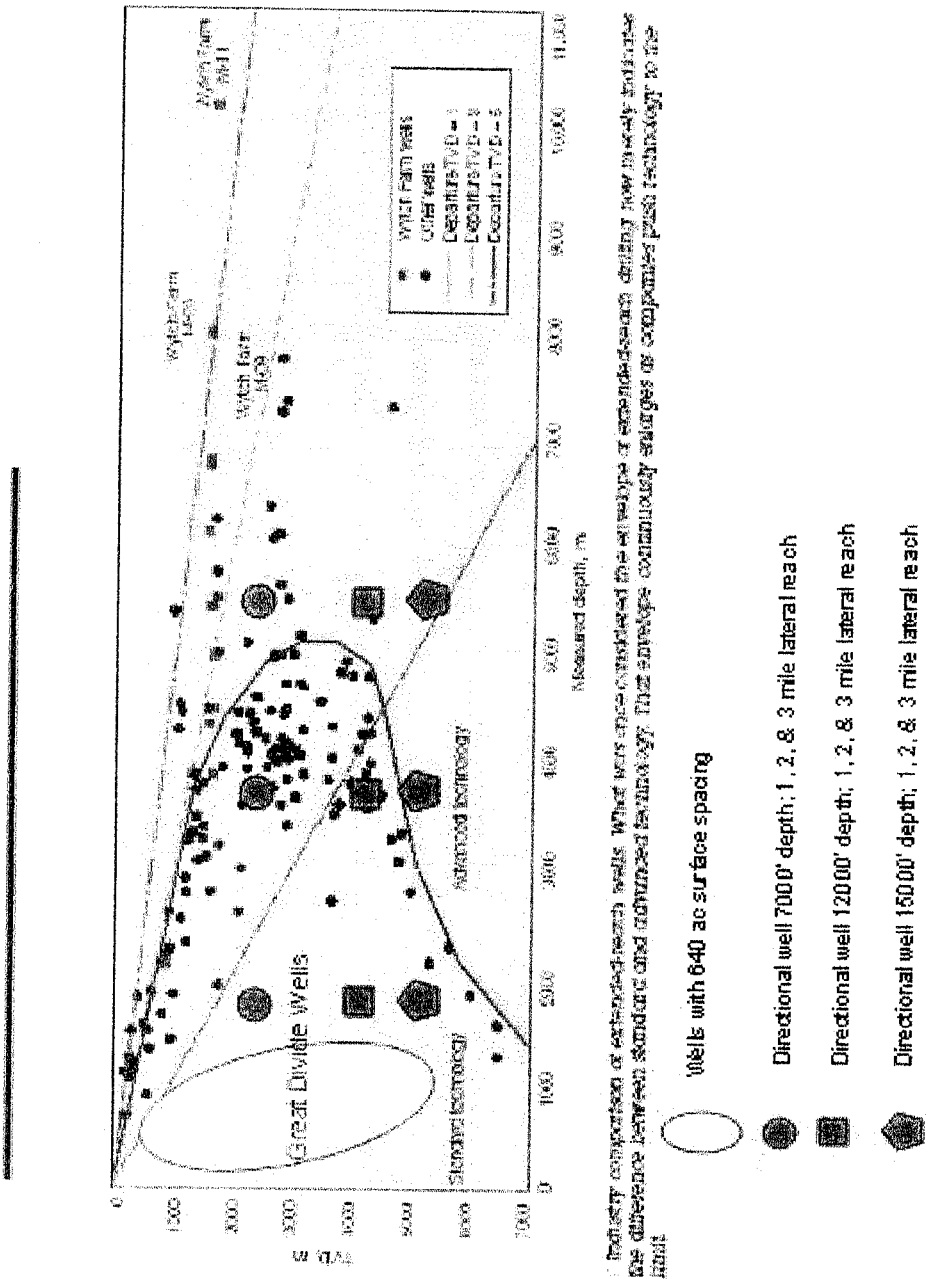
Great Divide Wells
Standard technology
Advanced technology
Measured depth, m
Wells with 640 ac surface spacing
Directional well 7000' depth; 1, 2, & 3 mile lateral reach
Directional well 12000' depth; 1, 2, & 3 mile lateral reach
Directional well 15000' depth; 1, 2, & 3 mile lateral reach

Figure 10

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Kenneth Kreckel
3670 Placid Drive
Casper, Wyoming 82604
307 235 3505
E-mail: kreckel1@yahoo.com

Manager with over thirty years major oil company experience in the exploration and development of oil and gas reserves in the U.S. and Europe. Career highlights are:

- Proven oil & gas finder, with several hundred MMBOE discovered. Personally led the initiation, discovery and subsequent development of the Cotton Valley Reef play in east Texas.
- Eight years experience as Exploitation Manager responsible for the development of multiple fields as well as exploration throughout a large region of the U.S.
- Expertise in horizontal drilling, especially in the Austin Chalk
- Confirmed judgment in prospect evaluations
- Many years experience managing multidisciplinary teams in successful exploration and development projects.
- Proficient at partner and contractor negotiations. Experienced with contracts.
- Performed numerous evaluations of company exploration assets.
- Many years as on-campus recruiter. Skilled in interviews and new employee evaluations.
- Particular ability with office relocations, and the establishment of new exploration offices.
- Recent experience in managing an exploration workstation support team.
- Personally designed and carried out numerous 3-D surveys. Particular expertise in cost-effective, suited-to-purpose surveys.
- Excellent at supervising seismic acquisition, processing and interpretation projects.
- Superior communication skills, especially written.

Experienced in most U.S. basins, particularly Gulf Coast and Rocky Mountains. Recent experience in NW Europe offshore basins.

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EXPERIENCE

Geoscience Consultant

2001-Current Casper, Wyoming
Performing small to midsize oil & gas projects in the Rocky Mountain region.

Marathon Oil Company

1998-2000 London, England Manager of Exploration Support
Responsible for the technical quality of interpretations of several geophysicists working throughout NW Europe. Managed UNIX workstation support department. Designed, contracted, and carried out several large 3D surveys. Supervised acquisition and processing of large multi-client surveys. Company representative with partners, research groups, NGO's, etc.

1990-1998 Tyler, Texas Exploitation Manager
Directed over thirty professionals engaged in exploration and development in East Texas, Gulf Coast onshore and Louisiana. Personally responsible for the initiation and successful development of the Cotton Valley Reef Play, discovering several fields totaling in excess of 200 BCF, largely through the application of 3D technology. Drilled over 50 successful horizontal wells in the Austin Chalk. Also active in tight gas sand development. Initiated, presented, and secured $50MM annual budgets.

1988-1990 Midland, Texas Region Geophysicist
Responsible for the technical excellence of seismic interpretations in West Texas, the Mid-continent, and Michigan Basin. Designed and carried out numerous seismic projects, from acquisition through interpretation.

1978-1988 Cody & Casper, Wyoming Geophysicist, Exploration Supervisor, Region Geophysicist
Interpreted and acquired seismic data throughout the Rocky Mountain Region, particularly the Thrust Belt, Paradox and Powder River Basins. Involved in the discoveries in the Paradox Basin.

Texaco, Inc.

1974-1978 Bellaire, Texas Geophysicist & Geologist
Developed fields in the Vicksburg of South Texas. Explored in the Atlantic margin, Illinois Basin, and offshore Gulf.

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EDUCATION

Michigan Technological University B.S. Geology with Honor 1974

RECENT CIVIC POSITIONS

Member, City of Casper Optional One-cent #12 Sales Tax Committee, 2002

Commissioner, Casper Planning & Zoning Commission, 2003-Current

SAMPLE PUBLICATIONS

[technical] with co-author, Valen D Ott; "The Thousand Dollar Project, Rich County, Utah"; Geologic Studies of the Cordilleran Thrust Belt, Rocky Mountain Association of Petroleum Geologists, 1982

[popular] "I'm in London and I Have No Clothes"; Foreign Ground, Travelers' Tales, Pronghorn Press, 2003

[My fiction writing has also recently earned honorable mentions from Wyoming Writer's, Inc. and Writer's Digest Magazine]

ORGANIZATIONS

Active member of the Society of Exploration Geophysicists;

Longtime member of MENSA

Past member of the Petroleum Exploration Society of Great Britain, East Texas Geologic Society, Wyoming Geological Association, and other professional societies.

REFERENCES

Upon request

WEB PAGE

http://home.bresnan.net/~kreckel11/pro.HTM

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RESERVOIR MANAGEMENT SERVICES, INC.
INTEGRATED CONSULTING SERVICES FOR THE PETROLEUM INDUSTRY

Jonah Infill Drilling Project
Evaluation of Directional Drilling

prepared for

EnCana Oil and Gas (USA) Inc.

by
Reservoir Management Services, Inc.

16 JULY 2004

Attachment 6

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INTRODUCTION

The Jonah Field in the Green River Basin of Sublette County, Wyoming is a major gas resource with approximately 10.5 TCF of original gas-in-place (OGIP) corresponding to a surface area of approximately 21,000 acres. With current well limitations and current surface spacing of 40 acres per well, the projected recovery is expected to be 30% of the OGIP which would leave approximately 4.7 TCF of economically recoverable gas in the reservoir. The projected 30% recovery is low compared to typical recoveries in conventional gas fields of over 80% of OGIP. The objective of infill drilling is to optimize the development of the hydrocarbon resource by increasing the recovery of gas to about 80% of the OGIP.

In low permeability reservoirs in Wyoming and other western states there is a trend to decrease the well spacing in order to increase recovery of the gas resource. Jonah is a low permeability reservoir and the decision to drill more wells at Jonah is based on field performance and detailed technical studies completed by operators. The technical studies include 3D seismic acquisition and interpretation, detailed description of the subsurface rocks that makeup the gas reservoir, flow modeling of the field, acquisition of petrophysical and pressure data, and microseismic/tiltmeter surveys during completion operations.

Jonah is an important gas resource in Wyoming. The field currently produces about 680 MMSCF of gas per day or 248 BCF of gas per year and, as shown on Table 1, is the largest non-coalbed-methane gas field in Wyoming, yielding about 13.5% of the total gas produced in the state.

Top 25 Largest Gas Fields In Wyoming for 2003

FIELD	Gas 2003 MCF	% OF STATE GAS TOTAL	COUNTY
PRB COAL BED	345,998,970	18.86	CAMPBELL / SHERIDAN / JOHNSON
JONAH	247,923,542	13.52	SUBLETTE
FOGARTY CREEK	161,012,934	8.78	SUBLETTE
MADDEN	111,261,366	6.07	FREMONT
PINEDALE (Includes MESA UNIT FIELD)	102,522,360	5.59	SUBLETTE
PAINTER RESERVOIR EAST	72,757,458	3.97	UINTA
WHITNEY CANYON-CARTER CREEK	67,004,736	3.65	LINCOLN / UINTA
LAKE RIDGE	65,466,134	3.57	SUBLETTE
LOST SOLDIER	38,955,320	2.12	SWEETWATER/FREMONT
BRUFF	31,291,864	1.71	LINCOLN / SWEETWATER / UINTA
ECHO SPRINGS	29,732,358	1.62	CARBON / SWEETWATER
WAMSUTTER	27,376,592	1.49	SWEETWATER
STANDARD DRAW	24,071,278	1.31	CARBON / SWEETWATER
WALTMAN	23,845,277	1.30	NATRONA
WILD ROSE	22,398,570	1.22	CARBON / SWEETWATER
TIP TOP	17,503,510	0.95	SUBLETTE
FONTENELLE	13,379,094	0.73	LINCOLN / SWEETWATER
HOGSBACK	13,046,843	0.71	LINCOLN / SUBLETTE
PAVILLION	12,109,148	0.66	FREMONT
WERTZ	12,001,184	0.65	CARBON/SWEETWATER
LABARGE	11,544,751	0.63	LINCOLN / SUBLETTE
PAINTER RESERVOIR	11,220,192	0.61	UINTA
BEAVER CREEK	10,798,737	0.59	FREMONT
BRADY	10,694,488	0.58	SWEETWATER
CHURCH BUTTES	10,521,394	0.57	SWEETWATER / UINTA

Table 1: The 25 Largest Gas Producing Fields in Wyoming in 2003[1]

[1]The Wyoming Oil and Gas Commission," 2003 Wyoming Oil and Gas Statistics".

In terms of energy consumption in Wyoming, Jonah Field gas production is significant. Total annual residential consumption of natural gas for the State of Wyoming in 2002 was 13 BCF (81 MCF per year per household)[2]. Production from the Jonah Field could theoretically supply 3,000,000 households or 19 times the annual residential natural gas requirements for the state of Wyoming. Additionally, Jonah produces about 2,200,000 barrels of condensate (oil) each year, which is equivalent to approximately 9% of the field gas production (1 barrel of oil equals 10,000 standard cubic feet of gas).

Jonah Field was compared to four other sandstone reservoirs in SW Wyoming. Outlines of the five fields are shown on :

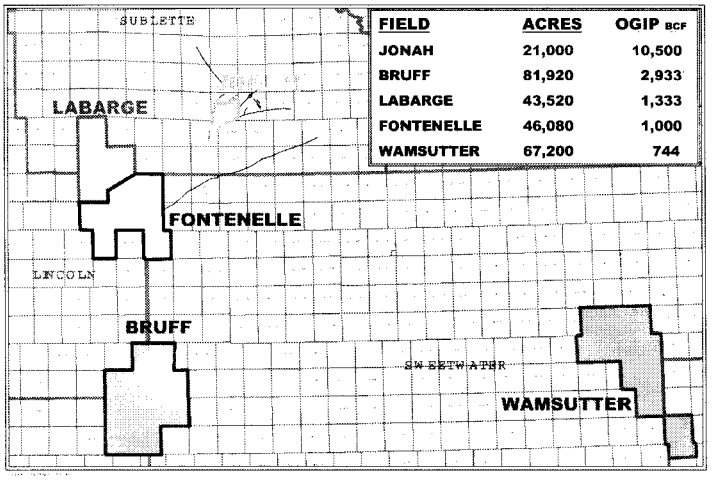

Figure 1: Outline of Jonah and comparison gas fields.

The portion of Jonah Field being proposed for infill drilling, which contains about 10.5 TCF of OGIP under 21,000 acres of surface area, is compared to four other fields from the top 25 gas producing fields in Wyoming. The areas shown for these fields are defined by the Wyoming Oil and Gas Commission (WOGC). Within these areas, the field production, number of wells, and acres were determined from WOGC data. The acres shown in the table on Figure 1 were calculated by multiplying the number of drilled sections within the outline by 640 acres.

A comparison of Jonah with other fields in Sublette and Lincoln Counties is shown in Table 2

Jonah Field Comparisons - Sublette, Lincoln, and Sweetwater Counties, Wyoming.

	ANNUAL VOLUMES			TOTAL	EST. ULTIMATE RECOVERY			OGIP	SURFACE AREA
FIELD	ANNUAL MCF	MCF per Well	ANNUAL BBLS	WELLS	GAS-BCF		Oil-MMBO	BCF	ACRES
JONAH	247,923,542	498,840	2,272,761	497	3000	1	30.0	10,500	21,000
JONAH				3,597	7947	2	79.5	10,500	21,000
BRUFF	31,291,864	70,957	194,943	441	2200	3	15.0	2,933	81,920
FONTENELLE	13,379,094	44,746	20,245	299	750	3	1.6	1,000	46,080
LABARGE	11,544,751	13,566	322,230	851	1000	3	26.0	1,333	43,520
WAMSUTTER	27,376,592	110,389	306,062	325	558	3	6.0	744	67,200

1. Estimated from EnCana's technical studies(no additional wells)
2. Estimated from EnCana's technical studies(proposed action)
3. Estimated from extrapolation of field gas rate vs. cum. gas production(Wyoming Oil and Gas Commission data)

Table 2: Comparison of Jonah and other gas fields in Sublette, Lincoln, and Sweetwater Counties, Wyoming.

[2] American Gas Association; "The Natural Gas Industry in Wyoming",2002.

Table 2 summarizes the comparison of Jonah Field to the other fields. Estimated ultimate gas recoveries were found by extrapolating the plot of field gas production versus cumulative gas production to a limit of 100,000 MCF/Month. Values for Jonah Field were taken from EnCana's technical studies. OGIP for the other four fields is not available and was estimated by assuming an arbitrary recovery factor of 75% of OGIP.

Table 2 shows that Jonah Field is a significant, highly-concentrated, energy source. A comparison of the data on a per-acre and per-well basis is shown in Table 3:

FIELD	OGIP-BCF		EUR-GAS(BCF)		EUR-OIL(STB)	
	Per well	Per Acre	Per Well	Per Acre	Per Well	Per Acre
JONAH(no Action)	21.1	0.500	6.0	0.143	60362	1429
JONAH(proposed action)	2.9	0.500	2.2	0.378	22102	3786
BRUFF	6.7	0.036	5.0	0.027	34014	183
FONTENELLE	3.3	0.022	2.5	0.016	5351	35
LABARGE	1.6	0.031	1.2	0.023	30552	597
WAMSUTTER	2.3	0.011	1.7	0.008	18462	89

Table 3: Comparison of OGIP and EUR: Jonah and some other Wyoming Gas Fields

For the proposed action, Jonah Field contains about 25 times more OGIP and gas reserves per-acre than the other fields. The OGIP and gas reserves per-well are about equal to the other fields. The Jonah oil reserves per-acre (proposed action) are 45 times higher than the other fields. Per-well oil reserves, on average, are about the same as the other fields. OGIP per acre for the fields is shown on Figure 2:

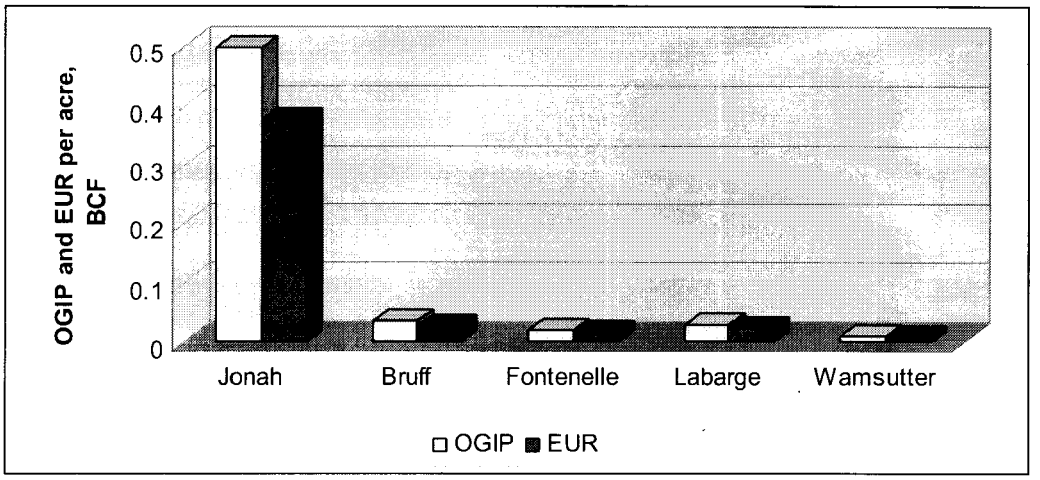

Figure 2: OGIP and EUR per acre for Jonah and comparison fields

Jonah is currently developed on 40 acre surface spacing and with the significant potential of increased gas recovery anticipated from infill drilling, optimized subsurface well spacing in the range of 5 to 10 acres is being considered. In this report, the various well architecture options available for infill drilling at Jonah are outlined and the "waste" associated with these options is quantified. State oil and gas commissions generally have rules addressing "prevention of waste", which in most cases they have defined as:

- Actions that result in irrecoverable loss of natural gas
- Drilling of unnecessary wells

The potential resource waste at Jonah results from incremental costs and lost gas reserves associated with directional drilling relative to vertically drilled wells. In this report, the potential

"waste" is quantified based on a review of actual directional well experience at Jonah where 54 directional wells have been drilled and completed as of May 2004.

BACKGROUND

Geological Setting. Jonah Field produces from a thick sequence of rocks that is defined by the intersection of two fault zones which form a wedge-shaped structural block. The updip termination at the southwest end of the field is the apex of the block. The downdip limit is defined as occurring along the structural low between Jonah and the Pinedale Anticline to the northeast.

Within the wedge-shaped Jonah block, overpressure conditions exist in the Lance Formation, whereas the same Lance Formation rocks outside the Jonah compartment appear to contain "normal" pressure (pressure equivalent to a column of water at the same depth). The Wyoming Oil & Gas Conservation Commission has defined the Lance Pool as the stratigraphic interval between the Ericson Sandstone of the Mesaverde Group and the base of Tertiary Fort Union (aka "Bois Marker"). This interval comprises the full range of productive rocks known at Jonah Field. Thickness of this interval ranges from about 3200 ft in the updip (southwestern) corner to about 5100 ft at the downdip extreme. Over the field the vertical depth to the top of the Lance from the surface varies from 7200 ft to 9000 ft.

The gas reservoir at Jonah is described as a combination structural-stratigraphic trap. The bounding fault zones form the lateral trap and the top-seal is comprised of the mudstones that are interbedded with the reservoir sandstones of the Lance. The Lance Formation sandstones are lenticular and discontinuous having been stream-deposited (fluvial), with interbedded siltstones and mudstones deposited outside the stream channels. The 3-dimensional geometry of the sandstones deposited in this fluvial setting and the overprint of faults results in extreme reservoir complexity. It is this geometric complexity that makes full recovery of the gas-in-place impossible on 40-acre well spacing. Additionally, the average permeability of these rocks is very low (0.01 millidarcies) making it more difficult to move gas over long distances within the sandstones.

The Lance at Jonah Field is highly over-pressured. In, general, for a given pore volume, higher initial reservoir pressures result in larger volumes of OGIP. The over-pressure also results in preservation of slightly better porosity relative to Lance sandstones outside the field boundary.

The lenticular nature of the fluvial Lance Formation sandstones created highly complex reservoir architecture and is a significant challenge to the gas recovery process. There is poor connectivity as indicated by difficulty in correlation of individual sandstone bodies between wellbores positioned as close as 5 acre spacing. The poorly connected sandstones mean that relatively close well spacing is required to produce a high percentage of the gas resource.

The Tertiary Fort Union Formation overlies the Lance Pool Interval. The Fort Union is comprised mostly of sandstone, much of which is porous, permeable and normally pressured. The large reservoir pressure difference between the over-pressured Lance and the normally pressured Fort Union is the main source of drilling problems at Jonah and will be discussed In detail later in the report.

Field history. Jonah Field was discovered by Davis Oil Company in 1975 with the drilling of the Wardell Federal #1 well. The discovery well was not economic and in 1992, McMurry Oil Company acquired the field after a total of three wells had been drilled. After testing the first three wells with encouraging results, McMurry Oil drilled the Jonah Federal #1-5 well, which initially produced 3.7 million cubic feet (MMCF) of gas and 40 barrels of oil per day. Initial assessments led to the request by McMurry Oil for a maximum of 497 wells to develop the field on 80 acre spacing over an area of 60,000 acres.

Alberta Energy Company, now EnCana after the merger with PanCanadian, acquired McMurry's interest in Jonah Field in 2000. In June of 2000, the BLM approved 40 acre spacing (497 well pads) over a smaller area corresponding to the core of the field defined by the over-pressured

Lance. The remaining area is in the normally pressured Lance and is excluded from the current environmental impact statement.

As of early 2004, Jonah Field has produced 1,020 BCF of gas (10% of the resource) and 10.2 MM barrels of condensate (oil). Current field production is about 680 MMSCF per day making it the largest non-coalbed-methane gas field in Wyoming. Projected recoveries without infill drilling will be about 30% of the resource. With infill drilling it is anticipated that close to 75% of the resource can be recovered.

Evaluation of infill drilling. More recently, detailed technical studies based on field performance and 3D seismic indicated that significant reserves would not be drained on 40 acre spacing. In 2002 EnCana initiated a pilot infill well program with some wells drilled as close together as 475 ft. The main objectives of this pilot were to gather technical information required to determine the spacing necessary to develop Jonah Field and to evaluate the feasibility of directional drilling.

A good understanding of the drainage areas and their shapes will prevent the drilling of unnecessary wells and will help locate wells to insure that the maximum possible volume of gas is recovered. Microseismic and tiltmeter surveys are being conducted in conjunction with well completion operations to better understand the size and shape of drainage areas associated with individual wells. The operators also constantly evaluate new technologies that might be used to maximize gas recovery. Examples of new technologies being evaluated are:

- New logging technologies such as Cased Hole Dynamic Testing
- Improved fluids utilized for hydraulic fracturing
- VSP seismic technology
- Geocellular interpretation and reservoir modeling

Subsurface Spacing – Waste Considerations. Analysis by EnCana based on pilot infill results, detailed reservoir description and reservoir modeling work, and volumetric analysis, gives the following estimated gas recovery volumes based on several different field development techniques. The results are shown in Table 4:

Field Development Alternative	Additional wells and pads	EUR (Bcf)	Waste Relative to Proposed Action (Bcf)
No Action	0	3,366	(4581)
Proposed Action	3,100 from 16,200 acres of disturbance	7,947	0
Max Development	Unrestricted development	8,191	244
Alternative A	3,100 from 497	6,124	(1824)
Alternative B	1,250 from 1,250	6,657	(1290)
	2,200 from 2,200	7,554	(393)
Alternative C	3,100 from 266 New (16 dis/Sec)	6,302	(1645)
	3,100 from 1,028 New (32 dis/Sec)	7,186	(761)
	3,100 from 2,553 New (64 dis/Sec)	7,876	(71)

Table 4: Anticipated Gas Recovery Volumes for various field development techniques, Jonah Infill Drilling Project, Sublette County, Wyoming, 2004.

Based upon EnCana's current technical understanding of the Jonah Field, original-gas-in-place (OGIP) is currently estimated at 10.5 trillion cubic feet of gas (TCF). Typical recovery factors for deep gas fields range between 75-85% of OGIP. With no further development, it is currently estimated that gas recovery will be approximately 30% of the 10.5 TCF of OGIP leaving 4,581 BCF of potential gas reserves in the ground unrecovered. This constitutes significant waste.

With no new surface locations and limiting the development of the northern third of the field (3100 wells/existing 497 well pads), it is currently estimated that approximately 1,824 BCF of gas would not be recovered, also constituting significant waste.

If the Jonah Field were developed with sixteen surface disturbances per section (40-acre spacing), this would limit development of the lower EUR/well population of the 5, 10 and 20-acre infill program, causing many wells to fall below the economic threshold due to increased directional drilling costs. This waste is significant and is estimated to be approximately 1,645 BCF of gas reserves.

To put this loss in perspective, 2,000 BCF, if produced over 25 years, represents 6 times Wyoming's current annual residential natural gas usage.

WELL ARCHITECTURE OPTIONS

Directional drilling has been proposed as a universally applicable technology for use in reducing surface disturbance that can easily be applied to Jonah Field[3]. This is a misconception resulting from superficial analysis of directional drilling technology applications in development of oil and gas fields.

The evaluation of well architecture options for thick, low permeability gas reservoirs is not a simple matter of stating that drilling multiple wells from a single pad will reduce surface disturbance. Many factors must be considered in order to select the appropriate well type and to evaluate the tradeoffs between vertical and deviated wells. The tradeoffs involve increased cost and potential lost reserves associated with increased risks in the deviated well drilling, completion and production processes. In addition, increased drilling times and higher engine load requirements for deviated wells increase cumulative surface activity, emissions, and environmental impact.

Directional drilling is a well-established technology in the oil and gas industry. However, the technology is not applicable to all situations. The proper application of directional or deviated well drilling must be carefully evaluated for each reservoir and a fit-for-purpose well architecture must be designed for each reservoir or field. For example, at Jonah, the Lance is over-pressured and in directional wells, the bends and inclined section of the borehole is contained within the normally pressured Fort Union above the Lance. Differential sticking caused by moving the drill pipe and casing through the bends of the directional well severely complicates directional drilling at Jonah. The position of the s-shaped well relative to the Fort Union and the Lance is shown on Figure 3:

[3] Amos, J.F.:"WITNESS STATEMENT:Environmental Aspects of Modern Onshore Oil and Gas Development", Testimony to the Committee on Resources of the United States House of Representatives, Subcommittee on Energy and Mineral Resources, September 17, 2003.

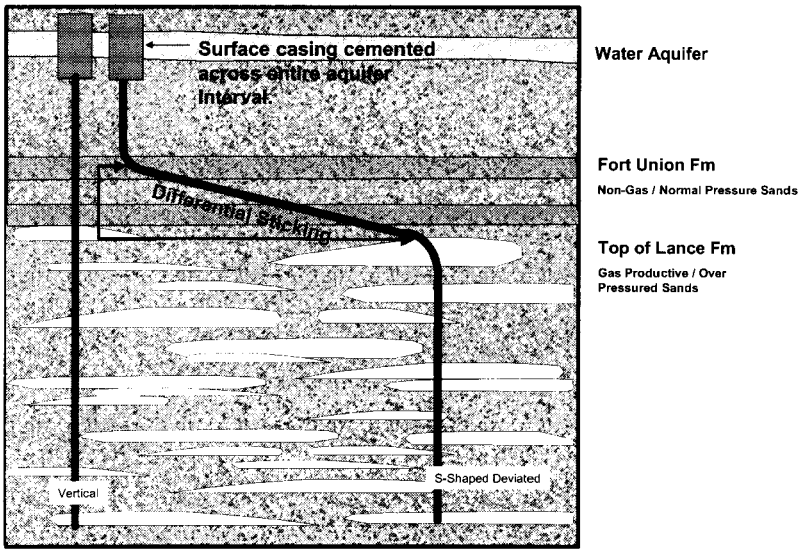

Figure 3: Schematic of S-Shaped directional and vertical wells showing location of differential sticking zone (not to scale - inclined section is 15˚ maximum).

Directional Well Types. The large number of thin sands distributed over a long interval impacts the selection of the appropriate well configuration. An example cross section at Jonah Field is shown in Figure 4:

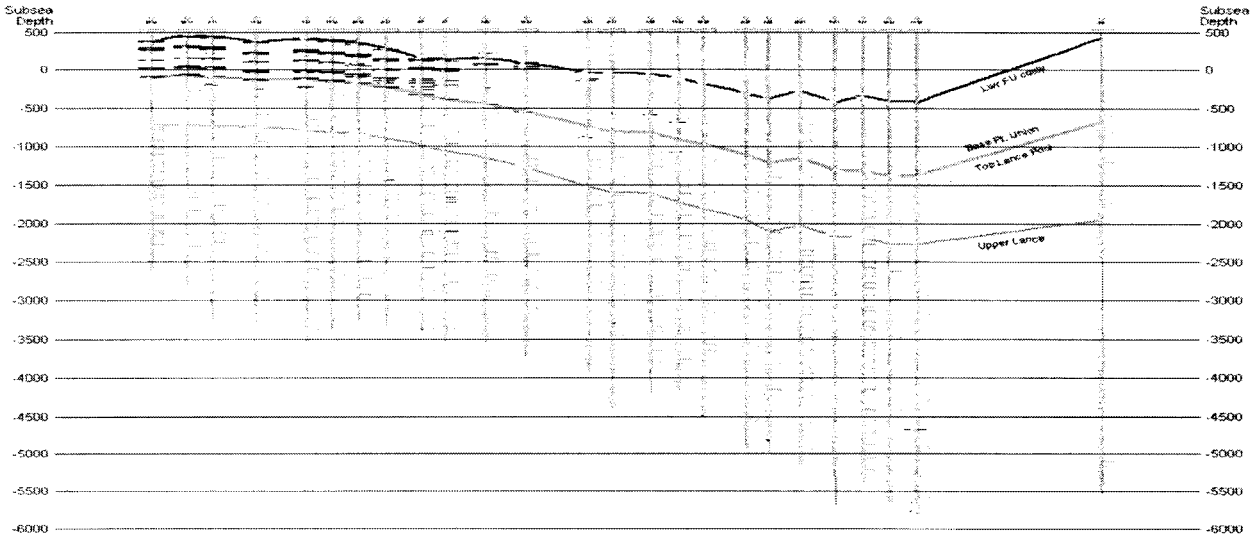

Figure 4: Cross section of the Lance at Jonah Field with potentially productive sands shown in yellow.

The section, which runs from SW to NE shows the structural dip on the top of the Lance. As the top of Lance increases in depth from 7200 ft. to almost 9000 ft, the gross thickness of the reservoir increases from 3000 ft to 5000 ft.

The possible well configurations for Jonah are shown on Figure 5:

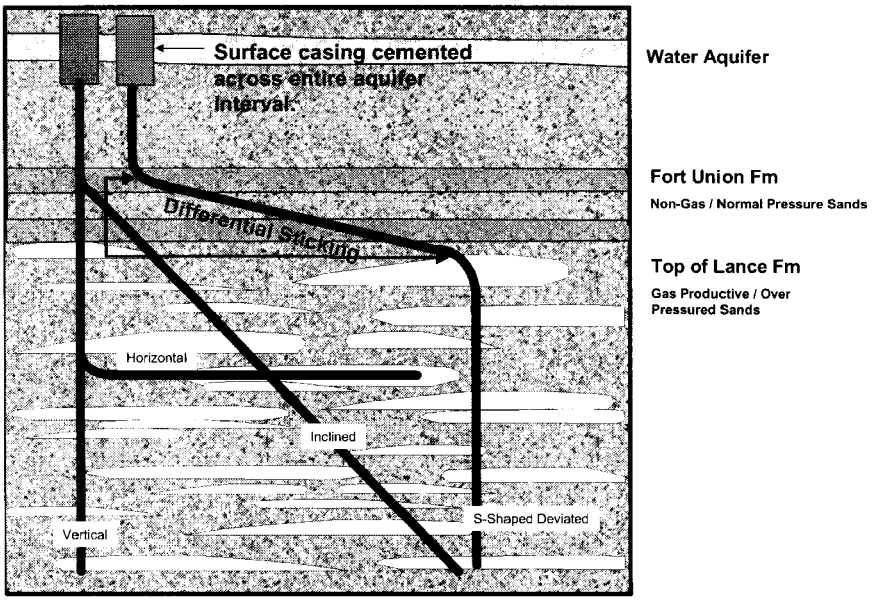

Figure 5: Well type options for Jonah development (not to scale).

Four well types are shown on this diagram: vertical well, s-shaped deviated well, high angle inclined well, and horizontal well.

A vertical well intersects all zones directly under the surface location. All zones of the Lance, including ones partially depleted by offset production, are perforated and hydraulically fractured in up to 10 stages. Drilling and completion operations are based on well-established, low risk technology. This type of well is the most commonly used well in developing thick, multiple zone, low permeability gas reservoirs. A typical well program is to run surface casing to 2500 ft through the surface aquifers then drill the normally pressured Fort Union and the over-pressured Lance with no intermediate casing. Mud weight is increased at the top of the Lance to control pressure and gas flow in the well. The increased mud weight creates a pressure differential (overbalance) across the Fort Union which can cause the drill pipe to stick in the deviated section of the borehole. In vertical wells, drill pipe sticking is generally not a problem.

A horizontal well can be drilled from vertical or high angle inclined wellbores. The horizontal section is deviated from vertical (kickoff point) close to the depth of the target zone and can easily reach lengths of 1500 ft to 3000 ft from the kickoff point. The main problem with this well architecture for the Lance at Jonah is that production is restricted to only one of the potential target zones. Although horizontal wells may drain reserves from a single zone more efficiently than a vertical well completed and hydraulically fractured in the same zone, single zone completions are generally not economic in the Lance. In multizone reservoirs, multilaterals or hydraulic fracturing has been used in some instances to access multiple zones. At Jonah these approaches are not feasible because of the large number of zones distributed over 3000 ft to 4000 ft of gross interval. Horizontal wells are clearly not applicable for development of the Lance at Jonah.

At Jonah, a high angle inclined well would be drilled at 30° to 60° from vertical starting at a 2600 ft kickoff point. This well intersects the reservoir zones at increasing distances from the surface location of the well. There is increased cost associated with drilling time required for the longer, deviated well in addition to increased mechanical risk of directional drilling. A major problem with this type of well is that, based on industry experience, hydraulically fracturing the multiple

individual zones is technically difficult due to problems with screenouts. During hydraulic fracturing, sand is carried into a fracture created by high-pressure fluid. If there is a restriction at the wellbore, the sand packs off prematurely (screenout) terminating the fracture treatment. If special, higher-cost technologies are not applied, the frequency of screenouts increases as wellbores are inclined to more than 10° from vertical.

The theoretical reasons for the screenouts in inclined wells are related to fracture initiation problems caused by certain well orientations in the stress field (Hossain[4] and Sankaran[5]). It is critical that the inclined well be correctly oriented in order to have successful hydraulic fracture treatments. However, the stress field is usually poorly defined leading to poor success rates for hydraulic fracturing in inclined wells. Zones that screenout during fracturing are generally not successfully refractured and the reserves are not produced. Orientation in the stress field is not a factor in vertical wells; consequently success rates for hydraulic fracturing are very high.

Finally, the diagonal wellbore on the diagram penetrates approximately the same number of sands the vertical wellbore does. However, the drainage areas are not equivalent as a large wedge-shaped area between the inclined well bores is left undeveloped. This wedge-shaped area on the two-dimensional diagram is actually a very large conical area when looked at in all three dimensions. That conical area would not be drained without the drilling of additional vertical wells.

The s-shaped well is the most common deviated well drilled for field development. A well of this type at Jonah would be kicked off at about 2600 ft and straightened to vertical before entering the first pay zone at about 7150 ft to 8700 ft from surface. From a completion standpoint, this well looks like the vertical well with possible problems working inside a deviated well with two doglegs (bends) in the well path. The main subsurface problem with this well type at Jonah is increased cost associated with directional drilling and mechanical risk due to differential sticking of drill pipe and casing through the normally pressured Fort Union above the Lance.

It is the Lower Fort Union that represents the most significant risk for differential sticking problems during drilling operations. The mud column pressure required to drill the underlying Lance is much higher than the Fort Union formation pressure. This large pressure difference over hundreds of feet in the Fort Union creates conditions where the drill pipe may become attached to the borehole wall (differential sticking) especially where the pipe moves through the bends of the directional wellbore. Directional drilling increases the probability of becoming differentially stuck because where the hole is deviated from vertical, pipe will lay against one side of the borehole instead of hanging near the center of a vertical borehole.

Therefore, the bends in the well paths, located in the Fort Union, increase the possibility of sticking the drill pipe and casing. The end result is increased cost and potential loss of gas reserves. There are some potential solutions to address the problem of differential sticking. These will be discussed in a later section.

In summary, from a reservoir management standpoint, vertical wells with hydraulically fractured, multiple zone completions are the preferred option for efficient recovery of gas reserves at Jonah. S-shaped deviated wells have application to develop gas reserves under areas of the field where surface occupancy is prohibited or not possible because of terrain. Using S-shaped deviated wells for infill development at Jonah in areas where vertical wells can be used involves a tradeoff between reducing surface disturbance and higher per well cost and lost reserves. As spacing is reduced below 40 acres per well, multiple directional wells drilled from a larger single pad reduce the total area of surface disturbance; however, increased cost and resulting loss of reserves associated with directional wells causes waste.

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[4] Hossain, M.K., M.K. Rahman and Sheik S. Rahman;"A comprehensive Monograph for Hydraulic Fracture Initiation from Deviated Wellbores Under Arbitrary Stress Regimes";SPE 54360, Dallas(2000).

[5] Sankaran, S.,Nikolaou, M., and Economides, M.J.: "Fracture Geometry and Vertical Migration in Multilayered Formations from Inclined Wells"; SPE paper 63177, Dallas(Oct 2000).

Maximum Reach. The depth of the top of the Lance from the surface varies from 7000 ft at the SW end of the field to almost 9000 ft at the NE end of the field. The objective is to have the wellbore vertical at the top of the Lance. Given a kick off point, maximum change in the deviation angle (dogleg severity, degrees/100 ft) and a maximum angle of the inclined section of the well, it is possible to calculate the reach of the deviated well versus the depth to the top of the Lance.

Assuming a dogleg severity (rate of bending between the vertical and inclined sections of the directional well) of 1 degree per 100 ft, a maximum inclination of 15 degrees from vertical and a kickoff point of 2600 ft, a typical well design is shown on Figure 6:

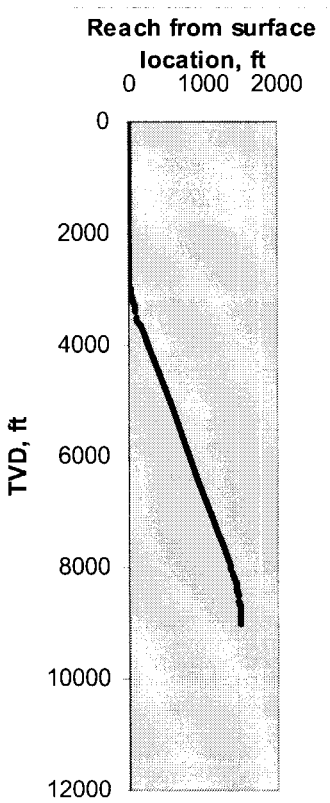

Figure 6: Well path for a typical directional well at Jonah

The maximum reach was calculated, assuming the above deviated-well design parameters and plotted versus the depth to the top of the Lance. The result is shown on Figure 7:

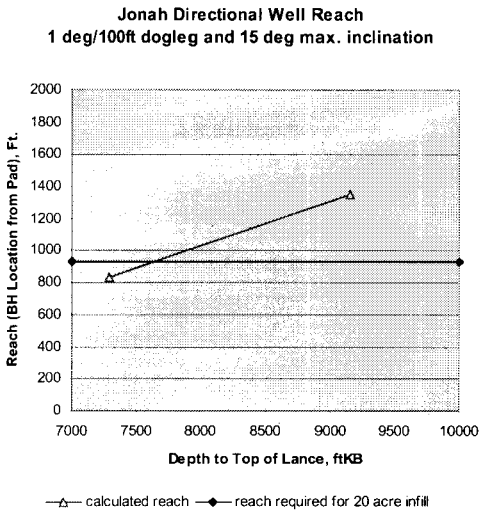

Figure 7: Maximum reach for a deviated well at Jonah for dogleg severity of 1°/100 ft and 15 ° maximum inclinations in the build section.

From the 40 acre vertical well location, it is possible to achieve 933 ft displacement of the bottomhole location (20 acre location) with an s-shaped well if the top of the Lance is deeper than 7659 ft. For the deepest part of the Lance, a displacement of 1300 ft is possible. With these design parameters it is not possible to reach the adjacent 40 acre location except in the deepest part of the field. A longer reach can be achieved by increasing the inclination angle or by kicking of the deviated section in the surface casing.

Well designs show that a maximum reach of 1500 ft from the surface location can be achieved with inclined sections greater than 15 degrees. The inclination required to reach 1500 ft ranges from 16 degrees for a Lance top at 9193 ft to 31 degrees if the Lance top is at 7500 ft. Therefore, it is possible to reach the adjacent 20 acre locations but not the adjacent 40 acre locations with less than 15 degrees of inclination. However, kicking off in the surface casing interval or increasing the inclination angle above 15 degrees to increase the reach may increase the risk of the directional drilling operation.

DRILLING AND COMPLETION COST

The drilling and completion costs for vertical wells and deviated wells from September 2002 (start of the directional well program) and May 2004 were analyzed to establish the incremental cost of drilling deviated wells. The data were also evaluated to determine how this incremental cost was changing over time as experience was gained in the 54 well directional drilling program.

Drilling Cost. When applying any new sophisticated drilling technology to a field, the costs generally start high and decrease with time as experience is gained and the process is optimized. Figure 8 shows the additional cost of a directional well relative to a vertical well versus the reach of the deviated well. In theory, problems in directional drilling are related to the length and inclination of the deviated borehole section which increase with reach (the distance of the bottomhole location from the surface location).

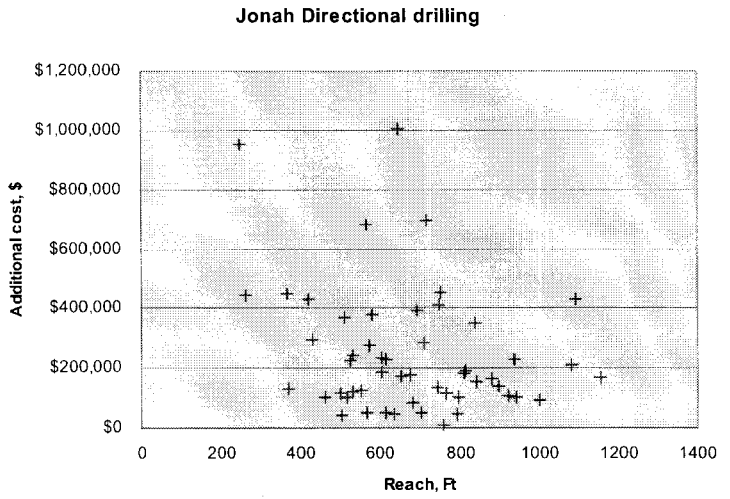

Figure 8: Directional to vertical additional well cost versus reach (distance of bottomhole location from surface location).

Experience to date indicates that there is no correlation between reach and additional well cost. In fact, some of the low reach wells have experienced more problems than longer reach wells. This suggests that other factors are more important in determining the incremental cost.

Generally, for directional drilling, the cost decreases with time as experience is gained. The cost for a directional well will always be higher; however, the additional cost is usually minimized as the number of directional wells drilled increases. Figure 9 shows the additional cost versus time (or number of wells) at Jonah Field.

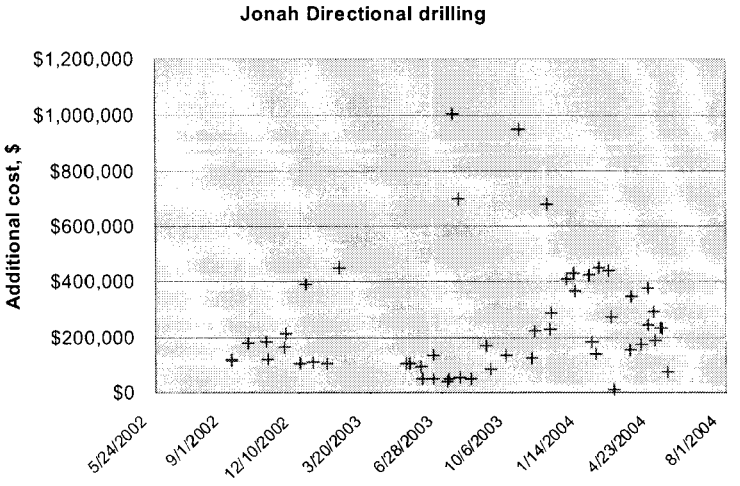

Figure 9: Directional to vertical additional well cost versus time.

The expected learning curve has been observed at Jonah with technology advancements to the end of 2003 when the additional cost reached a low of about $50,000. However, in 2004 problems and additional costs have increased and demonstrate that directional drilling continues to experience a significant risk. Recently, additional drilling costs are very high ranging from

$200,000 to $400,000 per well. This experience indicates that many factors are influencing the directional drilling results. Some of these factors are:

- depth to the top of the Lance where the mud weight is increased to control the overpressures varies across the field by about 1250 ft
- thickness of the Lance section drilled varies across the field by about 2500 ft
- rig crew experience and quality of the drilling rig and equipment may vary with time
- bit selection and optimization varies by area

From this data it can be concluded that many factors contribute to the mechanical risk of a directional well at Jonah. Therefore, a predictable decrease in the additional cost of a directional well relative to a vertical well over time cannot be expected. Even when some directional wells can be drilled at low additional cost, problems in a following well can result in 5 times the additional cost which significantly raises the average cost of the directional well program. Based on current data, it is expected that the additional cost for a directional well will be in the $200,000 to $400,000 per well range for the current well plan.

Factors Contributing to Additional Cost for Drilling Directional Wells. Several factors may contribute to the increased cost of directional wells at Jonah Field. Experience from the 54 directional wells drilled to date provides some basis for evaluating these factors.

Differential sticking. The 3000 ft to 4000 ft of over-pressured Lance Formation productive interval in the Jonah Field creates both a significant natural gas resource and an operational challenge for recovery of that resource. Directly above the Lance Formation lies the non gas-bearing, lower-pressured Fort Union, comprised mostly of sandstone much of which is porous and permeable. In order to have effective completion and avoid waste, all directional drilling operations must be completed in the Fort Union Formation, resulting in a vertical wellbore at the top of the productive Lance Formation. It is the Fort Union that represents the highest potential for differential sticking while drilling in the over-pressured Lance.

Mud weights required to safely drill the Lance Formation range from 11.0 to 13.0 pounds per gallon, while the Fort Union requires only 8.3 pounds per gallon. While drilling directional wells, this differential pressure requires significant attention to avoid stuck pipe and costly fishing jobs. Experienced rig personnel and above average drilling equipment is required to avoid problems.

Two changes could be made to the drilling program to eliminate most of the differential sticking problems: intermediate casing through the Fort Union or oil based drilling fluid.

Intermediate casing can be run to the top of the Lance where it is necessary to increase mud weight to control the well. Although the intermediate casing would eliminate the differential sticking problems, the estimated additional cost for this option ranges from $600,000 to $700,000 per well.

The high incremental cost for the intermediate casing option results from the significant changes that must be made to the drilling program. In order to run 4 ½" casing to total depth for efficient hydraulic fracturing, the borehole size to the top of the Lance must be increased. Drilling times are longer in the larger hole and additional time and cost are incurred for intermediate casing and the larger surface casing. For this option, crew experience and rig quality requirements would be nearly identical to a vertical well with no intermediate casing string.

Intermediate casing is used on the Pinedale Anticline because reservoir pressure gradients are higher at Pinedale (0.8 psi/ft) compared to Jonah (0.63 psi/ft)[6]. The higher mud weights required at Pinedale increase problems related to differential sticking in the Fort Union. In addition, higher bottomhole pressures require higher strength casing in the upper part of the hole for well control purposes. Because intermediate casing must be run in vertical wells in Pinedale due to a higher

[6] Charpentier, R.R., Law, B.E., and Prensky, S.E.;"Quantitative Model of Overpressured Gas Resources of the Pinedale Anticline, Wyoming",SPE/DOE 16404.

bottomhole pressure and increased differential pressure between the Fort Union and the Lance/Mesaverde, there is less incremental cost associated with directional wells relative to vertical wells in this case. At Jonah, where the pressure difference is smaller and the bottomhole pressures are lower, it is possible to drill vertical wells without intermediate casing. Therefore, Jonah wells will have a significant additional cost for this option that wells at Pinedale will not have.

The second option being considered for directional drilling in Jonah is changing from water based to oil based drilling fluids with either diesel or synthetic oil. There are two concerns with oil based drilling fluids; the first is cost of the oil and the second is the environmental cost of handling, transporting and disposing of this fluid. A mud plant for recycling of the oil for subsequent wells would be required.

Also, two mud systems would be required, water based for drilling the surface aquifers switching to oil based fluid at the top of the Lance. The estimated additional drilling cost for this option is about $200,000 per well. For this option, crew experience and rig quality requirements would still be a concern. Although the oil based drilling fluid decreases the probability of differential sticking it may not eliminate it.

Well Collisions. As the distance between well locations is decreased in order to reduce the size of the multi-well pads, the risk of collision between the drilling well and existing wellbores increases. EnCana recently experienced a wellbore collision during the drilling of the SHB 20-4 at 700 ft. The estimated cost to remediate the damage (redrill the well) is approximately $168,000. In addition to cost, there is a significant safety risk associated with well collisions. If the integrity of the existing well is lost, then high pressure gas could possibly enter shallow aquifers or the drilling well. High pressure gas entry at this shallow depth could be catastrophic.

Initially, Jonah directional wells on multi-well pads were drilled on 20 ft spacing. It is believed that this spacing significantly reduces the risk of collisions. At 8 ft spacing between wells on the pad (the spacing of the SHB 20-4) it will be necessary to steer the well from surface to avoid collisions. Steering from surface adds to the drilling cost and reduces, but may not eliminate, the risk of collisions. Because of these safety concerns, EnCana plans to return to 20 ft spacing between wells on the multi-well pads.

Gas leaks near the surface. Another problem associated with small multi-well pads, is that the drilling rig is positioned close to earlier completed wells. Where underground gas leaks near the surface occur, there is a serious safety issue for the drilling operation.

A solution for these low-probability, near-surface problems on multi-well pads is to increase the distance between wellheads to increase safety and minimize the risk of gas leaks and well collisions. However, this would increase the size of the multi-well pads and offset some of the surface benefits of directional drilling.

Completion Cost. On average, 10 hydraulic fracturing stages are performed per well working from the bottom of the well to the top of the Lance. Each zone is fractured, back-flowed to recover fracturing fluids (cleanup), and isolated with wireline conveyed plugs for the next stage. During cleanup of the next stage higher in the well, gas flows up through the plugs from the lower zones and provides energy for cleanup. There does not appear to be any problem with this procedure downhole for either vertical or directional wells. However, both vertical and directional wells have experienced problems in the zones where injection/falloff pressure tests are used to measure pressure. In these cases a bridge plug is run to isolate the underlying zone preventing energy from the lower zones from assisting the cleanup. With poor cleanup, sand falls back on top of the bridge plug and a clean-out with a rig or coiled tubing is required.

However, there is an additional cost for directional wells relating to surface layout if a sand clean-out is required. Due to the fact that wellheads at the surface are in close proximity, conventional rig work cannot be performed during the hydraulic fracturing cycle. Coiled tubing is required due to its small footprint. When coiled tubing is used, the incremental completion cost is $70,000.

Openhole Data Acquisition. Data acquisition in new infill wells is important. Good openhole logs and pressure data assist in determining the number and location of infill wells. Data from early infill wells will help define optimum location of later wells and will help insure that no more than the necessary number of wells is drilled to efficiently recover the gas reserves. Pressure data is obtained in cased hole so the problems in acquiring this data are similar for both vertical and directional wells. However, in directional wells without intermediate casing or oil based drilling fluids, there is high risk in obtaining openhole log data. If it is the judgment of drilling supervisors that hole conditions are poor then only a limited number or no openhole logs are run.

The reason for this cautious approach is that if wire line logging tools become stuck and the line parts or keyseats in the bends of the directional well, the tools must be recovered in order to run casing and complete the well. The worst case scenario is a total loss of the well requiring a sidetrack or total redrill.

Recovering stuck logging tools creates a serious safety issue. When the wire line is cut and the drill pipe is stripped over the line to recover the stuck tools, gas entry into the well may be difficult to control. Too much gas entry can cause loss of control of the well.

Total Additional Drilling and Completion Cost. Operator experience after 54 directional wells in Jonah Field has determined that the average increase in costs for drilling and completion ranges from $270,000 to $470,000 as compared to a vertical well. Using oil based drilling fluids will eliminate some of the risk related to differential sticking in the directional wells; however, the estimated total additional cost to drill and complete with these drilling fluids is about $270,000 per well. If oil based drilling fluids eliminate differential sticking problems, then this option gives about the same additional directional well cost as the current program.

Finally, running intermediate casing through the Fort Union is expected to eliminate most of the problems now experienced in directional wells; however, the estimated increased cost of this option ranges from $670,000 to $770,000 per well to drill and complete a directional well from a central pad.

RESERVES LOST DUE TO DIRECTIONAL DRILLING

In the current directional drilling well plan, without oil based drilling fluids or intermediate casing, there is a risk of bypassing gas reserves at the bottom of the Lance if the casing does not reach bottom due to differential sticking. If the casing is set high, then the gas resource below the casing will not be produced.

Casing Set Off Bottom. From Jonah directional well experience, in about 30% of the directional wells, the casing is set an average of 124 ft above the TD (Total Depth) of the well. If casing does not reach bottom, it is cemented high and a decision is made whether or not to run a 2 7/8" liner. The cost to run a liner is about $250,000.

For conditions at Jonah, in addition to the extra cost, cementing the small diameter pipe is difficult and stimulation is less effective.

Casing Stuck on Bottom. The normal practice in a vertical well at Jonah is to reciprocate the casing during cementing to improve the cement bond. In about 75% of directional wells the casing is stuck on bottom so movement during cementing is not possible. Thin cement pumped at high rate is normally used and not being able to reciprocate the casing does not appear to cause any major problem as indicated from cement bond logs. There also does not appear to be any problems with hydraulic fracturing wells that had stuck casing.

The only major issue with cement bond would be at the Lance-Fort Union contact where normally pressured and over-pressured zones would be in communication if the cement bond is poor. If the bond is poor, the interval would be cement squeezed to prevent communication. This

situation would lead to increased cost and also lost reserves because the Lance would have to be hydraulically fractured through 2 7/8" tubing to isolate the squeeze perforations. Fracturing through tubing is less efficient than through 4 ½" casing.

In the 54 directional wells drilled to date it has not been necessary to squeeze the top of the Lance.

If casing is stuck on bottom during cementing operations, experience to date indicates that there is no loss of gas resources.

Liquid Loading Effects. Jonah gas production is considered wet, as it also produces gas condensate liquids and water. As reservoir pressure decreases, water content in the gas also increases. These liquids contribute to liquid loading when the gas rate declines to low levels near the end of the producing life.

When liquids accumulate in the well the producing bottomhole pressure increases and can cause early abandonment of the well with loss of gas reserves. Artificial lift such as plunger lift may be used to unload liquids as pressure depletes and reduce the flowing bottomhole pressure.

A review of the petroleum literature suggests that there are no problems particular to directional wells relating to plunger lift. The plunger falls to bottom by gravity so the rate of fall will be slower in directional wells. However, the main disadvantage with plunger lift is that it does not work if there is sand production. In a directional well there may be a tendency for sand to accumulate in the inclined section if the angle is high. If the directional wells at Jonah are producing fracturing sand near the end of the well life, this would prevent the use of plunger lift and result in lost reserves. From the available data it is not possible to quantify this reserve loss.

Waste Attributed to Lost Reserves. The magnitude of the potential reserve loss was estimated by calculating the original gas-in-place in the bottom 400 ft of the hole (including the 150 ft rathole below the base of the Lance). Because gas is compressible, this calculation must be made using actual pressures and not a simple ratio of thickness.

Of the 54 directional wells drilled to May 11, 2004, 16 have failed to set casing on bottom. The average length of hole lost below the float collar (cementing equipment set one joint from the bottom) is 154 ft. When the rathole is added for perforation and stimulation, an average of 275 ft of hole is inaccessible.

The original gas-in-place for the bottom 275 ft of the Lance (including the rathole) was estimated from petrophysical analysis and actual reservoir pressure for 359 wells at Jonah. The gas resource loss per well ranges from 3 MMSCF to 1284 MMSCF with an average of 362 MMSCF. When a 30% probability of setting casing 124 ft high is applied to the 1824 wells to be drilled on 10 acre spacing, assuming an all directional option, the estimated lost gas reserve is 200 BCF.

A new gas field with 200 BCF of recoverable reserves would be considered significant in today's gas market. Also, 200 BCF is over 15 times the annual residential consumption of natural gas in the State of Wyoming.

DIRECTIONAL DRILLING TIMES

Directional drilling is particularly challenging in fields like Jonah where portions of the interval are over-pressured. In addition to increased costs relative to a vertical well, directional drilling requires longer development times and lengthier periods of drilling activity.

In attempting to quantify the increased time associated with directional drilling, it is not possible to directly compare drilling time between vertical and horizontal wells using average numbers. The reach, depth to the top of the Lance, and thickness of the Lance drilled varies throughout the field and these factors must be taken into account. In addition, bit selection, experience gained in drilling directional wells, and the rig being used may impact the drilling time.

Figure 10 shows days versus reach for all directional wells at Jonah.

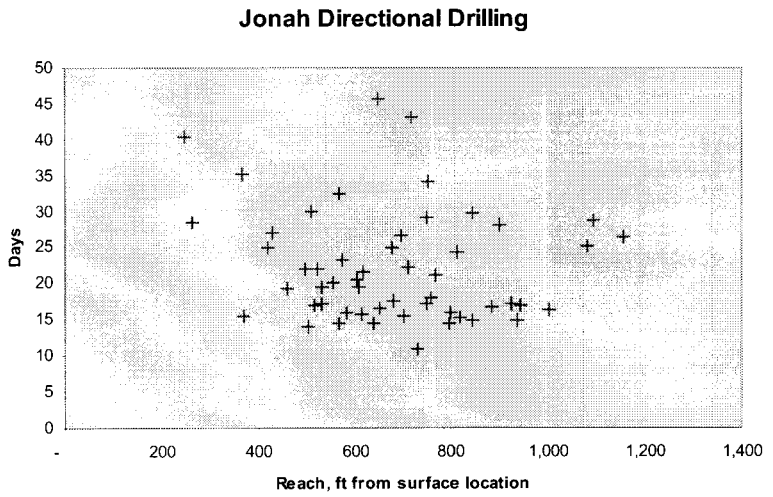

Figure 10: Total days from spud to rig release for Jonah directional wells versus reach.

The data is scattered and there appears to be no strong relationship between drilling days and reach.

Figure 11 shows the total time vs. the start data of the well.

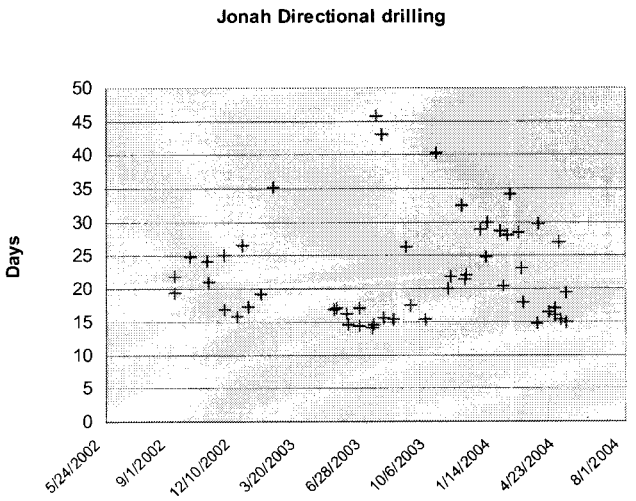

Figure 11: Total days from spud to rig release for Jonah directional wells versus spud date.

The average drilling time in 2004 for a directional well appears to be about the same or slightly higher than the time when directional drilling was started in Jonah in September 2002. As discussed, other factors may be causing this apparent increase.

In order to quantify the incremental time for a directional well, the drilling times for vertical and

directional wells drilled since September 2002 were compared a shown on Figure 12.

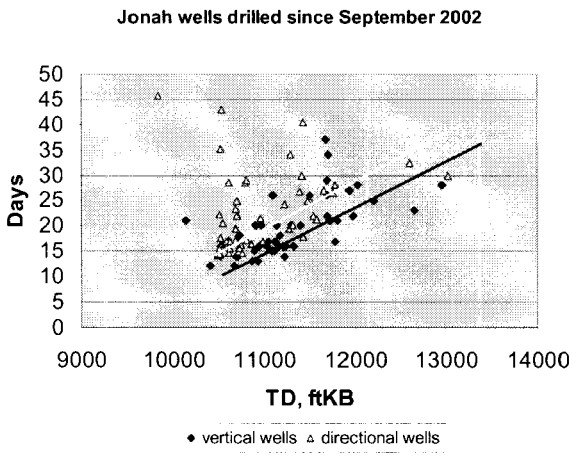

Figure 12: Total days from spud to rig release for Jonah directional and vertical wells versus total depth.

The figure shows days versus total depth drilled (TD). The total depth is a reasonable correlation parameter because:

- The time spent in the heavy mud weight (over-pressured) portion of the hole is a controlling parameter
- The top of the Lance deepens to the NE and the Lance thickens to the NE. The change in thickness (+2500 ft) is much greater than the deepening of the Lance top (+1250 ft)
- The surface elevations vary less than 200 ft for this group of wells.

Observations from this plot follow:

- Directional wells require about 5 to 6 days more drilling days than vertical wells
- There is more scatter in the directional well data with several wells taking 3 times longer than the average time at the same depth. The additional time is due mainly to differential sticking problems during drilling, logging, and casing operations.
- If there are problems in vertical wells, the increased time is only about 50% of the average time at the same depth

The number of rigs being utilized in developing the field, or the time required to develop the field must increase proportionately to the increased drilling time for directionally drilled wells.

Over the range of the above plot, directional wells, at best require 25% longer to drill and case than a vertical well drilled to the same depth. Because of 200% to 300% increase in time in 10% of the directional wells due to differential sticking problems, the average additional time to drill directional wells will be more than a 25% increase.

CONCLUSIONS

1. Jonah Field is a major energy source with about 10.5 TCF of original gas-in-place corresponding to a surface area of approximately 21,000 acres. On 40 acre spacing it is projected that only 30% of this resource will be produced and about 4.6 TCF of potential gas reserves will be unrecovered (difference between 30% and 75% recovery). This lost gas represents significant waste and when averaged over a 25 year period, represents about 15 times the annual residential natural gas consumption in the State of Wyoming.

2. The current incremental cost to drill and complete a directional well over a vertical well is about $270,000 to $470,000.

3. On average, directional wells take at least 5 to 6 days longer than a vertical well drilled to the same depth. The 25% increase in time should be considered in evaluating the impact of directional drilling on the surface operations.

4. Problems are more common in directional wells with 10% of these wells requiring 2 to 3 times longer than average to complete drilling operations. If problems are encountered in vertical wells, the increased time is only about 50% over an average well at the same depth.

5. The expected decrease in average cost difference, between vertical wells and directional wells, has not occurred with experience at Jonah. This is due to the unpredictable and difficult problem of differential sticking in the Fort Union. There is no reason to believe that the directional well costs will approach vertical well costs.

6. It is believed that differential sticking problems can be significantly reduced in directional wells at Jonah in two ways: 1) running intermediate casing through the Fort Union at approximately $670,000 to $770,000 additional drilling and completion cost per well or 2) changing from water based to oil based drilling fluids at approximately $270,000 additional drilling and completion cost per well. This additional cost is much higher than experienced at Pinedale Anticline where intermediate casing is usually required in vertical wells because of higher bottomhole pressures and higher pressure differences between the Fort Union and the deeper over-pressured intervals.

7. Failure to place casing at the bottom of the well in 30% of the directional wells represents a potential loss of gas reserves of 200 BCF for a 10 acre infill, all-directional option. A gas field with 200 BCF of recoverable reserves would be considered significant in today's market. This lost reserve volume is over 15 times the annual residential consumption of natural gas in the State of Wyoming and represents significant waste.

8. Considering all of the alternatives, the lowest incremental cost of drilling and completing directional wells at Jonah that also provides for acquisition of critical data is $270,000 per well (oil base drilling fluids). In addition to increased cost, oil based drilling fluids have environmental issues relating to handling, transporting and disposing of these fluids.

9. Directional drilling of development wells at Jonah may help control the impact of the footprint of the development on the surface. However, this impact includes not only the size of the disturbed area but also the length of time the development footprint impacts the surface. The additional time and cost, and potential for lost reserves associated with directional drilling may significantly increase the total life of the field.

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Drilling Smarter:

Using Directional Drilling to Reduce Oil and Gas Impacts in the Intermountain West

By Erik M. Molvar

Reviewed by

Dr. Pat Rickey
Senior Research Associate, Exxon Production Research Company, 1967-1996

Walter K. Merschat
Exploration Geologist, Unocal, 1969-76; Geoscientist, Gulf Research, 1976-84; Consultant, Scientific Geochemical Services, 1985-present

Prepared by
Biodiversity Conservation Alliance
P.O. Box 1512
Laramie, WY 82073
(307) 742-7978

Additional copies of this report are available online at:
www.voiceforthewild.org

Attachment 7

Acknowledgments
Persons who contributed materials, information, or edits to this report include Gwen Lachelt of the Oil and Gas Accountability Project, Mark Pearson, Tom Darin, Michele Barlow, The U.S. Department of Energy, Phillips Petroleum, Pacific Environment, Pete Morton, and many others.

FOREWORD
This study was compiled by researching technical and trade publications produced by the oil and gas industry. Conclusions and recommendations of this report rely heavily on the findings and conclusions of the industry experts who authored these studies. We recognize that success stories are more likely to be published than failures, and as a result great pains have been taken to present both the positive aspects and drawbacks of directional drilling, and to present data that reflects industry-wide averages (incorporating both successful and failed projects) wherever these data were available. As a result, a higher proportion of studies outlining the negative aspects of directional drilling are presented here than are found in the petroleum engineering literature, which almost universally provides glowing endorsements of the technical capabilities and economic feasibility of directional drilling. We chose this conservative approach in order to avoid overstating the capabilities of these technologies.

Report issued February 18, 2003

Cite this report as follows:

Molvar, E.M. 2003. Drilling smarter: Using minimum-footprint directional drilling to reduce oil and gas impacts in the Intermountain West. Laramie, WY: Biodiversity Conservation Alliance, 32 pp.

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BUREAU OF LAND MANAGEMENT

Drilling Smarter: Using Directional Drilling to Reduce Oil and Gas Impacts in the Intermountain West

ERIK M. MOLVAR, Biodiversity Conservation Alliance, Post Office Box 1512, Laramie, Wyoming 82073. www.voiceforthewild.org.

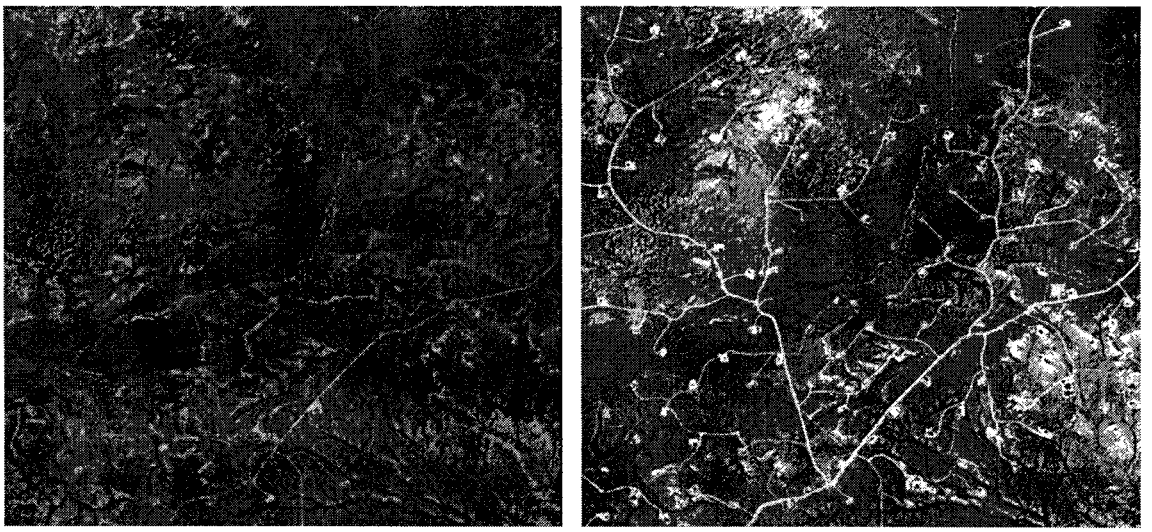
EXECUTIVE SUMMARY

Current practices in oil and gas exploration and development have produced massive environmental impacts across broad stretches of the Intermountain West. However, over the past several decades, the oil and gas industry has developed innovative technologies that can extract energy resources from the ground while reducing the impacts of that drilling on the natural environment. In particular, directional drilling technology has the potential to offer a less damaging alternative to conventional drilling methods in the Rocky Mountain West. Using directional drilling, energy firms can tap deposits of oil and gas at almost any depth from drilling sites up to 6½ miles away from the deposit.

Directional drilling has proven technically and economically feasible in a broad range of geologic settings, including tight gas, heavy oil, and coalbed methane. This method is proven to substantially increase producible reserves of oil and gas. Because the increased productivity of directional drilling compensates for additional costs, directional drilling is often more profitable than vertical drilling.

The Bush Administration's National Energy Policy calls for the use of directional drilling technology to reduce the environmental impacts of oil and gas exploration and development. However, federal agencies rarely even consider directional drilling as an alternative for oil and gas projects involving federal lands and minerals in the Intermountain West, and the oil and gas industry frequently balks when asked to use these technologies. On lands where oil and gas development is deemed appropriate and compatible with other uses in the Rocky Mountain West, federal agencies should consider whether they can reduce the damages from drilling activities through the implementation of directional drilling technologies, and if so, require their use.

Directional drilling does not prevent all environmental impacts of oil and gas exploration and development, and clustering operations lead to an intensification of impacts in the drilling area even while reducing the overall surface area across which those impacts occur. In addition, use of directional drilling technology does not address the numerous other impacts associated with oil and gas development and production, such as chemical spills and air pollution. As a result, some lands — including national wildlife refuges, parks, wilderness areas and monuments; roadless and wilderness-quality lands; and other sensitive lands — contain resources incompatible with oil and gas development and should remain withdrawn from all types of drilling. And appropriate buffers must be established to protect these lands from impacts in adjacent areas. Additionally, other lands such as important wildlife habitat, scenic landscapes, wetlands and other sensitive lands must be protected from the surface impacts of energy development.



Images provided by SkyTruth and the Upper Green River Valley Coalition

Recent full-field development in western Wyoming's Jonah Field as shown by aerial images. The photograph at left shows the landscape in 1994, before full-field development. By 1999 (at right), the landscape had become fragmented by roads and well pads.

AN ENVIRONMENTAL IMPERATIVE

A century of oil and gas development has left a heavy mark on many of our nation's public and private lands, particularly in the West. Oil and gas fields have become a vast spiderweb of pipelines and access roads, pockmarked with well pads, which fragment the landscape. Compressors, trucks, and pumpjacks generate noise, pollutants, and dust. Water and mud "produced" during the course of oil and gas development threatens local surface- and ground-water supplies used for residential and agricultural needs. Indeed, full-field development for oil and gas has often converted pristine wildlands and pastoral rural areas into industrial landscapes. In its conventional form, oil and gas production destroys the wild character of primitive areas, severely diminishes the recreational value of the landscape, creates long-term scarring across scenic viewsheds, and degrades or destroys habitat for native wildlife and fishes. As such, conventional oil and gas development is fundamentally incompatible with most other land uses, both public and private, particularly where dense well spacing is allowed.

The drilling activities associated with oil and gas production are just some of the sources of environmental damage associated with the production of oil and gas. While all of the potential impacts from oil and gas exploration, development and transportation must be considered before this activity is approved on federal lands, it is particularly important to consider alternatives to traditional drilling. The following sections describe a few examples of the impacts of drilling.

Oil and Gas Development Fragments Habitat

The sprawl of oil and gas fields can cause severe habitat fragmentation through the proliferation of roads, pipelines, and well pads across the landscape. The effects of forest fragmentation on bird densities are well-documented (e.g., Hansen and Rotella 2000). But fragmentation also impacts sagebrush bird species (Knick and Rotenberry 1995). In sagebrush habitats, major songbird declines have been found in areas with heavy oil and gas development (Inglefinger 2001). Lyon (2000) found that the construction of roads and wells within 2 miles of sage grouse strutting grounds had negative impacts on nesting. On a population scale, drilling has severe short-term impacts on sage grouse, while associated roads, pumping stations, and associated facilities have permanent negative impacts (Braun 1998, Braun et al. in press). Thus, oil and gas drilling can have serious effects even on relatively small, mobile wildlife.

Wells and Roads Displace Wildlife

Oil and gas development can also have a major impact on big game animals. Powell and Lindsey (2001) found that elk avoid lands within 1.5 kilometers of oilfield roads and well sites in

the sagebrush steppes of Wyoming. In mountainous habitats, the construction of a small number of oil or gas wells has caused elk to abandon substantial portions of their traditional winter range (Johnson and Wollrab 1987, Van Dyke and Klein 1996). Drilling in the mountains of western Wyoming displaced elk from their traditional calving range (Johnson and Lockman 1979, Johnson and Wollrab 1987). Migration corridors may in some cases be equally important to large mammals and are susceptible to impacts from oil and gas development (Sawyer et al., in press). A study by Nelleman and Cameron (1998) demonstrated that even where directional drilling is widespread, oil and gas development of the Kuparuk Field of Alaska's North Slope caused caribou of the Central Arctic Herd to abandon their traditional calving grounds and displaced concentrations of calving animals to areas with poorer habitat quality. Because winter ranges and calving areas are crucial to the survival of big game herds, these studies demonstrated the need to completely protect these sensitive habitats from surface development by the oil and gas industry.

A POLICY IMPERATIVE

President George W. Bush made the implementation of lower-impact directional drilling technologies the cornerstone of his energy policy. The President's National Energy Policy contains a section titled, "21st Century Technology: The Key to Environmental Protection and New Energy Production," which states:

> Producing oil and gas from geologically challenging areas while protecting the environment is important to Americans and to the future of our nation's energy security. New technology and management techniques will allow for sophisticated energy production as well as enhanced environmental protection... Smaller, lighter drilling rigs coupled with advances in directional and extended-reach drilling significantly increase protection of the environment...Modular drilling rigs, 'slimhole' drilling, directional drilling, and other advances enable: [...]
>
> • production of oil and gas with increased protection to wetlands and other sensitive environments;
>
> Other examples of advanced technology include: [...]
>
> • highly sophisticated directional drilling that enables wells to be drilled long horizontal distances from the drilling site[.]"

National Energy Policy, May 2001, "Reliable, Affordable, and Environmentally Sound Energy for America's Future: Report of the National Energy Policy Development Group," p. 5.5.

Likewise, the Secretary of the Interior, who is responsible for implementing much of the National Energy Policy, has emphasized the need to begin utilizing directional drilling technology:

> We must also harness 21st Century technology to help our environment. Where we once needed scores of wells to tap underground reserves, today in some areas we can use one hole on the surface to drill for oil in a circle extending seven miles. We can use the resources below ground while we preserve the landscape and habitat above.

Presentation of Gale Norton, Secretary of Interior, to the National Newspaper Association (Washington, DC, March 23, 2001). These policy statements represent an unequivocal commitment on the part of the administration to implement less environmentally damaging directional drilling technologies.

A POLICY FAILURE BY THE BUSH ADMINISTRATION

But despite these commitments, the Bush Administration has failed to live up to its promises to implement technologies to reduce the impacts of oil and gas exploration and drilling on the environment. In fact, rather than pushing for more directional drilling, under the Bush Administration, the Interior Department's Bureau of Land Management (BLM) has actively avoided any effort to consider directional drilling as an alternative when energy production is being considered on public lands in the Intermountain West (see Table 3).

For example, federal agencies under the Bush Administration failed to even consider directional drilling as an alternative for at least six western projects where the public specifically demanded the use of these techniques. The environmental consequences from ignoring the opportunity to reduce damages to these surface lands from drilling are staggering.

In western Wyoming's Vermillion Basin, the BLM refused to analyze a directional alternative to protect roadless lands even after a court order

Table 1. Approval documents for oil and gas developments that have been issued since George W. Bush became President in 2001.

Project	State	Document	Date(s)	Directional Requested?	Directional Analyzed?	Notes
Porcupine Tuit	WY	EA	8/02	Yes	No	Thunder Basin N.G. coalbed methane
Atlantic Rim (3 Pods)	WY	DRs	12/01-8/02	Yes	No	winter range, grouse leks coalbed methane
Hanna Draw	WY	DR	6/02	Yes	No	coalbed methane
Vermillion Basin	WY	DR	8/02	Yes	No[1]	in proposed wilderness
WY Powder River Basin	WY	EIS	1/02	Yes	No	coalbed methane 50,000 wells
Southern Ute	CO	EIS	8/02	Yes	No	700 coalbed methane wells
Raton Basin	CO/NM	EA	9/01	No	No	206 wells
Macum/Klabzuba	MT	EA	5/02	No	No	inside Missouri Breaks NM
Huber Six Well	CO	DR	4/02	No	No	6 wells
Pinon Mesa	NM	DR	4/02	No	No	high-profile recreation area
MT Powder River Basin	MT	EIS	2/02	Yes	Yes[2]	coalbed methane 30,000 wells
Otero Mesa	NM	EIS	10/00	Yes	Yes[3]	includes sensitive wildlife habitats
Farmington	NM	EIS	6/02	No	Yes[4]	10,000 wells

EA=Environmental Assessment (analyzing alternatives); EIS = Environmental Impact Statement (analyzing alternatives); DR = Decision Record (final decision).

1. Despite court ruling requiring the agency to take a harder look at directional drilling.
2. Not selected as the Proposed Action.
3. Proposed alternative under the Clinton administration, but withdrawn from proposed alternative status by the Bush administration.
4. Only 70 of 10,000 wells to be clustered on single well pads.

compelled them to undertake a detailed analysis of directional drilling. Big game habitat, declining sage grouse and prairie dog populations, and important recreational lands are all at risk.

In northern Wyoming's Powder River Basin, the Administration proposed to approve 50,000 new coalbed methane wells, without considering directional drilling as a means to reduce their massive impacts on ranchers and rural landowners who own property above the energy resource. This scale of development, without considering alternatives that could reduce the damage from drilling, could jeopardize the future of 16 species of plants and wildlife, according to the BLM's own report (BLM 2002a).

On New Mexico's Otero Mesa, directional drilling was the preferred method for producing energy after an analysis was completed under the Clinton Administration. However, the current the Bush Interior Department reversed course and changed the proposed action to conventional vertical drilling. A largely intact roadless area supporting a suite of rare wildlife and plant species is now at risk.

There is a stark contrast between what the Bush Administration has promised the public and the drilling policy it has been implementing throughout the Rocky Mountain West. If the Bush administration truly supports a responsible energy policy that reduces the environmental damage from oil and gas development, it will stop paying lip service to directional drilling while continuing to conduct business as usual.

WHAT IS DIRECTIONAL DRILLING?

Directional drilling is an advanced technology that allows oil and gas resources to be tapped a long horizontal distance away from the well site. For the purposes of this report, "directional drilling" will encompass all forms of drilling where the endpoint of the well is distant from the drill site, rather than directly beneath it. Under this definition, slant-hole wells, S-turn wells, and horizontal wells are all considered forms of directional drilling. The term "directional drilling" can also be used to describe drilling to lay subsurface pipelines beneath rivers and other sensitive areas; this application of

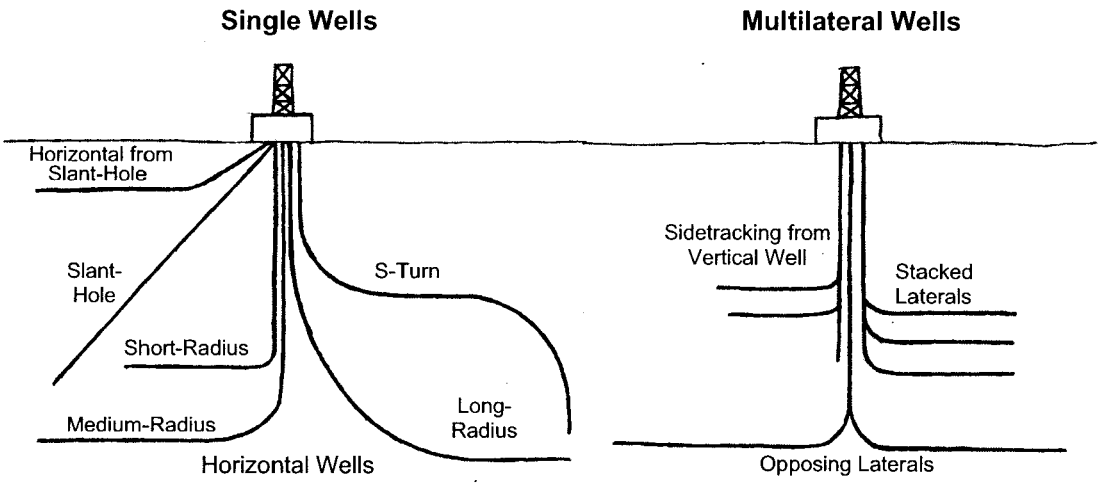


Figure 1. Different types of directional wells.

directional drilling is beyond the scope of this report. A brief synopsis of directional well types follows, and Figure 1 presents a schematic illustration of the various directional well types.

Slant-Hole Wells

Slant-hole wells are drilled at an angle from the vertical, using a tilting drilling rig. Slant-hole wells can be completed without making any bends at all, resulting in the equivalent of a conventional vertical well that is tilted on its axis. Alternately, slant-hole wells can be combined with a horizontal bend that is drilled in much the same way as traditional horizontal wells (see Figure 1), a configuration that is most commonly used for shallow target zones (Smith and Edwards 1992). Slant-holes can also be re-drilled at a later date to add a horizontal section (e.g., Myal and Frohne 1992).

S-Turn Wells

Sometimes known as "deviated wells," S-turn wells start out in a near-vertical orientation, have a long near-horizontal or diagonal section, and finish by approaching the vertical once again. This well type has been used in extended-reach applications. For example, the Sacate Sa-1, an offshore California well, achieved a horizontal distance of over 3½ miles from the well site using this drilling technique (Elks and Masonheimer 2002).

Horizontal Wells

Horizontal wells are defined as wells deviated more than 75 degrees from vertical (Lacy et al. 1992); they often depart from the horizontal in order to track the dip of the target formation. These wells have a characteristic "J" shape, with the horizontal section following the oil- or gas-bearing rock to maximize production.

Short-Radius

Short-radius wells feature a sharp, abrupt turn from the vertical to the horizontal plane. A comprehensive review of short-radius horizontal drilling found that "[r]eservoir management applications, water and gas coning, injection wells, irregular formations and coal degasification [coalbed methane production] are becoming more economically feasible" (Leazer and Marquez 1995). This study found that short radius horizontal wells make it easier to avoid problem formations above the pay zone. And with short-radius wells, submersible pumps can be placed deeper in the wellbore, improving pumping efficiency and extending pump life. The study concluded that "[s]hort radius technology has evolved to the point where it is a common occurrence to drill a 45-ft radius curve into a 10-ft target and achieve displacements in excess of 1,000 ft." These wells are not typically used to drill long horizontal distances from the well site.

Medium Radius

Medium-radius wells make their turn from the vertical to the horizontal at an intermediate rate, and the horizontal length is often longer. By the early 1990s in the United States, medium-radius wells were the most widely used and productive of horizontal wells (USDOE 1993). In 1990, the longest horizontal displacement for a medium-radius horizontal well reached 4,164 feet (Moritis 1990). This drilling style figures

prominently in the horizontal successes of the Austin chalk (Sheikholeslami et al. 1991), and also has been used for very shallow applications in coalbed methane drilling (USDOE 1993).

Long Radius

In a long-radius well, the wellbore shifts from the vertical to the horizontal very gradually, with only slight changes in the degree of slope over the course of the bend. Extended-reach, long-radius horizontal wells were being successfully drilled from platforms off the coast of California as early as 1989 (Moritis 1990). Because this type of drilling requires a long transition between vertical and horizontal, it is best suited to deep wells and/or extended-reach drilling that accesses reservoirs far away from the drill site.

Multilateral

Multilateral wells entail drilling two or more horizontal legs from a single vertical well in order to maximize exposure to the oil- or gas-bearing strata. Opposing laterals are most advantageous for deep wells or cases where drilling costs are high, because information gained in drilling the first lateral can be incorporated into the drilling of the second (Meehan 1995). Stacked laterals have been used for steam injection wells in Canadian heavy oil reservoirs (Sarma and Ono 1995), and to access multiple pay zones (Rixse and Johnson 2002). More complex "fishbone" configurations have been drilled in Venezuela's Orinoco Basin, in which even the laterals have laterals (Moritis 2000).

Chambers (2000) concluded that multilateral drilling was practical for all geologic situations: "There is no depth or specific reservoir type to which multi-lateral use is limited. Multi-laterals are being used for shallow reservoirs (800' TVD [True Vertical Depth]) to deep (15,000' TVD) formations, for completions in heavy oil, light oil, and gas." Meehan (1995) reported that by 1995, multilateral drilling had become "routine" at Union Pacific Resources. Meehan (1995) stated, "State of the art drilling includes as many as four, 4,000+ ft horizontal laterals, horizontal wells at TVDs [True Vertical Depths] greater than 16,000 ft."

Multilateral drilling has now become an established practice within the oil and gas industry. Chambers (1998) summarized this growing role: "The implementation of multiple lateral wellbores, or multiple horizontal wells exiting a single wellbore, has gained wider acceptance in the oil industry, particularly from a reservoir management point of view. The deeper the junction, the more attractive multilaterals become. The more wells drilled, the cheaper the technology, the more laterals drilled from a well, the less the incremental cost for additional laterals. Open hole branches are very easy to create and fast to implement."

HISTORY OF DIRECTIONAL DRILLING

Directional drilling is not a new technology. In fact, all types of directional drilling have been around for years, but it is only in the last several decades that these techniques have gained broad acceptance and widespread application. The first horizontal well was drilled near Texon, Texas in 1929 (USDOE 1993). Chambers (1998) noted early horizontal activity dating from 1939. In the early 1940s, horizontal wells were drilled with horizontal distances of 100 to 500 feet (Anon. 1999). China attempted its first horizontal well in 1957 (USDOE 1993). The first coiled-tube and slimhole drilling was also done during this period (USDOE 1999a). The first multilateral well was drilled in the Soviet Union in 1953 (Chambers 1998), and between 1953 and 1980, the Soviet Union drilled 111 multi-branch horizontal wells including exploration wells, production wells, and injector wells (Maurer 1995). Nonetheless, during these early years, directional drilling was comparatively costly and failed to achieve broad acceptance within the industry.

Slant-hole drilling was the first directional technique to achieve widespread use. Between 1982 and 1992, over 1,000 slant or angle wells were drilled, primarily in Canada, Venezuela, and China (Smith and Edwards 1992).

But the big boom came with the widespread use of horizontal drilling. European offshore successes with directional drilling in the North Sea (e.g., Andersen et al. 1988, Jacobsen and Rushworth 1993) led to increasing application of directional technologies to land-based drilling. Horizontal drilling soon took off in North Dakota's Williston Basin, and as of 1990, some 70 horizontal wells were producing about 7% of North Dakota's oil from the Bakken Shale formation (Petzet 1990). For northern Alaska's Prudhoe Bay field, Standing (2000) noted, "Horizontal drilling started experimentally in 1986, and in the 1990s became routine for lengthening wellbores and avoiding gas-oil or water-oil contacts." Perhaps the largest application of horizontal drilling came in the Austin Chalk deposits in Texas, a formation

where production from vertical drilling had been declining. Union Pacific Resources drilled more than 1,100 new horizontal wells and 1,250 horizontal laterals from existing wells in the Austin Chalk between 1987 and 1995 (Meehan 1995). With success in the Texas Austin Chalk, 134 horizontal wells were soon drilled or permitted in the same formation in Louisiana (Maloy 1997). The first directional well in Wyoming was completed in 1987, and as of 1994, 80 producing wells were completed out of 117 attempts (Stewart 1995).

Directional drilling has caught on not only in North America but all around the world. Between 1990 and 1998, Petroleum Development Oman drilled 350 horizontal wells in 33 different Middle Eastern oil and gas fields (Ishak et al 1998). Horizontal wells have been drilled on every continent except Antarctica. Today, horizontal drilling technology is so efficient at extracting oil and gas that it has become the benchmark for the industry: Miller and Steiger (1999) boasted that their array of vertical and directional wells had production that equaled high benchmark projections from horizontal drilling. In the words of Pinney and Rodrigues (1999), "Over the past 20 years, horizontal drilling has progressed from an exotic technology to a standard industry tool."

DIRECTIONAL CAPABILITIES

Directional drilling in general, and horizontal drilling in particular, are extremely versatile and offer capabilities that make these technologies superior to vertical drilling for the recovery of oil and gas. Deskins et al. (1995) stated that horizontal wells can improve production and increase reserves through (1) intersecting natural fractures that can't be accessed with vertical wells; (2) delaying the onset of water or gas coning so that more oil is produced; (3) improving production from thin or tight reservoirs; and (4) improving waterflood sweep efficiency (for reservoirs injected with fluids to increase oil or gas production). Zammerilli (1989) compared the effectiveness of three drilling methods for the Devonian Shale of West Virginia and found that "new-lease horizontal drilling is the optimal method [for maximizing production] in West Virginia, and high-angle drilling results in a slight improvement over vertical drilling." An article in *Journal of Petroleum Technology* summarized the current role of horizontal drilling: "Most experts agree that horizontal wells have become a preferred method of recovering oil and gas from reservoirs in which these fluids occupy strata that are horizontal, or nearly so, because they offer greater contact area with the productive layer than vertical wells. While the cost factor may be as much as two or three times that of a vertical well, the production factor can be enhanced as much as 15 or 20 times, making it very attractive to producers" (Anon. 1999).

Each of the qualities of directional drilling that make it a viable alternative to vertical drilling in the Intermountain West have been thoroughly documented in the published literature, and are discussed in more detail below.

Directional Drilling Increases Production

Directional wells, and horizontal wells in particular, offer substantial increases in production over vertical wells, chiefly because in the words of Hall (1998), "[h]orizontal drilling exposes magnitudes more of the pay zone to the wellbore. Hutzler (2000) summarized the basis for this phenomenon as follows: "Drilling a horizontal, as opposed to a conventional vertical well, enables more of the reservoir to be exposed to the wellbore since most reservoirs are wider than they are deep." Table 2 displays the results of a number of studies worldwide that directly compared the productivity of horizontal wells with their vertical counterparts.

In one Utah project, for example, 143 laterals were drilled and completed as re-entries from 43 vertical wells. For those 43 wells, 180,000 feet of wellbore penetrated the pay zone, compared with only 26,000 feet for all 379 of the previous vertical wells in the field (Hall 1998). Iverson et al. (1995) found that even without hydraulic fracturing, a horizontal well in Wyoming produced as much gas as a comparable conventional well that used hydraulic fracturing (see Appendix for an explanation of hydraulic fracturing). In Texas, Sheikholeslami et al. (1991) found a linear increase in production with longer horizontal sections: "This relationship and the low cost of drilling incremental medium-radius horizontal lengths show the economic benefit of drilling the longest possible horizontal length."

But there are limits to the increases that horizontal wells can achieve over conventional vertical wells. Cho and Shah (2002) found that beyond 3,000 feet horizontal distance, wellbore friction and turbulence may reduce gains achieved through a longer exposure to the pay zone, to the point that a maximum output is achieved. These researchers pointed out that

Table 2. Horizontal/directional well production expressed as a percentage of vertical wells from the same field.

Location	Production Increase	Notes	Source
Alaska	200-300%	Prudhoe Bay	Broman and Schmor 1992
California	300%	Elk Hills	Gangle et al. 1991
California	700%	Elk Hills	Gangle and Ezekwe 1995
California	350-900%	Elk Hills	Anon. 1996
Colorado	500-1000%	Piceance Basin	Myal and Frohne 1992
Canada	250-800%	underbalanced, heavy oil	Teichrob 1994
Colombia	400-600%	offshore	Huang et al. 1996
Germany	200-300%	deep gas	Graute et al. 1994
Germany	500%	deep, sour gas	Schuler 1992
North Dakota	200-500%	Bakken shale	Lacy et al. 1992
North Sea	600%	offshore	Reynolds and Seymour 1991
Texas	250-700%	Austin chalk	Sheikholeslami et al. 1991, Lacy 1992
Venezuela	1300%	Orinoco heavy oil	Lacy 1992
West Virginia	700%	hydraulic fractured	Yost and Overbey 1989
West Virginia	400-2500%	Devonian shale	Lacy 1992

friction may be less important if the wellbore is subjected to low pressures. Thus, there may be an upper limit to production increases over vertical wells that can be realized by drilling with horizontal technologies. But in no case does wellbore friction reduce productivity of a horizontal well below that of a vertical well.

Because one might expect directional drilling attempts that produce successfully to be publicized more often than failures, it is useful to examine the overall technical success rate of horizontal wells over a broad area. Deskins et al. (1995) took a comprehensive survey of horizontal wells in North America, and found that horizontal wells enjoyed technical success in 95% of U.S. reservoirs where they were employed, compared to a success rate over 90% for Canadian horizontal wells. These figures were calculated by reservoir rather than by individual well, and the technical success figures are likely to underestimate the true success rate because reservoirs with a handful of failures were given the same weight as reservoirs with thousands of successful wells (Deskins, pers. comm.). Unfortunately, technical success rates for vertical wells were not presented for the sake of comparison.

Directional drilling has been shown to maximize oil and gas production in virtually any oil and gas recovery situation. As early as 1990, Stagg and Reilly proclaimed that "Industry is no longer constrained by the mechanical aspects of horizontal well completions. Equipment and techniques are available, or soon will be available, to meet all completion needs." These methods are feasible for both exploration and full-field development (French Oil and Gas Industry Association 1990). The effectiveness of horizontal drilling as an exploration tool was noted by Hawkings et al. (1990), who reported that a horizontal well was able to locate high permeability sands where conventional wells had failed. Aguilera et al. (1991) lauded the potential of horizontal drilling in infill situations. According to Thakur (1999), "As a general rule, readers are encouraged to consider horizontal wells as the primary option for a field." These studies and technical reports by the oil and gas industry illustrate that directional drilling is a versatile and viable alternative and should be considered where oil and gas is proposed for development because of its ability to meet or exceed the production ability of vertical wells.

Directional Drilling Can Tap Distant Resources

Directional drilling can now tap pockets of oil and gas that are miles away from the drilling site. Horizontal drilling can reach subsurface reservoirs up to 29,000 feet away from the drilling site in horizontal distance (Al-Blehed et al. 2000) and, in some cases, even farther. The Exxon-Mobil Sacate Sa-2 well is believed to hold the current North American record for horizontal displacement, reaching a final distance of 21,277 feet (just over 4 miles) from the drilling site; this feat was achieved offshore in over 650 feet of water (Elks and Masonheimer 2002). Elks and Masonheimer went on to state,

"Horizontal deviations [for wells in this project] could ultimately exceed 35,000 feet," a distance of over 6½ miles.

In 1997, China's Xijiang 24-3-A14 well achieved a horizontal displacement of 26,452 feet, or over 5 miles (Jiang and Nian 1998). Vighetto et al. (1999) reported on the successful drilling of extended-reach horizontal wells with horizontal displacements of up to 34,728 feet. This example shows the oil and gas industry's current ability to use horizontal drilling to produce from reservoirs more than 6½ miles away from the drilling rig. And according to industry, even greater gains in distance capabilities are likely in the offing. Ron Auflick of K and M Technologies even goes so far as to claim in the press that extended reach drilling rigs will be able to drill nearly 20 miles from the drilling site within the next 10 years (in Schneider 2001).

These industry reports demonstrate the viability of extended-reach drilling technologies to tap oil and gas reserves across great distances. Such long-reach technologies provide the technical capability to extract oil and gas from lands where surface damage from conventional drilling is barred in order to protect the important surface values of sensitive landscapes.

New Steering Technologies Allow for Greater Drilling Accuracy

Advances in modern technology now allow operators to steer the drill bit through the Earth with pinpoint accuracy, unlocking the resources from distant pools of oil and gas. This "geo-steering" is aided by three-dimensional computer programs that allow modeling and visualization of the drill path through the Earth, enabling the operator to guide the drill bit in real-time; this technology has been tested and proven accurate in the Gulf of Mexico, North Sea, and onshore Latin American locations (Sanstrom and Longorio 2002).

The technology that allows this real-time steering of the drill bit is alternately known as "Measurement While Drilling" (MWD) or "Logging While Drilling" (LWD). These technologies gather information at the well bit and instantaneously send it back to the drill engineer, who controls the bit. Corrections can be made immediately if the drill bit strays from the target zone, or to avoid obstacles (Maurer 1995). Barry et al. (1998) reported a case history where Logging-While-Drilling techniques were used to geosteer horizontal wells in real-time along a 40-foot column of oil trapped between an aquifer and a gas cap. The authors of this study noted, "Excellent well performance supports the general validity of the geosteering approach and a static pressure survey in one of the wells verifies the steering accuracy." Geosteering has become so precise that a multilateral well off the coast of Nigeria was successfully completed within a target window of only +/– 2 feet (Aloko et al. 1998).

DIRECTIONAL DRILLING IS EFFECTIVE IN MANY GEOLOGIC SETTINGS

Directional drilling, in its several forms, has proven to be remarkably versatile as an alternative to conventional vertical drilling in recovery of all types of petroleum resources. In the United States, directional drilling has met with economic success in most of the major oil- and gas-bearing rock formations (see Table 3, following page). Aguilera et al. (1991) stated, "Theoretically, all reservoirs can benefit from horizontal wells." Al-Blehed et al. (2000) asserted that horizontal drilling is superior to vertical drilling for a variety of conditions including naturally frac-tured reservoirs, thin reservoirs, heterogeneous reservoirs, vertical permeability homogeneous reservoirs, reefs or isolated sand bodies, and faulted reservoirs. Joshi (1991) asserted that for natural gas production, horizontal wells improve drainage area per well for low-permeability geologic formations and reduced near-wellbore turbulence and increase delivery efficiency for high-permeability formations. Robertson et al. (1992) concluded, "Horizontal wells appear to improve the chances of attaining commercial gas production rates from heterogeneous formations."

Directional drilling offers superior production even when applied to most geologically difficult circumstances. In Germany, an 11,200-foot-deep sour gas well achieved a fivefold production increase over nearby vertical wells. Of this well, Schuler (1992) noted, "The drilling was in a geologically difficult environment with tight target tolerances." In Argentina, horizontal drilling was used to successfully explore a deep, fractured gas reservoir involving hanging wall anticline traps (Blangy 2002). In China's Shixi Field, 5 horizontal wells were drilled into deep volcanic formations with multiple fracture systems and high pore pressure. Of these wells, Xinzhong et al. (1998) observed, "It is very difficult to drill the horizontal well due to the specialty and complexity of its geological configuration, hole construction, and operational requirement. Now 5 horizontal wells with 5000m

Table 3. U. S. geologic formations where directional projects have successfully produced oil and gas.

Location	Formation	Source
Alabama	Pottsville coal	Swindell 1996
Alaska	Tarn formation	Phillips Petroleum 2002
	West Sak formation	Phillips Petroleum 2002
	Alpine formation	Phillips Petroleum 2002
California	Stevens sand	Gangle and Ezekwe 1995, Anon. 1996
	Veder sand	Chenot et al. 2002
	Monterey chert	Elks and Masonheimer 2002
Colorado	Niobrara sandstone	Petzet 1990, Stright and Robertson 1993
	Codell formation	Swindell 1996
	Mesa Verde sandstone	Myal and Frohne 1992
	Cameo coals	USDOE 1993
Kentucky	Devonian Shale	Bellinger 1991
Louisiana	Austin Chalk	Swindell 1996, Maloy 1997
	Miocene	Swindell 1996
	Cotton Valley	Swindell 1996
	Wilcox sandstone	Lacy et al. 1992
Michigan	Antrim	Swindell 1996
	Dundee limestone	Wood 1997
Montana	Red River	Swindell 1996
	Mission Canyon	Swindell 1996
New Mexico	Fruitland coal	USDOE 1993, Swindell 1996
	Mancos shale	Swindell 1996
North Dakota	Bakken shale	Swindell 1996
	Madison limestone	Swindell 1996
Ohio	Clinton sandstone	McCormac 1996
	Rose Run sandstone	McCormac 1996
Oklahoma	Bartlesville	Swindell 1996
	Mississippi	Swindell 1996
	Viola	Swindell 1996
	Hunton	Swindell 1996
South Dakota	Red River	Swindell 1996
Texas	San Andres dolomite	Leazer and Marquez 1995
	Montoya limestone	Fletcher 2002
	Devonian fm.	Fletcher 2002
	Austin Chalk	Swindell 1996
	Buda	Swindell 1996
	Georgetown	Swindell 1996
	Ellenburger	Swindell 1996
	Wilcox fm.	Doughtie 1994
Utah	Desert Creek dolomite	Leazer and Marquez 1995, Swindell 1996, Chidsey et al. 2002
	Twin Creek	Swindell 1996
	Paradox shale	Morgan 1996
	Ismay limestone	Chidsey et al. 2002
West Virginia	Devonian Shale	Zammerilli 1989, Salamy et al. 1991
Wyoming	Nugget sandstone	Weatherl 1998
	Almond formation	Iverson et al. 1995
	Niobrara sandstone	Swindell 1996
	Minnelusa	Swindell 1996
	Frontier sandstone	Swindell 1996
	Hanna coals	Logan 1988

MD [Measured Depth, the overall length of the wellbore] have been drilled successfully." On Alaska's North Slope, the Schrader Bluff Pilot Project involved two stacked horizontal wells drilled into heavily faulted sandstone formations with target zones only 25 feet and 28 feet thick, respectively. Using geosteering technology, the paired wells successfully followed the narrow pay formation as it rose and dipped across numerous faults; both wells achieved economic success (Rixse and Johnson 2002).

Horizontal drilling has proven successful in a variety of geological settings, as discussed in numerous industry and government reports summarized on Table 3.

Shallow Reservoirs

Directional drilling has been employed to successfully access shallow reservoirs in a number of cases. Slant-hole drilling can be paired with horizontal techniques for shallow reservoirs; a well was drilled using this technique near the town of Brooks in southern Alberta, reaching a depth of 1,886 feet and a horizontal displacement of 4,200 feet (Smith and Edwards 1992). In the Black Warrior Basin, Mississippi Valley Gas Company successfully drilled a well 1,805 feet in depth with a horizontal leg of 1,650 feet. The well produced gas from a storage field at 6 times the rate of neighboring vertical wells (Butler and Skeen 1996). Multiple horizontal laterals have been drilled for formations as shallow as 800 feet (Chambers 2000). In Wyoming's Hanna Basin, three medium-radius horizontal wells successfully accessed coalbed methane at a depth of only 363 feet (Logan 1988). Thus, there appears to be no reservoir too shallow for horizontal drilling.

Deep Reservoirs

Directionally drilling has accessed some of the world's deepest oil and gas deposits. As of 1995, the Navasota #1 well was the deepest horizontal well in the Austin Chalk, at 14,172 feet (Pearce et al. 1995). In the Goodwyn gas/conglomerate field in Australia, the GWA-13 well was drilled to 24,620 feet total depth with a horizontal displacement of 9,400 feet (Dolan et al. 1998). Horizontal wells in the Permian Basin of west Texas now exceed depths of 14,000 feet (Fletcher 2002). Schuler and Santos (1996) reported success with hydraulic fracturing on what was then the world's deepest horizontal well (15,687 feet deep). In Alaska's Cook Inlet, the Forest Oil Redoubt #4 well was drilled

deeper than 18,872 feet from an offshore rig (Anon. 2002b).

Horizontal and directional technology has proven itself in ultra-deep settings where temperatures and pressures can be intense. In the Middle East, a short-radius sour gas well was successfully drilled to a depth of 14,115 feet in the deep, hot Thamama limestone from an offshore drilling rig (Simpson et al. 1993). Based on drilling deep horizontal wells in Germany, Graute et al. (1994) concluded, "Results of both wells proved that horizontal drilling into these deep reservoirs is technically feasible and economically attractive."

Deep horizontal wells have achieved substantial production successes. A well drilled into the ultra-tight, high pressure, high temperature Roetliegendes sandstone in Germany produced at a rate 3.5-9 times greater than hydraulically fractured vertical wells (Schuler and Santos 1996). According to Krystinik (2001), a horizontal well drilled in Wyoming's Green River Basin reached a depth greater than 15,000 feet in tight-gas sandstone, was drilled at a cost that was reduced to 50% of the industry average, and achieved economic production of greater than 14 million cubic feet of gas per day.

These reports illustrate that use of directional drilling in deep reservoirs is effective and productive. Reaching depths of over 15,000 feet in Wyoming and elsewhere in the world, this technology clearly is versatile enough to be considered in all reservoirs.

Tight Reservoirs

Tight reservoirs are formations of very low permeability, which impedes the flow of oil and gas to the well. Nonetheless, directional wells have proven both feasible and profitable in these geologically challenging settings. Mostafa (1993) reported that horizontal drilling in tight carbonate reservoirs improved production and reduced oil and water coning. Horizontal drilling has proven profitable in the tight chalk reservoirs of the Danish North Sea (Andersen et al. 1988). In the Permian Basin of west Texas, EOG Resources reported successful completions in 14 of 15 horizontal wells of the tight Devonian formation (Fletcher 2002). Directional drilling has been shown to increase rate of gas production and overall recoverable quantity for tight gas sands (e.g., Cassetta 1998).

Kabir et al. (1997) linked horizontal drilling effectiveness in tight carbonate reservoirs with ability to intercept fractures. Because fractures tend to be oriented vertically, wellbores traveling horizontally through a formation have a far greater capability to successfully intercept fractures than vertical wells, which have a rather short passage through the target formation. For tight gas reservoirs that are naturally fractured, horizontal drilling compares favorably with massive hydraulic fracturing and is a sound alternative (van Kruysdijk and Niko 1988). For northwestern Colorado fractured sandstones, Stright and Robertson (1993) stated, "The advantage of a horizontal well over a vertical Niobrara well is higher probability of encountering well-developed fractures, a common problem with vertical Niobrara wells." Hydraulic fracturing can be used in conjunction with horizontal drilling to enhance the productivity of tight reservoirs lacking in natural fractures (Soliman et al. 1996).

Based on these studies, it appears that directional drilling may have a distinct advantage over conventional vertical drilling in tight formations, particularly where fractures are intercepted to release the gas resource.

Heavy Oil

Directional drilling has proven effective in tapping heavy oil deposits in tar sands. Luhowy (1993) reported that "Horizontal wells proved economical for developing, under primary recovery, viscous heavy oil from the unconsolidated McLaren sand channels in Saskatchewan." On Alaska's North Slope, the West Sak heavy oil reservoir is being developed using multilateral horizontal technology (Phillips Petroleum 2002). For heavy oil recovery, Shirif (2000) noted that, "For a given pattern, there is a horizontal well configuration that maximizes the total production rate."

Coalbed Methane

Although vertical drilling currently dominates coalbed methane fields, directional drilling is increasingly being applied to the production of this unconventional resource. According to Moore and Moore (1999), directional drilling is applicable to coalbed methane production, but drilling rig placement may be constrained by rock jointing and fracture patterns. Horizontal wells have been drilled for coalbed methane in Colorado's Piceance Basin using short radius technique, and in Wyoming's Hanna Basin using medium-radius technique (Logan 1988). According to the West Virginia Geological and Economic Survey's coalbed methane database, CDX Gas drilled 13 horizontal wells in West Virginia's Welch Field, which produced 1.5

trillion cubic feet of coalbed methane between 1999 and 2000.

Furthermore, horizontal drilling for coalbed methane appears to be an effective method to increase production. In discussing Penn Virginia Corporation's coalbed methane program, company president A. James Dearlove has stated, "By using horizontal drilling on our coalbed methane and Devonian shale acreage, we expect to significantly accelerate gas production, which should increase the present value of our properties" (quoted in Anon. 2002a). One horizontal well drilled in New Mexico's San Juan Basin produced almost seven times the coalbed methane as the average vertical well in the area (USDOE 1993).

Horizontal methods can also yield substantial increases in coalbed methane producible reserves. In Colorado's San Juan Basin, multilateral drilling by CDX gas is expected to recover 50-75% of available coalbed methane reserves, compared to 10% for conventional methods (McWilliams 2002). According to Wayne Kelley, president of Texas-based Omega Oil Company, multilateral technology using coiled-tube drilling in coalbed methane fields "would replace 220 well pads on the surface with a single well pad" (as quoted in Bleizeffer 2002).

With the dramatic expansion of coalbed methane contemplated for the Intermountain West, directional drilling appears to be a viable alternative to the conventional wells that currently dominate the production of this resource. Conventional methods of coalbed methane production typically entail a high density of roads, well pads, pipelines and transmission lines that can be reduced to some extent by clustered directional drilling. But coalbed methane development also creates the additional problem of disposal of millions of gallons of wastewater, which must be removed from the coal seam before the gas can be extracted. This water is often highly saline or alkaline (e.g., Hulin 2001), and the dumping of such toxic wastewater into streams and groundwater can have disastrous ecological effects. Dumping coalbed methane wastewater onto the surface has unacceptable ecological, economic, and social impacts that are beyond the scope of this report but that should be addressed before this resource is developed.

Thin Reservoirs

Horizontal wells can travel along the pay zone of thin reservoirs for long distances, dramatically improving production over vertical wells that have only a short trip through the pay zone. In Trinidad's Immortelle Field, six "highly successful" horizontal wells were drilled to tap a 48-foot thick oil play (Thakur et al. 1996). In a remote area of Sumatra, a horizontal well was successfully drilled into a 33-foot-deep oil column (Curnutt et al. 1993). Horizontal drilling has been used to produce gas from a pay zone only 10 feet thick in Pleistocene sands in the Gulf of Mexico (Gidman et al. 1995). A dual-lateral horizontal well off the coast of Nigeria was successfully drilled along an 11-foot oil column trapped between a gas cap and an aquifer.

Horizontal drilling yields superior production for thin reservoirs. Production from horizontal drilling into a 130-foot thick oil rim off the coast of East Malaysia has yielded two to eight times the production of vertical wells in the area (van der Harst 1991). In its Pelican Lake project, CS Resources used horizontal wells to target pay zone that was a mere 13-20 feet thick. These horizontal wells achieved productivities that were five to thirty times greater than neighboring vertical wells, with longer horizontals yielding the higher productivities (Sarma and Ono 1995).

Depleted Reservoirs

Due to its higher efficiency in recovering oil and gas, horizontal drilling has proven to be an excellent method to revitalize depleted reservoirs. In Oklahoma's Caddo County, a well with a 4,000-foot horizontal displacement was drilled into a depleted sandstone reservoir, achieving a production of 1,800 barrels of oil per day with very little gas coning—the mixture of gas and oil that reduces production efficiency (Beardmore et al. 1994). In Michigan, horizontal laterals from old wellbores yielded more than a threefold increase in oil production over vertical wells, effectively revitalizing the depleted Niagaran fields (Lanier 1996). A more complete accounting of successes in depleted reservoirs is presented in the section of this report titled "Increasing Producible Reserves."

ECONOMIC ADVANTAGES OF DIRECTIONAL DRILLING

The oil and gas business has always been inherently risky, and profitability is based in large part on market prices of oil and gas products. No drilling method, whether vertical or directional, can insulate a drilling company from the possibility of individual economic failures. Nonetheless, the overwhelming majority of published studies on the subject demonstrate that

directional drilling is not only economically feasible but is in fact substantially more profitable than conventional, vertical drilling due to its superior cost-benefit ratio, even though the costs to drill a directional well may be higher in some cases.

Costs of Individual Wells

In 1991, Fritz et al. noted, "If the cost of drilling a horizontal well was equal to that of drilling a vertical well, most reservoirs would be candidates for horizontal drilling." These costs are in fact equalizing. Aalund and Rappold (1993) found that the cost of drilling two horizontal wells in Egypt was 1.4 times the cost of drilling conventional wells, and made the following prediction: "As horizontal drilling becomes more common, the cost of horizontal wells will decrease to near that of vertical wells in the Middle East." Under Elf Aquitaine's drilling program, horizontal well costs averaged 1.5 times the cost of vertical wells (Thakur 1999). On the basis of cost per foot of drilled wellbore, directional drilling is only slightly more expensive than vertical drilling. According to Sarma and Ono (1995), "The 1993 Joint Association Survey of drilling costs on 845 horizontal wells indicated that at $80.76/ft, a horizontal well was only 8% more expensive to drill per foot than a vertical well." Hawkings et al. (1990) reported that a horizontal gas well in the Roetliegendes Field in Germany cost roughly the same to complete as a fracture-stimulated conventional well. Thus, compared to vertical wells, the costs for drilling a directional well can be higher than, or sometimes equal to, costs for drilling a vertical well. But horizontal wells often yield much higher oil and gas production than vertical well, offsetting cost increases (see following section).

For each new formation, there is a learning curve that progressively drives down the cost of horizontal drilling as more wells are completed. Lacy et al. (1992) summarized this effect as follows: "As drilling experience is gained in a certain area, horizontal well costs decrease. The first well usually costs two or three times more than a vertical well. The second well usually costs much less than the first one. After drilling a few wells, the horizontal/vertical well cost ratio is about 1.5. Therefore, a multi-horizontal well program has a better chance for economic success."

Technological advances are bringing down the cost of horizontal drilling. Slant-hole and coiled-tube drilling can be used to bring down the costs of horizontal drilling. According to Smith and Edwards (1992), "Slant hole drilling technology can result in considerable savings over conventionally drilled deviated holes because mud motors and deviation control with measurement while drilling tools are usually unnecessary." Slimhole and coiled-tube drilling offers further economic advantages in drilling horizontal laterals from existing boreholes. McCarty et al. (2002) reported that for 64 sidetracks drilled in 2002 on the North Slope with coiled-tube methods, costs averaged less than one-half that of conventional rotary sidetracks. This study concluded that "CTD [coiled-tube drilling] has matured into a highly efficient and economical means of sidetracking wells on the North Slope." According to the U.S. Department of Energy, "a typical 10,000-foot well drilled in southwest Wyoming costs about $700,000, but with coiled tubing and slimhole, the same well would cost $200,000 less" (USDOE 1999a).

Multilateral horizontal wells take the economic savings to an even higher level. According to Maurer (1995), "Multibranch horizontal wells can reduce horizontal drilling costs by 20 to 30% and the size and number of offshore platforms by 50%." In the same study, Maurer noted that "Unocal stated that its B-34 trilateral well [in the Dos Quadras offshore field] cost $2 million compared to $3 million for three conventional horizontal wells ($1 million each)." Just as with single horizontal wells, there is a learning curve associated with multilateral wells (Chambers 1998). Moritis (2000) found that for multilateral wells in Venezuela, the cost of drilling a single lateral leg decreased from $1 million to $700,000 during the course of the project, while the cost of drilling complex "fishbone" configurations decreased from $1.7 million per well to $1.2 million. For drilling horizontal laterals from existing wellbores, Lanier (1996) reported that costs decreased from $600,000 to $350,000 per well during the course of the 20-well program.

Higher Cost-Benefit Ratio of Directional Wells

It is important to recognize that well cost alone provides a poor comparison between conventional and horizontal technologies; it tells only half the story. For a true economic comparison, the difference in cost must be measured against difference in productivity. For the Seidenburg Z-17 well, a deep well in a German sour gas field, drilling and production costs were 1.2 times greater for a horizontal well, but production exceeded that of vertical wells by

a factor of 4.5 (Niggeman and Ehlers 1991). In a continent-wide survey of horizontal wells in 1995, Deskins et al. found that while U.S. horizontal wells were twice as expensive on average than vertical wells, their output of oil or gas averaged 3.2 times as much as vertical wells. With over three times the product for only twice the cost, it is easy to see that horizontal wells were in fact more economical on average than vertical wells. In the same study, Canadian horizontal wells produced 4.1 times as much product on average as vertical wells with only 2.2 times the investment, an even higher economic advantage for horizontal wells than in the U.S. For the Devonian shales of the Appalachian Basin, Salamy et al. (1991) stated, "Recent drilling and completion operations have demonstrated the technical and economic successes of horizontal wells over vertical wells." Thus, while costs are slightly higher to drill directional wells, the higher costs of individual wells are more than offset by dramatically increased production.

Economic Success of Individual Wells

As is the case with vertical wells, there are no guarantees that individual directional wells will turn a profit. For 20 horizontal wells in Colombia, Saavedra and Joshi (2002) reported that costs were 1.5-2.5 times the cost of comparable vertical wells. Of these wells, two of the four completed in carbonate formations became economic successes, while 88% of the horizontal wells drilled in sandstone achieved economic success. In a survey of horizontal drilling in U.S. fields (Deskins et al. 1995), economic success rates averaged 54% (59% for clastics, 45% for carbonates). Canadian economic success rates were 59% for light-oil clastics, 79% for carbonates, and 92% for heavy oil reservoirs. Once again, this survey likely underestimated economic success rates for individual wells by calculating economic success by reservoir rather than by individual well: Reservoirs with initial horizontal failures do not inspire repeat attempts, and this survey gave reservoirs with a few failed wells the same weighting as reservoirs with thousands of successful wells (Deskins, pers. comm.). No economic success data were provided for vertical wells over the same period for comparison purposes, and it is unknown how the market prices of the day may have influenced the profitability ratings of wells in this study.

It is useful to consider the factors behind the minority of horizontal wells that do not prove profitable. For Canadian horizontal wells that failed to achieve economic success, Sarma and Ono (1995) summarized the primary factors: (1) The wellbore missed the target zone or improperly placed within target zone; (2) Vertical permeability was low. Deviated wells with multiple laterals were found to be favorable for this situation; (3) In a fractured reservoir, the well failed to intersect fractures as anticipated; (4) Formation damage or excessive well undulation made cleaning difficult; (5) The well traversed unexpected variations in rock formations, leading to water coning; (6) The presence of flow barriers such as shale streaks inhibited production (but flow barriers can also augment production by inhibiting coning); (7) Feasibility studies were poor (e.g., based solely on simulations). Some of these problems can be overcome through improved planning and performance, while others are inherent and would likely affect vertical wells in much the same way.

Profitability for Large-Scale Projects

To evaluate a fundamental shift from vertical drilling to directional drilling, it is best to evaluate the economic advantages of implementing directional drilling on a large scale. Because each directional well drains a greater reservoir volume than a corresponding vertical well, fewer wells are required to drain a reservoir, reducing up-front project costs (Fritz et al. 1991). The technology continues to improve and efficiencies in using this technology will also likely increase. Al-Blehed et al. (2000) stated that their use of horizontal wells reduced drilling, flowline, and facilities costs by 20-25% over vertical drilling. Turaiki and Raza (1998) reviewed the track record of horizontal drilling in Saudi Arabia. They reached the conclusion that "Implementation of [3-D seismic, horizontal drilling, and multi-lateral drilling] has had a pronounced effect on reducing capital and operating costs. Development planning has become more cost-effective, oil production rate declines are being arrested, plateau oil rates are being sustained over longer duration, and oil recoveries are being improved."

These improved efficiencies in oil and gas recovery have translated into real economic successes when directional drilling technologies are applied on a large scale. Meehan (1995) evaluated Union Pacific Resources' horizontal drilling program in the Austin Chalk: "UPRC's first 1,000 horizontal wells have been an economic success," he reported, returning 19%

over their expenses. As of 1993, horizontal drilling was reducing total drilling, flowline, and facilities costs in the Middle East by 20-25% while improving well capacity by 150-400% (Aalund and Rappold 1993). Fritz et al. (1991) compared the costs of older-technology directional drilling with vertical drilling and found that oil production costs per barrel were lower for directional drilling in the Austin Chalk, but higher in the Williston Basin of North Dakota. According to Maloy (1992), "Horizontal drilling in Giddings field Austin Chalk has significantly improved well recoveries and more than offset drilling costs."

According to Harrison et al. (1994), techniques to control production unique to horizontal drilling make production from certain types of sandstone reservoirs profitable, which would be unprofitable with vertical drilling. Baker et al. (1984) performed an economic analysis on coalbed methane recovery via directional drilling and found it to be economically feasible. Based on BP's horizontal drilling experiences in the Gulf of Mexico, Badgett et al. (1994) stated that "[t]he wells have provided access to reserves isolated by depositional features within the reservoir at a cost equal to or less than that of conventional drilling." According to Sarma and Ono (1995), "Most IOR [improved oil recovery] with horizontal wells has been successful, both in terms of oil productivity and economics. In most cases, project cost has been realized within months of production."

When horizontal drilling is applied broadly, the increases in oil and gas production more than compensate for higher costs per well. According to studies, directional drilling appears to yield economic advantages on a large scale. Even in individual cases where directional costs are higher, the overall cost-benefit of directional drilling appears to favor this technology over conventional vertical drilling.

INCREASING PRODUCIBLE RESERVES

Numerous reports have also found that directional drilling is also more effective at removing oil and gas from geologic formations than conventional vertical wells. Thakur (1999) reported that because horizontal drilling is a more efficient extraction method, it increases the recoverable reserves for a given reservoir.

There are numerous cases where horizontal or other directional drilling has rejuvenated oil and gas reservoirs that previously were dormant. The Anglia gas field of the western North Sea was unproductive with vertical drilling, even with well stimulation and fracturing technologies. But "at a small cost premium, the [horizontal drilling] method enabled a marginal field to be developed successfully" (Guyatt and Allen 1996). The Tyra Field of the Danish North Sea, which originally produced only gas, became a productive oil field due entirely to the success of horizontal drilling (Nykjaer 1994). In northern Alberta, horizontal wells are being used to tap "attic oil" missed by previously existing vertical wells (Morrissey 1996). In Canada, declining or shut-in fields such as the South Bodo, Edam West Sparky, Midale Bed Unit 5, Weyburn, and Cummings-Dina pools returned to strong production through horizontal drilling (Sarma and Ono 1995). In south Texas, the Pearsall Field had been abandoned as uneconomic until it was rejuvenated through horizontal drilling (Lichtenburger 1990). Based on initial successes, horizontal drilling is expected to yield an additional 80 million barrels of oil from the moribund Crystal Field in Michigan (Wood 1997).

Directional drilling can profitably tap new fields that are unprofitable to develop with conventional vertical methods. Jacobsen and Rushworth (1993) evaluated horizontal drilling in the Troll field of the Norwegian North Sea. They summarized their findings as follows: "Under the large gas accumulation of the Troll field lies a significant quantity of oil. However, this oil is contained in thin layers distributed over a wide area and therefore cannot be developed using conventional wells. In 1988 Norsk Hydro re-evaluated possible development schemes for the oil resource, and concluded that the application of horizontal well technology could provide an economically viable means of developing the resource." Following successful test wells, full-scale development followed. A five trillion cubic foot sweet gas play in northeastern British Columbia was rendered feasible by horizontal drilling; *Oil and Gas Journal* reported that "En Cana said Greater Sierra would be uneconomic without two technologies: horizontal drilling and underbalanced circulation" (Anon. 2002c).

Finally, horizontal drilling maximizes the amount of oil in place that can be extracted from underground reservoirs. Hawkings et al. (1990) reported that horizontal drilling would double the producible reserves from the Rotliegendes Field in Germany. According to Maloy (1992), horizontal drilling in the Austin Chalk "has conceivably increased recoverable reserves by 400 million BOE [barrels of oil equivalent, a measure

allowing comparison of gas and oil production]." In the Elk Hills field in California, Gangle and Ezekwe (1995) concluded, "The horizontal wells produce at higher rates, lower drawdowns, and lower gas-oil ratio which will extend the life of the project and result in higher recovery." Horizontal drilling has increased the recovery potential for this tilted reservoir to over 70% of the oil in place, an increase of 10 million barrels of producible oil per horizontal well (Gangle et al. 1991). For the Paradox formation of Utah, Arizona, and Colorado, Chidsey et al. (2002) reported, "Proper geological evaluation of the reservoirs may increase production by 20 to 50% by the application of horizontal, possibly multilateral drilling projects." Deskins et al. (1995) predicted that horizontal drilling would increase U.S. producible reserves by 38%.

Directional Drilling Exploratory Wells

Based on industry reports, directional drilling is feasible for both exploration and full field development (French Oil and Gas Industry Association 1990). The effectiveness of horizontal drilling in particular as an exploration tool was noted by Hawkings et al (1990) who reported that a horizontal well was able to locate high permeability sands where conventional wells had failed.

THE POTENTIAL TO REDUCE IMPACTS THROUGH DIRECTIONAL DRILLING

Directional drilling, coupled with new well spacing patterns, can reform the way that the oil and gas industry does business. This is particularly important on public lands and on private lands overlaying federal minerals in the Rocky Mountain West, which must be managed for multiple uses. These tools have great potential to reduce damages from exploration wells, infill projects, and new full-field development. As a result, directional drilling technology should be considered in all pending and future oil and gas projects, and if found to be more environmentally beneficial, it should be implemented.

However, directional drilling is by no means an environmental panacea. When properly employed, these techniques can reduce the quantity of roads, well pads, pipelines, and overall surface impacts, and also concentrate human activity and vehicle traffic in a smaller area. But directional techniques do not eliminate these impacts, nor do they necessarily reduce other environmental impacts such as noise, some types of air pollution, chemical spills, and in the case of coalbed methane, toxic wastewater. In order to truly minimize the environmental impacts when producing oil or gas, additional measures beyond the scope of this report will be required. In addition, directional drilling does not eliminate all impacts of oil and gas development, and in some cases merely shifts the impacts to other lands.

Consequently, directional drilling is not suitable for use in all instances. There are a number of sensitive lands and habitats that are fundamentally incompatible with industrial use, where oil and gas development of any kind is inappropriate. These lands include national wildlife refuges, parks, monuments, and wilderness areas; roadless and wilderness-quality lands; and other sensitive areas; as well as appropriate buffers around these lands.

Other sensitive lands, such as important wildlife habitat, areas of high archaeological and cultural interest, floodplains, and lands of critical importance to endangered and threatened species and other rare plants and wildlife, should be withdrawn from all surface developments to protect these sensitive lands from the surface impacts associated with energy development. Directional drilling has potential as a tool to access subsurface energy resources while protecting important surface values that would be damaged through conventional vertical drilling operations. It is directional drilling that allows for oil and gas to be extracted from federal lands with a "no surface occupancy" lease requirement.

However, environmental benefits can only be maximized if all surface activities, including exploration, are eliminated. The following paragraphs outline some of the potential environmental damage-reduction benefits of this technology.

Directional Drilling Requires Fewer Wells in Existing Fields

Because each horizontal well drains a much larger area than a vertical well does, fewer horizontal wells (and their associated roads, wellpads, pipelines, and in some cases, powerlines) are needed to drain a given oil or gas field. Maurer (1995) reported that Petro-Hunt used a single multibranch horizontal well to drain an entire lease; this dual wellbore produced at a rate that was 1.5 times greater than single-bore horizontal wells. For offshore drilling, Huang et al. (1996) reported, "In this application, the horizontal well can replace at least four vertical wells." According to Al-Blehed et al.

(2000), horizontal drilling has decreased the number of wells required to drain Middle Eastern reservoirs by 30%.

Because fewer directional wells are required to drain a subsurface reservoir, well spacing is greater for directional wells (Fritz et al. 1991). Joshi (1991) stated that "to achieve larger producible reserves, horizontal wells will have to be drilled with a larger well spacing than vertical wells." In one full-field horizontal drilling scenario, Stright and Robertson (1993) noted "It is also concluded that horizontal well spacing in the fractured Niobrara should be greater than 640 acres." Indeed, horizontal wells that are spaced close together compete to draw the same oil or gas, reducing production efficiencies. In the Austin Chalk, Meehan (1995) found that "[i]nterference between [horizontal] wells more than 8,000 feet apart was not uncommon." Thus, it would be foolish from a technical perspective to implement a directional drilling program with an ultra-dense (20- to 80-acre) well spacing pattern.

In existing oil and gas fields, horizontal and multilateral drilling allows additional production to occur without an increase in well density, by drilling from existing wells or well pads. The U.S. Department of Energy agrees, stating that "new techniques for sidetrack drilling (drilling a lateral extending from an existing wellbore) and deeper drilling from existing wells can allow some of these resources to be developed without drilling new wells or disturbing previously undisturbed areas" (USDOE 1999a). Horizontal infill drilling can utilize existing wellpads to produce additional resources with few added impacts.

Directional Drilling Extends the Reach of Drilling Operations

Extended-reach drilling is both practical and economical. Based on experience in offshore California fields, Elks and Masonheimer (2002) concluded that "[a]lmost any rig can drill ERD [extended-reach drilling] wells, when the wells are designed and engineered within the rig's limitations." In 1994, emerging technological advances allowed extended-reach wells in Australia's Bass Strait field to be drilled "more economically and consistently" (Santostefano and Krepp 1994). The literature abounds with examples of technically and economically feasible "extended reach," or long-distance directional drilling, in a variety of settings, as summarized in this report. Such extended-reach drilling provides the possibility for extracting energy resources from under sensitive lands needing protection from surface disturbances. However, to date there are only a few examples where this has taken place. According to Deskins (1995), only 7% of the horizontal wells in a nationwide survey were drilled to avoid surface restrictions above the target formation. In Brazil, PetroBras has employed horizontal drilling in the Amazon to reduce the need to clear rainforest (Knott 1994). In this case, equipment was brought in by barge, and crews were helicoptered in, eliminating the construction of access roads to the wellpad. Slimhole drilling was used to access natural gas beneath the city of Howell, Michigan (Gredell and Benson 1995). In Texas, horizontal drilling was employed to access a large gas deposit beneath Falcon Reservoir, which was protected from surface drilling for ecological reasons (Doughtie 1994). These cases show that where surface resources require protection through lease stipulations or other measures, companies with a vested interest in a specific area may still be able to access the resource through directional drilling although this will displace impacts to other areas.

Cluster Drilling Reduces Surface Damage

Extended-reach drilling can be paired with cluster development to reduce the surface footprint associated with oil and gas drilling operations Slant and conventional directional drilling was used to drill 23 shallow wells (ranging from 1,716 feet to 1,860 feet deep) from a single pad near Wolf Lake in northeastern Alberta (Smith and Edwards 1992). In Venezuela's Orinoco Basin, Petrozuata has drilled up to 12 wells from a single pad (Moritis 2000). The Tabasco satellite field in the North Slope's Kuparuk area has been produced entirely from 9 wells drilled from a single pad (Phillips Petroleum 2002). Foregoing sentence reinstated. Elsewhere on Alaska's North Slope, a 25,000-acre reservoir was drained with 36 wells on two drilling pads (Redman 2002). The surface disturbance from the well pads, roads, and airstrip constructed during this project totaled 97 acres, compared to a total of 128 vertical well pads and 1,925 acres of surface disturbance for a comparable 25,000-acre part of Wyoming's Moxa Arch field (data from BLM 1995). But it is important to note that such cluster drilling has been shown to cause caribou to abandon the critically important calving grounds (Nelleman and Cameron 1998).

Cluster drilling from a single well pad not only reduces the overall footprint of oil and gas

development on the landscape by concentrating the activity and impacts of many wells at a few widely dispersed sites but also minimizes the capital investments of drilling companies (French Oil and Gas Industry Association 1990), and reduces costs for an expensive and ecologically damaging network of improved roadways. "By minimizing the number of production wells and usage of cluster locations," noted Graute et al. (1994), "a reduction of field investment and operating costs should be attained...." British Petroleum (2002) also has acknowledged the economic advantages of cluster development, stating that "limiting the size and number of new facilities also allows petroleum operations to be conducted more efficiently." Hub and cluster development is currently being used to develop the Tchibouela-Est field in Congo; this full-field production method is expected to improve production at reduced capital outlays (Energy Information Administration 2002).

By implementing cluster development in conjunction with directional drilling technology, there is the potential to simultaneously reduce environmental damages associated with full-field development using traditional vertical wells, as well as reduce industry costs. This provides an additional incentive for considering directional drilling, coupled with cluster development, when developing mineral resources in the Intermountain West.

CONCLUSIONS

This report demonstrates that directional drilling is a proven, feasible method to extract oil and gas resources in a variety of geologic settings throughout the Intermountain West and elsewhere across the globe. It is frequently economically superior to vertical drilling when the cost of drilling and the benefit from increased production associated with directional wells is taken into account

Where directional drilling is undertaken in a localized area by clustering wells, the surface disturbance associated with the drilling activity can be reduced, compared to vertical drilling. Directional wells generally need wider spacing within an area as well, which spreads out the amount of surface disturbance and may reduce the damage to any particular area. Thus, in a full-field development scenario, cluster drilling incurs a much more compact impact on the landscape when compared to the sprawl of roads, pipelines, and wellsites inherent to conventional vertical drilling. Directional drilling also enables oil and gas to be extracted from beneath lands where "No Surface Occupancy" restrictions have been place to protect sensitive resources valued by the public.

Directional drilling will not prevent all environmental impacts of oil and gas exploration and development. While clustering operations reduce the overall amount of land disturbance, they do intensify impacts in localized drilling areas. Directional drilling technologies also will not address other impacts associated with oil and gas development, such as air pollution and chemical spills. As a result, lands that contain resources incompatible with oil and gas development should remain withdrawn from all types of drilling, with buffers established to protect these lands. Still other sensitive lands must be protected from the surface impacts of energy development.

Given the availability and utility of this technology, it should be considered as an alternative wherever the federal government is examining oil and gas development of publicly owned minerals in the Intermountain West. When found to be the more environmentally protective alternative, this technology should be required in the development of federal mineral resources.

Although the Bush Administration has lauded directional drilling for its potential to reduce environmental impacts, so far it has failed to implement or even study the widespread use of directional drilling technology. Directional drilling should be factored into every decision about oil and gas activity affecting the minerals owned and managed by the federal government in the West. It could be a replacement for vertical drilling in a variety of circumstances, from exploration wells to infill projects to full-scale development of new fields.

APPENDIX A

Other Means to Reduce Surface Impacts

Pitless Drilling

One method that is universally applicable to reduce drilling impacts is "pitless drilling," entailing closed-loop systems that recycle drilling mud rather than dumping it into open pits. In addition to the elimination of toxic waste pits on the surface, this method reduces wellfield truck traffic by up to 75%, reduces water consumption by 80%, and is actually 8% less costly than constructing and maintaining a reserve pit (Longwell and Hertzler 1997). This method has proven successful in Alaska (Phillips Petroleum 2002) and Colorado (Longwell and Hertzler 1997), and is planned for the Sakhalin I project in Russia (Sumrow 2002). Due to its environmental advantage, pitless drilling should be mandated as a standard requirement for drilling operations.

The Need to Reduce the Impact of Seismic Exploration

Seismic oil and gas exploration can also have serious environmental impacts. There are two main methods: vibroseis, which relies on heavy equipment to send vibrations through the Earth, and shot-hole method, which required setting off underground explosive charges. The resulting shock waves are recorded by geophones to produce an underground map of oil and gas deposits. Desert soils, particularly those with biological soil crusts, are acutely susceptible to compaction and destruction when subjected to off-road vehicle driving of the type that accompanies heavy-impact types of seismic exploration; these soils and crusts can take 50-200 years to recover (Belnap 1995). Menkens and Anderson (1985) reported that prairie dog colonies subjected to vibroseis-method explor-

Photos by Scott Groene, Greater Yellowstone Coalition

Top: 26-ton vibroseis trucks used for heavy-impact seismic exploration.
Bottom: The aftermath of vibroseis truck use.

ation showed population declines while neighboring colonies experienced population increases. Seismic exploration projects can also have impacts on big game, particularly in sensitive habitats. Both shot-hole and vibroseis methods have been shown to disturb and displace elk on winter ranges (Ward 1986). Seismic exploration can also cause elk to abandon preferred calving habitats (Gillin 1989). Shot-hole seismic projects, while less damaging to the land, may also have negative impacts on wildlife. Explosions from shot-hole seismic testing may injure or kill fish when the shots are placed too close to aquatic habitats (Yukon Fish and Wildlife Management Board 2002). When performed in the winter, seismic shots can disturb and cause stress to hibernating bears (Reynolds et al. 1983). For these reasons, seismic exploration projects also deserve special planning to minimize their impacts on lands and wildlife.

The most prevalent method, 3-D seismic exploration, can be accomplished through two distinct techniques. In both types of seismic work, strings of receivers called "geophones" are strung out along set patterns across the landscape to pick up vibration signals from artificial sources. "Vibroseis" techniques employ 56,000-pound trucks that lower a 6,000-pound vibrating pad to create the vibration. "Shot-hole" methods employ drilling shallow holes and setting off explosive charges to set up the vibration signals. When properly conducted, this method can be a lower-impact alternative to vibroseis.

The vibroseis truck method is very heavy handed, requiring extensive off-road driving by massive machinery, which crushes vegetation and destroys fragile soils. According to the U.S. Bureau of Land Management, "Thumper trucks are obsolete technology that generate a greater shock wave through the ground and have the potential for greater impact to undiscovered cultural sites (due to the fact that they operated by dropping a 6,000 pound weight)" (BLM 2002b). Nonetheless, vibroseis trucks continue to be widely used throughout the American West.

The shot-hole method is much lighter on the land, particularly if it is performed without off-road vehicle travel. For environmentally sensitive areas, geophone cables can be laid by hand, and heliportable drills can be airlifted in to shot-hole sites (BLM 2001). This eliminates the need for damaging off-road truck and buggy traffic. Advances in shot-hole technology now allow 3-D seismic exploration to be conducted even in cities (Hansen 1993). Hansen later pointed out that exploration companies have a high degree of flexibility in locating shot points, increasing their ability to reduce impacts with this method (Hansen 1996). As in the case of drilling, some lands are so sensitive to disturbance that they are inappropriate for any type of seismic exploration.

APPENDIX B

Emerging Technologies Compatible with Directional Drilling

Virtually every technological advance developed for vertical drilling has also been successfully applied to directional drilling. For directional wells, these technological advances further improve the technical capabilities, increase oil and gas recovery, and lower drilling and production costs. As more advances are made in drilling technology, these methods will be able to access oil and gas from deeper reservoirs, farther from the drilling pad, and at lower costs per barrel produced than ever before.

Hydraulic Fracturing

Hydraulic fracturing has been successfully implemented with horizontal wells on any number of occasions (Yost and Overbey 1989, Salamy et al. 1991, Iverson et al. 1995, Soliman et al. 1996). Multiple hydraulic fractures have been successfully employed with very deep horizontal wells (Schuler and Santos 1996). Guo and Evans (1993) developed algorithms to predict production for horizontal wells with any combination of fracturing and oil or gas viscosity. Thus, for low-permeability (tight) reservoirs, the option of hydraulic fracturing is

available to companies employing directional drilling technologies.

It is important to note that hydraulic fracturing is a controversial technique for gas extraction. Fracturing can have dramatic impacts on water supplies and nearby dwellings. These impacts, while outside the scope of this report, must be carefully considered before undertaking this approach.

Steam Injection

Steam injection can be used to improve heavy oil recovery from unconsolidated sand formations. Horizontal wells have been effectively employed in conjunction with steam injection from vertical wells (Chenot et al. 2002) and with paired horizontal injector wells (Sarma and Ono 1995). O'Rourke et al. (1997) found horizontal drilling of paired wells to be effective in gas production using steam injection techniques.

Underbalanced Drilling

In underbalanced drilling, drilling mud is infused with gas to make it lower-pressure than the producing formation. This prevents the drilling mud from being forced out from the wellbore into the reservoir formation, impairing the flow of gas into the wellbore (Teichrob 1994, Pinney and Rodrigues 1999). Brookey (1998) recently developed new drilling fluids using long-lasting "micro-bubbles," enabling balanced and underbalanced drilling fluids to be created at a fraction of the cost of injecting air or gas into drilling mud. Underbalanced drilling is particularly effective in producing oil and gas from low-pressure formations using horizontal drilling.

Well Casings

Originally, most horizontal wells were drilled as "open hole" completions, with no liner or casing of any type. Later, a number of different well casing types were developed for use with directional wells. Gomez et al. (2002) provide a useful synopsis of horizontal well casing types. According to this study, horizontal wellbores are most commonly completed in "open hole" fashion, or with slotted liners in unstable formations where wellbore collapse is a potential problem. Slotted-liner completions can be gravel packed to reduce sand production, which lowers efficiency. Gels can be used to isolate problem zones, even with slotted liners (Gomez et al. 2002). At the beginning of the 1990s, cased horizontal wells in Alaska were being completed with either cemented or slotted liners (Stagg and Reilly 1990). These researchers noted that cement casings were being used to isolate problematic rock formations outside the pay zone. Thus, many different well casing options are available to drillers of horizontal wells.

Coiled Tube and Slimhole Drilling

Coiled-tube drilling replaces the segmented drill pipe of conventional drilling with flexible tubing. The coiled tubing is run under compression in order to maintain the necessary pressure on the drill bit (Faure et al. 1994a). According to Faure et al. (1994b), coiled tubing allows re-drilling old wells and performing horizontal re-entries, even in offshore situations where there is no derrick in place. Graham et al. (1999) extolled the advantages of coiled-tube drilling for drilling horizontal lateral sections from existing vertical wellbores: "Due to economic, environmental, and surface logistics concerns, re-entry drilling from existing wellbores is often an extremely viable solution to horizontal development in existing reservoirs. By utilizing an existing wellbore, many of the costs can be avoided and often troublesome formations are already secured behind casing."

Coiled-tube methods have been paired with underbalanced drilling to achieve significant production improvements over vertical wells in a deep chalk reservoir in the Gorm Field of the Danish North Sea (Wodka et al. 1995) and also in the deep Elkton formation (McGregor et al. 1997). In addition, coiled-tube methods require a smaller wellpad and produce less toxic waste (Faure et al. 1994a) and are quieter than conventional drilling (USDOE 1999a).

Slimhole drilling, often accomplished through coiled-tube technology, entails the drilling of smaller-diameter wellbores, often from an existing vertical well. The new generation of smaller-diameter drilling bits developed for slimhole drilling are more durable, have increased penetration rates, and develop more power (McDonald et al. 1996). Slimhole drilling can also reduce wellpad footprint. According to the U.S. Department of Energy, "Operational footprints are also reduced, since equipment for slimhole drilling is smaller than that used in conventional operations. The area cleared for drilling locations and site access can be as little as 9,000 square feet with mud holding pits, as much as 75 percent less than that required for conventional drilling operations" (USDOE 1999a). Like coiled-tube drilling, slimhole

drilling is quieter than conventional methods, reducing disturbance to local people or wildlife (USDOE 1999a).

A technique known as "microdrilling" is currently under development with the U.S. Department of Energy. This technique uses coiled-tube drilling from a trailer that can be pulled by a pickup truck, and can drill new wells up to 500 feet deep with no site preparation. According to the U.S. Department of Energy (1999b), "When developed for deep drilling, the technology will replace traditional methods that use massive amounts of equipment, material, and manpower, all of which are extremely expensive." This technique may allow drilling to occur without additional well pad construction.

Waterfloods and Miscible Floods

Oil and gas producers may use waterfloods and miscible floods to increase reservoir production; these methods entail the injection of water or solvent to raise reservoir pressure and force oil or gas out through producing wells. These methods are typically employed in a coordinated fashion over entire reservoirs to maximize the production of oil or gas. Horizontal wells enhance the effectiveness of waterfloods through maximizing the "sweep efficiency," or ability to force more oil out of the reservoir (Aalund and Rappold 1993, Deskins et al. 1995).

Cases abound regarding the successful pairing of horizontal drilling with waterfloods and miscible flood. The combination of waterfloods and horizontal drilling has achieved success in Utah (Hall 1998). With miscible floods, horizontal wells in Canada's Rainbow Keg River G Pool achieved 3.5 times the hydrocarbon production of the best vertical well in the pool (Sarma and Ono 1995). In addition, the drilling of horizontal wells actually improved the productivity of offset vertical wells for miscible floods in the Rainbow Keg River E Pool (Fong et al. 1996). The cost of these horizontal wells in this pool as well as similar miscible flood horizontal projects in the Brazeau River field were recovered within the first year of production (Sarma and Ono 1995). Miscible floods have also been effectively employed in conjunction with cluster drilling on Alaska's North Slope (Redman 2002).

Rotary Steerable Drill Bits

Rotary steerable drill bits can change direction on a dime and offer faster drilling through the rock than older directional systems. In the Norwegian North Sea, a rotary steerable system drilled through 8,586 feet of horizontal reservoir section in only 8.9 days, saving the rig operator $1 million in rig time (Gaddy 1999). Similarly, rotary drilling systems saved 100 days of rig time (and the associated costs) in Norway's North Sea Jotun Field (Grini et al. 2002). Grini et al. noted that "Rotary-steerable systems provided greater directional-steering accuracy and drilling efficiency in extended-reach drilling applications." Most importantly, rotary steerable technology holds the promise of increasing extended reach distances by 25% over current achievements (Sumrow 2002).

But there are limitations to rotary-steerable technology. Chenot et al. (2002) reported that unconsolidated sands were poor candidates for rotary steerable drilling after a well failed in this formation where a conventional horizontal well was successful. Rotary-steerable systems remain an expensive option at the current time. Sumrow (2002) noted, "Anecdotally, only about 15% of the rigs in the North Sea can afford to run rotary steerable systems, limiting rotary steerable technology to only the more expensive wells." But if rotary-steerable technologies follow the trends of other advances in petroleum engineering, costs may soon decrease to the point where this technology is economically feasible for a broad range of applications.

Other Emerging Technologies

A host of other technologies have arisen to increase the productivity or economic efficiency of directional drilling. Ali et al. (1996) developed an acid foam treatment to repair "skin damage" problems for open-hole wells in unconsolidated sands. Miller and Geehan (1998) also found that acid stimulation improved production in under-producing horizontal wells in carbonate formations. A plunger lift has been developed specifically for use in removing liquids from horizontal wellbores (Pullin and Porter 2001). Mathematical algorithms to predict bit walk in diagonal, directional, and horizontal wells have been developed to achieve even greater accuracy in drilling (Liu and Zaihong 2002). All of these technologies improve the performance of directional wells and increase their cost effectiveness.

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THE
WILDERNESS
SOCIETY

ECOLOGY AND ECONOMICS
RESEARCH DEPARTMENT

THE ECONOMIC & SOCIAL IMPACTS OF OIL AND GAS DEVELOPMENT

June 2006

I. PURPOSE

This brief is submitted as part of the NEPA process for this public land oil and gas development proposal. It is intended to identify some of the socio-economic issues that must be analyzed as part of the NEPA process. We also offer methodologies to assist agencies responsible for analyzing the impacts of proposed land use decisions on communities and economies. These issues are particularly relevant in the Rocky Mountain West, where current land management priorities have shifted distinctly toward oil and gas extraction. For this reason our analyses and examples in his brief will center on the five states which have been the focus of the current oil and gas development: Colorado, Montana, New Mexico, Utah, and Wyoming.

In making land use decisions, federal agencies have an obligation under the National Environmental Policy Act (NEPA) to take a "hard look" at the environmental consequences of a proposed action, and the requisite analysis "must be appropriate to the action in question." This brief presents issues to be analyzed, and data and methods for use in the analysis of the impact of oil and gas development proposals on the social and economic health of Western communities. Federal agencies, the public and communities cannot evaluate the consequences of proposed decisions or determine how best to avoid or mitigate negative impacts without adequate data and analysis. Through the examination of the issues and potential costs described below, federal agencies can better fulfill their obligations to evaluate the direct, indirect, and cumulative impacts of oil and gas development on the communities adjacent to Western public lands.

II. INTRODUCTION

As an agency prepares a management plan or an Environmental Impact Statement for publicly owned lands, it must do a full and accurate accounting of the costs and benefits of each of the alternatives proposed, including both market and non-market values (Loomis, 1993). Historically, analyses by land management agencies of alternatives that emphasize resource extraction alternatives (oil and gas drilling, mining, timber) emphasized the benefits of extraction and ignored the costs. Failure to include all the costs of an oil and gas drilling proposal has two distorting influences on the decision making process. First, the alternatives that emphasize drilling appear more attractive than they actually are, and second, the opportunity costs of conservation-oriented alternatives will appear greater than they really are. Agency planners must provide a full accounting of the costs associated with extraction activities. Only when all the costs and benefits are fully accounted for can a truly informed assessment of the alternatives occur.

We have organized this paper to facilitate the identification of key issues related to oil and gas development on public lands, and the environmental, social, and economic impacts these decisions have on communities in the West. The first section discusses the need to examine economically recoverable resources, the need to correctly assess net benefits by accounting for all impacts and costs, and presents several potential impacts of oil and gas development that are either absent from, or incorrectly represented in, many federal agency oil and gas leasing analyses. We also provide examples of specific analyses or methods for improving the analysis. The next section presents our NEPA scoping comments which include specific costs and impacts that we feel must be analyzed in order to complete a thorough examination of land use plans. These analyses and

Attachment 8

methods provide a necessary, but not sufficient, analysis of the impacts of oil and gas leasing on public lands and the adjacent communities. We formally request that the agency incorporate these analyses and methods into its planning for, and analysis of, land allocation decisions that lead to oil and gas leasing and drilling proposals and at the project level implementation phase.

III. Characterizing Oil and Gas Development Potential

A. Estimating the Economically Recoverable Volume of Oil and Gas

Technically recoverable oil and gas resources are the subset of the total resource base for which technology currently exists making extraction possible. This definition relies only on technological feasibility without regard to the cost of extraction or the prevailing prices. Economically recoverable oil and gas resources are the subset of technically recoverable resources that would be economic to produce.
Analyses of the benefits of oil and gas development must be made based on accurate and appropriate estimates of the resources that are economically recoverable.

As noted by LaTourrette, et al. (2002), economic constraints are, in most cases, the limiting factor on gas production in the Rocky Mountains, not environmental laws. The majority of undiscovered natural gas currently being proposed for exploitation in the Rocky Mountains are "unconventional" gases (continuous-type, tight sands gas, and coalbed methane). Economic recovery rates for unconventional oil and gas resources are lower than recovery rates for the conventional resources – reinforcing the need to base decisions on estimates of economically recoverable amounts of gas, not estimates of technically recoverable resources.

The Congressional Research Service (Corn, et al. 2001) and most, if not all, economists agree that the policy relevant opportunity cost of an environmental regulation is the economically recoverable amount of gas – not the technically recoverable amounts. It is inappropriate to base energy policy decisions solely on technically recoverable estimates. When economic criteria are considered, the estimates of oil and gas that are actually recoverable drop significantly from the initial estimates of technically recoverable resources (Attanasi 1998, LaTourrete et. al, 2002, 2003).

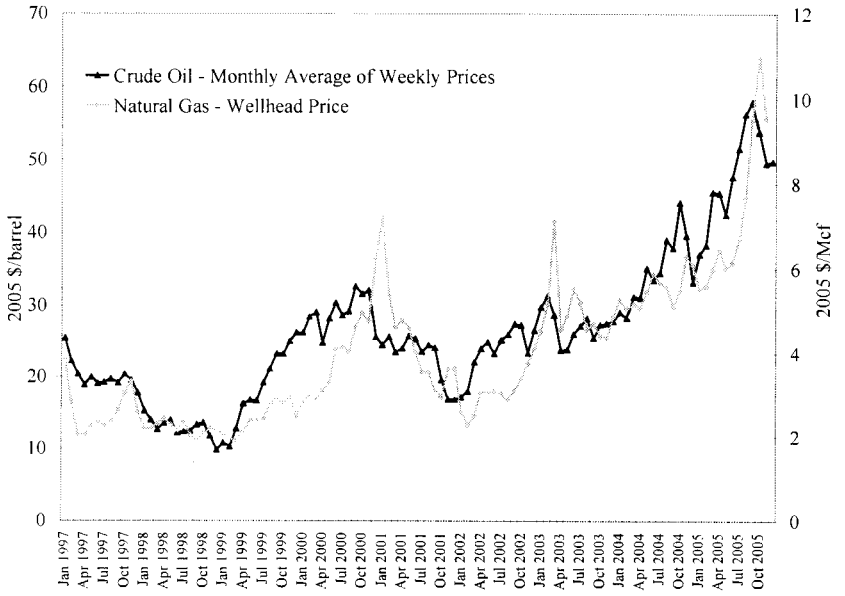
If economic factors are not considered, the opportunity costs of all forms of environmental protection will be overestimated. The agency will also likely overestimate the cost of lease stipulations, wilderness designation, and other protective measures if technically recoverable estimates are used. If the oil and/or gas are not economical to extract, there is no adverse impact on resource supplies from protecting wildlife, archeological sites, recreation sites and other public resources with leasing stipulations. Further, an EIS that relies on misleading economic information or fails to include all relevant costs in its economic analysis will violate NEPA, because it does not provide decision-makers and the public a valid realistic foundation on which to judge proposed projects.

Recent research by economists at The Wilderness Society indicates that the federal government's assessments of the oil and gas resources on public lands are flawed and consistently over-estimate the energy potential of these lands (Morton, et al. 2002, The Wilderness Society 2004a and b). The oil and gas industry also has a history of exaggerating the amount of gas recoverable and exaggerating the cost of protecting the environment. Rose (2001) states, "Since 1993, most oil companies have acknowledged that their geotechnical staffs persistently overestimate prospect reserves, commonly by about 30% to 80%." Rose goes on to say, "...over optimism is not limited to certain companies -- it appears to be a chronic industry shortcoming that has proved to be difficult to correct." The inherent upward bias in industry estimates of energy potential should eliminate them for use by public land agencies. Shanley et al. (2004), veterans of the oil and gas industry, reinforce this point for public land in the Rockies: "...it is likely that resource volumes are substantially overestimated, while the risks associated with finding and recovering those resources have most certainly been underestimated."

Exaggeration of the oil and gas resources by relying on technically recoverable estimates, distorts the analysis and increases risks to communities from false promises. For example, relying on estimates of technically recoverable resources will lead the agency to dramatically overestimate the number of new jobs that oil and gas drilling might create in a community. Basing decisions on technically recoverable estimates will exaggerate the potential tax revenues to the federal treasury, as well as state and local tax revenue. In addition, the potential spillover effects in the local economy from drilling will be exaggerated. Such exaggeration of the benefits of an oil and gas drilling project is an inappropriate distortion of the analysis of public land management alternatives and will lead to unrealistic expectations and possibly inappropriate support in local communities.

The agency should not rely exclusively on a deterministic, single value resource estimate due to the high risk and uncertainty with such estimates. According to Rose (2001), "Single-value estimates...predict an outcome that is possible, usually optimistic, and nearly always wrong." A better approach is to base estimates of gas and oil resources on a probabilistic range of values based on different levels of confidence. A probabilistic range of values more accurately portrays the risk and uncertainty inherent in industry estimates of undiscovered gas and oil resources. Reliance on a single value estimate does not comply with NEPA because it fails to use a range of values in order to fully consider the risk and uncertainty inherent in oil and gas estimates.

In addition to a range of probabilistic resource values, estimates of economically recoverable resources must be made based on a realistic range of prices in order to account for the uncertainty in forecasting future prices. Figure 1 shows historic prices for oil and gas in the U.S., and the potential volatility of these prices. To account for price uncertainty, USGS scientists use high and low price scenarios when estimating economically recoverable resources. We recommend a similar approach, including using USGS data for estimating undiscovered oil and gas resources



Source: U.S. Department of Energy, Energy Information Administration (http://www.eia.gov)

Figure 1. US Crude Oil and Natural Gas Prices

Many factors (flow rates, market price, drilling costs, etc.), not just environmental protection will influence whether resources are economic to produce, and economists make these assessments all the time. The price and costs assumptions used to estimate total production under each alternative must be critically examined

and made clear. To be specific, when estimating the amount of gas recoverable the price or price range that was assumed, and the costs of production that were assumed in the analysis must be spelled out. If a company cannot get the gas out of the ground at a cost less than the assumed wellhead price, then the opportunity costs of protecting the environment are zero. This is just basic economics. To comply with NEPA, all analyses of impacts must be based on estimates of economically recoverable resources.

Please review the RAND Corporation reports (LaTourette, et. al 2002, and 2003; Vidas et. al, 2003) detailing methods to estimate economically recoverable resources. We also request that the agency review Attanasi (1998) which describes methods used by the USGS to estimate economically recoverable resources for all the basins analyzed in the Energy Planning and Conservation Act's (EPCA) 2002 Assessment. It should be noted that the RAND analyses include some environmental cost, however, because they exclude non-market costs, USGS estimates are just the starting point to determine whether undiscovered gas is economically viable to extract. The RAND and USGS documents both demonstrate the feasibility of making estimates of economically recoverable resources and provide useful guidance on methodology.

NEPA requires a realistic assessment of economic impacts, and it is not realistic to assume that 100% of the technically recoverable oil and gas will ever be recovered The potential cost of protecting the environment and the possible benefits of drilling must all be based on estimates of economically recoverable resources. As the management plan and Reasonably Foreseeable Development scenario are developed, we formally request that they be based on economically recoverable amounts of oil and gas, not technically recoverable oil and gas.

B. Estimating the Employment and Income Benefits from Oil and Gas Development.

The IMPLAN model is an economic model often used by public land management agencies to project jobs and income from proposed actions. While the IMPLAN model can be useful as a tool to develop static analyses of the regional economy, the agency and local communities must be aware of the shortcomings and poor track record of the model as a predictive tool.

In general, models like IMPLAN are grounded in economic base theory, which makes the incorrect assumption that an economy is static (i.e. it does not change). IMPLAN models do not consider the impacts of many important variables that affect regional growth in many rural communities, especially in the West. Such as amenities as high quality hunting, fishing and recreational opportunities, open space, scenic beauty, clean air and clean water, a sense of community, and our overall high quality of life are not measured or accounted for in IMPLAN models. Many of these amenities are associated with attracting new migrants as well as retaining long-time residents.

Many residents of Western communities (both long-time and new) earn retirement and investment income. An analysis of economic trends will show that retirement and investment income is becoming increasingly important to rural economies of the West. A recent letter from 100 economists (Whitelaw, et al. 2003) reinforces the importance of non-labor income to the economy of the West. While it is technically possible, most IMPLAN models completely fail to consider the important economic role of retirement and investment in the economy of a community or region. A more accurate, dynamic, and complimentary approach requires planners to examine regional trends in jobs and income.

In a review of 23 studies that empirically tested the economic base hypothesis, Krikelas (1991) found only four that provided any evidence in support of economic base theory as a long run theory of economic growth -- a dismal track record. Despite dire predictions, history is replete with cases of communities and areas that lost their export base and continued as successful economies with their social capital intact. The local-serving sectors of the economy were the persistent ones, as new exports were substituted for the old. Tiebout (1956) recognized the shortcomings of the economic base theory when he wrote, "Without the ability to develop residentiary activities, the cost of development of export activities will be prohibitive." Krikelas (1992) concludes that economic base theory has severe limitations, especially for economic planning and policy

analysis. This is a conclusion that community leaders and land management officials and planners can no longer ignore, and one that should be incorporated into public land and community-level planning. As Haynes and Horne (1997) note:

> Where the economic base approach gets into trouble is when it is **used inappropriately as a tool for planning or predicting impacts** (emphasis added) of greater than one year in duration; a snapshot of current conditions tells little about the form a region's future economy may take.

Economists with both the Forest Service (Hoekstra, et. al 1990) and the Office of Technology Assessment (1992) concluded that while IMPLAN is useful for appraising the economic impacts of a management plan, the model is insufficient for evaluating the overall economic impacts for communities. And according to the OTA (1992), IMPLAN has an additional shortcoming for assessing community impacts: the economic data used to construct IMPLAN do not provide comparable details for all resource-based sectors of the economy. While economic data for oil and gas is classified as a separate manufacturing industry, recreation is scattered among a variety of industries generally classified in services and retail, with some in transportation. The ease of data acquisition for estimating oil and gas impacts combined with the difficulty of estimating the impacts of recreation and tourism underscores the potential bias favoring oil and gas development in IMPLAN modeling.

The 25th anniversary issue of the Journal of Regional Science includes an article by H.W. Richardson, a noted regional scientist, who believed that 40 years of research on economic base models "has done nothing to increase confidence in them." In addition, he concluded that it would be hard to "resist the conclusion that economic base models should be buried, and without prospects for resurrection" (Richardson, 1985). He is not alone. Many have suggested that economic base theories be abandoned in favor of other, more comprehensive theories of regional growth and development (Krikelas, 1992; Rasker, 1994; Power, 1995 and 1996). Many of these economists recommend analysis of regional trends in total personal income as a better way to understand where the local economy came from and where it is headed.

Our more specific concerns have to do with the technical assumptions used in most IMPLAN models. These questionable assumptions include: no changes in relative prices, no input substitution or technological change in the production processes, no labor mobility, no change in products or tastes, no regional migration, and no changes in state and local tax laws. The assumption of no labor mobility is particularly important for oil and gas drilling proposals, since it draws into question the issue of local versus non-local job creation. Workers are mobile, especially in the oil and gas industry as crews move from drill site to drill site. There is no guarantee that the oil and gas jobs projected by IMPLAN will be filled by local workers. And in fact, there is considerable evidence that workers in non-local crews fill most, if not all the direct jobs in oil and gas drilling.[1]

Another major assumption used by IMPLAN is the constant technology assumption. Most IMPLAN models, by failing to consider the downward impact of technology on job growth, will exaggerate the job potential from oil and gas drilling. Industries attempting to maximize profits seek to reduce production costs. One way to do this is to replace labor with technology resulting in fewer jobs. The downward trend in resource extraction jobs only becomes apparent if the agency completes a trend analysis showing changes in jobs and income over time.

Laitner, et. al (1998) cite Bureau of Labor Statistics (BLS) data which indicate that in 1988, oil and gas drilling generated about 1.72 jobs per million dollars of spending. By 1998 that number fell to 1.44 jobs per million dollars. Further, BLS (cited by Laitner et al.) estimates that the number of oil-gas jobs will fall to 0.71 jobs per million dollars of spending by 2008. This indicates that the direct jobs estimated with a static model like

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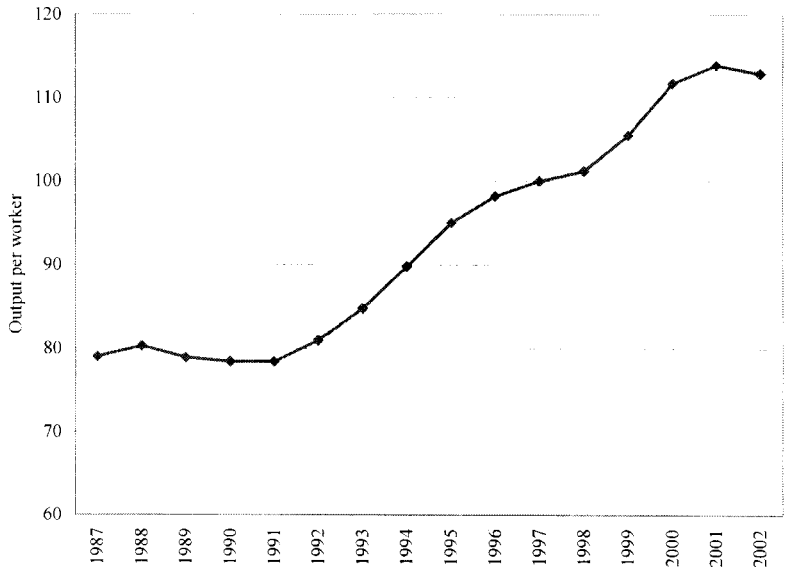
[1] For example: "Where Will the Workers Come From?" Casper (WY) Star Tribune, 6 October 2005, and "Chinese Labor for Oil Drilling Eyed in Colo." United Press International, 11 July 2005 both discuss the origins of oil and gas workers in the Western U.S.

IMPLAN model will be much more than the number actually created from drilling. As a result of this failure to account for technology improvements, input-output models are well known to predict higher multiplier effects than are actually experienced (Hoffman and Fortmann, 1996). A review of government data confirms this downward trend: since 1987 output per worker in the oil and gas industry has been increasing (Figure 2). Investments in technology in the oil and gas industry have resulted in fewer and fewer workers required to drill each well and to produce natural gas and oil. The trends of technology replacing jobs in the oil and gas industry will continue.



Source: Bureau of Labor Statistics (http://www.bea.gov)

Figure 2. Labor Productivity in Oil and Gas Extraction

The concern over the accuracy of models like IMPLAN combined with concern over the use of these models for planning, suggests that it is not only inappropriate but a disservice to rural communities to rely on IMPLAN to estimate the economic impacts of public land management alternatives on rural communities.

We recommend that the agency stop relying on IMPLAN and other models derived from economic base theory.

If planners use IMPLAN, the model must account for non-labor income, as well as income from hunting, fishing, and recreation. If the agency uses IMPLAN, it must also account for the fact that most drilling is completed by non-local crews. If the agency uses IMPLAN, the analysis must account for increasing labor productivity and hence declining jobs per well drilled. We insist that the agency fully discuss the assumptions, the shortcomings, and the risk and uncertainty due to the poor track record of the IMPLAN model in planning efforts. We also request that all data and multipliers used to project local impacts be made public.

We also request that the agency complete a trend analysis of regional jobs and income – to provide a better and more complete understanding of their economic past and their economic future. We formally request and recommend that the agency analyze economic trends using the Economic Profile System model developed by the Sonoran Institute in cooperation with the Bureau of Land Management (available at http://www.sonoran.org).

C. Estimating Gross and Net Revenues from Oil and Gas Production

Oil and gas production results in revenues flowing to federal, state and local governments. To help make better informed decisions, the revenues must be estimated accurately and with full consideration of resource production over time (production curves) and all relevant tax laws.

Furthermore, oil and gas revenues, by themselves, only represent flows of **gross** revenue – while **net** revenue is the policy relevant metric that must be analyzed. In order to estimate the **net** revenues from oil and gas production, the associated costs must be fully accounted for in the analysis (see next section). The costs to local communities from drilling are real and have already been demonstrated to be significant (Western Organization of Resource Councils 1999, Darin 2000, Pedersen Planning Consultants 2001, Pinedale Anticline Working Group, 2005), must be accounted for in the analysis of net revenues from gas production.

1. Estimate revenues based on the realities of oil and gas production

As conventional oil and gas fields are developed, production is initially high, before gradually decreasing over time. Production is not linear. This declining production curve for gas and oil wells must be taken into account when estimating tax revenues based on the value of produced resources. In the case of conventional wells this means that communities might enjoy large initial revenues that will decline in later years. The decline in revenues leaves communities with a lower stream of income when the time comes to deal with increasing oil and gas cleanup and remediation costs.

In contrast with production from conventional gas, production of coalbed methane (an unconventional gas) is initially slow due to the "dewatering" phase that may last several years before production can begin. In coalbed methane areas local communities are more likely to experience significant increases in the costs to local governments early without the immediate benefit of corresponding increases in local tax revenues.

We request that the agency make realistic assessments of the likely production curves along with the expected rate of development and production for the type of resources to be produced, and that all estimates of local revenues be made on an annual basis which reflects the expected annual production.

2. Estimate revenues based on the realities of Federal, state, and local tax laws

Revenue estimates must also account for variations and exceptions in local tax structures rather than simply estimating the value of the total resource and multiplying by the current or average tax rate. For example, Montana's tax structure encourages exploration and development by taxing the first year of production at a lower rate. In Colorado, producers are able to deduct any local property taxes and ad valorem severances taxes paid from their state severance taxes. Other policies which may reduce overall revenues are lower tax rates for directional drilling and for wells that are considered "marginal" (that is, producing below some minimum daily amount). These exceptions and reductions in the actual taxes paid need to be accounted for and included in the analysis of potential public revenue estimates for oil and gas drilling proposals.

We request that the agency determine all applicable Federal, state and local tax laws (including exceptions and reductions) and that these laws and regulations be used to make realistic and accurate estimates of net tax revenues from oil and gas production. As discussed above, revenue estimates must be made based on economically recoverable resources rather than technically recoverable – and must include the environmental and community costs from drilling and production.

D. Include a full accounting of the hidden economic costs from oil and gas extraction

As discussed, oil and gas revenues, by themselves, only represent flows of **gross** revenue – while **net** revenue is the policy relevant metric that must be analyzed. In order to estimate the **net** revenues from oil and gas production, the associated costs must be fully accounted for in the analysis. Similarly, oil and gas jobs by

themselves, represent gross jobs. In order to estimate the net jobs associated with an alternative, the job losses associated with drilling must be accounted for.

In addition to market costs, economic analyses of recoverable gas must include a full accounting of non-market costs. After 35 years of research by academic and federal agency economists (Krutilla 1967, Krutilla and Fisher 1985, Peterson and Sorg 1987, Loomis and Richardson 2001), it is now possible to quantify non-market environmental costs that arise from development of natural resources (see Table 1). The BLM and the Forest Service should include a full accounting of non-market costs in the effects analysis required by the National Environmental Policy Act (NEPA) for leasing and drilling decisions (Morton et al. 2004). To assist the agency with this task, we have included in the table various methods for estimating these costs. Furthermore, while the details are beyond the scope of this brief, agency analyses should also include estimates of the non-market benefits associated with each alternative.

Table 1. Economic Costs of Mining and Oil and Gas Extraction

Cost Category	Description of Potential Cost	Methods for Estimating Cost
Direct use	Decline in quality of recreation including hunting, fishing, hiking, biking, horseback riding. Loss of productive land for grazing and farming	Travel cost method, contingent valuation surveys.
Community	Air, water and noise pollution negatively impacts quality of life for area residents with potential decline in the number of retirees and households with non-labor income, loss of an educated workforce, and negative impacts on non-recreation businesses. Decline in recreation visits and return visits negatively impacts recreation businesses. Socio-economic costs of boom and bust cycles.	Surveys of residents and businesses. Averting expenditure methods for estimating the costs of mitigating health and noise impacts. Change in recreation visitation, expenditures and business income. Documented migration patterns.
Science	Oil and gas extraction in roadless areas reduces the value of the area for study of natural ecosystems and as an experimental control for adaptive ecosystem management.	Change in management costs, loss of information from natural studies foregone.
Off-site	Air, water and noise pollution decrease the quality of recreation experiences for downstream and downwind visitors. Haze and drilling rigs in viewsheds reduce the quality of scenic landscapes, impacting activities like driving for pleasure, and other recreation activities and negatively impacts adjacent property values. Groundwater discharged can negatively impact adjacent habitat, property, and crop yields, while depleting aquifers and wells.	Contingent valuation surveys, hedonic pricing analysis of property values, preventative expenditures, well replacement costs, restoration and environmental mitigation costs, direct impact analysis of the change in crop yields and revenues.

Table 1. Economic Costs of Mining and Oil and Gas Extraction

Cost Category	Description of Potential Cost	Methods for Estimating Cost
Biodiversity	Air, water and noise pollution can negatively impact fish and wildlife species. Ground water discharge changes hydrological regimes with negative impacts on riparian areas and species. Road and drill site construction displaces wildlife and fragments wildlife habitat.	Replacement costs, restoration and environmental mitigation costs.
Ecosystem services	Discharging ground water negatively impacts aquifer recharge and wetland filtration services. Road and drill site construction increase erosion causing a decline in watershed protection services.	Change in productivity, replacement costs, increased water treatment costs for cities, preventative expenditures.
Passive use	Roads, drilling and pipelines in roadless areas results in the decline in passive use benefits for natural environments.	Contingent valuation surveys, opportunity costs of not utilizing future information about the health, safety, and environmental impacts of oil and gas drilling.

We request that the agency include both market and non-market costs and benefits in order to fully account for all the impacts of potential development.

E. Estimating the Socio-economic Costs to Communities from Oil and Gas Development

1. Increased costs to private land owners and residents

The current oil and gas boom has generated significant costs to communities in the West. Notably in Wyoming's Powder River Basin, the site of massive coalbed methane development. While this development has increased the fortunes of some, others are not faring as well (Pederson Planning Consultants 2001). Landowners in the Powder River Basin are spending thousands of dollars on attorneys in order to attempt to protect their property, often to no avail, as these areas have seen dramatic declines in property values. Other areas are also experiencing declines in private property values as the result of the accelerated oil and gas development. A recent study in La Plata County, Colorado found that coalbed methane wells there resulted in a decline in property values of 22 percent (BBC Research and Consulting 2001).

Residents' quality of life also suffers during accelerated oil and gas development. These costs must be accounted for in the analysis. In a survey of residents of Sublette County, Wyoming (one of the communities currently experiencing accelerated oil and gas development, McLeod et al. (1998) found that when asked why people chose to live in the area, most cited the scenery, recreation, lifestyle, and clean air and water over economic factors such as jobs or low taxes. Another more recent survey of Sublette County Wyoming (Porter et al. 2004) residents also found that many listed the quality of life and the beauty of the area among the assets they value. These results also pointed out an awareness among county residents of the need to diversify the economy, and that opportunities and settings for tourism and recreation are important economic assets. All of these amenities are diminished when oil and gas drilling increases in pace and scale. The loss of amenities and the economic impacts created by this loss must be acknowledged and accounted for in the analysis.

We formally request that the agency estimate the costs associated with oil and gas development to private landowners as part of the NEPA process.

2. Increased costs to local governments

Accelerated oil and gas development is often touted as a fiscal savior for struggling Western communities. However, the potential windfall is not without costs (Morton, et al. 2002). These include added strain on infrastructure, increased road maintenance costs, increased demand for public services such as hospitals and schools, increased need for emergency services (due both to increased population and an increase in the number of people working in more dangerous occupations such as those found in oil and gas extraction), and a host of less tangible costs due to the effects of a changing demographic and social makeup of the towns and communities.

Costs to boomtowns in the West include an increase in truck traffic resulting in increased road maintenance costs (Pinedale Anticline Working Group 2005, Craig Daily Press 2004, 2005). Increased traffic also results in dust from poorly constructed access roads which causes health problems for both humans and livestock, reduces the grass available for cattle, and negatively impacts air quality and visibility. Crime and other social problems intensify in boomtowns, with these areas seeing increases in larceny, traffic violations and accidents, destruction of private property, family violence, and child abuse. Oil and gas workers facing long shifts and time away from families often turn to drugs (High Country News 2005). All of these escalating problems increase the cost of emergency and social services for cities and counties. Boomtowns also often experience a shift in the labor force. Workers leave for oil and gas jobs, resulting in instability in the labor force and difficulty hiring public workers (e.g. policemen, firemen) at a time when the counties and cities are stretched thin to handle the increased workload (Pederson Planning Consultants 2001).

Gulliford (1989) examined the consequences of the boom and bust nature of oil and gas development. He chronicles the fortunes of Garfield County, Colorado before, during, and after the push to extract oil from oil shale in the late 1970's. Oil shale production proved to be uneconomical even at high prices. The companies who had planned to exploit the resources encouraged the communities in the area to make large investments in infrastructure to accommodate workers for the oil shale boom, and then abandoned them before any oil was produced, leaving overbuilt towns with large debt burdens. Before leaving the county however, the oil shale boom also resulted in an increase in social problems related to rapid population growth and the prospect of easy money.

These added costs due to rapid increases in oil and gas drilling are being experienced by the communities in the Pinedale Anticline area of Wyoming (Pinedale Anticline Working Group 2005). Emergency calls more than doubled between 2000 and 2003, while ambulance runs increased by 36% since oil and gas drilling has accelerated. Traffic and automobile accidents have also increased in conjunction with oil and gas drilling. One major intersection in Sublette County saw traffic rates nearly triple between 1995 and 2003. After declining in the mid 1990's, accident rates per capita increased 23% between 1999 and 2003, and this increase mirrors the increase in drilling rigs in the area (Pinedale Anticline Working Group, 2005).

Accelerated oil and gas development has left many counties and communities unable to pay for or finance the increase in public service costs or the cleanup cost after the bust. We have every reason to believe that similar costs and burdens will be placed on other communities where public and private land is threatened by oil and gas drilling. <u>When estimating the benefits of an oil and gas development project the agency must show these benefits as net rather than gross. The increased public service and infrastructure costs associated with expedited oil and gas development must be fully accounted for as part of the NEPA process for the current push to develop oil and gas in the West.</u>

3. Economic instability and a loss of economic diversity

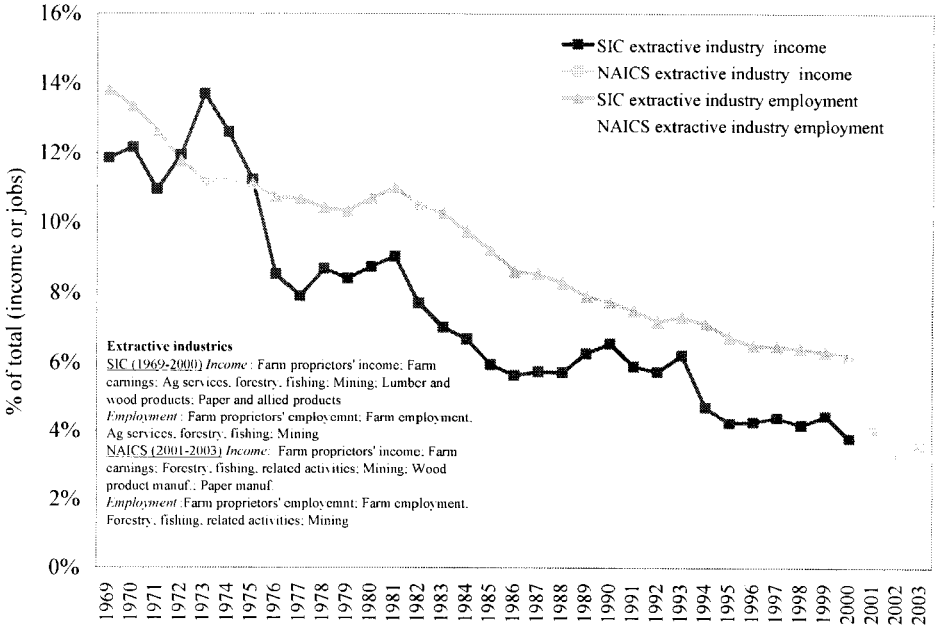
The agency should analyze and discuss the socio-economic costs associated with an historic emphasis on resource extraction, which has resulted in repetitious cycles of socio-economic distress for rural communities. When

an area is dependent upon only one or a few industries for most of its employment and income, there are often negative consequences, mostly stemming from fluctuations in the dominant industries. Limerick et al. (2002) describe Western resource-dependent communities this way:

> "In many towns, communities, settlements, and sub-regions of the West, everyone's fortune depended on the production and marketing of one commodity. Dependence on one commodity brought a particular kind of precariousness, instability, and vulnerability to external changes, whether of markets or climate. Farm towns, mining towns, cattle towns, and logging towns had no insulation from any problems that might strike the industries on which they relied."

Research has indicated that an emphasis on resource extraction results in inherently economically unstable communities. This instability in income and employment is usually a result of labor saving technological improvements and fluctuations in world resource markets -- macroeconomic forces completely outside local control. Such economic instability and lack of local control can be expected if agencies are successful promoting rapid oil and gas development. Communities have little control over the local economy because they have absolutely no control over global commodity prices. When prices drop, companies abandon wells, lay off workers, and leave the communities high and dry to suffer the economic and environmental consequences.

The extractive industries, including oil and gas development represent an ever smaller portion of the total jobs and income in the Rocky Mountain West (see Figure 3). This is true even during the current boom. The relative importance of these industries compared to expanding industries in the professional and service sectors and those which depend on non-labor income must be acknowledged in the NEPA and planning process for public land management.



Source: US Department of Commerce. Bureau of Economic Analysis (http://www.bea.doc.gov)
Note: The figure is based on SIC data for 1969-2000 and NAICS data for 2001-2003 in order to show the long-term trend. While not explicitly compatible, the two classification systems show similar trends for extractive industry income and employment and illustrate the general downward trend, even during the current oil and gas drilling boom in the Rockies.

Figure 3. Extractive Industry Income and Employment in the Rocky Mountain Region

Several studies have examined the problem of poverty in rural areas which are dependent on the extraction of only one or a few natural resources for most of their economic activity. As Freudenburg and

Gramling (1994) point out, "At the regional level, the highest levels of long-term poverty in the United States... tend to be found in the very places that were once the sites of thriving extractive industries..." They point out that the problem of poverty in these resource-dependent regions is not limited to the times of lower or zero production, but also occurs during the active operations of the extractive industry. Resource extractive workers find themselves in a vicious cycle of relatively high paying jobs with frequent layoffs and unemployment. This cycle is what Freudenburg (1992) calls the "intermittent positive reinforcement regime." While resource extractive workers develop high skills, such skills are not readily transferable to other jobs, and the workers become overspecialized (Freudenburg and Gramling, 1994). These areas attract resource extraction industries, often to the exclusion of other industries. Investment in education and job retraining is low because "the potential return on their investment in their education is either too low or too uncertain to justify sacrifice" (Humphrey et al. 1993). The resultant pattern of "rational under-investment" in the development of skills and other forms of human capital can result in reduced economic competitiveness in resource-dependent communities.

Economic instability is of concern to community leaders because if a local economy is unstable, economic development plans are more likely to fail. The economic instability created in the "boom and bust" economies associated with resource extraction increases the risk for capital investment in linked industries. As such, resource specialization and the resulting economic instability can prevent the formation of forward and backward economic linkages in the local and regional economy. After examining the less desirable aspects of the wood products industry Fortmann et al. (1989) concluded:

> Disincentives for stable employment, preferences for younger and cheaper labor that leave the less mobile and less trainable older worker out of work, cycles of market activity that carry with them high rates of unemployment, injury and illness rates and fatality rates that top all other employment categories are not attributes of a stabilizing industry, no matter how stability is defined.

Similar socio-economic patterns are associated with the oil and gas industry. Smith (1986), examining the boom and bust phenomenon in oil and gas extraction, points out that high prices for oil in the late 1970's led to an increase in drilling, but there was no corresponding increase in production during the same period. He speculates about the reason for this: "Drilling in some states may have been extended into marginal areas under very optimistic price expectations, and such operations had to be abandoned when prices were no longer adequate." These sorts of activities lead to the classic boom and bust economic cycle typical of many rural resource-dependent areas. "Those states that showed the largest rate of growth in oil and gas extraction during 1972-81 tended to have the largest rate of decline in the post 1981 period." There is every reason to expect that the current boom will eventually lead to a similar bust. See also Goldsmith (1992) and Guilliford (1989) for further research examining the socio-economic costs to communities associated with an economy focused on oil and gas drilling.

Continued emphasis on export activities, if left unchallenged, will only insure future cycles of socio-economic distress in rural communities in the West, especially in isolated Western communities The impacts on local economic diversity, the socio-economic risks to communities from cycles of boom and bust, as well as the economic instability associated with oil and gas development, must be analyzed and addressed as part of the NEPA process.

F. Estimate and Evaluate the Environmental Costs of Oil and Gas Development

The environmental costs of drilling include erosion, loss of wildlife and fish habitat, declines in the quality of recreational opportunities, proliferation of noxious weeds, and increased air and water pollution. These costs increase with the scale and speed of oil and gas operations. Environmental impacts can be mitigated with the implementation and enforcement of lease stipulations and monitoring of impacts throughout the project's life. Proper monitoring of the environmental impacts of oil and gas and other development programs require that accurate and complete data be collected and used.

1. Water Impacts

One of the major environmental costs associated with oil and gas drilling is increased water pollution. Oil and gas drilling will have impacts on the amount of water available for other uses and the displacement of large volumes of water - *quantity* impacts, as well as *quality* impacts resulting from the discharge of pollutants and from the increased levels of pollutants resulting indirectly from quantity changes.

a) Water quantity impacts

Accelerated drilling activity for coalbed methane is having profound real life impacts on many families and communities in the West. In order to release the natural gas from coal beds, enormous amounts of ground water must be pumped from coal aquifers to the surface. While all oil and gas operations result in produced water, the amount of water produced from individual coalbed methane wells is generally much higher than that from other types of oil and gas wells (USGS, 1995). Coalbed methane wells in Wyoming and Colorado discharge between 20,000 to 40,000 gallons per day per well (Darin, 2000). The disposal of the produced water not only affects the economics of development, but also poses serious environmental concerns.

The total amount of water discharged from CBM wells in Wyoming alone has skyrocketed in recent years, increasing from approximately 43.5 million gallons (134 acre feet) in 1990, to 18 billion gallons (56,000 acre feet) in 2005 (Wyoming Oil and Gas Conservation Commission, 2006). The discharging of 56,000 acre feet of water in the arid West is wasteful in the short-term (generally an acre-foot of water will supply a family of four for one year), and has potentially devastating economic impacts for affected communities in the long-term. Dewatering of deep aquifers may upset the hydrologic balance, eliminating or reducing the availability of this water for future agricultural and domestic uses, and impacting the recharge of shallow aquifers and surface water.

The discharge of ground water can deplete freshwater aquifers, lower the water table, and dry up the drinking and irrigation water wells of homeowners and agricultural users. The short-term economic costs include drilling new wells for current and future landowners, when successful wells can be found, and the costs of acquiring new water sources when they cannot. If the freshwater aquifers do not fully re-charge, the long-term economic costs to affected landowners, homeowners, communities, and states across the West could be severe, including the foregone opportunity (option value) to use aquifer water in the future. The expected costs of these damages must be accounted for in the analysis.

The discharge of tens of thousands of gallons of ground water transforms many streams that normally flow intermittently (only during spring runoff or after storms) into all-season streams. The influx of water has resulted in deep channel scouring, erosion, and increased sedimentation. Increased sedimentation in streams can negatively impact native fisheries. This in turn increases the financial costs for fishery restoration projects. The altered water flows from surface discharge of produced water will negatively impact thermal and flow regimes, and likely contribute to bank erosion and changes in riparian vegetation (Allan, 2002). Gore (2002) warned that the loss of habitat caused by increased water flows from discharged water at coalbed methane projects could eliminate up to 30 aquatic species within 20 years.

The discharge of water into intermittent stream channels damages native flora and fauna not adapted to year-round water and promotes the spread of noxious weeds such as Scotch burr and Canadian thistle. The change in native vegetation composition, combined with the increase in noxious weeds, negatively impacts threatened and endangered species and other wildlife, along with cattle production. The loss of native species and the spread of noxious weeds across the West has enormous economic costs to both public and private interests.

The landscape is also impacted from the retaining ponds or reservoirs constructed to store the water discharged from the drilling operation. The constructed earthen dams and retaining ponds destroy additional habitat and introduce artificial structures to the landscape. Habitat and homes on property near these reservoirs also face the potential risk of flooding from structural failure.

When proposing oil and gas development, the agency must fully examine and account for the risks and costs associated with water depletion, loss of native fisheries and fisheries restoration, the additional costs of noxious weed mitigation, and the costs associated with the building and potential failure of artificial water retention structures.

b) Water quality impacts

Trout Unlimited recently published a literature review of the impacts of oil and gas development and exploration on coldwater fisheries (Trout Unlimited, 2004). The findings of the report conclude that many of the studies reviewed "point towards confirmed deleterious effects caused by gas and oil exploration and development." One study found that the allowable discharge level in most states were far too high, 400 times that recommended by the EPA, and produced significant physical and toxic effects on trout in Wyoming. The Trout Unlimited study supports the conclusion that oil and gas development results in substantial negative effects on water and the wildlife that depends on it for survival.

The water discharged from oil and gas wells can be highly saline with a very high sodium absorption ratio (SAR) – a ratio that affects how water interacts with soil. Water with a high SAR can permanently change chemical composition of soils, reducing soil, air, and water permeability and thereby decreasing productivity of both native plants and irrigated crops.

Oil and gas drilling and production can also lead to increased sedimentation of water bodies, which in turn is harmful to aquatic species. According to Clement (2002), referring to proposed coalbed methane development in the Powder River Basin:

> "Increased sedimentation resulting from erosion of stream banks, overland flow, and road construction will likely impact aquatic organisms... Input of sediments to aquatic ecosystems is widely regarded as a major source of stream degradation in North America."

And finally, drilling for oil involves ecological risks and potential economic costs associated with blowouts -- the catastrophic surge of the highly pressurized fluid from the drill hole that can cause fires, loss of life and property, and the potential contamination of surface drinking water sources. To reduce the number of blowouts, rotary drilling operations typically inject a fluid of drilling muds into the drill hole in order to lubricate and cool the drill bit. While reducing the number of blowouts, the drilling fluids themselves create the risk of contamination of adjacent freshwater aquifers (Gauthier-Warinner, 2000). Recently, the New Mexico Oil Conservation Division (OCD) compiled and posted on its website information regarding groundwater impacts from leaks, spills and releases resulting from oil and gas operations. Although this data does not include all such impacts or all sources associated with oil and gas development and operations it illustrates the nature and extent of the potential for water contamination from oil and gas drilling. There are close to 1400 groundwater contamination instances in the OCD's database that are attributed to oil and gas activities.

We formally request that all of the potential impacts on and risks to water quality from oil and gas be fully analyzed and that the costs of these impacts be included in the NEPA analysis for oil and gas development.

2. Oil and Gas Footprint

Oil and gas drilling operations leave behind a large footprint on the landscape – a footprint that extends well beyond the several-acre drilling sites. Beginning with exploratory activities, large trucks with seismic surveying equipment crisscross the landscape using a crude system of roads. These roads are made to the lowest standards possible in order to minimize the financial costs of gathering geophysical information, with little consideration for wetlands, fragile soils, storm water runoff or critical habitat. Exploratory drilling operations then require more large trucks with drill rigs using a network of constructed roads to access drill sites. If the exploratory well is determined to have no potential for production, the well is plugged, but the landscape scars

remain. If producible resources are found more wells, along with the attendant roads and pipelines will follow. Depending on the agency with oversight, there is typically little enforcement or monitoring of environmental regulations. In addition, no surety bonds are required for restoration or clean up. All of these factors create a footprint that extends beyond the drill-pad and the costs associated with this extended zone of impacts must be accounted for in agency analyses of oil and gas development.

a) Well spacing and actual well numbers

States usually have general rules setting default minimum spacing requirements between producing wells. They are set to establish the maximum area of an oil or gas deposit that can be efficiently drained with one well. In most cases the operator can petition for a reduction in well spacing if they can show that such spacing changes will result in more efficient production. Well spacing limits apply to each formation, meaning that if formations overlap, more well pads may be established on the surface than might be indicated by the stated spacing limits. The spacing limits do not include dry holes, only producing wells.

When a well is drilled it is unknown whether it will eventually produce oil or gas, or whether it will be a dry hole. If the well has potential for production, the well is cased with pipe and cemented (in an attempt to prevent oil and gas from seeping into nearby aquifers), and the drilling rig is replaced by a well head or pump jack. Electric or gas powered motors are used to power the pumps that collect the gas at each well and to power the series of compressor stations that pressurize gas for pipeline transport from the wells to customers in distant markets (WORC, 1999). These compressors run 24-hours a day. Furthermore, additional wells are usually drilling in the immediate vicinity when a producing well is discovered. All of these activities create a cumulative impact on wildlife habitat, air quality, water quality, and noise levels that goes beyond the immediate footprint of development.

Many drill sites also involve the construction of sediment ponds and retention reservoirs to collect storm water drainage and store the ground water brought to the surface as a result of the drilling and extraction operation. Injection wells are sometimes used to dispose of the water produced and to enhance oil and gas recovery – an action that may necessitate additional drilling of up to hundreds of injection wells throughout the field (Gauthier-Warinner 2000). The ecological footprint not only extends across the landscape, it also penetrates to shallow aquifers as well as aquifers thousands of feet below the earth's surface.

Exploiting the gas in unconventional, tight sands deposits will require drilling a significant number of wells, as the distribution of these resources is not well understood. Extracting this tight sands gas may require 5 or 10 acre spacing, which has been proposed in the Jonah field in Wyoming. As noted by the USGS (1996), "...**land-use planners are not in a good position to determine the societal impacts of the drilling (density) that would be necessary if these continuous reservoirs of (tight) gas were exploited** (emphasis added)."

In order to estimate the full extent of surface disturbance, the agency must correctly account for potential decreases in spacing limits, success rates for both exploratory and development wells, and estimate the cumulative environmental and economic impact of all wells drilled and all well pads established on the surface. The agency must fully examine the environmental impacts from the footprint associated with oil and gas development and include the pipelines, roads, and other oil and gas infrastructure and the impacts on the landscape from this development.

We formally request that the agency provide an accurate estimate of the numbers of producing wells, dry holes, and injection wells. We request that the cumulative impacts of all wells and associated roads, pipelines and other infrastructure be analyzed fully as part of the NEPA process.

b) Pace of development

The pace at which an oil or gas field is developed will influence the extent of the oil and gas footprint. When drilling is phased to take place over a longer period of time, the impact of concurrent drilling operations

can be lessened, and dry holes and wells that stop producing can be reclaimed before beginning new well drilling. When drilling is pushed through in a short period of time the total area impacted is much larger. Rapid development also intensifies the socio-economic impacts which accompany drilling. More wells being drilled at once mean more workers moving into an area at the same time. If development is staged the community will be better able to absorb them, reducing the need for accelerated infrastructure upgrades. Phased development will also prevent the rapid economic swings associated with the boom and bust cycle typical of the oil and gas industry.

We formally request that the agency require phased development of oil and gas resources on public lands, and that the costs associated with rapid versus phased development be fully analyzed and compared as part of the NEPA process.

c) Impacts on wildlife

The impacts of oil and gas development extend beyond the footprint of development (Trombulak and Frissell 2000, Lyon and Christensen 2002, Lutz et al. 2003, WGFD 2004, Sawyer 2005). It is insufficient to simply indicate the percentage of the planning area that will be impacted by drilling. The analysis must estimate the percentage of critical wildlife habitat that will be directly and indirectly impacted. These estimates must include measures of the direct fragmentation of wildlife habitat, the indirect impacts, and not just the footprint. In addition to their direct effects (such as immediate landscape disturbance and habitat fragmentation), motorized routes also have negative impacts on wildlife such as noise, dust, air pollution, water pollution, erosion, and human presence that extend beyond the immediately disturbed area. Road densities as low as one percent or less of a given landscape can impact more than 99 percent of that landscape, leaving little undisturbed area in which wildlife can thrive. (Weller, et al., 2002; Hartley, et. al, 2003, Thomson, et. al, 2004; Thomson, et al., 2005).

Lease stipulations help protect wildlife but only if they are required and enforced, and data from the Bureau of Land Management and other sources indicate that they are not (GAO 2005). In the Rocky Mountain West, where hunting, fishing, and wildlife viewing generated $5.9 billion in revenue in 2001 (U.S. FWS and U.S. Census Bureau 2001). Drilling (and its direct impacts on wildlife and their habitat) has hidden economic costs in terms of lost revenues from license fees, equipment sales, and other related purchases. See Morton et al. (2002), Weller, et al,(2002), Hartley, et. a,(2003), Morton et al. (2004), Thomson, et. al, (2004,) and Thomson, et al (2005).

Wildlife habitat fragmentation results in both market and non-market costs. These costs must be analyzed as part of the NEPA process for oil and gas development.

d) Pipelines

In order to bring gas to market, thousands of miles of pipeline must be constructed – extending the impacts of gas drilling far from the actual drill site. There are currently more than 270,000 miles of gas transmission pipelines and another 952,000 miles of gas distribution lines. The cumulative costs and environmental impacts associated with pipeline construction must be included in the agency analysis – because drilling wells and building pipelines are connected actions.

The environmental costs associated with construction, maintenance, and repair of pipelines, as well as the costs of the habitat fragmentation due to pipelines must be examined as part of the NEPA process for and oil and gas development.

e) Roads

Oil and gas exploration also requires roads which increase ecological costs and invite cross-country travel and subsequent habitat damage. Oil and gas drilling and production often require daily vehicular trips to

monitor and maintain wells and pipelines. The increased traffic disrupts wildlife, may result in more road kill, and diminishes quality of life for local residents. Road construction degrades habitat and fragments travel corridors needed by wildlife species. Roads become conduits for non-native species that displace native species resulting in significant mitigation costs for taxpayers.

Proliferation of roads increases ORV use and thus the costs of the ecological and habitat damage associated with motorized recreation. Increased access and use by ORV-riders leads to increased ORV monitoring and enforcement costs. Roads, by providing access, may increase the frequency of human-caused fires. Humans caused sixty percent of all wildfires in the Rocky Mountains between 2001 and 2005 (National Interagency Fire Center, 2006). Furthermore, Forest Service statistics show that eighty-six percent of human-caused fires occurred in roaded areas (USDA Forest Service, 2000). Roads increase the damage to historical, cultural and archeological resources due to increased ease of access. Roads increase sediment deposits in streams resulting in reductions in fish habitat productivity. Roadless areas protect communities from sedimentation of water supplies and catastrophic events such as landslides.

The agency also needs to analyze the costs of road maintenance and restoration and compare these costs with the budgets available to complete the work. Each new mile of road added to the public lands transportation system competes for limited road maintenance funding. The Forest Service has a 10 billion dollar backlog of road maintenance projects and additional roads on public lands will only increase this backlog unless adequate funding is assured (Taxpayers for Common Sense, 2004).

The costs associated with the ecological damage due to oil and gas roads must be included in the analysis of plan alternatives involving oil and gas drilling and oil and gas projects. The agency must also include a detailed analysis of the costs associated with monitoring and enforcement of increased recreation use of expanded road mileage as part of the NEPA analysis. The costs for road maintenance must also be accounted for in the NEPA process.

G. Correctly Account for Budget Constraints and Fiscal Realities

1. Environmental mitigation costs must be estimated and included in NEPA analysis

The NEPA analysis should be based on reasonable budget expectations, which should be clearly stated. Successful organizations can rarely afford to ignore budgets when developing long-term plans. Without adequate funding, the mitigation plans and resource protection described in management plans will not be attainable. Rather than presenting the maximum production potential of public lands unconstrained by budgets, the agency should present the public with a more accurate picture of what can actually be accomplished given expected appropriations. Williams (1998) says, "policy is the effective result of 'what is intended' and 'what actually happens.'" What actually happens will depend on the budge available to achieve what is intended.

The agency must include a fiscal analysis of each alternative's implementation and mitigation costs. We are especially concerned with a potential lack of analysis of the costs to mitigate the environmental consequences of each alternative. Ignoring budget constraints is completely unrealistic and somewhat deceiving to the public, because the ability to achieve the levels of resource protection and damage mitigation described in each alternative will depend on the agency's budget. While the budget available to manage the planning area should be considered constant across alternatives, the costs to implement each management alternative are not equal. For example, an alternative resulting in resource damage will require more money to mitigate this damage than a less damaging alternative. It makes no sense for taxpayers to subsidize a more damaging and costly alternative when a less damaging, less costly alternative is available. There is simply no justification for any assumption that funding will be sufficient to implement each alternative and that all resource damage will be fully mitigated – unless costs and budgets are fully analyzed.

According to a Council of Environmental Quality memorandum on NEPA requirements [cited in NEPA Compliance Manual, 2nd Edition (Freeman, et al. 1994)]:

> [T]o ensure that environmental effects of a proposed action are fairly assessed, the probability of the mitigation measure being implemented must also be discussed. Thus the EIS and the Record of Decision should indicate the likelihood that such measures will be adopted or enforced by the responsible agencies. (Section 1502.16(h), and 1505.2)

The "probability of mitigation measures being implemented" is directly related to how much the mitigation will cost and how those costs relate to the expected budget available. The U.S. General Accounting Office (1992) reviewed federal land management budgets and found that the funding received by public land management agencies has been significantly less than the budgets required to fully implement plans. The lower-than-planned budgets have prevented public agencies from producing many of the outputs projected in land management plans, and implementing mitigation measures promised in NEPA documents (Morton 1997).

2. Bonding requirements for industry must be estimated and included in NEPA analysis

As part of the fiscal analysis of the plan alternatives, the agency must also realistically assess the bonding needs for the oil and gas development proposed. Operators must be required to post adequate bonds to ensure that acceptable reclamation and remediation are conducted. Insufficient bonds will increase the costs of reclamation for taxpayers and/or reduce the likelihood that reclamation will be adequate.

In order to fully comply with NEPA, the agency must include an analysis of the costs of implementing each alternative, which includes the costs of the mitigation plans contained within each alternative. These costs must then be compared to the expected budget level to assess the probability of mitigation measures being fully implemented. The agency should therefore, as part of the NEPA process, include a reasonable budget limitation and evaluate a set of management alternatives that are constrained by that budget level. The agency must require adequate funding from oil and gas operators (in the form of reclamation bond) to insure that the reclamation is complete and adequate.

3.The cost of enforcement of environmental protection and mitigation requirements must be estimated and included in NEPA analysis

Additional costs are associated with the inability of agency enforcement staff to adequately inspect oil and gas wells and associated facilities for violations of applicable laws and to enforce requirements for protection and restoration of the area. A recent report by the Western Organization of Resource Councils (2005) found that:

- agency enforcement staff levels have not kept pace with the rapid expansion of oil and gas development;
- oil and gas wells and associated facilities are not inspected often enough;
- agency environmental compliance inspectors spend too much time on other activities;
- agencies take too few enforcement actions; and
- citizen complaints are often ignored.

The Government Accountability Office (2005) also found a similar lack of resources for monitoring and enforcement of oil and gas development and attributed this lack to an unbalanced emphasis on processing permits to drill. The resulting costs are evidenced in the impact on the ecosystem.

The agency must assess the adequacy of funding and staffing to achieve the required environmental and safety enforcement for an oil and gas development. If inadequate funding and/or staff resources might prevent thorough enforcement and monitoring, this needs to be made clear and the costs associated with the additional impacts must be analyzed as part of the NEPA process.

IV. Specific Recommendations for Analysis of Social and Economic Impacts of Oil and Gas Development

These recommendations are organized to correspond with the more detailed sections above. We formally request that the NEPA analysis fully reflect and account for the following scoping comments:

A. The agency must base analyses of the impacts of oil and gas development proposals on estimates of economically recoverable resources, rather than technically recoverable resources.

We formally request that the Reasonably Foreseeable Development scenario be based on economically recoverable amounts of oil and gas, not technically recoverable oil and gas.

We formally request that estimates of jobs and income and local and state revenues be based on economically recoverable amounts of oil and gas, not technically recoverable oil and gas.

B. The plan must reflect an accurate and realistic projection of jobs and income associated with the oil and gas development proposal.

We formally request that the agency stop relying on IMPLAN and other models derived from economic base theory.

If the agency planners use IMPLAN:

The agency must fully discuss the assumptions, the shortcomings, and the risk and uncertainty due to the poor track record of the IMPLAN model in planning efforts.

We request that all data and multipliers used in the socio-economic impact analysis, including those used in IMPLAN be made public.

The model must account for non-labor income, as well as income from hunting, fishing, and recreation.

The model must also account for the fact that most drilling is completed by non-local crews.

The analysis must account for increased labor productivity and hence declining jobs per well drilled.

The agency must also complete a trend analysis of regional jobs and income – to provide a better and more complete understanding of their economic past and their economic future.

We formally request and recommend that the agency rely on trend analysis of income and employment for the counties impacted using the Economic Profile System (EPS) developed by the Sonoran Institute in cooperation with the BLM (available at http://www.sonoran.org).

C. The agency must make accurate and realistic estimates of gross and net revenues.

We requests that the agency determine all applicable Federal, state and local tax laws (including exceptions and reductions) and that these laws and regulations be used to make realistic and accurate estimates of net tax revenues from oil and gas production.

Revenue estimates must be made based on economically recoverable resources rather than technically recoverable – and must include the environmental and community costs from drilling and production.

D. The agency must Include a full accounting of the hidden economic costs from oil and gas extraction.

We request that the agency include both market and non-market costs and benefits in order to fully account for all the impacts of potential development.

E. The agency must analyze and discuss the socio-economic costs to communities associated the boom and bust cycles of oil and gas development.

We formally request that the agency estimate the costs associated with oil and gas development to private landowners as part of the NEPA process.

When estimating the benefits of an oil and gas development project the agency must show these benefits as net benefits rather than gross benefits.

The increased public service and infrastructure costs associated with expedited oil and gas development must be fully accounted for as part of the NEPA process for the current push to develop oil and gas in the West.

The impacts on local economic diversity, the socio-economic risks to communities from cycles of boom and bust, as well as the economic instability associated with oil and gas development, must be analyzed and addressed as part of the NEPA process.

A thorough plan for monitoring the socio-economic impacts of oil and gas development must be developed and implemented as part of the NEPA process and the implementation of all development and non-development alternatives.

F. The agency must fully and correctly account for the environmental costs of oil and gas development.

Impacts on water resources must be analyzed and accounted for

When proposing oil and gas development, the agency must fully examine and account for the risks and costs associated with water depletion, loss of native fisheries and fisheries restoration, the additional costs of noxious week mitigation, and the costs associated with the building and potential failure of artificial water retention.

We formally request that the impacts on water quality from oil and gas be fully analyzed and the costs of these impacts included in the NEPA process for oil and gas development.

The full extent of the footprint of oil and gas development must be analyzed and accounted for in the NEPA process

We formally request that the agency provide an accurate estimate of the numbers of both producing wells and dry holes and that the impacts of these wells be analyzed fully as part of the NEPA process.

We formally request that the agency require phased development of oil and gas resources on public lands, and that the costs associated with rapid development be fully analyzed as part of the NEPA process.

Wildlife fragmentation results in both market and non-market costs. These costs must be analyzed as part of the NEPA process for oil and gas development.

The environmental costs associated with construction, maintenance, and repair of pipelines, as well as the costs of the habitat fragmentation pipelines cause must be examined as part of the NEPA process for and oil and gas development.

Roads

The agency must include a detailed analysis of the costs associated with increased road mileage as part of the NEPA analysis.

The costs for road maintenance must be accounted for in the NEPA process.

The additional ORV monitoring and enforcement costs associated with expanded road mileage must be included in the NEPA analysis.

The agency must make a realistic estimate of the probability for enforcement of existing environmental protection

F. The agency must fully and correctly account for the environmental costs of oil and gas development.

The agency must assess the adequacy of funding and staffing to achieve the required environmental and safety enforcement for an oil and gas development. If inadequate funding and/or staff resources might prevent thorough enforcement and monitoring, this needs to be made clear and the costs associated with the additional impacts must be analyzed as part of the NEPA process.

G. The agency must correctly account for budget constraints and fiscal realities.

In order to fully comply with NEPA, the agency must include an analysis of the costs of implementing each alternative, which includes the costs of the mitigation plans contained within each alternative.

These costs must then be compared to the expected budget level to assess the probability of mitigation measures being fully implemented.

The agency should therefore, as part of the NEPA process, include a reasonable budget limitation and evaluate a set of management alternatives that are constrained by that budget level.

As part of the fiscal analysis of the plan alternatives, the agency must realistically assess the bonding needs for the oil and gas development proposed. Operators must be required to post adequate bonds to ensure that acceptable reclamation and remediation are conducted.

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FOR FURTHER INFORMATION:

Pete Morton: (303) 650-5818 ext. 105
Nada Culver: (303) 650-5818 ext. 117
Michelle Haefele: (303) 650-5818 ext. 109

THE WILDERNESS SOCIETY

ECOLOGY AND ECONOMICS RESEARCH DEPARTMENT

SOCIO-ECONOMIC FRAMEWORK FOR PUBLIC LAND MANAGEMENT PLANNING: INDICATORS FOR THE WEST'S ECONOMY

Michelle Haefele, Ph.D.
Pete Morton, Ph.D.
Nada Culver
March 2, 2006

I. PURPOSE

This brief is submitted as part of the NEPA process for this land use proposal. It is intended to identify issues that must be analyzed in the plan and offer methodologies to assist agencies responsible for analyzing the socio-economic impacts of proposed land use decisions on Western economies.

In making land use decisions, federal agencies have an obligation under the National Environmental Policy Act (NEPA) to take a "hard look" at the environmental consequences of a proposed action, and the requisite analysis "must be appropriate to the action in question." This brief presents a framework and indicators to be used in analyzing the impact of public land management proposals on the economies of Western communities. Federal agencies cannot evaluate the consequences of proposed decisions or determine how best to avoid or mitigate negative impacts without adequate data and analysis. Through the application of the methodology we have provided below, using data collected from identified sources and measuring potential impacts through key indicators, federal agencies can better fulfill their obligations to evaluate the direct, indirect, and cumulative socio-economic impacts of various alternative decisions.

II. INTRODUCTION

We have organized this paper to facilitate the identification of key issues related to the impact of federal public land decisions on Western economies, and to provide key indicators for analyzing the impacts of those decisions on the economy of the West. The first section describes the changing economy of the western region, and how public land management planners should evaluate the economic impacts of land management alternatives. Next, we present key economic indicators with which to measure the vigor of the West's economy and discuss the implications of these indicators for the selection and analysis of land management alternatives.[1] The third section presents sources of data that are readily available at the state and county level, to which land managers should refer when preparing economic analyses for public lands. Next we outline the methodology we recommend agencies use to analyze the economies of western communities, in order to fully account for information that is traditionally absent in public land management assessments. Finally we provide a detailed list of our NEPA scoping questions, including specific recommendations for analyzing economic trends and conditions affected by the proposed management decisions.

These analyses and methods provide a necessary, but by no means sufficient, framework for the evaluation of proposed land management decisions. Socio-economic impacts are only one facet of the total impact of such decisions on communities. Western federal public lands belong to all Americans, and in order to fully evaluate the merits of land management decisions a complete benefit-cost analysis, including non-market values, must be made. While the specific methods for benefit-cost analyses are beyond the scope of this brief, we expect the agency to implement benefit-cost analyses in addition to the requested socio-economic impact analyses outlined here.

III. OVERVIEW OF THE WESTERN ECONOMY

In the last 30 years, the West has evolved from a region largely focused on extractive industries into a much more diverse area with a more diversified economy (Bennett and McBeth 1998, Johnson 2001). Table 1 shows the current proportion of total personal income from resource extraction industries in the Rocky Mountains. Recent research shows that most western counties are not "resource dependent," and have instead developed diversified economies

[1] We provide examples of the statistics and data available to analyze each of the key indicators. These examples focus on the five Rocky Mountain states, but the methods and analyses presented apply to other states throughout the region. The states we focus on in this brief are: Colorado, Montana, New Mexico, Utah, and Wyoming. The Western states, especially the Rocky Mountains, are currently facing accelerated development of oil and gas on their federal public lands while at the same time realizing the potential embodied in the amenity-based economy.

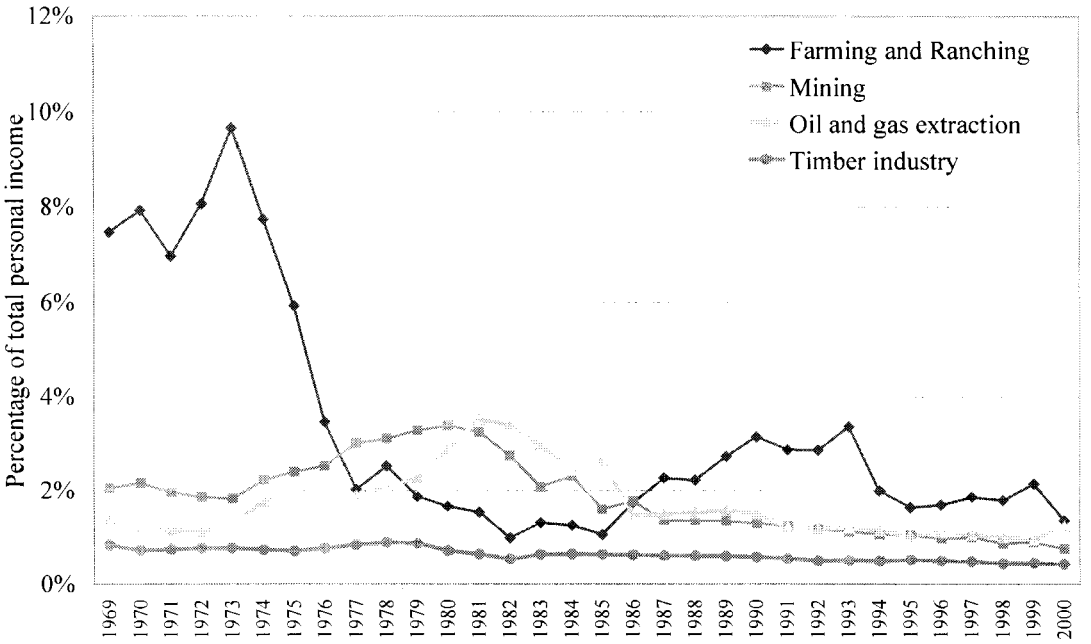
Attachment 9

based on recreation, tourism, knowledge-based industries and the service sector. A recent study examining the impact of public lands on economic well-being in 11 western states found that only 3 percent of western counties could be classified as resource-extraction dependent (Rasker et al. 2004). Figure 1 shows the 30-year trend in resource extractive industry income in the Rocky Mountain Region. Public land management decisions all too often rely on a misconception of a resource-extraction-dependent rural West. Given the changing nature of the western economy, such assumptions exclude important non-extractive economic drivers and may even harm the economy of the region in the long run by depleting the natural capital responsible for the economic growth of Western communities.

Table 1. Extractive Industry Income as a Percentage of Total Personal Income (2003)

	Colorado	Montana	New Mexico	Utah	Wyoming	Rocky Mountains
Farming and ranching	0.77%	1.19%	2.52%	0.73%	2.11%	1.14%
Mining (excluding oil and gas extraction)	0.47%	1.49%	1.41%	0.71%	6.99%	1.09%
Oil and gas extraction	0.88%	0.44%	1.10%	0.16%	2.79%	0.84%
Timber industry	0.25%	1.40%	0.19%	0.39%	0.23%	0.35%
Total extractive industry income	2.37%	4.52%	5.22%	1.99%	12.11%	3.43%

Source: Regional Economic Information System, Bureau of Economic Analysis (http://www.bea.doc.gov)



Source: Regional Economic Information System, Bureau of Economic Analysis
Farming and Ranching: "Farm proprietors' income," "Farm earnings," "Agricultural services," and "Fishing"
Timber Industry: "Forestry," "Lumber and wood products," and "Paper and allied products"
Mining: Includes all segments of Mining sector except "Oil and gas extraction"
Note: The figure is based on SIC data for 1969-2000 in order to show the long-term trend. While not explicitly compatible, NAICS data for 2001-2003 show similar trends for extractive industry income and illustrate the general downward trend, even during the current oil and gas drilling boom in the Rockies.

Figure 1. Resource Extractive Industry Income in the Rocky Mountain Region

As the economies of rural communities in the West diversify, the framework for making public land management decisions must also evolve. Merely counting jobs in resource extraction is not a sufficient way to measure the economic impact of public land management decisions. Many of these communities have diversified economies that

are no longer solely dependent on the export of fossil fuels or logs. Management plans for public lands need to account for all aspects of the economic and social systems of these communities, including recreation, tourism, and entrepreneurial businesses attracted to scenic locations, when evaluating alternatives.

There is a vast and growing body of research that indicates that the environmental amenities provided by public lands are an important economic driver in the rural West (Rudzitis and Johansen 1989; Johnson and Rasker 1993, 1995; Rasker 1994; Power 1995, 1996; Duffy-Deno 1998; Rudzitis 1999; Rasker et al. 2004; Holmes and Hecox 2004). In a letter to the President and the Governors of the western states, economists from universities and other organizations throughout the United States pointed out that, "The West's natural environment is, arguably, its greatest long-run economic strength" (Whitelaw et al. 2003).

The western United States is growing at a rate faster than any other region (U.S. Census Bureau 2001), and, counter to the norm, population growth has preceded employment growth in the rural West (Vias 1999), indicating that people migrate to the region for its amenity resources. Furthermore, counties with high levels of natural amenities (such as varied topography, access to water bodies, and a pleasant climate) are more likely to experience higher growth than those counties with fewer such amenities (McGranahan 1999). Along with that growth comes demographic change. As Shumway and Otterstrom (2001) point out, "Population change represents more than a simple redistribution of people; it is an indicator and, in many instances an instigator, of a wide range of economic, social, cultural, political/policy, and environmental changes." As more people move from urban areas to rural communities they bring with them expectations about how local public lands ought to be managed. Changing community values must be accounted for in land management planning.

Management plans for the public lands in the West must consider the increasing importance of industries and economic sectors that rely on these public lands, but not necessarily on the extraction of natural resources. As the population of the entire country grows, the presence of undeveloped lands becomes more and more important. Indeed, much recent research has concluded that the presence of protected public lands strengthen western rural economies by meeting growing needs for clean water, wildlife habitat and recreation opportunities (Power 1995, 1996; Rasker 1994; Rasker et al. 2004; Rudzitis 1999; Rudzitis and Johansen 1989; Johnson and Rasker 1993, 1995; Whitelaw et al. 2004).

IV. KEY ECONOMIC INDICATORS OF THE WEST'S ECONOMY

The West's economy is characterized by many indicators that must be considered in the economic analyses performed by land management agencies; we have selected only a few to focus on in this brief. These include the growing importance of non-labor income from investments and retirement; increasing employment in high technology, knowledge-based, and service industries; the important role that recreation and tourism plays in providing jobs and income; and the rise of small businesses and other entrepreneurial endeavors. Other features of the western economy include the decline in extractive industries, the increase in public awareness and appreciation of the environmental and recreation amenities of their home counties, and the diversification of rural economies. This section describes a concise set of indicators that land use planners should examine as part of the description of the socio-economic profile of an area, and presents example data from the Rocky Mountain states for each indicator.

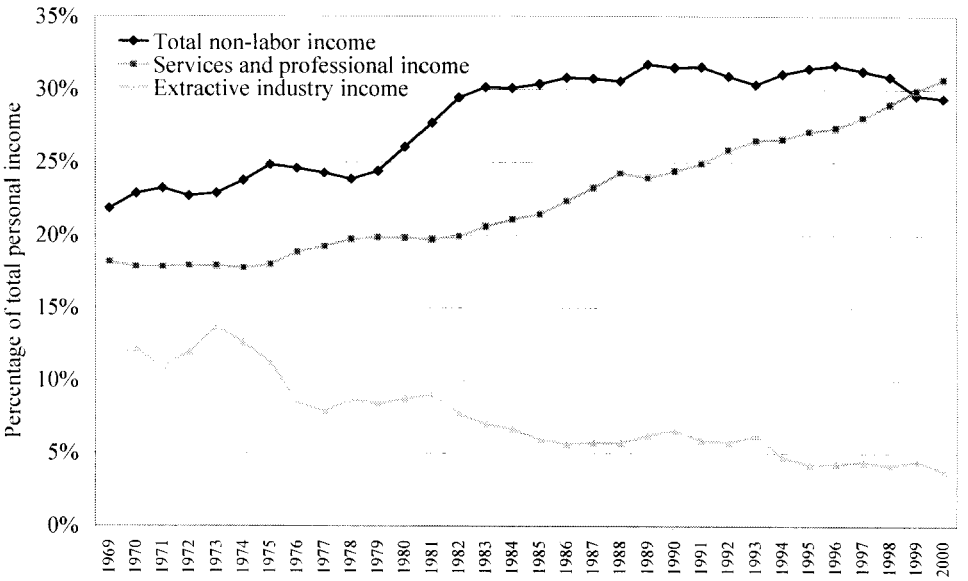
A. Non-labor income

A complete analysis of regional economic trends should include an analysis of total personal income, including all sources of income, rather than relying solely on employment. A full accounting of income is necessary to an understanding of the important role that non-labor income — such as retirement income, interest payments, rents, and profits — plays in the regional economy. Investment and retirement income makes up nearly one-quarter of total personal income in the Rockies, which would make it the top "industry" in the region. An economic impact analysis that excludes this income is inadequate and misleading.

Researchers have found that areas with high levels of natural amenities attract residents, many of whom rely on non-traditional sources of income (Duffy-Deno 1998, Nelson 1999, McGranahan 1999, Rudzitis 1999, Shumway and Otterstrom 2001, Lorah and Southwick 2003). When an investor living in a community receives dividends on his or her investments, that money represents an influx of income for the local community. The same thing is true of a retiree's

income. Due to the high levels of natural amenities in the coastal and mountain regions of the West, these non-labor sources of income are concentrated in those areas (Nelson 1999).

An influx of retirees in those rural communities has been shown to have positive effects on both income and employment (Deller 1995), with non-labor income fueling increases in income and employment for many other sectors including health, financial and real estate services. Figure 2 shows the trend in total personal income for the five-state Rocky Mountain region. Service sector income has been rising in recent years while extractive industry income has fallen. Non-labor income makes up the largest proportion of total personal income.



Source: Regional Economic Information System, Bureau of Economic Analsyis, US Department of Commerce
Extractive industries: "Farm proprietors' income," "Farm earnings," "Agricultural services, forestry, fishing," "Mining," "Lumber and wood products," and "Paper and allied products"
Service and professional: "Services," "Eating and drinking places," and "Finance, insurance, and real estate"
Note: The figure is based on SIC data for 1969-2000 in order to show the long-term trend. While not explicitly compatible, NAICS data for 2001-2003 show similar trends for non-labor, service and professional, and extractive industry income.

Figure 2. Total Personal Income in the Rocky Mountains

Table 2. Non-labor income as a percentage of total personal income (2003)

	Colorado	Montana	New Mexico	Utah	Wyoming	Rocky Mountain Region
Investment income [a]	17%	19%	15%	15%	23%	16%
Retirement income [b]	6%	11%	10%	7%	9%	7%
Income support [c]	3%	4%	7%	3%	3%	4%
Other [d]	0.7%	1.1%	1.4%	1.1%	0.8%	0.9%
All non-labor income	26%	35%	33%	26%	36%	28%

Source: Regional Economic Information System, Bureau of Economic Analysis (http://www.bea.doc.gov)

[a] Dividends, interest, and rent

[b] Includes veterans' benefits, military benefits, and Medicare

[c] Income Maintenance, Supplemental Security Income, Family Assistance, Food Stamps, Medicaid, Unemployment

[d] Includes federal education and training assistance, settlements between individuals and businesses and transfer payments from non-profit institutions

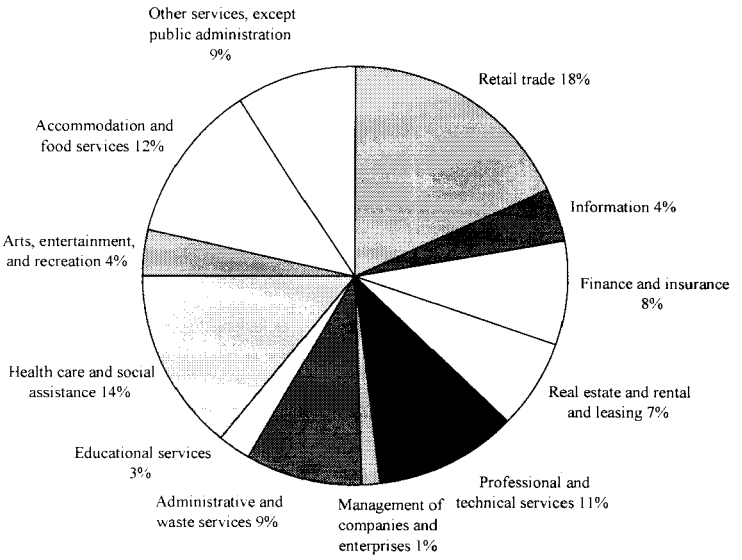
It should be noted that non-labor income also includes income support payments such as Medicaid, welfare and unemployment. However this category is consistently a small portion of total non-labor income and therefore a small portion of total personal income. Income support is less than 4 percent of total personal income and only 14 percent of non-labor income in the Rockies. It is important for a complete analysis of non-labor income to make a distinction between income support and other forms of non-labor income. Table 2 shows non-labor income, broken into its components as a percentage of total personal income for the five Rocky Mountain States. Investment and retirement income is the largest portion of non-labor income for each state, while income support reflects a much smaller portion.

A complete analysis of an area's economy must consider non-labor income, and a thorough evaluation of land management alternatives must consider the impacts of each alternative on non-labor income.

B. Knowledge-Based, Service Sector and Other Non-Recreation Businesses

Bennett and McBeth (1998) cite the emergence of a trend toward increasing western rural populations as early as the 1970s and state that this trend was partly motivated by the high quality of life in these areas. Johnson (2001) points out the importance of technology in this transition. He credits the advancement of technology with both the downward trend in extractive employment (where improved technology results in reduced labor requirements) and the potential (currently being realized in many communities) for economic growth and stability. Johnson points out that improving technology, especially in information and communication, also mitigates the constraints imposed by remoteness and permits employment in knowledge-based and service industries previously unavailable for rural residents.

Many of the counties in the Rocky Mountain West with economies that are characterized by a predominance of service industries have the highest incomes (Shumway and Otterstrom 2001). Over the past quarter-century, the U.S. economy has seen a shift from extractive and primary manufacturing industries to service oriented businesses. A common misconception about the service sector is that it includes only low paying jobs. This is not the case. The service sector in the West includes several high-paying industries, many of which are linked closely with the increase in non-labor income. Employment and income in the health care services increase as the number of retirees in an area increases. As people with investment income move into a region, the demand for financial, insurance, and real-estate service also increases.



Source: Regional Economic Information System, Bureau of Economic Analysis (http: www.bea.doc.gov)

Figure 3. Service and Professional Employment in the Rocky Mountains (2003)

The service sector includes occupations and industries that are classified as "knowledge based," defined by Henderson and Abraham (2004):

> "Knowledge-based activities emerge from an intangible resource that enables workers to use existing facts and understandings to generate new ideas. These ideas produce innovations that lead to increased productivity, new products and services, and economic growth."

Knowledge-based occupations have grown nationwide since 1980, with growth in the Rocky Mountain region being among the highest (Henderson and Abraham 2004). Local amenities that enhance quality of life are among the factors correlated with this growth. Other factors contributing to the growth of knowledge-based occupations are a high quality workforce, colleges and universities, infrastructure in the area, and the size and diversity of the local economy. These factors are likely to be interrelated and in many cases dependent on the quality of the environment and the availability of public lands, as cities and counties in the region leverage scenic amenities to attract high quality workers and knowledge-based industries. Other research confirms the role that amenities, including environmental and recreational amenities, play in attracting businesses to locations in the rural Rocky Mountain West (Whitelaw and Niemi 1989; Johnson and Rasker 1993, 1995). The most recent income data available from the Bureau of Economic Analysis (BEA) include a category called "information," which captures a good deal of the new knowledge-based industry. Land management decision makers should take advantage of these expanded industry classification categories when analyzing the potential impacts of public land management on the diverse economies of western counties.

A complete analysis of an area's economy must take into account the growth in income and employment in the service and professional sectors, and consider the impacts of each alternative on those sectors.

C. Recreation & Tourism

Many rural communities in the Rocky Mountain region have experienced firsthand the surge in demand for recreation experiences outdoors, especially on federal public lands. Moab, Utah is a good example. This town was once a dying mining center and is now a top destination for recreation seekers of all sorts. Other towns around the West have seen an upswing in migration and economic health as they become "discovered" by recreationists (Rasker, et al. 2003, 2004; Holmes and Hecox 2004).

A 2005 report by the Outdoor Industry Association estimates that 159 million Americans participate in outdoor recreation each year. A 2002 study by the same organization estimates annual spending on outdoor recreation at $18 billion. The public lands provide much of the open space that makes this important economic activity possible.

In 2000, the Forest Service estimated the economic impacts of their program areas. These estimates account for the impact a range of activities exerts on both income and employment. Recreation and protection programs account for a much greater economic impact than do extractive programs (Alward et al. 2003).

Table 3. Economic Significance of Forest Service Program Activities (for 1999)

	Percentage of Total Value Added (GDP)	Percentage of Total Income	Percentage of Total Wages	Percentage of Total Jobs
Recreation and Landscape Protection *Recreation, Heritage & Wilderness; Wildlife, Fish & Rare Plants; Watershed & Air Mgt; Ecosystem Mgt. Coord.; Access & Travel Mgt.*	70%	69%	71%	76%
Extraction of Commercial Resources *Range Mgt.; Forest Mgt.; Minerals & Geology Mgt.*	22%	22%	20%	17%
Other *Lands & Realty Mgt.; Fire & Aviation Mgt.; Law Enforcement; Facilities Mgt., General Admin.; S&P Forestry; R&D*	9%	9%	8%	7%

Source: Alward et al. 2003.

Quality hunting and fishing opportunities require wildlife habitat, which generally means large areas of open land. As the population grows, these are increasingly found only on the federal and other public lands. Pickton and Sikorowski (2004) estimate that the total economic impact of hunting, fishing, and wildlife-watching in Colorado at over $1.8 billion, with corresponding employment at 33,000 full-time jobs. An April 2004 report from the Center for the Study of Rural America calls wildlife recreation "rural America's newest billion-dollar industry" (Henderson 2004), with wildlife-related activities boosting tourism, spurring business growth and contributing to increased property values. The U.S. Fish and Wildlife Service and the Census Bureau jointly track participation and expenditures on wildlife-related recreation. Nationwide these activities generate $108 billion for local economies. Much of these expenditures are in the Rocky Mountain West, with hunters, anglers, and wildlife watchers spending nearly $6 billion in the five-state region alone in 2001 (U.S. FWS and U.S. Census Bureau 2001). Table 4 presents the participation in and expenditures on wildlife recreation for Colorado, Montana, New Mexico, Utah and Wyoming.

Table 4. Participation and expenditures from hunting, fishing, and wildlife-associated recreation in the Rocky Mountains (2001)

	Participation	Expenditures
Colorado	2.1 million	$2 billion
Montana	871,000	$943 million
New Mexico	884,000	$1 billion
Utah	1.1 million	$1.4 billion
Wyoming	662,000	$634 million

Source: U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2001.

A complete analysis of an area's economy must present data and analysis that fully account for the important role that tourism, recreation, hunting, and fishing play in ensuring a sustainable and diversified economy for rural western communities.

D. Entrepreneurs

All of the indicators previously discussed are related to the increasing entrepreneurial activity being experienced West-wide. Entrepreneurs in high technology and knowledge-based industries can often choose their location, and are likely to choose high-amenity locations (Rasker and Glick 1994, Snepenger et al. 1995, Johnson and Rasker 1995, Beyers and Lindahl 1996, Rasker and Hansen 2000, Low 2004, Henderson and Abraham 2004). Recreation- and tourism-oriented businesses are often founded by footloose entrepreneurs seeking to live and work in places rich in amenities. Retirees and others relying on investment income also choose amenity-rich locations that include certain businesses and services. These new migrants bring with them entrepreneurial opportunities for those who can provide the services they seek.

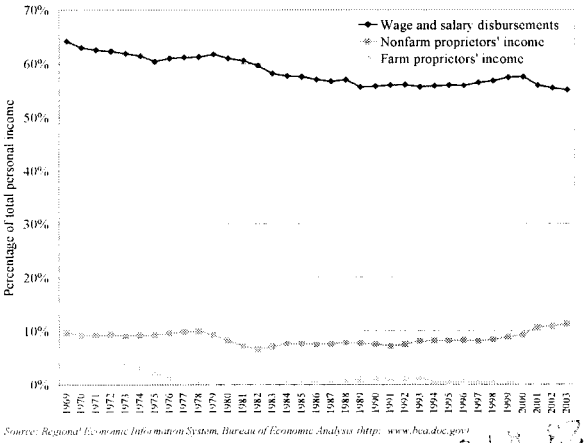


Figure 4. Rocky Mountain Personal Income by Type

Figure 4 shows personal income by type for the Rocky Mountain region. While wage and salary income is still the largest portion of total personal income, non-farm proprietors' income has shown an upturn in recent years.

As the proportion of total personal income from non-farm proprietors grows, implications for rural communities and for management of the public lands that surround them also grows. As Low (2004) points out: "Entrepreneurs create local jobs, wealth, and growth — and are themselves innovative users of other regional assets and resources." Furthermore, Low notes: "Entrepreneurs bolster a region's quality of life while promoting economic prosperity. Research has found a strong correlation between entrepreneurship and long-term regional employment growth."

Beyers and Lindahl (1996) specifically examine businesses which provide "producer services" and find these businesses are expanding rapidly in rural areas, and that most of them conduct much of their business interregionally or even internationally, bringing outside income into the rural region where they are located. These researchers also found that the decision to locate in rural areas is mostly for quality-of-life reasons, providing further evidence of the importance of such factors to local economies and the need to examine public land management activities and the potential impacts on quality of life.

A complete analysis of an area's economy must take into account the growing role of entrepreneurial businesses, and consider the impacts of each alternative on those businesses attracted by the environmental amenities provided by public lands in those communities.

E. The Role of Protected Public Lands

More and more people in the West, and all over the US, are able to choose where they live and work. Technology makes it easier for professionals to "telework" using electronic communications. Many businesses are able to conduct national or international commerce from any location they choose. Other entrepreneurs simple choose to live in a particular place and build a business in response to local needs. Retirees and others who collect non-labor income are not tied by a job to a specific location. All of these people seek an attractive place to live. More and more, as development pressures increase, public lands become a backdrop or setting which contributes to or even creates the amenities on which a community's economy will thrive and grow. Research supports the assertion that protected public lands contribute to rural economic health (Rudzitis and Johansen 1989, Rudzitis and Johnson 2000, Rasker et al. 2004).

Local communities with protected wildlands reap measurable benefits in terms of employment and personal income. For instance, the Sonoran Institute (Sonoran Institute 2004b) has found that protected lands have the greatest influence on economic growth in rural isolated counties that lack easy access to larger markets. From 1970 to 2000, real per capita income in isolated rural counties with protected land grew more than 60 percent faster than isolated counties without any protected lands.

These findings confirm earlier research showing that wilderness is in fact beneficial for local economies. Residents of counties with wilderness cite the presence of that wilderness as an important reason why they moved to the county, and long-term residents cite it as a reason they stay. Recent survey results also indicate that many firms decide to locate or stay in the West because of scenic amenities and wildlife-based recreation, both of which are strongly supported by wilderness areas (Morton 2000).

As noted by Freudenburg and Gramling (1994):

> "...it needs to be recognized as a serious empirical possibility that the future economic hope for resource-dependent communities of...the United States could have less to do with the consumption of natural resources than with their preservation."

This sentiment is reiterated by Deller et al. (2001):

> "Rural areas endowed with key natural resource amenities can manage those resources to capture growth more effectively. This may entail expansion beyond policies that have historically been focused on extraction of the resource base."

Resource managers, economic planners and community leaders must become aware of this potential. We therefore request that the NEPA process fully address the economic importance to local communities of protecting public wildlands from resource extraction.

V. SOURCES OF DATA

This section presents selected sources of economic, demographic, and recreation data.

A. Economic and Demographic Data

Data are available for several economic indicators by county from the U.S. Department of Commerce, Bureau of Economic Analysis and the U.S. Department of Labor, Bureau of Labor Statistics. The U.S. Census Bureau also tracks economic trends along with demographic trends, most by county as well. Economic profiles showing these and other trends by state, county, or groups of counties are available from the Sonoran Institute's Economic Profile System.

Federal economic and demographic data sources:

- Bureau of Economic Analysis (Department of Commerce): http://www.bea.doc.gov
  - Date on income, farm income, transfer payments, and employment for states, counties, and regions. Annual data, 1969-2000 (Standard Industry Classification) and 2001-2003 (North American Industry Classification System)
- Bureau of Labor Statistics (Department of Labor): http://www.bls.gov
  - Data on income, wage and salary, employment, unemployment rates by industry, for counties, states, and regions. Monthly data, 1990-2005
- Census Bureau (U.S. Department of Commerce): http://www.census.gov
  - Data on population, demographics, business, and economics for states and counties
- The Sonoran Institute Economic Profile System: http://www.sonoran.org
  - Generates detailed economic profiles, including trends in employment and income, farm income, economic resilience, and demographics for states, counties, or groups of counties. The companion, Economic Profile System — Community, will generate profiles to reflect just the rural or urban areas of a county.
- The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, Census Bureau): http://www.census.gov/prod/www/abs/fishing.html
  - Data at the state level on participation in and expenditures for wildlife-associated recreation

Selected state economic and demographic data sources:

- Colorado Economic and Demographic Information System: http://www.dola.state.co.us/is/cedishom.htm
- Montana Census and Economic Information Center (CEIC): http://ceic.commerce.state.mt.us/
- New Mexico Labor Market Information: http://www.dol.state.nm.us/dol_lmif.html
- New Mexico Economic Development Data Center: http://ww1.edd.state.nm.us/index.php?/data/C31/
- Utah Governor's Office of Planning and Development, Demographic and Economic Analysis: http://www.governor.utah.gov/dea/
- Wyoming Department of Administration and Information, Economic Analysis Division: http://eadiv.state.wy.us/

B. Recreation Data

Data on recreation use in the area where a land management plan is being developed is critical to making an informed decision. Surveys of users at recreation areas can be utilized to obtain information on the levels and types of

recreation use. Information on users' expenditures in the area is also important to learn the overall impact of public lands recreation. Federal land management agencies collect some data on recreation use of public lands. The Bureau of Land Management's Recreation Information Management System (RIMS) and the USDA Forests Service's National Visitor Use Monitoring System (NVUMS) are two examples.

Other information may be obtained through surveys of local residents, recreation visitors and through using existing data on the recreation and tourism revenues to local businesses, and the value of these activities to participants. The lack of complete visitation data does not justify ignoring the jobs and income from recreation. Furthermore, the Data Quality Act requires use of the best available, reliable data on all impacts and affected sectors of the economy.

The National Survey on Hunting, Fishing and Wildlife-Associated Recreation (noted above) is also a source of state-wide data on participation in wildlife recreation that should be used to supplement more specific studies for the location in question. State agencies are also a source of data on fishing and hunting and other wildlife-associated recreation.

Colorado Division of Wildlife: http://wildlife.state.co.us/index.asp
Montana Fish, Wildlife, and Parks: http://fwp.state.mt.us/default.html
New Mexico Game and Fish: http://www.wildlife.state.nm.us/index.htm
Utah Division of Wildlife Resources: http://wildlife.utah.gov/index.php
Wyoming Game and Fish: http://gf.state.wy.us/

C. Data Gaps and Other Issues

Land managers may encounter gaps in county- or state-level economic data or may notice that data series are not continuous. These are not, however, obstacles to doing a thorough and comprehensive analysis of the trends in the economies of the local area.

1. Disclosure Gaps

Some data gaps are due to disclosure restrictions. The Bureau of Economic Analysis and the Bureau of Labor Statistics will suppress data in cases where disclosing it may reveal private information about individuals. For example, if only one business represents a specific industry in a given area, any data on employment and/or income in that industry will not be publicly disclosed since it may make it possible to identify an individual's or business' private information. Disclosure suppression is more likely to be a problem in counties with small populations. The Sonoran Institute suggests several potential techniques to address the issue of data gaps due to disclosure issues. The Economic Profile System will also automatically estimate the data gaps for major industry categories. These are described in detail in the User's Manual for the EPS (Sonoran Institute 2004b.)

2. Other Data Gaps

BEA and Bureau of Labor Statistics (BLS) data are sometimes not available for certain industries and/or certain years. Other data are suppressed, but are identified as falling within a range of values. Data gaps where an "L" appears instead of a number are described as follows:

Less than 10 jobs, but the estimates for this item are included in the totals, or
Less than $50,000 (for income data), but the estimates for this item are included in the totals

3. Industry Classification Using SIC and NAICS

Income and employment data from the Bureau of Economic Analysis and the Bureau of Labor Statistics for 1969-2000 are classified according to the Standard Industry Classification system (SIC), while the most recent data (2001 and forward) are classified by the North American Industry Classification System (NAICS). NAICS was developed jointly by the U.S., Canada, and Mexico in order to make statistics comparable across all three countries.

The NAICS provides greater detail for the service and professional sectors which are of growing importance in the rural West, and indeed all over the country. This classification scheme also includes some emerging industries such as "information" which includes the growing Internet and information phenomenon. The Bureau of Economic

Analysis' Regional Economic Information System (REIS) uses SIC to classify industries and the Sonoran Institute's EPS system uses SIC data from the REIS in order to show trend analyses, along with NAICS data.

VI. RECOMMENDED METHODS FOR ANALYSIS

In general, it is inappropriate to examine a region's economy solely as a single point in time because economies are dynamic. To the extent that data are available, the economic profile of an area should be developed based on the trends in key economic indicators. This can help guide resource management by showing the likely future situation in an area and can point out periods of economic downturn. It may be instructive to look at other variables during these periods to see if there are correlations between land management activities and economic activity.

Looking at the changes in employment and income (including non-labor income) is important to understanding the overall direction in which an area's economy is moving. Trend analysis will show long-term patterns in income and employment that may be masked when looking at only a point in time. Data on employment and income are available from 1969-2000 from the BEA under the SIC system. The BEA changed to the NAICS in 2001, and reconstructed NAICS data for years prior to 2001 are not yet available. However, one can certainly look at a general picture of the economy over time by using both sets of data. This analysis should be applied to all the segments of the economy to see the long-term trends in both extractive and other industries along with non-labor income.

A lack of data on recreation activities on public lands should not be an excuse to avoid analysis of potential impacts of public land management decisions on the recreation sector. Several examples of research on recreation use, values to participants, and expenditures are available (a very limited sample includes: Fix and Loomis 1997, Chakraborty and Keith 2004, Cordell and Tarrant 2002, Kaval and Loomis 2003). Rosenberger and Loomis (2001) present a detailed bibliography of recreation valuation studies and present methods by which analysts can transfer estimates of the value of recreation in one area to other similar areas. Of course, the best way to truly understand the value of recreation in an area is to conduct a survey specifically focused on that area. At a minimum, such a survey should collect information on recreation visitation and expenditures. An estimate of the economic impacts of recreation can be made by multiplying the total number of recreation visitors in an area by the estimated expenditures per visitor day. These data should be collected and analyzed as part of a comprehensive analysis of the socio-economic impacts of land management.

VII. RECOMMENDED ANALYSES

The preceding sections of this brief have presented the key indicators that must be included in a socio-economic impact analysis, identified data sources for conducting that analysis, and provided methods for completing an analysis that more accurately reflects the West's economy. In making land-use decisions, federal agencies have an obligation under NEPA to take a "hard look" at the environmental consequences of a proposed action, and the requisite analysis "must be appropriate to the action in question." [2] The impacts and effects of a proposed action, such as oil and gas development, that federal agencies are required to assess include: "ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative."[3] Under the Data Quality Act, federal agencies are required to use information that is of high quality and that is objective, useful, and verifiable by others.[4] The agency must also use "sound statistical and research" methods.[5]

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[2] 42 U.S.C. § 4321 et seq.; *Metcalf v. Daley*, 214 F.3d 1135, 1151 (9th Cir. 2000); *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 348 (1989).

[3] 40 C.F.R. § 1508.8.

[4] Treasury and General Government Appropriations Act for Fiscal Year 2001, Pub.L.No. 106-554, § 515. *See also*, Office of Management and Budget "Information Quality Guidelines," available at http://www.whitehouse.gov/omb/inforeg/iqg_oct2002.pdf and individual "Agency Information Quality Guidelines," available at http:/www.whitehouse.gov/omb/inforeg/agency_info_quality_links.html.

[5] *Ibid.*

Federal agencies cannot evaluate the consequences of proposed decisions or determine how best to avoid or mitigate negative impacts without adequate data and analysis. NEPA's hard look at environmental consequences must be based on "accurate scientific information" of "high quality."[6] Essentially, NEPA "ensures that the agency, in reaching its decision, will have available and will carefully consider detailed information concerning significant environmental impacts."[7] The Data Quality Act and the agencies' interpreting guidance expand on this obligation, requiring that influential information or decision-making input be based on "best available science and supporting studies conducted in accordance with sound and objective scientific practices."[8]

Through the application of the methodology, key indicators and data sources we have provided, federal agencies can better fulfill their obligations to evaluate the direct, indirect, and cumulative impacts of various alternative decisions. In this section, we have provided both general recommendations on the scope of the socio-economic impact analysis that should occur and specific inquiries to be made in this analysis. Again we note that completion of the socio-economic analyses outlined in this brief is necessary but not sufficient to fully evaluate a land management decision. A thorough benefit-cost analysis is also required and expected.

We formally request that the NEPA analysis fully reflect and account for the following scoping comments:

A. The socio-economic analysis should include an analysis, graphs and discussion of historic personal income trends — including non-labor sources of income.

The analysis of regional economic impacts must include an analysis of all sources of income, including non-labor income. A full accounting of all sources of income is necessary to understand the important role that retirement and investment income — as well as other sources of non-labor income, such as interest payments, rents, and profits — play in the regional economy. An economic impact analysis that excludes non-labor income is inadequate and misleading.

- **Specific Requests and Requirements for examining the Total Personal Income and the Importance of Non-Labor Income as Part of the NEPA Process:**

For all counties in the planning area, please show the role of non-labor income in the area's economy.

- Show the percentage of current total personal income that is non-labor income (excluding income support).
  - Analyze and discuss the role that retirement and investment income currently plays in the area's economy, including the spillover effects of non-labor income on businesses in the area.
  - Analyze and discuss the role that amenities, including recreation opportunities and environmental quality, currently play in attracting and retaining non-labor income to the area.
  - Analyze and discuss the potential impacts that public land management alternatives will have on the level and trend of investment and retirement income in the area.
- Show the trend in non-labor income (again excluding income support) as a percentage of total personal income.

[6] 40 C.F.R. § 1500.1(b).
[7] *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 349 (1989).
[8] Treasury and General Government Appropriations Act for Fiscal Year 2001, Pub.L.No. 106-554, § 515. *See also*, Office of Management and Budget "Information Quality Guidelines," available at http://www.whitehouse.gov/omb/inforeg/iqg_oct2002.pdf and individual "Agency Information Quality Guidelines," available at http://www.whitehouse.gov/omb/inforeg/agency_info_quality_links.html.

B. The socio-economic analysis must include an analysis and discussion on the indirect role public lands play in the regional economy in attracting knowledge-based businesses, service sector business, recreation and tourism businesses, and other entrepreneurs.

Public wildlands often define the character of an area and are an important component of the quality of life for local residents and future generations. Their protection enables the customs and culture of western communities to continue. The socio-economic analysis also must account for these economic benefits.

A growing number of economists are recognizing that protecting the quality of the natural environment is key in attracting new residents and businesses, and that therefore the environment is the engine propelling the regional economy. A letter to President Bush from 100 economists concludes, "The West's natural environment is, arguably, its greatest, long-run economic strength... A community's ability to retain and attract workers and firms now drives its prosperity. But if a community's natural environment is degraded, it has greater difficult retaining and attracting workers and firms" (Whitelaw et. al, 2003). Given these findings, we request that, as part of the economic impact analysis of management alternatives, the socio-economic analysis fully consider the indirect role of public lands in attracting and retaining non-recreational businesses and retirees and encouraging entrepreneurial efforts.

- **Specific Requests and Requirements for Examining the Role of Protected Public Lands in the Local Economy as Part of the NEPA Process:**

For all counties in the planning area, please show the role of various industries in the area's economy.

- Show the current distribution of employment and income by industry (for each industry, show employment as a percentage of total jobs and income as a percentage of total personal income).
  - Discuss the relative importance of each industry.
  - Analyze and discuss the impacts that public land management alternatives will have on non-extractive industries if extractive activities are accelerated on public lands in the area.
- Show a complete analysis of the segments of service and professional employment and income for the area.
  - Analyze and discuss the potential impacts of land management alternatives on these sectors of the economy.
- Show trends in employment and income by industry, including a detailed examination of the service and professional sectors.
  - Discuss the level of diversity in the region's economy. Discuss trends in income and employment that have led to the current mix of industries
  - Analyze and discuss the potential impacts of public lands management alternatives on the overall makeup of the economy of the area.
- Show trends in non-farm proprietor's income as a percentage of total personal income for the area.
  - Collect data on the various sectors that make up non-farm proprietors. Analyze the sectors where entrepreneurship is growing.
  - Analyze and discuss the factors that have attracted new businesses to the area.
  - Analyze and discuss the potential impacts that public land management alternatives will have on these sectors and the ability of proprietors to start and grow businesses.

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C. The socio-economic analysis must account for the economic importance of the recreation, hunting, and fishing that occurs on public land.

The recreation opportunities provided by wilderness-quality lands also yield direct economic benefits to local communities. The socio-economic analysis must include an analysis of the income and jobs associated with recreation, hunting and fishing from each alternative.

- **Specific Requests and Requirements for Examining the Economic Importance of Recreation, Hunting and Fishing on Public Lands as Part of the NEPA Process:**

For all counties in the planning area, show the role of recreation, hunting and fishing in the area's economy.

Collect data on participation in all recreation activities (hunting, fishing, hiking, camping, backpacking, biking, skiing, wildlife watching, boating, ORV use, etc.)

Collect data on expenditures by recreation visitors in the region.

Analyze the economic impact of hunters' and anglers' expenditures on area businesses and local economies.

Analyze the economic impact of other recreationists' expenditures on area businesses and local economies.

Show the impact of lodging taxes, sales taxes, and property taxes in the local economy.

Analyze and discuss the impact of public land management alternatives on recreation, hunting, and fishing businesses.

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FOR FURTHER INFORMATION:

Michelle Haefele: (303) 650-5818 ext. 109
Pete Morton: (303) 650-5818 ext. 105
Nada Culver: (303) 650-5818 ext. 117

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