WYOMING OUTDOOR COUNCIL

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Casper RMP/EIS
BLM Casper Field Office
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To whom it may concern:

Please accept the following comments on the Draft Resource Management Plan and Environmental Impact Statement for the Casper Field Office Planning Area (Casper RMP/EIS) on behalf of the Sierra Club and Wyoming Outdoor Council.

Executive Summary

We believe the list of things that will be sought to be achieved by the new Resource Management Plan (RMP) must be modified. Casper RMP/EIS at ES-1.[1] In addition to citing the provision in the Federal Land Policy and Management Act (FLPMA) at 43 U.S.C. § 1701(a)(12) that mandates management of the public lands for minerals, food, and fiber, the Bureau of Land Management (BLM) must also recognize the co-equal requirement also specified in FLPMA that

> the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that where appropriate will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use.

43 U.S.C. § 1701(a)(8). In addition, BLM has protective mandates pursuant to a number of environmental laws and policies that it should explicitly recognize as what is being sought to be achieved by this planning effort.[2]

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[1] Hereinafter, rather than specifying that the page number being referred to as the "Casper RMP/EIS", we will simply cite the page number. So, for example, the citation will simply be "ES-1" rather than "Casper RMP/EIS at ES-1."

[2] See, e.g., 16 U.S.C. §§ 1531(b), 1536(a)(1) (Endangered Species Act (ESA) requires BLM to further the purposes of the **ESA,** which include conservation of the ecosystems upon which endangered species

In this regard, BLM is approaching its protective obligations in negative way. See, e.g., ES-2 ("How should special status species conservation strategies be applied given BLM's requirement for multiple use and sustained yield?"). Actually, the answer to this particular question is quite simple. At least with regard to listed species, BLM's multiple use management obligations have been modified, and listed species are to receive first priority. Tennessee Valley Authority v. Hill, 98 S.Ct. 2279,2297 (1978) (Supreme Court determines that section 7 of the ESA "reveals an explicit congressional decision to require agencies to afford first priority to the declared national policy of saving endangered species."). BLM should recognize the strong protective obligations it operates under pursuant to literally dozens of laws (including FLPMA) and simply implement those commandments, not seek to diminish them based on other laws or obligations, none of which amended protective statutes like the ESA.

On page ES-2, BLM asks rhetorically, "What areas, if any, contain unique or sensitive resources requiring special management?" Part of the answer to this question can be found in FLPMA, which requires that in land use planning BLM "give priority to the designation and protection of areas of critical environmental concern." 43 U.S.C. § 1712(c)(3) (emphasis added). Thus, BLM's command under FLPMA is to give priority to designating areas of critical environmental concern (ACEC); this is the type of special management for unique or sensitive resources that must be given emphasis (priority) in the planning process. Emphasizing other forms special management to protect unique or sensitive resources simply does not comply with the direction in FLPMA. As will be discussed below, BLM has failed to meet this obligation.

BLM states that it will "comply" with FLPMA, the National Environmental Policy Act (NEPA), and other laws. ES-2. We believe BLM must also ensure that it complies with the intent of these laws, and does not simply meet bare legal requirements. Specifically, we believe that BLM must fully comply with the policies of NEPA and its ends, which are specified in sections 101 and 102(1) of NEPA. 42 U.S.C. §§ 4331(a)-(b), 4332(1). While it has become popular to claim that NEPA is merely procedural, in fact BLM is legally obligated to meet the requirements of sections 101 and 102(1). 40 C.F.R. §§ 1500.1(c) (NEPA is intended to make public officials "take actions that protect, restore, and enhance the environment"), 1500.2(a) (federal agencies are to act "in accordance with the policies set forth in [NEPA]"), 1500.2(f) (federal agencies are to "Use all practicable means . . . to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions"), 1502.1 (the primary purpose of an EIS is to infuse the policies and goals of NEPA into programs and actions of the Federal government), 1502.1(d) (an EIS must state how it and decisions based on it "will or will not achieve the requirements of sections 101 and 102(1) of [NEPA]") (emphasis added). See also 42 U.S.C. § 4332(1) (Congress directs that "to the fullest

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depend); 42 U.S.C. §§ 7401(b)(1), 7470(2) (purposes of the Clean Air Act (CAA) include promoting public health and welfare and the preservation, protection, and enhancement of air quality in protected areas and other areas with special value); 33 U.S.C. §§ 1251(a), 1251(a)(1)-(3) (the objective of the Clean Water Act is to restore the chemical, physical, and biological integrity of the Nation's waters, and it establishes goals for zero discharge of pollutants and protection of fish and wildlife).

extent possible" actions of federal agencies under the laws of the United States "shall be interpreted and administered in accordance with the policies set forth in this chapter."). Consequently, we believe BLM must reveal in the EIS how the proposed land use plan will comply with the requirements established in section 101 of NEPA, including, for example, the requirement to "preserve important historical, cultural, and natural aspects of our national heritage." 42 U.S.C. § 4331(b)(4). The draft EIS fails to do this in any explicit fashion. Likewise, BLM must ensure it complies with the policies established by FLPMA, including, as mentioned above, the requirement to ensure its management actions protect the natural qualities of the public lands under consideration here. 43 U.S.C. § 1701(a)(8).

Purpose and Need for Action—Chapter 1

The purpose for the revision of the Platte River RMP (now the Casper RMP) is stated on page 1-4. Again, and as noted above, the purpose is selectively defined as providing a recognition of this nation's need for minerals and food and fiber, but it pointedly leaves out other just-as-applicable purposes of this land use plan established by FLPMA, such as the need to protect environmental values. 43 U.S.C. § 1701(a)(8). This oversight must be corrected, and full and complete portrayal of the purpose of the land use plan must be presented and pursued. As noted above, in additions to pursuit of the policies established in FLPMA, these include the policies established by NEPA, the CAA, the ESA, and the Clean Water Act, among others. Until this correction is made, the purpose of this effort is improperly defined. While the purpose statement states that there is a need to "provide for compliance" with various laws, policies and regulations, this blanket statement is insufficient when BLM has singled out one particular aspect of law and policy (the need to provide minerals and food and fiber) for special mention and left all other particulars relating to environmental protection which are at least as firmly established in law and policy unmentioned and unacknowledged. This must be corrected so that BLM has a clear recognition of what the purpose of this effort is, and does not impermissibly limit the purpose.

Similarly, in the statement of need for this RMP revision, BLM attempts to make a case that this nation's fundamental policies have switched in favor of minerals development. See 1-5 ("For example, the EPCA Reauthorization of 2000, coupled with the Nation's growing demand for domestic energy, resulted in <u>different priorities</u> than were foreseen when the existing plan was established in 1985." (emphasis added)). There is no basis for this claim. NEPA, including its implementing regulations, has not been changed. FLPMA has not changed. The ESA has not changed. The CAA has not changed (if anything, it was greatly strengthened in 1990). The Clean Water Act has undergone only very minor amendment. There is no basis for claiming this nation now has different priorities than the priorities established by the laws that are in place—all of those laws. At most, legislation like the Energy Policy Act of 2005 has <u>refined</u> or <u>restated</u> the long-standing policy of allowing for leaseable minerals development on public lands, for example, but it in no way <u>trumps</u> laws like the ESA and NEPA, creating purported "different priorities." This misstatement must be corrected and the need for this project

redefined in a way that recognizes the equal applicability and relevance of all of the environmental laws of this nation.

An important stated need for the RMP revision is new data that has become available. In this regard a number of documents are cited. 1-5. Throughout these comments various scientific and other studies will be cited and are attached hereto. We ask that these scientific studies be treated as new data triggering a need for this RMP revision, and that these data be addressed in the Casper RMP/EIS.

In addition to new data, BLM also lists a number of new and revised policies that it is responding to. This list seems somewhat selective to us. For example, BLM Instruction Memorandum (IM) 2004-194, relating to the requirement to use best management practices (BMP) is not listed. We believe that it is important for BLM to ensure this list is all-inclusive, otherwise we believe there is a danger of overlooking important policies. More importantly, we want to reemphasize that even if there are number of new and revised policies in place those cannot trump, usurp, or negate long-standing policies, particularly if the long-standing policy is of a "higher order" of law. So, for example, a BLM IM (or a policy statement from the President such as his National Energy Policy developed in 2001) cannot trump an Act of Congress, such as the ESA, and court decisions interpreting such a law. We believe BLM must recognize this hierarchy of law and policy before it simply bows to "new and revised policies" as a basis for changing management direction.

Furthermore, we believe there is an important missing category of "new and revised policies," namely decisions rendered by the U.S. Courts and the Interior Board of Land Appeals (IBLA), both of which issue decisions interpreting the law that are binding on BLM. We believe that BLM must modify the list of "new and revised policies" so as to also recognize and include important court and IBLA decisions that have been rendered since the 1985 RMP. So, for example, in Kern v. U.S. Bureau of Land Management, the court determined that

> An agency may not avoid an obligation to analyze in an EIS environmental consequences that foreseeably arise from an RMP merely by saying that the consequences are unclear or will be analyzed later when an [environmental assessment] is prepared or a site-specific program proposed pursuant to the RMP. "[T]he purpose of an [EIS] is to evaluate the possibilities in light of current *and contemplated* plans and to produce an informed estimate of the environmental consequences . . . . Drafting an [EIS] necessarily involves some degree of forecasting."

284 F.3d 1062, 1072 (9th Cir. 2002) (emphasis added by court) (citation omitted). As will be discussed below, BLM in many instances in the Casper RMP/EIS has impermissibly attempted to delay environmental analysis, contrary to requirements of Kern. This emphasizes the need for BLM to ensure it is fully aware of and complies with IBLA and court decisions as it crafts this RMP. There are of course many other examples of court and IBLA decisions that have been rendered since 1985 that BLM should recognize as

creating a need for RMP revision, and which guide and define management obligations and limits. Moreover, since BLM has a large number of lawyers available to it through it's and the Department of the Interior's Solicitor offices, it has the skills and personnel at hand to locate these decisions and interpret their requirements.

On page 1-10 several "key planning issues" are identified. This list seems unduly limited. Clean water and clean air are key issues by definition under the Clean Water Act and CAA. With respect to energy development, the numerous toxic and hazardous wastes generated by these activities are certainly an important issue, especially given BLM's trust responsibilities for the health of the public lands relative to hazardous wastes under the Comprehensive Environmental Response Compensation Liability Act (CERCLA). Providing fish and wildlife habitat is an unduly foreshortened view; another key issue is also to support fish and wildlife populations that meet ecological and societal needs. Habitat without animals is an empty outcome. And as noted above, BLM's statement regarding the relative importance of special status species versus multiple use management is easily answered at least relative to listed species; listed species clearly get priority. This wording must be reworked to accurately reflect the degree of discretion that BLM has, which is little?

On pages 1-10 to 1-11 several issues that were not "carried forward for detailed study'' are listed. Several of these clearly should be addressed in the Casper RMP/EIS. BLM apparently decided it did not need to "consult, work, and coordinate with" agencies and/or other authorities. Yet under FLPMA, BLM is given special responsibility to consider and ensure consistency with local plans, 43 U.S.C. § 1712(c)(9); we do not see how it can do this if it is not consulting with these entities. BLM claims that it can be excused from analyzing "impacts from specific actions or activities" and that it can postpone these analyses to the future. Yet as noted above, at a minimum BLM must analyze "environmental consequences that foreseeably arise from an RMP" and cannot put those analyses off. Kern, 284 F.3d at 1072. BLM should make clear that impacts that foreseeably arise from the RMP will be analyzed in the EIS, and in fact conduct such analyses. Certainty is not the standard for whether an analysis will be conducted. The failure to analyze air quality impacts is an especially egregious example of BLM's failure to do this, and this will be discussed in more detail below. BLM claims it is excused from ensuring the RMP "is compatible with specific regulations, policies, mandates, guidance, or plans" and adopting or integrating such into the RMP. This is far too broad an exclusion from EIS analysis requirements for at least two reasons. First, under FLPMA, BLM must "provide for compliance" with not only pollution control laws, but also related "standards" and "implementation plans." 43 U.S.C. § 1712(c)(8). This certainly demands that pollution control requirements be subject to "detailed study in the EIS" and does not allow for them to not be carried forward. Second, as noted above, BLM is under a special obligation to consider and ensure consistency with state and local plans and other policies. Id. § 1712(c)(9). Given this obligation, it is impossible to see how BLM can legitimately refuse to consider in detail in the EIS how the RMP can be

[3] BLM's Special Status Species Management Manual establishes similar obligations relative to many species.

made compatible with "specific regulations, policies, mandates, or plans . . ." of other governmental entities.

Resource Management Alternatives—Chapter 2

On pages 2-5 to 2-6 BLM discusses the elimination from consideration of an alternative that would have required the use of directional drilling. This decision needs to be reconsidered. Specifically, while directional drilling, like almost anything else, probably cannot be required all the time, it certainly can and should be used to the maximum extent possible; it has wide applicability. Thus, we request that BLM consider as a sub-alternative to all alternatives a requirement to use direction drilling to the maximum extent possible. See 43 C.F.R. §§ 1610.4-5 (requiring all reasonable variations on an alternative to be considered as a sub-alternative). See also IM 2004-194 (identifying requiring drilling multiple wells from a single pad as a "typical" BMP that should be considered). BLM's attempt to frame the use of directional drilling as only something that can be required in every case creates a false choice that of course must be rejected; requiring the use of direction drilling to the maximum extent possible creates a real choice that should be fully considered by BLM.

BLM indicates that the reason directional drilling cannot be used is that the natural gas deposits being sought are in "deep formations with limited porosity", thus requiring fraccing to stimulate production. Yet we would note that directional drilling is being used very heavily by Shell, Ultra, Anschutz, and Questar on the Pinedale Anticline field in the Pinedale Field Office, and natural gas deposits in this area are both very deep and in formations of limited porosity. These conditions alone do not mean that the use of directional drilling is impractical, less economical, etc. We request that BLM consider the conditions that occur in the Pinedale Anticline and compare them to the likely conditions in the Casper Field Office, and make decisions regarding the viability of directional drilling accordingly. On page 2-6 BLM states that directional drilling can be eliminated from consideration because it would not meet the nation's energy needs and would not lead to maximum recovery with minimum waste. We request that BLM eliminate these self-serving and highly biased comments from the EIS. This is a totally incomplete picture and statement of the obligations BLM must meet. As discussed throughout these comments, BLM has equally binding obligations to protect the environment, and thus whether directional drilling might lead to less than absolute maximum recovery is simply not the basis for decision-making. In fact, at a minimum, the bases to decide whether to use it or not are outlined in IM 2004-194 (BLM must consider the effectiveness of the BMP, balance increased costs versus "the benefit to the public and resource values'' of requiring the BMP, the availability of other mitigation alternatives, and other factors). IM 2004-194 at 2. These are the considerations that should determine whether directional drilling will be required, not a singular focus on the amount of gas recovered and the economic considerations of gas companies.

On page 2-28 goals and objectives for air quality are presented. An additional goal should be added to this list. Namely the requirement to protect visibility in Class I and

other sensitive areas should be recognized and pursued. 42 U.S.C. §§ 7470(2), 7491(a)(1) (both establishing protective goals for these areas).

On page 2-29 it is stated that within one year of approval of the RMP background air quality will be defined and a monitoring system established. These activities must be done as part of the RMP process, and not postponed. Under FLPMA, the RMP must "provide for compliance'' with the CAA, and it is impossible to see how this can be done if basic background conditions are not even known. 43 U.S.C. § 1712(c)(8). As noted above, Kern prohibits BLM from postponing analyses to the future that can be accomplished in the RMP EIS. BLM has air quality monitoring data available from Pinedale and numerous other locations, and if these are the best data available, BLM must use it, not put off the analysis. Furthermore, the failure to have "define[d] the background air quality associated with federal actions approved under the RMP" violates NEPA in a number of respects—there is no baseline against which to measure the impacts of the proposed action, a fundamental flaw. Halfmoon Bay Fisherman's Marketing Assoc. v. Carlucci, 857 F.2d 505 (9th Cir. 1989). In Record No. 1005 BLM states that it will "encourage" efforts to reduce emissions. It must do more than this, under FLPMA it must "provide for compliance" with the CAA.

Page 2-30. BLM states monitoring relative to air quality will be pursued. It can and should do much more that would ensure there is timely installation of monitors. Namely, it can require companies that are operating in the area to install and maintain monitors. This is being done in the Pinedale Field Office and probably elsewhere. Given BLM's obligation to provide for compliance with the CAA, this is well within its authority, and given the tremendous profits being reaped by oil and gas companies operating on the public lands, they are in a position to afford this. BLM also states with respect to alternatives B and E that it will consider implementing mitigations relative air pollution. BLM should be more specific about what will be required. At a minimum, we believe that BLM should require the establishment of an office similar to what has been established for the Jonah Infill project (the Jonah Interagency Mitigation and Monitoring Office—JIO) to ensure that the maximum control of air pollutants is put in place. Specifically, at a minimum, BLM should require the use of flareless completions, and the adoption of Tier 2 compliant technology for drill rigs, as well as compliance with the Wyoming Department of Environmental Quality's "presumptive BACT" (best available control technology) for oil and gas operations. Moreover, BLM should explicitly adopt and state as its governing management requirement relative to air pollution that it will "provide for compliance" with the CAA, as required by FLPMA. See also 43 C.F.R. § 2920.7(a)(3) (BLM will "require compliance" with the CAA when establishing terms and conditions for land use authorizations).

Page 2-31. With respect to assessments of soils limitations relative to Alternative E (as described for Alternative C), we believe that the 20 acre trigger for conducting assessments and inspections must be viewed from a cumulative perspective. In other words, these potential triggers should not be viewed from the perspective of each individual action (for example, individual oil and gas wells), but rather should be viewed from the perspective of the totality of actions being pursued (for example, all wells

drilled in a field in a given year, or the total of road building that is conducted in a given year). If this approach is not taken, very few actions will be subject to these provisions and they will be largely meaningless. In addition, we believe the provision specified for Alternative B that highly erosive soils (575,788 acres) will be deemed No Surface Occupancy (NSO) must be adopted regardless of what alternative is selected. BLM has an obligation to take "any" action that is needed to prevent "unnecessary or undue degradation" of the public lands." 43 U.S.C. § 1732(b). The loss of soils is a fundamental impact affecting entire ecosystems and their function. BLM has presented no analysis whatsoever showing that these admittedly "highly erosive" soils will not be unnecessarily or unduly degraded by allowing "surface-disturbing activities," as it would permit under Alternative E. BLM recognizes in the EIS, and there is no denying, that soils are the prerequisite for desired vegetation (whether Desired Plant Community — DPC—or Desired Future Condition — DFC) and indirectly for supporting wildlife populations, in addition to contributing to air quality problems if they are eroded. If these highly erosive soils are eroded, there is a high probability of INPS invasion, something BLM recognizes throughout the EIS as being severe environmental degradation. Streams could be choked and polluted by the sediment washed into them if these soils erode through lack of adequate protection. Thus, it is clear that allowing "surface-disturbing activities" on these "highly erosive" soils could lead to unnecessary or undue degradation of the public lands, something BLM has a mandatory statutory obligation to prevent, and which the EIS provides no evidence whatsoever will be prevented by the provisions under Alternative E, although Alternative B clearly would prevent such impacts since NSO would be required. See Mineral Policy Center v. Norton, 292 F.Supp.2d 30, 41-43 (holding that the unnecessary and undue degradation clause imposes the obligation to prevent both unnecessary degradation and undue degradation, and that undue degradation is environmentally "excessive" impact).

Page 2-32. It is indicated that under Alternative E (described under Alternative A) that surface disturbance of slopes greater than 25 percent could be allowed as a routine matter ("NSO or other surface disturbance is allowed on slopes of more than 25 percent with permission from the authorized officer."). This provision is contrary to the provisions in Appendix I, which clearly state that surface disturbance is "prohibited" (subject to well documented provisions for exception) on slopes greater than 25 percent. Appendix I at I-2. The "Wyoming Bureau of Land Management Mitigation Guidelines for Surface-Disturbing and Disruptive Activities" are applicable throughout BLM lands in Wyoming, and thus the Casper RMP/EIS cannot cast these provisions aside. The provision for Alternative B reflects the provision in Appendix I (slopes greater than 25 percent are NSO), and thus should be adopted by BLM. With respect to the provisions for reseeding, BLM must adopt the standard for reclamation provided for in the Mineral Leasing Act. BLM must "ensure the complete and timely" reclamation of any lease that is developed. 30 U.S.C. § 226(g) (emphasis added). Furthermore, BM must ensure complete adherence to the provisions in its newly revised "Gold Book." Under these authorities, BLM must use locally adapted varieties in all cases, not just when "practical." All seed must be certified weed free in all cases. And, BLM must require the use of containerized shrubs, not seed, in order to ensure timely return of sagebrush habitats.

Page 2-33. The same comments just made regarding the need to comply with the Mineral Leasing Act reclamation standard and the provisions in the Gold Book also apply with reference to the provisions to require retreatment of reclaimed areas that are not adequately reclaimed. Under these authorities BLM must adopt the reclamation provisions applicable to Alternative B and not those applicable to alternative E (as described under Alternative C). BLM has shown by this analysis that both more complete and more timely reclamation is possible than would occur under its preferred alternative, and thus it must adopt this approach (Alternative B) to more complete and timely reclamation in order to comply with the Mineral Leasing, as well as BLM's Gold Book. BLM has presented no analysis showing that there is any reason whatsoever to allow for slower and less complete reclamation, although it is perhaps implied that BLM wants to "cut some slack" for companies having more difficulty with reclamation (or who are not pursuing reclamation with conviction or adequate resources), but this rationale is not enough to meet BLM's obligation to provide for complete and timely reclamation. We appreciate that BLM will seek to limit total long-term surface disturbance on each section of land (80 acres, 12.5% of a 640 acre section) and urge BLM to retain such a limitation, although we believe BLM could and should be able to further limit disturbance (for example, by greater use of a requirement for directional drilling), while still allowing activities to occur; moreover, this limit would be greatly improved if it also limited the <u>number</u> of surface disturbances adding up to 80 acres, because of the problems of habitat fragmentation created by numerous small disturbances. We would suggest that in addition to a limitation on the number of acres disturbed BLM should also limit the total number of disturbances that can occur per section (160 one-half acre disturbances might well do more harm than one 80 acre disturbance). We also appreciate that BLM will close and reclaim unused roads. We encourage BLM to make this a priority. The provision for Alternative E (described under Alternative A) allowing "case-by-case" determinations of short and long-term disturbance "where warrant[ed]" should be abandoned and the provision under Alternative B adopted. BLM will be blind to the impacts of implementation of this RMP if it does not measure short and long-term cumulative disturbance, which is clearly contrary to both FLPMA and NEPA. <u>See</u> 40 C.F.R. § 1505.2(c). Unless cumulative short and long-term disturbance levels are measured, BLM will be in no position to make any informed assessment of the effects of its management actions in future project specific analyses. Again, it will be blind, which is exactly what NEPA and FLPMA are intended to prevent.

Page 2-34. We support BLM's plans to require storm water permits on all projects greater than one acre and urge that this provision be maintained. Sedimentation from surface-disturbing project is a severe problem and must be guarded against. Likewise, we support the use of pitless drilling technology and urge that it be adopted as a land use plan decision and requirement. This provision should be required for all drilling, only being waived when it is shown there is no likelihood of impacts to water or soils. Given the vast array of toxic and hazardous chemicals used in drilling and stored or deposited in pits, the presumption should be that there is a potential for adverse impacts, not that there is no potential for such impacts.

Page 2-39. BLM should revise the terminology used to describe the protections under which oil and gas drilling and development can occur. The term "constraints" is pejorative and this is especially true of the term "major constraints." This language colors and biases the consideration of protections for other resources that BLM has an equal (and in some cases greater) obligation to provide for. BLM has presented no objective data showing that simple seasonal restrictions are a "constraint" on development. They may require some changes in plans or careful, thoughtful foresight, but there is no objective evidence that seasonal stipulations have hampered oil and gas development in any way. Likewise, there is no objective evidence presented showing that NSO stipulations are any significant "constraint" on development. We would note that any such leases would be bought by a willing buyer, so the only way that BLM can show that any stipulations on a lease have caused any limitation on development would be to come forward with data from past lease sales showing that, for example, leases with NSO stipulations were not sold, and showing that leases that have been sold with NSO and overlapping seasonal stipulations have not been subject to development at the same rate as other leases. Until then BLM should present the acreages available with simple, non-pejorative language: open subject to the terms and conditions of the standard lease form, open subject to seasonal stipulations, open with NSO or overlapping seasonal stipulations. BLM will apparently require directional drilling on a case-by-case basis, which we agree should be a requirement on the table for every application for permit (APD) to drill that is filed. But we think BLM should take this provision farther. It should state that directional drilling will be required if the analysis prescribed by IM 2004-194 (comparison of costs versus the benefits to the public and resource values) shows that directional drilling is appropriate. BLM should commit in the land use plan to conducting the analysis prescribed by IM 2004-194 for every APD that is filed, and require directional drilling to the maximum extent practicable. BLM should provide clarifying language and requirements relative to the provision that would allow geophysical exploration to occur in NSO areas. NSO areas have been deemed that precisely because they have special resource values that must be protected—in fact it has been determined that the only way these values can be protected is through NSO. Appendix I at 1-5 to -6. Thus, BLM should state as a land use plan decision that geophysical exploration will only be allowed if the special values for which the area was designated NSO can be shown to not be negatively affected by geophysical activities; the more general reference to no significant impacts being required should be retained, but the more specific values of the area should specially noted, provided for, and fully protected.[4]

Page 2-42. The term "wildland industrial interface" where full fire suppression will be applied is troubling. What does this term mean? It does not appear in the glossary. Does it include oil and gas wells; oil and gas fields? BLM appears to be taking the well known "wildland urban interface" where special efforts to deal with wildfires are widely—perhaps uniformly—acknowledged to require special attention and expanding it greatly. Creating this whole new category seems entirely inappropriate. If it includes oil and gas wells, BLM could be essentially abandoning or making moot the use of prescribed and

[4] We would note that "no significant impact" means there will <u>no</u> significant <u>potential</u> impacts. 40 C.F.R. § 1508.13.

"let burn" fires across literally millions of acres of land. That would be totally inconsistent with the need expressed throughout the Casper RMP/EIS to restore natural fire regimes as much as possible. Furthermore, can BLM afford to take on this task in terms of personnel and financing? It is well know that this past summer BLM and other agencies were hard pressed to keep up with the demand for firefighters and fire suppression. BLM could be creating a totally unworkable situation if it is going to try to fully suppress all fires in the general vicinity of the thousands of wells already in place and planned for the planning area. This issue must at least be considered by BLM and options for dealing with it considered. For example, it may well be appropriate to require oil and gas companies to provide there own firefighters (or at least to fund additional firefighters) if additional effort must be expended due to their decision to build where they have chosen to build. The prohibition on heavy equipment near sage grouse leks is a good provision, however, other crucial sage grouse habitat should also be protected. Furthermore, the plan should provide for how these limitations will be communicated to firefighters, impressed upon them, and enforced. We doubt that many firefighters will be reading the Casper RMP/EIS; it is crucial its provisions relative to fire be communicated to and impressed upon the rank and file firefighters, as well as the "fire bosses."

Page 2-46. It is not clear to us why Alternative E (as expressed under Alternative D) should provide for so much lesser protection of floodplains and incised streams than Alternative B does. Especially when Alternative E provides for protecting just as much lotic and lentic habitat as does Alternative B. Throughout the Casper RMP/EIS the critical importance of riparian and wetland habitats is emphasized. They are by far the most important habitats for providing a host of resource values, especially wildlife related values. Thus, we believe that floodplain connectivity and incised streams should receive as much enhancement under the preferred alternative as they do under Alternative B, just as is the case for the closely related lotic and lentic habitats.

Page 2-47. While BLM may not be able to pursue instream flows, it can encourage the Wyoming Game and Fish Department to pursue such flows, and BLM should commit to doing that in the RMP. BLM must commit to adopting the Wyoming Game and Fish Department's "Minimum Recommendations for Development of Oil and Gas Resources Within Crucial and Important Wildlife Habitats on BLM Lands," as appears to be provided for under Alternative B, but not the preferred alternative. Attached as Exhibit 1 are detailed arguments as to why the BLM must adopt this guidance, or at a minimum consider it when APDs are processed. Fundamentally the provision in FLPMA at 43 U.S.C. § 1712(c)(9) requiring BLM to act consistently with state and local plans and other policy requires BLM to adopt the Minimum Recommendations report. While the appeal to the IBLA presented in Exhibit 1 is related to lease parcels sold in the Rawlins Field Office, the arguments and law discussed therein are just as applicable to leases that might be sold in the Casper Field Office. Consequently we ask that BLM consider the arguments in Exhibit 1 and adopt the Minimum Recommendations report, or at least commit to fully consider it when APDs are processed, and to make this requirement a land use plan decision. The statement regarding negotiating easements under Alternative E is very unclear; it is not clear what this applies to or what the "program needs" are.

Page 2-48. Provision is made for designation of blocks of contiguous sagebrush habitat as off-limits to development. This is a very important concept and we congratulate BLM for pursuing it. Unfortunately, however, far less habitat would be protected under Alternative E than Alternative B. We believe this needs to be corrected and the provisions of Alternative B adopted in the preferred alternative. Throughout these comments we will raise points that support this contention. One of these points is that by definition all of these areas have "low development potential for coal and oil and gas resources." 2-48. On this basis alone we therefore see no valid reason for not fully protecting as much of this habitat as possible. It is relatively cost free, yet the benefits to wildlife (and users and appreciators of wildlife) would be tremendous. This opportunity should not be missed. Again, we will return the importance of fully protecting these large blocks of sagebrush habitat throughout these comments.

Page 2-49. Under Alternative E BLM will manage forests for wood products while Alternative B would manage them for ecological health and diversity. We urge BLM to adopt the emphasis of Alternative B rather than that in Alternative E. Apparently, forest management under Alternative E focuses on disease control and promoting the use of small diameter wood. 2-50. The EIS presents no basis that we are aware of to support this emphasis. See 3-37 to 3-39 (providing no indication these are issues or problems that need to be addressed through management or that these are the best means to meet defined needs). Yet it provides substantial support for the need to focus forest management on protecting ecological health and function. See, e.g., 3-34 to 3-36 (emphasizing the need to prevent fragmentation and protect biological diversity).

Page 2-51. It is stated that vegetation mosaics will be created in forests. What this means needs to be explained and limits on the degree "mosaics" are created needs to be specified in the RMP. "Mosaics" can be another way of saying "habitat fragmentation"—something BLM wants to prevent—so there needs to be definition of and limitation on the number or types of mosaics that are permissible. Likewise, the impact of "mosaics" on biological diversity needs to be considered and appropriately provided for in the plan—while creating "edge" can favor some species, often these species are habitat generalists that are in no need of management emphasis, while mosaics/edge can be very unfavorable for species that have more specialized habitat needs, such as old growth forests. These issues need to be carefully considered before BLM commits to a management regime of creating mosaics, a consideration that is not apparent in the Casper RMP/EIS. It is stated that "silvicultural treatments will be applied as needed to achieve objectives." This is a remarkably broad statement that contains no standards, no definitions, or any other indication of what exactly is permissible or impermissible under the plan. Because there are no sideboards for this provision, it should be eliminated. Plan provisions should provide actual guidance to future management, not a virtual "anything is possible" authorization.

On page 2-51 an important concern is made apparent. Under both Alternatives B and E, sagebrush communities would managed toward a Desired Plant Community (DPC) while under Alternative A, these communities are managed toward a Desired Future Condition (DFC). Especially in Chapter 4 (the environmental consequences chapter), there are

repeated statements or strong implications that environmental impacts are less when DPC is managed for rather than DFC, and this is used repeatedly to argue that the impacts of Alternative E are not so bad. Yet there is a problem here. **As** far as we can tell, neither of these terms are defined, except in the context of riparian functionality classifications. Glossary-10. Obviously a concept that is defined for riparian vegetation has no relevance relative to sagebrush communities and the various other upland plant communities where DPC is asserted to be a better outcome than DFC. This needs to be corrected and a careful definition provided of what exactly these concepts mean in the context of upland vegetation. This failure has totally hindered our ability to meaningfully and effectively review the Casper RMP/EIS due to the pervasive invocation of claims that DPC is environmentally better than DFC. Therefore, we request that definitions be provided and the public afforded additional opportunities to review the Casper RMP/EIS. Furthermore, even if it were assumed that the definition of DPC relative to riparian communities also applies to other plant communities, what exactly it means is totally unapparent. Essentially, the DPC can be any of a number of (unstated) plant communities that a "management plan" (which is apparently not in existence yet) identifies as "best" for a site. Glossary-10. This provides no basis whatsoever for making any statements regarding (1) what management will apply in the plant community, (2) what it will seek to achieve, and (3) what the environmental impacts will be. For this term to have any utility at all, BLM needs to provide guidance regarding what the management objectives are for sagebrush (and other) plant communities. For example, the objective might be to manage for native species and naturally occurring plant communities that are within the range of variability in communities that occurred under pre-settlement conditions. This would provide some indication of what the objectives are for the plant community and thus what is being sought to be achieved, and thus provide a basis for making claims that environmental impacts are greater or lesser. It would also provide guidance on what management actions should seek to achieve, and why. This would not prevent pursuing other plant communities under certain conditions (such as crested wheatgrass plantings in sagebrush habitat), but it would be recognized that these plant communities are not generally as desirable as the defined desired plant community, they are not the overarching goal. But as DPC is currently defined (for riparian areas), none of this guidance is available; it is a totally empty concept at present waiting to be filled in the future. That is not planning, even at a "strategic" level. With respect to DFC, under the current definition, it does not appear to have any applicability at all, except to riparian habitat. Glossary-10 to -11.

With respect to the statement that riparian habitats will be protected with various special management actions applied, BLM should also make clear that the BLM standards and guidelines (and the fundamentals of rangeland health) will be applied and must be adhered to, and that the DFC for riparian communities defined in the Glossary will be achieved.

Page 2-52. BLM states that under Alternative B 1,700 acres of salt cedar will be eradicated, while under Alternative E the plan is to develop a plan to reduce unknown amounts of salt cedar. We urge BLM to pursue the approach under Alternative B in its preferred alternative. Throughout the EIS, BLM emphasizes the special importance of

riparian habitats, and their need for special management. Given this recognition, BLM should commit to the well defined management action defined under Alternative B that would have vast benefits for riparian habitats in the planning area rather than establishing a plan to develop a plan that would lead to no known benefits or particular outcomes. BLM should view elimination of salt cedar (tamarisk) as a special opportunity—it occurs in well defined areas and the ecological values of eliminating it are clear and well defined, unlike other INPS that BLM might focus on, which often may have little or no chance of being eradicated. With regard to INPS management, we urge BLM to give special emphasis to the Level II weed management areas rather than Level I. As indicated, when small isolated patches of weeds can be found, control and eradication may in fact be possible and cost effective, whereas when weeds become widespread there may be little or no chance of effectively controlling or eradicating them in an environmentally acceptable manner—BLM should make cold, calculated determinations of the relative values of different weed control efforts and purse the options that are most effective.

Page 2-53. Here, for most classes of wildlife, BLM makes an assertion that management for the class is "encompassed" in other management actions and that no special management will be attempted. This claim is also evident on page 2-54. BLM must provide a rational basis for this claim. It should not just be assumed that this wide array of species is being provided for through other management. At a minimum, BLM's Special Status Species manual requires species-specific management actions relative to listed, proposed, candidate, and sensitive species. BLM Manual § 6840.06.E (providing that sensitive species shall be managed at a minimum level of protection as that afforded candidate species).

Page 2-54. The management provision for raptors provided for under Alternative B should be adopted rather than the provisions under Alternative E (as described under Alternative D). At a minimum, BLM should adopt the provisions relative to raptors from the Wyoming Game and Fish Department's (WGFD) Minimum Recommendations report, which require that noise levels at raptor nests be kept to 49 dBA or less, and that buffer areas be determined through consultation with state and federal wildlife agencies, i.e., the WGFD and the U.S. Fish and Wildlife Service. Further guidance relative to raptor protection provided by the Fish and Wildlife Service will be discussed below. BLM should adopt the buffers recommended by these agencies as they are the experts on wildlife management, whereas BLM, as it unfortunately claims time and time again, only has special expertise relative to habitat issues.

Page 2-55. Under the Bates Hole provisions in Alternative E for sage grouse, it is stated sage grouse winter habitat and wintering birds will be protected "where possible." This condition should be eliminated because it makes this provision totally ineffective and speculative. At a minimum, BLM should state when and where it will not be possible to apply this protection, and why that is the case.

Page 2-56. We request that BLM consider and adopt the protections for sage grouse that have recently been put forth in several publications. First, attached as Exhibit 2 is a

recent publication by Dr. Clait Braun that BLM should consider and adopt provisions from. We would note that BLM cites at least four of Dr. Braun's publications in the EIS, thus it recognizes his expertise relative to sage grouse. Additionally, Dr. David Naugle of the University of Montana has recently published articles regarding the impacts of coalbed methane (CBM) development in the Powder River Basin on sage grouse. We request that BLM avail itself of this new research, which shows that CBM development is having severe impacts on sage grouse, and adjust its stipulations accordingly. Last, we request that BLM consider the Ph.D dissertation of Matthew Holloran regarding the impacts of oil and gas development on sage grouse on the Pinedale Anticline. Available at http://\?;ww.voiceforthewild.ore/SaqeGrouseStudies/Matt_Holloran_Version4.pdf. His research shows severe impacts on sage grouse from oil and gas development. We believe that if this new research is considered, it is apparent that at a minimum the protections for sage grouse provided for under Alternative B must be adopted rather than the minimal protections provided by Alternative E, in order for BLM to comply with both its National Sage-Grouse Habitat Conservation Strategy and the WGFD's Wyoming Sage-Grouse Conservation Plan.

Page 2-57. BLM should adopt the provisions of Alternative B relative to black-footed ferret management rather than the provisions in Alternative E (as described under Alternative D). BLM has an obligation under the ESA to use its programs "in furtherance of the purposes" of the ESA. 16 U.S.C. § 1536(a)(1). The purposes of the ESA—which BLM must seek to implement as its first priority, as recognized in TVA v. Hill, noted above—include the conservation of ecosystems listed species depend on (not just designated critical habitat), and providing a program for the conservation of listed species. Id. § 1531(b). Conservation under the ESA means the use of "all methods and procedures" that are necessary to bring a species to the point where the protections of the ESA are no longer needed. Id. § 1532(3). Given these obligations, BLM should clearly adopt the provisions of Alternative B and affirmatively seek to further the recovery of the black-footed ferret.

Page 2-58. BLM makes a statement regarding paleontological resources that we strongly support: BLM will seek to "instill a conservation ethic within the public regarding paleontological resources." This statement is laudable and certainly should be part of BLM's mission and land use plan. We request that this same statement be adopted as a goal/objective for all resources, particularly wildlife resources. BLM should actively seek to instill conservation values—given the vast array of environmental laws that have been enacted, this is clearly a national priority that should be furthered.

Page 2-60. A number of references are made to protections that will be applied to "paleontological values." These references should be expanded to also include historical and cultural values/resources, as well as archeological resources/values.

Page 2-61. We are astounded that no visual landscapes in the entire Casper Field Office area are deemed deserving of Class I designation and protection. Certainly, at a minimum, the various special designation areas (ACECs, etc.) should receive this designation to fully protect not only the resources but also the values that are being

protected. Likewise, National Historic Trails should be afforded Class I status, at least in areas where the trails are intact and the surrounding area is largely as it appeared in the 1800s, so as to fully comply with the letter and spirit of the Nationals Historic Trails Act. Furthermore, we believe the protections afforded under Alternative B should be adopted rather than the much more limited protections of Alternative E. We do not believe that there is any support from anyone but those seeking maximum industrial development for designating virtually half of BLM surface lands and the minerals estate as being managed to allow for an industrial landscape. This is a remarkably unbalanced approach that could lead toward a fundamental change in the landscape of Wyoming, and we urge BLM to abandon this attempt to allow a large part of Wyoming to be turned into landscape one might find in New Jersey. There is no support for that.

Page 2-62. In setting up the discussion regarding land resources, BLM uses very troubling language. BLM repeatedly makes statements regarding "internal and external customers," "major ROW customers," etc. This language is offensive coming from an agency that is charged with representing and protecting the interests of the citizens of the United States. In contrast to this highly offensive language (it is offensive because it indicates BLM has lost perspective; it indicates BLM views its obligations as owing to certain money-spending or economically powerful "customers" and not the citizens of this country), we note this goal regarding recreation resources: "Manage recreation resources on public lands to provide a diverse array of benefits to the public, including economic, environmental, personal, and social benefits." (emphasis added). This is an appropriate statement that should be replicated in all goals and objectives stated in the RMP, and which should guide the BLM management plan when it is adopted.

Page 2-64. BLM should insert a statement regarding livestock management that BLM's standards and guidelines and the fundamentals of rangeland health will be applied and be abided by. These regulations are binding obligations on BLM that it cannot avoid; BLM's attempt to abandon these regulations has been totally rejected by the Idaho U.S. District Court, so BLM must continue to recognize these obligations.

Page 2-65. While we appreciate the difficulty inherent in managing the scattered land holdings in the Casper Field Office (especially in the eastern portions), we believe the statement that disposal of 224,834 acres will be pursued needs to be clarified. Certainly BLM cannot dispose of these lands by sale as a general matter, yet no distinction is made between disposal via sale versus disposal via exchange. This needs to be corrected and some clarity of what methods will be favored provided. We would note that it is national policy "the public lands [will] be retained in federal ownership" unless disposal of "a particular parcel" is found to be in the national interest through the planning process. 43 U.S.C. § 1701(a)(1) (emphasis added). We think is very important for BLM to make it clear that this effort to "dispose" of lands will not become some sort of fire-sale under any circumstances, but rather will be used as a means to achieve a more rational land ownership pattern, with at least some guidance provided in the RMP as to what BLM will be seeking and demanding as a condition of disposal.

With regard to some of these parcels we have specific comments. One of the key criteria the BLM should consider is public accessibility. Many of the tracts in Platte, Goshen, and Converse Counties are accessible for public recreation, and are some of the only places the public has to recreate. Examples include prairie tracts at the base of the Laramie range in Platte County, Table Mountain in Goshen County, and the Pine Ridge country in northwestern Converse County. Tracts adjacent to Glendo State Park are integral to management of the state park. Tracts are also adjacent to Ayers Natural Bridge County Park in Converse County. Some other tracts we are concerned about include tracts attached to the LaBonte and Downs roadless areas on the Medicine Bow National Forest and Thunder Basin National Grasslands. BLM tracts in both of these areas add to the wild nature and roadless character of these places. Both LaBonte Canyon and Downs are being managed by the Forest Service for backcountry no-motorized recreation, but the BLM failed to examine how its adjacent tracts could be managed in coordination and conjunction with the Forest Service's management.

Page 2-66. The provision allowing disposal within 5 miles of communities needs an acreage figure attached to. This could potentially be a huge expanse of BLM lands, so BLM needs to specify precisely just how many acres are potentially "on the blocks" and make a determination of whether disposal of that much land is in the public interest and in accordance with the RMP. Furthermore, the definition of "communities" is far too broad, apparently including any residential development and subdivision. Allowing these kinds of developments-often inholdings, isolated rural developments, a couple of houses, etc.—is a prescription for large headaches for BLM and the public that BLM should not facilitate. This is a prescription for creating more firefighting obligations and costs for BLM. This is a prescription for greater habitat fragmentation, which BLM claims it wants to avoid. This is a prescription for more law enforcement requirements. Etc, etc. While we appreciate that real communities (towns and cities) may have legitimate needs for expansion and development, we think it is a mistake to facilitate this kind of expansion at untold numbers of isolated "satellite developments."

Pages 2-67 to 2-68. We support continuation, and in some cases expansion, of the various withdrawals in protected areas like National Wildlife Refuges.

Pages 2-72 to 2-73. We support the provisions relative to OHVs in Alternative B relative to Alternative E. We believe it is crucial to maximize the amount of land where OHV use is only permitted on designated roads and trails, rather than being allowed on "existing" roads and trails. As recognized in Chapters 3 and 4 of the EIS, the existing roads and trails category is essentially unenforceable because new roads and trails can and are created all the time, creating a perpetually new and expanding pool of "existing" roads. BLM needs to get away from this self-defeating approach as soon as possible and move to the maximum amount of OHV use on designated roads and trails only, which is an enforceable provision. OHV enthusiasts will suffer few if any hardships with this approach; many hundreds if not thousands of miles of roads would be available for their activities. This approach does of course require more work on the part of BLM, but this is good work that BLM should be willing to give a high priority to—OHV use is

probably second only to oil and gas development in terms of the impacts it is having on public lands.

Page 2-75. With respect to the provisions related to adjustment of grazing leases (permits) and management of livestock grazing, BLM must again specifically incorporate and abide by its Fundamentals of Rangeland Health and Standards and Guidelines for Grazing Administration. As noted above, BLM efforts to abandon these sensible requirements have been stopped by the U.S. District Court in Idaho. Thus, the fundamentals and standards and guidelines remains BLM's law relative to livestock grazing, and consequently these regulatory provisions must be adopted in the land use plan relative to livestock grazing and carefully implemented and abided by. In particular, we note that BLM must "take appropriate action as soon as practicable but not later than the start of the next grazing year upon determining that existing grazing management practices or levels of grazing use on public lands are significant factors in failing to achieve the standards and conform with the guidelines . . . ." 43 C.F.R. § 4180.2(c). See ~~also id.~~ § 4180.1 (requiring the same actions relative to the nationally applicable Fundamentals of Rangeland Health). Significant progress toward fulfillment of the standards and guidelines must be achieved. Id. § 4180.2(c). These binding, non-discretionary standards must be recognized and adopted in the Casper RMP.

Pages 2-83 to 2-84. We support establishment of the Bates Hole Special Management Area, although as discussed above we believe it should be designated an ACEC. We also support special emphasis on protection of sage grouse in this area. The provisions requiring controlled surface use of surface disturbing activities and engaging in intensive management should be maintained.

Page 2-85. The black-tailed prairie dog ACEC should be established. BLM is missing a prime opportunity to provide enhanced protection for a keystone species of the sagebrush ecosystem. See page 3-115 (describing the critically important functions and values of prairie dog colonies). Providing special protection to the black-tailed prairie dog would not only protect this species that has been reduced to a mere shadow of its pre-settlement populations (black-tailed prairie dog populations have been reduced by 99 percent on the Great Plains), it would also be beneficial to a number of other species, such as the burrowing owl and ferruginous hawk (BLM sensitive species) and perhaps even to the endangered black-footed ferret. 3-115. BLM has identified biological diversity as a key consideration, and protection for black-tailed prairie dogs is a means to maintain diversity. 3-34 to 3-36. Moreover, as a BLM sensitive species (Table 3-23), BLM owes black-tailed prairie dogs special management consideration, not just management for "multiple uses" as provided by Alternative E. Since the same management requirements that apply to candidate species also apply to sensitive species pursuant to BLM's sensitive species manual, BLM must engage in a host of activities to protect the species, which collectively dictate designation of the ACEC, or certainly special management area protection. See Special Status Species Manual §§ 6840.06.C.2.a to .d (requiring proactive, focused management of special status species, not "multiple use" management, as provided for by Alternative E). In 1998 a petition was filed by the National Wildlife Federation to list the Black-tailed Prairie Dog as an endangered species. As a way to

avert this listing, the 11 states which have black-tailed prairie dogs agreed to put together state management plans for the black-tailed prairie dogs. In Wyoming this plan was never written. This means that BLM has a responsibility to fill in this gap left by the State of Wyoming.

Page 2-88. The North Platte River ACEC should be designated. The provision in Alternative E is unsatisfactory because it would only protect a fraction of the area. Given the great public interest in and use of this area, it should be fully protected. The National Historic Trails that track along the river and Blue Ribbon fisheries in the area are additional reasons for protection.

Page 2-92. The South Bighorns/Red Wall ACEC should be designated as provided for in Alternative B. This area contains a plethora of resource values, ranging from wildlife habitat for a number of species, to unique plant communities (curl-leaf mountain mahogany), to a "dense and diverse range of cultural and historical resources rivaling that found anywhere within in Wyoming," to existing developed campgrounds in the area associated with a national backcountry byway. This area is in close proximity to the famous Hole in the Wall. In addition, the Nature Conservancy, in its study Ecoregional Conservation in the Northern Great Plains Steppe, dated March 1, 1999 identified Buffalo Creek, Wyoming, which is the same area. According to the Nature Conservancy this site is an excellent example of a bluebunch-wheatgrass community, because of shallow soils in the area. The World Wildlife Fund in conjunction with the Northern Plains Conservation Network has also identified this area as one of the ten best remaining examples of northern mixed grass prairie left in North America. Its study Ocean of Grass: A Conservation Assessment for the Northern Great Plains, completed in 2003 stated, "[t]his area rated high due to significant mountain plover habitat, significant prairie dog acreage, relatively intact grasslands, and large contiguous acreage in BLM lands." Given that this area meets the relevance and importance criteria for designation as an ACEC, BLM must give "priority" to such designation, and not seek to minimize this needed protection.

Page 2-96. With respect to historic trails, an additional goal and objective should be stated: compliance with the letter and spirit of the National Historic Trails Act. We believe the provisions under Alternative B better meet the standards and intent of the National Historic Trails Act than do the provisions of Alternative E, and we ask for BLM to engage in a careful analysis of this question.

Page 2-98. We believe the provision that BLM will "Cooperatively manage" trails pursuant to the agreement with the National Park Service should be changed to a statement that BLM will "abide by" or "comply" with the terms of this agreement.

Page 2-99. BLM should recommend all six segments of waterways for Wild and Scenic River designation. BLM recognizes that all six segments are eligible for this designation. 3-124. Yet it claims they do not meet suitability factors. Id. BLM provided no details regarding why these segments were deemed non-suitable, stating in a conclusory manner that the "review team" made a non-suitable determination. Having no details of this

determination to review, there is little for the public to react to other than bare statements regarding the three factors that are presented. However, at a minimum, Factors 2 and 3 cannot serve as a basis for a non-suitability determination. Factor 2 is presented as demanding exclusion if there is any level of development in the area, any mixed ownership of land, and the presence of so called "incompatible uses." This is a total misapprehension of the Wild and Scenic Rivers Act. For example, the Little Miami River outside of Cincinnati, Ohio has long been designated a recreation river (it was designated in 1968 when the Wild and Scenic Rivers Act was enacted), yet it flows through almost entirely private lands (it is unlikely it flows across any federal lands), it flows through numerous small towns (in this part of Ohio, a "small" town is probably anything less than 20,000 people, far larger than many communities in Wyoming), and it is adjacent to literally countless factories, farms, railroads, etc. (this Wild and Scenic River is in the industrial heartland). Thus, BLM's claim that mixed land ownership and "incompatible land uses" in the area disqualifies the segment is without foundation. BLM is attempting to apply wilderness designation standards to these segments, but that is not necessarily the standard that applies, unless the river is being considered for wild river status. Likewise, claims that Factor 3 prevents these segments from being suitable is unfounded for the same reasons. There is no requirement that BLM be able to manage these river segments solo. Again, the Little Miami River stands as an example. There are probably no federal agencies that own lands along this river, yet is has been designated and is carefully managed, and greatly treasured by people in the area.

Chapter 3—Air Quality and Air Pollution

BLM's air quality analysis in the Casper RMP/EIS is totally inadequate and must be totally revised. First, BLM presents no data regarding the concentrations of criteria pollutants that are predicted from implementation of the RMP, and in conjunction with other emissions sources. All it does is present the total amounts of pollutants that will be generated. 3-7, 3-8, Appendix J. Knowing only the total amount of pollutants that will be generated does not allow any statement to be made regarding what the concentrations of pollutants will be. If the concentrations of the pollutants are totally unknown, nothing can be said about whether CAA standards (National Ambient Air Quality Standards—NAAQS) will or will not be violated. The quantity of air pollution generated is apples, while the NAAQS are expressed in concentrations, that is, they are oranges. Having made no attempt to compare oranges to oranges, BLM cannot make any objective statements regarding whether the NAAQS will or will not be violated, it can only engage in speculation.

BLM's claim that it is "likely" NAAQS will not be violated under the preferred alternative is nothing but speculation—it does not know and cannot know this given that all it has presented are the amounts of pollution that will be generated. 4-11. This also makes it impossible for BLM to ensure that its land use plan will "provide for compliance" with the CAA, as required by FLPMA. Again, BLM has no idea of whether this will be the case when it is not even addressing or predicting the relevant measure, concentrations. The NAAQS are health based standards, 42 U.S.C. § 7409(b)(1), and an EIS must evaluate impacts to human health. 40 C.F.R. §§ 1502.16(a)-(b), 1508.8. See

~~also id.~~ § 1508.27(b)((2) (significance partly defined by impacts to human health and safety). An EIS is invalid if it fails to consider the health effects of air pollution, and even a marginal degradation of air quality is environmentally significant. Public Citizen v. Department of Transp., 316 F.3d 1002, 1024 (9th Cir. 2000), rev'd on other grounds, 541 U.S. 752 (2004). Thus, BLM's failure—actually, its inability given that concentrations were not determined—to consider the human health effects of the activities pursued under its RMP that create air pollution violates NEPA.

BLM seems to feel it can be excused from conducting a meaningful analysis of air quality impacts because site-specific data are not available and because later analyses will be conducted. 4-5, J-9. This is incorrect for several reasons. BLM has provided no evidence that it cannot make any meaningful predictions of future emissions concentrations simply because the precise locations of future development are not known. BLM has predicted areas of high, medium, and low oil and gas potential. It plans to designate two special management areas dedicated to oil and gas production (Salt Creek and Wind River Basin). It knows precisely where oil and gas development pressure is greatest based on APD filings. With respect to CBM, BLM acknowledges that most development will occur in the Antelope Creek and Dry Fork of the Cheyenne River, so it knows exactly where that development is most likely. 4-25. Thus, BLM can make reasoned projections about where development is likely to occur and what the level is likely to be, and thus engage in a "quantitative" analysis that predicts concentrations of pollutants so that meaningful comparisons to the NAAQS can be made. Furthermore, there is nothing to stop BLM from analyzing two or three development scenarios so as to make reasoned analyses about what pollution concentrations will be. For example, one scenario (a low pollution concentration scenario) might assume uniform distribution in the planning area of all 1,813 wells that are projected to be drilled, and another scenario might assume that the vast majority of development will occur almost entirely in high potential areas (such as Salt Creek and Wind River Basin).' We would also note that even when a development proposal has become specific, BLM still engages in highly "stylized" analyses; it does not engage in an analysis based on the exact location of each well. See, e.g., Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement at 33 (describing the 1 mile by 1 mile "patch" of 128 wells used to make ozone predictions). It still makes assumptions about the nature of the development even at the project level. As noted in Kern v. Bureau of Land Management (discussed above), BLM is not excused from engaging in needed analyses in an RMP EIS just because all the details of development are not yet known. It is also not excused by potential future DEQ analyses. Among other things, DEQ analyses are limited to major sources of air pollution, yet the dominant contributor to air pollution in the planning area will be oil and gas wells, which are minor sources of air pollution not subject to intense DEQ analysis.[6] When BLM seeks to claim information is impossible to present in an EIS, the CEQ NEPA regulations nevertheless require BLM to engage in an analysis of impacts "based upon theoretical approaches or research methods

[5] There is no doubt that oil and gas development will create the majority of the air pollution problems for most pollutants. Table 3-3, page 3-7.

[6] Oil and gas wells only need to apply the "presumptive BACT" required by DEQ, but there is no analysis of impacts to Class I areas, the amount of increment consumption, consideration of cumulative impacts, etc.

generally accepted in the scientific community." 40 C.F.R. § 1502.22(b)(1). Such an approach might well be like the scenarios suggested above, consultation with scientists would confirm or rebut this; in any event BLM has provided no indication that its approach is "generally accepted in the scientific community," as it must if it wants to avoid this analysis.[7]

A second major shortcoming in BLM's air quality analysis is that ozone and ozone impacts are totally ignored. This is unacceptable given that ozone is a criteria pollutant with an established NAAQS. NEPA requires consideration of potentially significant environmental impacts, and ozone pollution certainly falls into that category. The Rawlins Field Office draft RMP/EIS showed that ozone levels were already 94% of the NAAQS in southern Wyoming. In the Pinedale Field Office, exceedances of the ozone NAAQS are being monitored by BLM. Yellowstone National Park is seeing increasing ozone pollution. http://www2.nature.nps.gov/air/who/npsPerfMeasures.cfm. Given this, ozone is clearly of increasing environmental concern, and BLM cannot just ignore consideration of it in the Casper RMP/EIS.

If BLM does not have data regarding ozone emissions and status in the Casper Field Office, it must acquire such data or use the best data that is available, which may well be the data from recent BLM EISs such as the Jonah Infill Project, Rawlins draft RMP/EIS, etc. Furthermore, in conducting an ozone analysis, BLM cannot rely on the "Scheffe method," which is the method it has typically used. Dr. Scheffe himself, the developer of the this method, is on record stating its invalidity, Exhibit 3, and other more appropriate methods, such as CAMQ, are readily available, Exhibits 4 and 5.

Last, we would like to note that on September 21,2006 EPA adopted a new far more stringent NAAQS for PM2.5. **http://www.epa.gov/pm/actions.html** BLM should correct the tables in the Casper RMP/EIS to reflect this, and conduct the needed environmental analysis based on this new standard.

Chapter 3—Leasable Minerals, Oil and Gas

On page 3-21 BLM states that it authorizes geophysical exploration via sundry notices. This seems like an inappropriate use of a sundry notice to us, and we believe that environmental assessments under NEPA must be used, unless perhaps a categorical exclusion is available.

Chapter 3—Fire Management and Ecology

We request that BLM consider several recent articles published in Science, this nation's premier scientific journal, regarding fire management. Exhibits 6 and 7. The work of Westerling shows that increasing wildfire incidence and intensity may largely be due to increasingly warm temperatures and earlier snow melts, and that "land use history had

[7] That **EPA** and DEQ may acquiesce to BLM's approach is not dispositive. BLM must show general acceptance in the scientific community of the approach it has chosen. The scientific community is far broader than just the two agencies.

little impact on fire risks", which indicates "ecological restoration and fuels management alone will not be sufficient to reverse current wildfire trends." The work of Donato brings into question the efficacy of post-fire salvage logging as an ecological restoration tool relative to allowing natural recovery. We ask that BLM consider these reports in designing its fire management plans for the Casper planning area.

Chapter 3—Biological Resources

With respect to the discussion of fragmentation on page 3-34 to 3-35, we believe there is a need for a separate consideration of the impacts of habitat fragmentation created by oil and gas development. See 4-59 (noting that oil and gas leasing is of particular concern relative to fragmentation). Furthermore, we believe that with respect to fragmentation, several vegetation types require special consideration and protection. Table 3-15 on page 3-37 shows the size of various vegetation types in the planning area. **A** number of these vegetation types are quite small, occupying tiny percentages of the planning area. Given these small areas, fragmentation could have a disproportionate impact on these habitat types. Therefore, they should receive special protection against fragmentation. We believe BLM should set numerical standards for the level of fragmentation that are acceptable. For example, limits on the number of miles of roads per square mile of land should be established.

On page 3-38 to 3-39, BLM engages in an analysis and uses language that seems entirely designed to justify logging in lodgepole pine habitat types. It uses non-scientific language such as "unbalanced" and "struggling" to characterize these stands, presenting no evidence there are in fact any particular "problems" in this vegetation type. The lodgepole pine and ponderosa pine vegetation types only occupy 66,000 acres in the planning area, so it would seem impossible to us to reach conclusions regarding the status of these vegetation types just based on their status on BLM lands. Rather, we encourage BLM to take a regional perspective so as to appropriately define any "problems" that are apparent. Moreover, we believe that BLM must consider the impact of global warming in creating any "mature, heavily stocked stands,'' etc. There is increasing evidence showing that global warming is having dramatic impacts on western forests and western forest ecology, and BLM must design its management regime cognizant of this new science. Exhibits **6, 7,** and **8.** Quite simply, the role of classical silviculture (i.e., logging) in managing forests needs to be carefully evaluated in light of this new evidence.

We note that on pages 3-41 and 3-42, BLM highlights the great importance of mesic upland shrub habitats and xeric upland shrub habitats. Yet these vegetation types only occupy 3.4% of the planning area. Table 3-15. This highlights the need for BLM to take special steps to ensure this habitat is not damaged. We encourage BLM to set numerical standards regarding the amount of this habitat that can be disturbed in order to ensure these important values are not lost.

With respect to sagebrush habitats, BLM repeatedly makes statements they are "mature and often decadent" and similar other pejorative, non-scientific statements. These

statements are clearly intended to provide a rationale for engaging in various management activities. We ask BLM to reconsider whether there are really any "problems" with these sagebrush stands. In particular, we ask BLM to reconsider the role of fire in this ecosystem. The most recent science of Baker shows that fires typically are only of very long intervals in the sage brush ecosystems, and "a program of prescribed burning is unwarranted or inadvisable if maintaining and restoring sagebrush landscapes and sagebrush-dependent species is the goal." Exhibit 9. Consequently, we ask BLM to reconsider its management plans for the sagebrush ecosystem, particularly the role of fire and advisability of prescribed burning, and provide careful documentation showing that these management activities are in fact effective in maintaining and restoring sagebrush habitats. Frankly, many of the techniques used to "improve" sagebrush habitats had their origins in 1960s and 1950s, a time when eradication of sagebrush and replacement by grass (typically introduced grasses) was the goal and outcome for which these techniques were developed, so BLM needs to provide careful assurance that these techniques that are now put forward as means to improve sagebrush habitats do in fact improve sagebrush habitats, and are in fact effective.

Pages 3-44 to 3-46 establish the extreme importance of riparian habitats for maintaining ecological health. This fact supports a number of claims and concerns raised in these comments, such as focusing on salt cedar (tamarisk) eradication as being a particularly appropriate place for BLM to focus its INPS control efforts. On page 3-46, compliance with the Standards for Healthy Rangelands is repeatedly referred to as a "goal." This needs to be corrected. As discussed above, compliance with the standards is a non-discretionary duty that must be abided by. In addition, Executive Orders related to wetlands and riparian areas mandate that BLM protect these areas—these are also binding obligations BLM must recognize and abide by. It is stated on page 3-46 that "the condition of riparian areas is one reason some grazing allotments have not met rangeland health standards . . . ." This statement needs to be quantified—how many acres or miles have been assessed, and how many are failing to meet the standards, and what actions is BLM taking to meet the requirement to modify livestock grazing management within one year, as required by rule?'

On page 3-47, INPS are discussed. Apparently 41 species are "the focus of control efforts within the planning area." BLM must consider whether it is practical (financially and in terms of personnel) to "focus" on this number of weed species. We doubt that BLM can afford to "focus" nearly the attention that would be required to deal with all these species. Rather, as has been mentioned, BLM should identify species where its efforts can really make a difference and pursue INPS management on that basis. Salt cedar is an obvious target because of its well-defined areas of occurrence and the extreme importance of riparian areas for many values. Also on this page, BLM falls into the use

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[8] This same comment applies generally to all livestock grazing issues, not just those in riparian areas. How many acres have been assessed? How much of this land is failing to meet standards? How much of this is due to livestock grazing? For areas where livestock grazing is the source of the problem, what actions have been taken and will be taken (within the required timeline) to correct these problems. BLM needs to provide quantitative information regarding how the fundamentals of rangeland health and standards and guidelines are being implemented, and how they will be implemented in the future under the new plan.

of pejorative, non-scientific terminology such as "infested." We urge BLM to strike this kind of language from the document, it is non-scientific and tends to infuse in weed control efforts something of a war mentality rather than being a carefully designed management program. At a minimum, terms like "infest" need to be defined in they are going to be used.

On page 3-50, the problems created by tamarisk are identified in some detail. Again, this provides support for our view that BLM should focus INPS efforts on this species and establish specific goals for its eradication as is done under Alternative B.

On pages 3-52 to 3-53, issues related to fish species are discussed. It appears based on this discussion that even if BLM lands may provide only a small area of fish habitat, these areas may be important "refugia" or otherwise provide protected areas that can better support fish. BLM should at least consider this issue. On page 3-53, a number of potential management actions that can benefit fish are identified; BLM should fully consider applying these on its lands, even if they are relatively small areas, especially if its lands are disproportionately valuable for fish.

On page 3-54, the results of the Bates Hole and Rattlesnake Hills studies are discussed. BLM fails to answer a critical question here: what was the difference in these two areas that most likely lead to the differential number of years in which sagebrush over-utilization occurred? Does one area have drastically more mule deer, or is it much more heavily grazed by livestock?, for example. The answer to this and related questions needs to be provided so as to understand the significance of these differences. Moreover, under the livestock grazing standards and guidelines, management action is probably called for, and BLM should commit to taking such action. Moreover, BLM should establish 35 percent utilization of sagebrush as a management standard throughout the planning area, with a commitment to take needed management actions if this standard is exceeded.

On page 3-55 activities that have degraded wildlife habitat are mentioned. BLM needs to recognize that there are many <u>indirect</u> impacts to wildlife habitat, especially from oil and gas development. Exhibits 10, 11 and 12. BLM should take steps to control these indirect impacts, and these studies may be helpful in that regard.[9]

On page 3-56 BMPs are discussed. The WGFD's Minimum Recommendations report is even mentioned. But as mentioned above, from what we have seen BLM never implements any of the BMPs in the WGFD report. It totally ignores it. As discussed above, this is contrary to the law, and BLM should at least consider the BMPs in the WGFD report, and should in fact adopt them when APDs are processed. The RMP should so provide.

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[9] The 2005 Annual Report from the Pinedale Anticline mule deer study, Exhibit 12, is of special significance. This report demonstrates the extraordinary impacts oil and gas development can have on mule deer. This study should be considered not only relative to assessing indirect impacts from oil and gas development, but also more generally in a consideration of the stipulations that should be put in place to protect big game, particularly mule deer.

On page 3-57 "management challenges" facing big game are mentioned. Oil and gas development is notably absent from this discussion. But oil and gas development may well be the most significant challenge big game species are facing. Exhibits 10, 11, and 12.

On page 3-59, the poor conditions of many ranges for mule deer and pronghorn are mentioned. This heightens the need to designate as many blocks of sagebrush habitat for protection as possible, as Alternative B would do relative to what is provided for under Alternative E. Furthermore, the plan must address and seek to resolve what is an apparent difference of opinion: the WGFD apparently has herd population objectives that BLM feels cannot be supported by current habitat conditions (in fact, BLM feels the habitat cannot meet current populations, which are generally below the WGFD objectives). Again, this needs to be resolved because BLM cannot allow for overuse of these lands, which would lead to prohibited unnecessary or undue degradation of the public lands.

On page 3-60 the importance of beaver in often benefiting riparian habitats is discussed. Given this, BLM should state what it will do to favor beaver presence on its lands, or where they are deemed a problem, what it will do to discourage them. This represents a specific example of the need for BLM make some provisions for management of wildlife besides big game and a few select other species; its claims that for furbearers no additional management direction is needed and that they are taken care of by other management actions are not persuasive when BLM is elsewhere recognizing the important values of some of these species in a habitat it views as probably the most crucial habitat in the planning area. See 2-53.

On page 3-61, the gray wolf is referred to as a "predatory" species because this is how Wyoming law defines it. The gray wolf is a species managed by the U.S. Fish and Wildlife Service pursuant to the ESA, and BLM should recognize this. Wyoming's attempts to have the wolf delisted and impose its categorization of the wolf on its management have been uniformly rejected. There is no telling if or when Wyoming will resume management of the wolf. Consequently BLM should not recognize Wyoming's classifications, and rather focus on the classification that counts: gray wolves are an experimental population in Wyoming and are managed under the terms of the **ESA.**

On page 3-63 a brief mention is made of the Migratory Bird Treaty Act (MBTA). BLM should recognize that the MBTA prohibits it and its permitees from taking migratory birds. A number of BLM-authorized activities, such as cell phone towers and power lines, may well result in take, and BLM should state what it will do or require to monitor any takings and what actions it will take if takings become apparent.

BLM states that several bat species are "a management priority" on page 3-64. Yet again, BLM makes no specific provisions for how it will manage these species or their habitats. See 2-53 to 2-54. This must be corrected. If these species are a priority (many are sensitive species), at a minimum, BLM can seek to identify the caves these species are using and protect them (often by prohibiting public entry by constructing gates that

allow bat passage) when caves are identified. See 3-82. It can also take steps to protect them from the wind turbines that kill them. Id.

On page 3-65 BLM states what it views as its obligations under its special status species manual. These species are to be "considered" and management is to be "consistent" with their conservation. Actually, BLM's obligations are more stringent than that. For sensitive and candidate species, it must, for example, develop management plans and conservation strategies, develop "specific habitat and population management objectives," "ensure" that its management actions are consistent with the stated objectives for the species, and engage in monitoring to ensure management objectives are met. Special Status Species Management Manual § 6840.06.C.2.a-d. BLM should restate the language on page 3-65 to carefully adhere to that used in the Special Status Species Management Manual, and ensure through land use plan decisions that it adheres to these requirements. Also on this page, BLM mentions that it manages habitat while WGFD manages wildlife populations. It should also be mentioned that the Fish and Wildlife Service manages listed species and migratory birds; BLM must not lose sight of this and should fully support the Service's management objectives in the RMP.

On page 3-66 specific threats are identified to Porter's sagebrush, namely oil and gas development. This seems to be a clear case where a new, special stipulation should be developed and put in place. All known locations of this species should be off limits to leasing and development, and the "geologic structure [where this species occurs] identified as a high priority for gas exploration and development" should be subject to this stipulation. Likewise, special stipulations should be developed for William's wafer-parsnip and Laramie false sagebrush because the threats to both species are well defined, namely limestone quarrying. 3-66 to -67.

In general, with respect to the special status plant species described on pages 3-65 to -69, it cannot be claimed that these species' protection is assured through general purpose vegetation management and that all that is required to meet their needs is to limit livestock water development and salt placement. 2-55. The discussion on these pages makes it clear that these species have very specialized, and very well defined, habitat needs. Therefore, BLM must put in place far more specific management practices designed to protect these species in order to comply with its Special Status Species Management Manual.

On page 3-73 the status of sage grouse is discussed. Certain areas are clearly extremely important for these birds: Bates Hole, Shirley Basin, Rattlesnake Hills, South Bighorns, and Laramie Range foothills. Given these well defined areas of special importance, BLM must maximize protection for this species in this area. This supports the need to fully designate all blocks of sagebrush habitat for protection and to fully protect all potential ACECs and/or special management areas, as is done under Alternative B relative to Alternative E. BLM must do this to comply with the WGFD sage grouse plan, its own sage grouse plan, and its Special Status Species Management Manual. It is also noted on this page that winter concentration areas have not been well defined yet. BLM needs to state what it is doing and will do to remedy this situation, as winter concentration areas

have become recognized as very important for ensuring the health of sage grouse populations. More generally, BLM needs to state what is doing and will do to map sage grouse leks and brood rearing areas, as well as mapping winter concentration areas and important winter habitat.

On page 3-77, the Fish and Wildlife Service's publication "Guidelines for Raptor Protection from Human and Land Use Disturbances" is mentioned, but only in the context of what are typical nesting periods for these species. This publication needs to be discussed much more thoroughly. What provisions for protection of raptors does it make? How do they compare to BLM stipulations for protecting raptors? If BLM stipulations do not fully embrace the Fish and Wildlife Service guidelines, why is that case, what biological basis is there for any differences? We would note that the Fish and Wildlife Service is given special authority to manage these species under the MBTA, so BLM must fully consider its guidelines, and can only reject these views of the expert wildlife agency if it offers a careful explanation as to why they should not apply on BLM lands. BLM mentions that it establishes buffer zones around raptor nests; are these consistent with the Fish and Wildlife Service guidelines? More generally, these guidelines should be considered as a source of new stipulations for raptor protection, and BLM should fully evaluate and to the maximum extent possible adopt these guidelines as stipulations governing land-disturbing activities. It is also mentioned on this page that raptors are impacted by powerlines and collisions with wind turbines. This raises takings issues under the MBTA, which as discussed above BLM must fully consider and take steps to prevent.

On page 3-80 it is stated that the yellow-billed cuckoo has known occupied habitat in the Sybille Creek and east slope of the Laramie Range areas. This would seem to provide all the specificity that is required to provide for special management of this BLM sensitive species, as required by the BLM Special Status Species Management Manual. The RMP should so provide for such special management in these areas. Surface disturbing activities in these areas should be subject to stipulations designed to ensure this species is not harmed. Likewise, Lewis's woodpecker breeding populations have been "confirmed" in the planning area. To the extent these locations are well defined and on BLM lands (or BLM mineral estate), BLM should put in place protections in the RMP designed to protect this species. It is also mentioned that sagebrush obligate species (e.g., Brewer's sparrow, sage thrasher, sage sparrow, sage grouse) require "intact" sagebrush habitats. This again emphasizes the need for BLM to designate the largest number of intact sagebrush blocks for protection as is possible. BLM will not be meeting its duties under its Special Status Species Management Manual if it fails to do so.

On page 3-81 the black-footed ferret is mentioned, including their presence in the Black-Footed Ferret Management Area and near proximity to the planning area. Yet the EIS is silent regarding BLM's views about this, blandly stating that they may move into the planning area. BLM, should <u>encourage</u> the expansion of ferret populations into the planning area. It should openly welcome and embrace this species into the planning area. What a success that would be! It should take no steps (like allowing prairie dog control) that would hinder expansion into the planning area. BLM has a responsibility to do this

under the provisions of section 7(a)(1) of the ESA, as discussed above (BLM must further the purposes of the ESA, which include protecting the ecosystems upon which listed species depend and facilitating recovery and delisting). It also has these duties under its Special Status Species Management Manual. Further down on page 3-81, BLM notes that white-tailed prairie dogs (itself a sensitive species) occur in the ferret experimental release area. If these colonies occur on BLM land, BLM must provide for special protection of them. Also on page 3-81 the Preble's meadow jumping mouse is discussed. It states that delisting has recently been proposed. We believe this assertion is out of date. The Fish and Wildlife Service has recently engaged in an intense analysis of whether the mouse is a "good" species, and the weight of science is showing that it is indeed a separate and unique species, which would preclude delisting. BLM must ensure this discussion is up to date.

On page 3-82, the critical importance and value of black-tailed prairie dog colonies is recognized by BLM. This recognition just emphasizes the need to protect the single prairie dog colony that would be protected under Alternative B, but not under Alternative E, as an ACEC. In fact, it makes it clear that protection should be expanded even further. At a minimum, the large complexes that are present on BLM lands should be protected. At most these represent a few thousands of acres out the 1.4 million acres of BLM land in the planning area, a tiny fraction. Certainly there must be room to protect this tiny amount of land in the RMP without significantly disrupting other activities. BLM should reevaluate the protection of black-tailed prairie dog colonies and provide a full explanation of why they are being protected or not, particularly in light of their recognized value as "important habitats for future black-footed ferret populations." It is also recognized on page 3-82 that one of the management challenges facing special status species is "lack of cottonwood and willow regeneration." This just reemphasizes the need for BLM to provide for specific measures to control tamarisk (which greatly inhibits cottonwood regeneration), as is done under Alternative B, but not Alternative E.

Chapter 3—Heritage and Visual Resources

On page 3-84 it is said that section 110 of the National Historic Preservation Act requires BLM to "identify and manage" cultural resources. Actually, section 110 requires much more. It requires that "to the maximum extent possible" BLM will "minimize" harm to cultural resources, and work with the Advisory Council on Historic Preservation to accomplish this. 16 U.S.C §470h-2(f). BLM should recognize this substantive obligation and fully abide by it. It must make sure the RMP reflects that BLM is doing everything possible to minimize harm to cultural resources. Thus, for example, the Cedar Ridge Traditional Cultural Property must be protected as an ACEC, and the National Historic Trails must be given the protections afforded under Alternative B. Anything less shows that BLM is not doing "to the maximum extent possible" what it can to "minimize" harm to these properties (if these more protective measures under Alternative B were not even possible, BLM could not even propose them).

On page 3-90, it is stated that the 2004 VRM inventory showed "the majority of the planning area should be classified as VRM Class II and Class IV." This is nothing but an

assertion sustained by no objective evidence. What is the current status of most BLM lands in this area? We suspect that the vast majority are Class I (the landscape "appears unaltered by humans") or at worst Class II (the existing character of the landscape is largely unaltered and activities do not attract the attention of the casual observer). If this is the case, what is the basis for fundamentally reworking the visual character of the landscape to predominantly Class III and Class IV? What is the authority directing that radical transformation be pursued as a management objective? We do not think it can be found in FLPMA—the national policy is to manage the public lands in a way that will "protect" their "scenic" values and "preserve and protect" some public lands in their "natural condition"; to manage public lands without "permanent impairment of the . . . quality of the environment"; and to prevent unnecessary or undue degradation of the public lands. 43 U.S.C. §§ 1701(a)(8), 1702(c), 1732(b). Again, what authority does BLM claim for pursuing a management plan that would allow the public lands to be transformed permanently from an essentially natural visual environment into an industrial viewshed? We do not think it can be found, or at a minimum it is tempered by other directives such as those just cited, and thus we ask BLM to reconsider its management direction regarding visual resources. We believe the management direction should be that existing natural visual environments will be protected and maintained to the maximum extent possible and that transformations to lower visual Classes will only be allowed when the maximum level of mitigation possible is applied to the activity. This is certainly consistent with the direction under IM 2004-194 relative to oil and gas operations, at a minimum. More generally, BLM should emphasize that visibility classes are binding management requirements.

Chapter 33—Lands and Reality

On page 3-103, certain areas especially susceptible to OHV impacts are mentioned. We believe this emphasizes the need for these areas to be given special management designation (ACEC) and/or the need for limiting OHVs to designated roads and trails only.

On pages 3-105 to 3-107, issues related to grazing are discussed. BLM gives more attention to the I, M, C classifications that date to the early 1980s than it does to its new grazing regulations adopted in 1995. This needs to be corrected. As emphasized several times, BLM's standards and guidelines for grazing administration (and its Fundamentals of Rangeland Health) form the basic direction and requirements that BLM must pursue and abide by relative to livestock grazing, not the old I, M, C categories. These categories can only be given management focus to the extent they do not prevent or hinder BLM from pursuing its responsibilities relative to grazing management defined in its regulations. On pages 3-105 over to page 3-106, BLM states that the rangeland health standards are "guidelines" that are specified in Allotment Management Plans or "management agreements." This is total misstatement of the requirements of BLM's grazing regulations. As discussed above, the standard and guidelines are binding, non-discretionary obligations that must be met and if they are not, livestock grazing management changes must be made within a specified timeframe and the options that are available for the changes in livestock management are also specified. 43 C.F.R. §§

4180.1, 4180.2(c). BLM also states that management emphasis is on I and M allotments; this is incorrect, management emphasis is and must be on any allotment that has been determined to not be meeting the standards and guidelines. BLM states that 22 out of 26 allotments that have been evaluated are not meeting the standards and guidelines and this is due to livestock grazing. 3-106. It does not state what if any actions have been taken to correct these problems (as it must do), and we request that BLM state what actions have been taken. It is not relevant that only portions of the allotments were not meeting standards, BLM must still take action once a violation of the standards is determined. BLM states that where the rangeland health standards are being violated "guidelines or BMPs will be implemented." These must be implemented within one year, and BLM must so commit. Moreover, "guidelines or BMPs" can only be used to remedy the problems if they are among those allowed for at 43 C.F.R. 4180.2(c) (i.e., they must be provided for in sections 4110, 4120, 4130, or 4160 of the grazing regulations). We appreciate that range condition seems to be improving in the Casper Field Office area, but this needs to be reconciled with the fact that 24 out of 26 allotments that have been evaluated are not meeting the standards and guidelines. There seems to be a disconnect here, and this should be resolved—are the range condition surveys measuring the specified rangeland health markers? If not, they may not have much relevance for management decision-making.

Chapter 3—Special Designations

On pages 3-114 to 3-119 the various special management areas are described. Many of these descriptions support our view that the protections afforded by Alternative B should be adopted by BLM rather than the provisions of Alternative E. The Alcova Fossil Area contains tracks that are "one of only four such trackway occurrences known worldwide; The Bates Hole area contains sagebrush habitats that "represent the best quality greater sage grouse habitats in the planning area and some of the finest habitats in Wyoming;" the Cedar Ridge TCP is "high importance" to the Eastern Shoshone people; the South Bighorns/Red Wall has important habitat for big game and raptors, unique plant communities, a "dense and diverse range of cultural and historical resources rivaling that found anywhere within Wyoming," and there are two existing BLM campgrounds in the area.

With respect to the two oil and gas special management areas (Wind River Basin, and Salt Creek), we believe BLM must rethink whether it can allow oil and gas leasing in these areas to occur with nothing more than standard stipulations. Allowing development on these terms will lead to unnecessary or undue degradation of the public lands in that many, many other leases are being issued with greater stipulations. Under BLM policy (IMs) those leases could not be issued with additional stipulations unless the stipulations were absolutely necessary to prevent unnecessary or undue degradation. BLM policy prohibits attaching stipulations "just because it wants to." Thus, BLM cannot decide that leases can be issued in these areas with few stipulations when it has determined in other areas under exactly the same circumstances that additional stipulations were required to meet its statutory obligations. Moreover, BLM is not excused from many other obligations. It must still comply with its Special Status Species Management Manual. It

must still consider and comply with state policies to the maximum extent possible, including the Wyoming Game and Fish Minimum Recommendations report. IM 2004-194 still applies, as does the Gold Book. While BLM can emphasize energy development in these areas, it cannot establish what could be "leasing and development without rules" areas.

Chapter 4—Mineral Resources

Pages 4-34 to 4-39 discuss some important issues relative to oil and gas development. On pages 4-34 to -35 BLM attempts to argue that NSO is a "major restriction[]" on oil and gas development and that overlapping timing limitation stipulations create problems for oil and gas companies. These assertions are remarkably evidence-free and totally subjective speculation that is essentially a rote repetition of petroleum industry claims. There is no objective support presented for the claim that NSO and overlapping timing limitation stipulations "have the potential of resulting in adverse impacts to the oil and gas exploration and development." **A** very small part of the planning area will be NSO, and no evidence is presented showing overall oil and gas production will be limited. BLM must come forward with such evidence if it wants to make broad claims such as these. That timing limitation stipulations may create smaller timeframes within which to drill means nothing absent evidence this is creating real problems on a broad scale. BLM must present evidence showing that companies cannot plan for and deal with these limitations before it can claim there is any impact of any significance. That the companies don't like them is not enough; there must be objective evidence showing a reduction in drilling rates due to these limitations before this claim can be made. Companies have been eagerly buying leases with overlapping timing limitation stipulations at virtually every BLM lease sale, so obviously they do not view these limitations as such an encumbrance that they cannot develop the lease. BLM's whole premise in this discussion is that anything but drilling with no rules creates adverse impacts to the oil and gas industry. But that is a false basis for impacts analysis—BLM should recognize (and support, since it has a responsibility to faithfully execute the laws of the United States) that the environment in which oil and gas development will proceed is one where environmental protection is assumed and will be given a high priority. The dozens of laws enacted in the last 40 years to protect the environment stand as testament to this national will and direction. We request that BLM totally revise this impacts analysis based on the reality that environmental protection is an overarching national priority and thus does not represent a "major restriction" or other similar pejorative classification. Furthermore, we ask that BLM recognize that many environmental protections may actually reduce costs, making oil and gas development even more appealing. This reality has been recognized in BLM's national BMPs presented on its website and referenced in IM 2004-194. For example, if multiple wells are drilled from a well pad, fewer roads need to be built and drilling rig moves are much shorter and more efficient which may make the development more economically viable, not less.

The discussion of "impacts" resulting from Alternative B makes it clear that there would be few impacts resulting from this alternative relative to oil and gas development. The proposed South Bighorns/Red Wall ACEC and the habitat fragmentation blocks "contain

the bulk of the acreage closed to oil and gas leasing" but these areas have "low to very low or no development potential . . . ." 4-37. The 580,007 acres of habitat fragmentation blocks have "low to very low to no development potential . . . ." The Sand Hills SMA "would have only minor impact" on development. The Muddy Mountain EEA "will not have a substantial impact on development." The Bates Hole SMA would have limited impacts since "this area [has] very low to no development potential." 4-38. The Cedar Ridge ACEC "has a very low to no development potential for oil and gas,." Of the 575,778 acres of highly erosive soils that would be subject to NSO only 6,661 acres "have a high development potential." Of the 1,782,953 acres of BLM mineral estate within 4 miles of sage grouse leks, only 12,015 acres "have a moderate development potential" and would be subject to NSO. Of the 80,285 acres of BLM mineral estate within ¼ mile of historic trails subject to NSO, only 2,517 acres "have a high development potential" and only 4,213 acres "have a moderate development potential." The NSO associated with the Jackson Canyon ACEC and the Muddy Mountain elk crucial winter range "will have a limited impact" on oil and gas development. Thus it is clear that Alternative B will have only the most minor of impacts on oil and gas development and BLM's claim that "Alternative B would have the greatest adverse impacts on oil and gas development" is taken totally out of context. Furthermore, the minor—trivial—impacts on oil and gas development that would occur under Alternative B reemphasize our claims throughout these comments that BLM should adopt the protection measures in Alternative B relative to special management area designation, sagebrush habitat block protection, etc. It is clear the alternative will only have minor impacts on oil and gas development, and BLM states repeatedly throughout the EIS that oil and gas is by far the major development activity that will occur (coal, locatable minerals, salable minerals, etc. development will be relatively minor activities, and thus are not great issues relative to selecting Alternative B).

We must take exception with BLM's claim in Table 4-7 that only 190 wells would be drilled under this alternative. What is the basis for this claim? What objective proof is there that this alternative will reduce drilling by 90% over the current plan and the preferred alternative? This claim seems preposterous, and we would like to see the objective basis for it. As just described, many of the "major" limits on development in Alternative B would occur in areas with minor and even no development potential, and if BLM is assuming that every area subject to overlapping timing limitation stipulations will see almost no development, it needs to come forward with evidence of that.

Chapter 4—Biological Resources

On page 4-59 it is stated that conservation measures identified in biological assessments "are applied to surface-disturbing and disruptive activities . . . ." 'What does this mean? Will these conservation measures be applied as stipulations, conditions of approval? We support BLM doing this, but think it should specify in more detail what exactly will be done and make it a land use plan decision. BLM cites Sierra Club v. Peterson for certain propositions. We believe BLM should note and abide by other determinations made by this same court. BLM cannot rely on a "prophecy that exploration activity. . . will be insignificant and generally fruitless." 717 F.2d at 1413. If BLM "asserts that it cannot

accurately evaluate the consequences of drilling . . . activities until site-specific plans are submitted" then BLM "may delay preparation of an EIS provided that it reserves both the authority to *preclude* all activities pending submission of site-specific proposals and the authority to *prevent* proposed activities if the environmental consequences are unacceptable." Id. at 1415. BLM cannot selectively abide by court decisions.

On page 4-61 it is pointed out that roads have the greatest fragmentation effects. Oil and gas activities are especially problematic in this regard, especially in large blocks of contiguous habitat. 4-59. This strengthens the need to adopt the provisions of Alternative B rather than those of Alternative E that relate to fragmentation, such as the protection of blocks of undisturbed sagebrush habitat.

On page 4-67 and in various other places in the EIS BLM makes clear that it intends to manage forests for commercial purposes, for logging and timber removal. This being the case, BLM needs to fully evaluate the impacts of logging and biomass removal, which it has failed to do. These include impacts such as nutrient removal, erosion (especially on steep slopes), impacts on the regeneration of forests, and numerous other well-recognized impacts that result from logging. On page 4-68 it is stated that fragmentation effects will be corrected "eventually." BLM has to do better than this. Does this mean 5 years? 10 years? 100 Years? 1000 Years?

Page 4-68 The conclusion regarding the impacts of silvicultural treatments on forest health (especially the consequences of fuel reduction and claims regarding future susceptibility to fire) need to be reevaluated in light of recent scientific studies. Exhibits 6, 7, and **8.** Likewise the claim on page 4-69 that the impacts to forests, woodlands, and forest products will be greatest under Alternative B needs to be reevaluated in light of this new science.

On pages 4-73 and 4-74 the impacts of Alternative B on grassland and shrub communities is discussed and on pages 4-76 and 4-77 this discussion is repeated for Alternative E. We believe there is an important missing element of these discussions, namely a consideration of the impacts of oil and gas development. There is no doubt that oil and gas development will be the most pervasive land disturbing activity in the planning area and that it has significant impacts on grass and shrub lands. Given this, the impacts of oil and gas development should be addressed separately. There is no basis for lumping all "surface-disturbing activities" together as one, as though they have no unique impacts. Certainly the impacts of 1800 wells with probably hundreds of miles of roads are not the same as the impacts of a single coal mine. If BLM is not going to present any separate assessment of the impacts of oil and gas development, it must articulate a rational basis for not doing so. This same problem also is apparent for a number of other resources, including the discussions on pages 4-90 and 4-101,[10]

[10] We note that on this page BLM acknowledges that "oil and gas development is anticipated to be the greatest single contributor to disturbance of wildlife habitat in the planning area." BLM cites to the WGFD Minimum Recommendations report for a further discussion of the important impacts of oil and gas development on wildlife. These points emphasize the need for a separate treatment of oil and gas development impacts that is not combined with an assessment of general surface-disturbing activities.

Page 4-113. The discussion of impacts is almost totally unhelpful because it does not even discuss impacts to wildlife. What are the anticipated impacts to wildlife reproduction, distribution, physiological condition (stress and reproduction, for example), behavior (avoidance of areas), etc. These are impacts to wildlife. At most this discussion only indicated whether wildlife will be "OK' or "not OK' which is not helpful and does not meet the requirements of NEPA. The discussion mostly focuses on what will be done, not on the impacts of what will be done.

Pages 4-127 to 4-132. The discussion of the impacts of Alternative E (and this applies to all other impacts discussions) again is almost no discussion of impacts at all. It is almost entirely a comparison of the relative impacts of Alternative E compared to Alternative A. About all that can be said is that the impacts of E may not be quite as great as A, but we have little idea just how great the impacts of either are. While it may be appropriate to compare the relative impacts of the alternatives, some indication of the absolute impacts on wildlife (not acres) of each alternative is also required in order to have an understanding of what will occur under each alternative. Will there be more or fewer deer? Furthermore, by definition, Alternative A (the present management regime) cannot serve as the basis for impacts comparison. BLM has already determined that no action (Alternative A) is totally inappropriate and will not be pursued. 1-5 (BLM has decided to revise the existing plan because it is severely out of date and "no longer serve[s] as a useful guide for resource management"), 2-2 (Alternative A does not meet the purpose and need of RMP revision but is included only because that is required).

Chapter 4—Cumulative Impacts

On page 4-296 to 4-299 BLM misinterprets how to estimate cumulative impacts. It attempts to estimate these by considering various land use plans (Table 4-22). But the CEQ regulations are clear, cumulative effects include the impacts of reasonably foreseeable future actions, not the actions themselves. Considering only a number of pending BLM land use plans is far off the mark in terms of consideration of the impacts of future actions. Many, many other future actions are pending and well-defined. At a minimum BLM must consider the impacts of many of the numerous projects that are currently undergoing NEPA review by BLM that are presented monthly in its "Hot Sheet" ("Wyoming BLM Land Use Planning and Projects" — published monthly by the BLM Wyoming State Office"). Many of these projects clearly relate to and could affect the Casper Field Office. Furthermore, the BLM's attempt to claim that these plans are "strategic in nature'' and therefore impacts "cannot be quantified" also misses the mark. BLM must attempt to assess the cumulative impacts in as much detail as possible. As noted in Kern, this may involve some degree of prognostication — BLM cannot avoid its duty to make an assessment of what the impacts will be.

On pages 4-301 to 4-308, BLM engages in a far too circumscribed an analysis of what the cumulative impacts may be. It considers only seven very narrow categories of impacts that ignore many significant impacts. While impacts on INPS may be of significance, what about impacts on the intactness of sagebrush ecosystems, the

functioning condition of riparian habitats? These are at least as significant as a narrow focus on INPS. The "cumulative impact'' on "oil and gas well development" is not even an environmental impact, and furthermore, the analysis does not even consider cumulative impacts on well numbers, it only considers the number of wells that might be built in the Casper Field Office. What about the number of wells projected from the Lander RMP, Newcastle RMP, and Rawlins RMP, actions BLM itself says are reasonably foreseeable future actions that should be considered in the cumulative impacts analysis. BLM claims the impacts of the limited number of wells it considers on INPS, special status plants, and a few other resources "are described under the appropriate cumulative impacts section" but many resources are ignored. What will the impacts of the cumulative number of wells be on visibility in Class I areas, for example? What will the impacts of these numbers of wells be on habitat fragmentation and crucial winter ranges? These are important issues that BLM itself recognizes, yet there is no consideration of these cumulative impacts on these resources or conditions. BLM narrowly focuses on the impacts of "water depletion on downstream special status species" but any number of other water quality and quantity issues are ignored. What will the cumulative impact be on the flow and water quality of the Platte River, for example. What about the cumulative impacts on other watersheds. The discussion of cumulative fragmentation impacts differs not at all from what appears in the direct impacts analysis in Chapter 4; there is just a restatement of how many acres will or will not be protected in contiguous blocks under the various alternatives. How intact will the sagebrush ecosystem be if the Casper RMP is implemented in conjunction with the Newcastle, Lander, Rawlins, and Buffalo RMPs? That would reflect cumulative impacts. All in all the cumulative impacts analysis is totally unhelpful and unilluminating. We are left totally uninformed regarding the status of big game populations if the "reasonable foreseeable actions" listed in Table 4-22 are implemented. We have no idea what the impacts on biological diversity are likely to be if the reasonably foreseeable actions are implemented. We have no idea how many acres of land will be off limits to oil and gas development and how much will be open with minimal limitations. We have no idea what the cumulative impacts on National Historic Trails will be if the Casper RMP is implemented in conjunction with the Lander RMP. How many acres of land are anticipated to converted from a current status and/or management classification of Class II to Class III or IV, not just from implementation of the Casper RMP/EIS, but cumulatively? That is the kind of information the cumulative impacts analysis needs to provide, but currently fails to do.

Chapter 4—Irreversible and Irretrievable Impacts

BLM inappropriately attempts to limit the consideration of irreversible and irretrievable commitments of resources by claiming that because "the decision does not authorize on-the-ground activities" many impacts are not irreversible or irretrievable. This is totally inappropriate. For one, many decisions in the land use plan are in fact final. Visual status classifications are final. The decision to designate contiguous tracts of sagebrush for protection or not is final. The determination of whether areas are open or closed to OHV use is final. The decision whether to designate an ACEC or not is final. The decision to greatly emphasize oil and gas development in the Salt Creek Wind River

Basin areas is final. Furthermore, the plan will guide, limit and significantly define all future actions. Thus, in the future, even if a specific decision has not been made to allow an oil and gas well in a particular sage grouse habitat, the decision will have been made to only avoid surface disturbing activities within ¼ mile of the perimeter of a lek (Alternative E) rather than to prohibit disturbance within ½ mile of the perimeter of a lek (Alternative B). Once the well is in place under these conditions it will have ongoing impacts for many years. This will have irreversible and irretrievable consequences for sage grouse populations. BLM must revise its analysis of irreversible and irretrievable commitments to present a good faith estimate of impacts not just on commodities (coal, mineral materials), but to also include an analysis of irreversible and irretrievable effects on resources such as cultural resources, wildlife, and visual quality.

Under NEPA, BLM must also "provide a detailed statement" in an EIS on "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity." 42 U.S.C. § 4332(2)(C)(iv). This discussion is totally absent from the Casper RMP/EIS and we request that such a careful statement be provided. Any claims that this discussion can be found here and there throughout the EIS are insufficient, the law is clear, a "detailed statement" on this issue must be provided, and that is not accomplished by disconnected and disparate statements. Even if these exist, it is BLM's obligation to pull them together into a detailed and understandable assessment of this issue. Additionally, this statement has particular importance due to BLM's obligation under FLPMA to manage its lands for "sustained yield." Sustained yield "means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources on the public lands . . . ." 43 U.S.C. §1702((h). BLM is obviously planning to allow a number of "local short-term uses" of lands in the planning area, yet under its sustained yield mandate it has an obligation to provide for and ensure "maintenance and enhancement of long-term productivity." BLM needs to provide a careful discussion and assessment of these issues in the context of a discussion of the irretrievable and irreversible commitment of resources.

Appendix L

BLM should commit to adopting and requiring these mitigation measures to the maximum extent possible. Many of these measures are being required by BLM as part of the Record of Decision for the Jonah Infill Project

Appendix U

The provisions for intensive management should be adopted widely, not just in the few specified special management areas. The protected contiguous blocks of sagebrush should certainly be subject to these requirements. Prairie dog colonies, especially if they may be areas that can be occupied by black-footed ferrets, should be subject to these requirements. We are also puzzled that no "intensive management" is specified relative to wildlife. We believe this should be corrected and specific additional measures for the protection of wildlife incorporated into this appendix.

Miscellaneous Issues

In 2005, the State of Wyoming enacted the Wyoming Surface Owner Accommodation Act that governs relations been oil and gas companies and private landowners on "split estates." W.S. §§ 30-5-401 to -410. We request that BLM abide by this new law, and provide a discussion in the Casper RMP/EIS of how it will do this. Attached to these comments as Exhibit 13 are comments we presented to BLM for its assessment of its split estate policies, and we ask that these also be considered by BLM.

We also request that BLM define and discuss in the RMP what it means by a "valid existing right" under an oil and gas lease. This is a critically important issue that will govern all future processing of oil and gas development proposals (APDs), and thus is very appropriate for consideration and definition at the RMP level. This issue should not be left to "case-by-case" definition out of view of the public at the APD level. This is an issue that needs to be transparently considered by the BLM in the RMP because the RMP is the overarching guidance for management in this area, and this is an overarching issue.

We specifically request that BLM consider the relationships and interactions between terms in BLM's standard lease form (especially section 6) and its regulation at 43 C.F.R. § 3101.1-2. We request that BLM address the provision in the standard lease form and the regulation stating that "reasonable measures" that BLM can require include certain measures "but are not limited to" those measures. Similarly, we request that BLM address the language in the regulation stating that "at a minimum'' certain reasonable measures are consistent with the lease rights granted. It is our view that BLM has retained substantial rights to condition oil and gas exploration and development activities, and that view is supported by the language in both the standard lease form and in the regulation. Under the standard lease form, the objective is to "minimize" environmental impacts, and BLM is given the right to require reasonable measures that are deemed necessary to meet the "intent" of minimizing impacts, but those measures "are not limited to" modifications of siting, design, or timing of operations, or the specification of reclamation measures. Under the regulation, BLM is likewise "not limited to" modifying siting, design, timing, and reclamation measures, and the specified reasonable measures that are deemed consistent with the lease rights granted are "at a minimum" of BLM authority. And overlying all of this is the obligation to prevent unnecessary or undue degradation of the public lands pursuant to FLPMA, which is clearly a nondiscretionary statutory command, as recognized in the regulation. Consequently, we ask that BLM discuss and provide as land use plan decisions what other reasonable measures it may impose that are consistent with lease rights. It is our view that BLM has far more retained rights to condition development than it typically claims. But under the mandates and intent of numerous statutes (FLPMA, CAA, ESA, etc., etc.), we believe BLM has a responsibility to assert that it has the <u>maximum</u> retained rights possible, and additionally under these statutes BLM must use this retained authority to <u>maximize</u> environmental protection.

Throughout these comments we have indicated that various stipulations should be considered and adopted by BLM in the RMP. Examples include the mitigation measures provided for in the WGFD's Minimum Recommendations report and the Fish and Wildlife Service guidelines publication regarding raptor protection. See also Exhibits 2 and 12. We request that BLM engage in a careful analysis in the Casper RMP/EIS of whether it can and should require additional stipulations besides those provided for in BLM's standard stipulation package (Appendix I). The RMP stage is exactly the time and place to engage in such an analysis. If stipulations are not provided for and authorized in the RMP, they will almost certainly never be considered or even be possibilities at the APD stage. We believe this analysis should be guided by the impacts anticipated for various resources, as well as the degree of retained rights BLM enjoys, as discussed in the prior paragraph.

We have referenced the WGFD's Minimum Recommendations report many times in these comments. We reiterate that we believe BLM should formally adopt and abide by these guidelines as a land use plan decision. However, the Minimum Recommendations report is an important asset from another perspective as well. Namely, it contains an annotated bibliography of at least a hundred scientific reports documenting impacts that may result from oil and gas development. We request that BLM consider these reports as it revises its impacts analysis with respect to oil and gas development impacts on wildlife, and as it considers what new stipulations should be required as land use plan decisions.

Last, attached as Exhibit 14 is a report on economic issues prepared by the Wilderness Society that we request BLM to consider as it revises the Casper RMP/EIS.

We appreciate your consideration of these comments and look forward to remaining involved in this process.

Sincerely,

Bruce Pendery,
And on behalf of:

Kirk Koepsel
Sierra Club

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Exhibit 1

UNITED STATES DEPARTMENT OF THE INTERIOR
OFFICE OF HEARINGS AND APPEALS
BOARD OF LAND APPEALS

Wyoming Outdoor Council, Biodiversity Conservation Alliance,	*	
	*	Dismissal of Protest of the Sale of 97 Oil and Gas Leases
	*	WY-BLM 3100 (921 Mistarka) August 2004 Lease Sale
	*	
Appellants	*	**IBLA No. 2005-147**

STATEMENT OF REASONS
SHOWING OF ADVERSELY AFFECTED PARTY STATUS
REQUEST TO DISMISS NON-ADVERSELY AFFECTED PARTIES

I. THE ISSUE PRESENTED FOR REVIEW

In this Appeal the Appellants will ask this Board to determine if the Bureau of Land Management ("BLM") is meeting its duty to consider the programs, policies, and guidelines of the State of Wyoming for the protection of mule deer, pronghorn, and elk crucial winter ranges by only requiring a stipulation on oil and gas leases located in crucial winter ranges that prohibits drilling of wells during the winter, but which does not regulate ongoing operations, as called for by the policies, programs, and guidelines of the State of Wyoming. Moreover, the Appellants will argue, and ask this Board to determine whether, the policies, programs, and guidelines of the State of Wyoming regarding protection of big game crucial winter ranges must not only be considered by BLM before offering oil and gas lease parcels for sale in crucial winter ranges, but in fact be adopted by BLM because the State's policies are not contrary to BLM policy, and thus

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be maintained here; i.e., parcels 063,064 066,069,070,071,095,096, and 108 will be referred to as the Crucial Winter Range Parcels herein. And as noted above, the arguments made in regard to the Crucial Winter Range Parcels in the Protest are incorporated in their entirety into this SOR and we ask that this Board consider them fully. See Exhibit 1 at 8 to 12 (presenting the Appellants' arguments in the Protest).

IV. STATEMENT OF REASONS

This SOR is divided into three sections. First is general background regarding the parcels being appealed and the importance of crucial winter ranges to big game species, as well as a review of the arguments raised in the Protest and BLM's response to those arguments in its Decision. The second section presents arguments showing that BLM has failed to meet its duty under the Federal Land Policy and Management Act ("FLPMA") and other BLM policy to ensure its leasing program is as consistent with State policy as possible. And last, arguments are presented showing that by pursuing leasing without requiring additional protections for big game winter ranges BLM is causing unnecessary or undue degradation of the public lands in violation of FLPMA

A. General Background

1. Description Of The Parcels Under Appeal

The Crucial Winter Range Parcels are generally located in three different areas of west-central Wyoming. Exhibit 8. Parcels 063,064 and 066 are in the Rawlins Field Office in an area north of the town of Rawlins, east and west of U.S. Highway 287 and Wyoming Route 789. Id. Parcels 069, 070, and 071 are located in the Rawlins Field Office south of Interstate 80 on the west side of Wyoming Route 789 in western Carbon County. Id. Parcels 095 and 096 are

located in the southern part of Sweetwater County near the Colorado Border. Id. These parcels are located in the Rawlins and Rock Springs Field Offices. Likewise, parcel 108 is located in the Rock Springs Field Office, north of Interstate 80 in the Jack Morrow Hills area. Id.

Each of the Crucial Winter Range Parcels contains a timing limitation stipulation ("TLS") that says "[n]o surface use is allowed during the following time period(s)," specifically, "(1) Nov 15 to Apr 30; (2) as mapped on [relevant Field Office] GIS database; (3) protecting big game crucial winter range."[5] Exhibit 3 at 14-17, 25, 27, unnumbered page entitled "Timing Limitation Stipulation-TLS." Thus, BLM recognizes these parcels lie on big game crucial winter ranges. And as shown in Exhibit 8, the Crucial Winter Range Parcels lie on pronghorn, mule deer, or elk crucial winter ranges, with parcels 070 and 071 lying on overlapping pronghorn and mule deer crucial winter ranges, which is particularly important wintering habitat.

Crucial winter ranges are vital habitats for maintaining the populations of big game species. They are a determining factor in whether a species can maintain itself. The basis for these statements will be elaborated on in detail below. But because of their importance, they frame the key question presented here: does the standard TLS for protecting big game crucial winter ranges in fact protect these vital habitats? As will be shown below the answer is clearly no. The primary reason the standard TLS does not protect these vital habitats is because it only prohibits drilling during certain times of the year (November 15 to April 30), but by its own terms it "does not apply to operation and maintenance of production facilities." Exhibit 3 at unnumbered page entitled "Timing Limitation Stipulation-TLS." Thus, as will be shown below, the standard TLS does not ensure crucial winter range function will be maintained.

[5] This stipulation will be referred to as the "standard **TLS"** hereinafter because BLM applies it to all lease parcels in crucial winter ranges.

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2. *Arguments Made In The Protest And The Life Of An Oil And Gas Well*

In their Protest, the Appellants presented two arguments as to why the standard TLS was not sufficient to protect big game crucial winter ranges. First, they argued that FLPMA requires BLM to consider, and adopt, State policies, programs, and guidelines that are not contrary to BLM policy, and in this case the WGFD has policies, programs, and guidelines that require much more than the standard TLS provides for in terms of protecting crucial winter ranges. Exhibit 1 at 8-11.[6] Second, they argued that sale of the Crucial Winter Range Parcels with only the standard TLS would cause unnecessary or undue degradation of the public lands, in contravention of FLPMA. Id. at 11-12. The Appellants specifically argued in their Protest that the standard TLS was not sufficient to protect crucial big game winter ranges because it does not regulate ongoing operations. Instead it only regulates drilling during a short period of time in the winter. **As** noted above, the arguments made in the Protest are incorporated into this Appeal in their entirety.

An important underlying principle in this appeal is that the standard TLS is insufficient to maintain the function of crucial winter ranges because the disturbance caused by oil and gas development is not limited to just the period during which wells are drilled. In particular crucial winter range function is not protected just by prohibiting actual drilling of wells between November 15 and April 30.

There is of course no doubt that significant disturbance occurs during the actual drilling of an oil and gas well. But after a well is drilled there is significant ongoing disturbance or causes of impacts. Ongoing activities can include well maintenance and repair, well

[6] On pages 9-10 of their Protest Appellants referenced documents they had submitted with prior protests as support for their arguments in the August 2004 lease sale protest. Those documents will be discussed below and are attached to this Appeal as Exhibits.

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"workovers," removal of petroleum products, and monitoring conditions such as the amount of oil and natural gas produced, and of course each of these activities can involve vehicle traffic to and from a well and human activity at the wells. See 43 C.F.R. §§ 3162.3-2 and 3162.3-3 (requiring "sundry notices'' for "operations to redrill, deepen, perform casing repairs, plug-back, alter casing, perform nonroutine fracturing jobs, recomplete in a different interval, perform water shut off, commingling production between intervals and/or conversion to injection," and for other operations besides well drilling on a leasehold). See also id. at §§ 3162.2-2 to 3162.2-4 (requiring actions to be taken to prevent drainage); 3162.4-1 (requiring well records and reports); 3162.4-3 (requiring monthly reports on operations); 3162.7-2 (requiring measurements of the hydrocarbons produced). Roads require periodic maintenance such as grading and graveling. And of course, ultimately a well must be abandoned and reclaimed, which involves additional activity and at least temporary disturbance. See id. §§ 3162.4-4 (making provisions for well abandonment); 3162.5-1(c) (recognizing that "spills or leakages of oil, gas, produced water, toxic liquids, or waste materials, blowouts, [and] fires" can occur at wells sites).

In a recent report entitled "Recommendations for Development of Oil and Gas Resources within Crucial and Important Wildlife Habitats" (hereinafter, "Recommendations Report"), the WGFD outlines concerns with ongoing impacts from oil and gas development. **As** noted in the Recommendations Report, "oil and gas operations [ ] disturb and displace wildlife throughout the production phase (up to 40 years and longer)." Exhibit **9** at 7. These disturbances include "excavations, roads, facilities, equipment, human activity, and noise [which] physically eliminate some habitat, impair the effectiveness of a larger area of otherwise suitable habitat, and may introduce or attract abnormally high numbers of competitive organisms." Id. at 4. And of

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course, the more wells there are, the greater the long-term, ongoing impacts become. See id. at 4-8.

Just the fact roads and a well pad have been constructed and of course remain in place for several decades causes impacts, often collectively referred to as habitat "fragmentation." The Wilderness Society has prepared a report that documents the significance of these effects in the Pinedale Field Office. Exhibit 10. Large percentages of some gas fields have road densities that exceed recognize thresholds that negatively affect big game. Id. at 12 (Figure 9). The report recognizes that the impacts of roads, most of which were constructed to support oil and gas development in this area, include mortality due to collisions, modification of animal behavior (and energetics), disruption of the physical environment, alteration of the chemical environment, fragmentation of connected habitats, spread of exotic species, and changes in human use of the land and water. Id. at 15 (citations omitted). The effects of energy development on mule deer are pervasive and "extend well beyond the area of development and continue past the time period of the development" and the same is likely true for pronghorn, which may have even greater avoidance of human disturbance. Id. at 17-18 (citations omitted). There is no doubt elk are also very sensitive to ongoing disturbance caused by roads. Id. at 18-19. Thus, it is clear there are substantial ongoing disturbances caused by oil and gas development; significant impacts are not limited to just the actual time when wells are drilled.

Further support for this view is provided in Exhibit 11, the declaration of wildlife biologist Erik Molvar. Oil and gas development has ongoing impacts to big game and big game crucial winter ranges that are significant. Exhibit 11 ¶¶ 7, 19. Negative impacts from oil and gas development have been shown for mule deer, elk, and pronghorn. Id. ¶¶ 10-17. Many of the

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studies referenced in Mr. Molvar's declaration will be discussed in more detail below, and his declaration makes it clear the standard TLS standing alone does not sufficiently protect the function of big game crucial winter ranges.

3. *BLM's Decision*

BLM's Decision on the Protest was based on this claim: ". . . we coordinated with WGFD and did not receive any objection to issuing the subject parcels for sale. Therefore we do not agree with your allegation that offering the subject parcels is inconsistent with State of Wyoming Policy." Exhibit 2 at 8. No evidence has been presented to date of any such coordination; at this point in time it is assertion. Much of the rest of the Decision, in fact most of it, sought to explain the process and rationale BLM uses to grant exceptions, modifications, or waivers to the standard TLS, and presented arguments why this is justified. Id. at 8-9. Yet the question of stipulation exceptions, modifications and waivers was not central to Appellants' Protest. That issue was only mentioned briefly to point out that the standard TLS is hardly an absolute requirement, regardless of what level of protection it might nominally provide; but the key point throughout the Protest was that the policies, programs, and guidelines of the State of Wyoming, and the scientific literature, make it clear the standard TLS standing alone, even when applied, does not ensure there is no loss of function of crucial winter ranges. Exhibit 1 at 8-11. The BLM made no attempt in its Decision to respond to the claim that the standard TLS, standing alone, would not prevent unnecessary or undue degradation of the public lands.

B. BLM Has Failed To Consider The Policies Of The State Of Wyoming For Protecting Big Game Crucial Winter Ranges As Required By FLPMA And Other BLM Policy

1. FLPMA And Other BLM Policy Requires BLM To Coordinate Its Management Activities With The Policies, Programs, ***And*** *Guidelines Of The State of Wyoming And Abide By And Adopt Those Policies, Programs, And Guidelines To The Extent Consistent With Federal Policy*

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The FLPMA makes a very lengthy provision governing requirements for the BLM to ensure its land use plans and management activities are as consistent with State policies, management programs, and management guidelines as possible. Section 202(c)(9) of FLPMA requires that:

> (c) In the development and revision of land use plans, the Secretary shall—
>
> . . . .
>
> (9) to the extent consistent with the laws governing the administration of the public lands, coordinate the land use inventory, planning, and management, activities of or for such lands with the land use planning and management programs of . . . the States and local governments within which the lands are located, including, but not limited to, [ ] statewide outdoor recreation plans developed under the Act of September 3, 1964 (78 Stat. 897), as amended, and of or for Indian tribes by, among other things, considering the policies of approved State and tribal land resource management programs. In implementing this directive, the Secretary shall, to the extent he finds practical, keep apprised of State, local, and tribal plans that are germane in the development of land use plans for public lands; assist in resolving, to the extent practical, inconsistencies between Federal and non-Federal plans, and shall provide for meaningful public involvement of State and local government officials, both elected and appointed, in the development of land use programs, land use regulations, and land use decisions for public lands, including early public notice of proposed decisions which may have a significant impact on non-Federal lands. Such officials in each State are authorized to furnish advice to the Secretary with respect to the development and revision of land use plans, land use guidelines, land use rules, and land use regulations for the public lands within such State and with respect to such other land use matters as may be referred to them by him. Land use plans of the Secretary under this section shall be consistent with State and local plans to the maximum extent he finds consistent with Federal law and the purposes of this Act.

43 U.S.C. § 1712(c)(9) (emphasis added).

This provision clearly anticipates that at a minimum the BLM must consider the management policies, programs, and guidelines of a State, coordinate BLM management policies and programs with those of a State, and in fact attempt to reconcile any inconsistencies between

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State and Federal management policies and programs to the extent consistent with Federal policy. It is Appellants' view that these requirements apply to specific management actions, such as leasing, as well as to land use planning.

Appellants have several reasons for taking this view. First, in various places the plain language of the statute states that it applies to management activities, management programs, land use guidelines, land use rules, and land use regulations. Thus, while this provision appears in a section of FLPMA dealing with land use planning, it is apparent this provision is intended to have broader reach. Second, it is now recognized that planning is an ongoing process, not punctuated. Thus, while development of an RMP may nominally have certain beginning and ending points, plans and planning are constantly subject to analysis, revision and amendment, and thus BLM must always be open to consideration of state policies, programs, and guidelines. And last, as recognized in Norton v. Southern Utah Wilderness Alliance, 124 S.Ct. 2373,2383 (2004), "a land use plan is generally a statement of priorities; it guides and constrains actions, but does not (at least in the usual case) prescribe them." See also 43 C.F.R. § 1601.0-5(k) (stating plans are "not a final implementation decision"). It would be incongruous for Congress to require consideration of the policies, programs, and guidelines of a State at the typically non-prescriptive planning level but not require equal consideration, and attempts to accommodate State policies, programs, and guidelines, when actions are actually being taken.

But even if section 202(c)(9) of FLPMA is not construed to apply to specific actions like oil and gas leasing, under 302(a) of FLPMA, the Secretary of the Interior must manage the public lands "in accordance" with the land use plans developed under section 202 of FLPMA. 43 U.S.C. § 1732(a). See also 43 CFR § 1610.5-3(a) (2003) ("All future resource management

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authorizations and actions ... and subsequent more detailed or specific planning, shall conform to the approved plan."). Thus, to the extent RMPs developed under section 202 require consideration of State policies, programs, or guidelines, BLM must abide by such provisions.

As noted, parcels 095, 096, and 108 are in the Rock Springs Field Office. The Record of Decision and Green River Resource Management plan provides that, "[tlo the extent possible, suitable wildlife habitat and forage will be provided to support the Wyoming Game and Fish Department 1989 Strategic Plan objectives." Exhibit 12 at 24 (emphasis added). Thus, BLM has specifically committed to attempting to fully abide by the plans of the State of Wyoming, which will be discussed below.

Parcels 063, 064, 066, 069, 070, 071, and 095 are in the Rawlins Field Office. The Great Divide Resource Area Record of Decision and Approved Resource Management Plan states that it is "consistent with the plans, programs, and policies of . . . the state of Wyoming, and local governments within the planning area." Exhibit 13 at 2. This is presumably an ongoing commitment. It goes on to state that "When considering needs for protective measures, the [WGFD] will be consulted concerning proposals involving surface disturbance and other disruptive activities in important habitats." Id. at 45. Perhaps more importantly, "other special management practices [besides the standard TLS] will be used as appropriate to focus management emphasis on important resources or to minimize potential conflicts." Id. Thus, again, even if section 202(c)(9) of FLPMA is construed so as to only apply to preparation of RMPs, the RMPs at issue here specifically adopt provisions similar to those in section 202(c)(9), and thus under section 302(a) of FLPMA BLM must abide by these provisions.

Furthermore, in 1991, BLM and the WGFD entered into an Umbrella Memorandum of

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Understanding regarding cooperative wildlife management (hereinafter, "Umbrella MOU"). Exhibit 14. In 1995 the Umbrella MOU was supplemented by the addition of Appendix 5G, which deals with cooperative wildlife management when oil and gas activities occur (hereinafter, "Oil and Gas MOU"). Exhibit 15. See also Exhibit 14 at 11 (making reference to Appendix 5g being a part of the Umbrella MOU).

The Umbrella and Oil and Gas MOUs are built on an understanding that there will be ongoing coordination between BLM and WGFD relative to BLM's oil and gas program with respect to the policies, programs, and guidelines of the WGFD. Exhibits 14, 15. For example, the objectives of the Umbrella MOU are to conduct coordinated programs, maintain a cooperative relationship, and provide for consideration of mitigation of impacts to wildlife from BLM activities. Exhibit 14 at 6. BLM has agreed to consult with the WGFD and coordinate with it "to ensure that all wildlife habitat concerns have been considered in any decisions that may modify terrestrial vegetation or influence aquatic habitat." Id. at 8-9. Not only is BLM to recognize wildlife values in planning, but also in "conducting all resource programs . . ." and it is to "[plractice those forms of land management . . . that will give full consideration to wildlife as one of the desirable resources on the public lands." Id. at 9. BLM has a responsibility that extends beyond planning to "[rlecognize existing State comprehensive or strategic long-range plans and cooperatively manage toward these goals and objectives." Id. BLM (and WGFD) are to cooperate in the formulation and application of objectives, plans, and programs for wildlife and wildlife habitat, and "revise such plans and programs to keep them current." Id. at 10. BLM has specifically agreed to:

> (1) prevent the destruction or deterioration of habitat, (2) utilize the best available knowledge and techniques to ensure the balance between wildlife numbers and habitat consistent with multiple use planning, and (3) improve existing wildlife

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habitat through habitat development and enhancement programs.

Id.

In the Oil and Gas MOU, BLM recognized "it is in the U.S. Government's (and therefore, the American public's) interest to consult with, and solicit, additional technical wildlife "input" regarding the effects of mineral management activities on wildlife from the State wildlife management agency." Exhibit 15 at unnumbered page 1. In fact, BLM recognizes that planning is an ongoing process, not a discrete effort that ends with a period when an RMP is completed: "It is essential that information sharing be continuous, current and complete, and that information be readily available between the WGFD and BLM and be fully utilized by BLM in the course of reaching its decisions. [Land Use Plans] are dynamic, and continuous monitoring of, and necessary modifications made thereto, are expected to keep LUPs current." Id. at unnumbered page 3-4. Thus, again, even if the provisions of section 202(c)(9) of FLPMA were construed to only apply strictly to the actual preparation of RMPs, it is clear BLM has committed itself through other mechanisms to fully consider, and if possible adopt or abide by, State policies, programs, and guidelines.

2. *Wyoming Policy For The Protection Of Crucial Winter Ranges Requires More Than The Standard Timing Limitation Stipulation, It Requires* ***No*** *Loss of Habitat Function On Crucial Winter Ranges And A Number Of Specific Management Actions To Control Ongoing Impacts*

a. The Wyoming Game And Fish Commission Mitigation Policy

The State of Wyoming has a formal policy relative to disturbance of crucial habitats, including crucial winter ranges (hereinafter, "Wyoming Mitigation Policy"). Exhibit 16. The Wyoming Mitigation Policy states that crucial habitats are "vital." Id. at 5. Vital crucial habitat "directly limits a community, population, or subpopulation" and replacement of this habitat "may

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not be possible." Id. at 5-6. Crucial habitat is habitat "which is the determining factor in a population's ability to maintain and reproduce itself. . . over the long term." Id. at **7.** The State of Wyoming's policy is that there should be "no loss of habitat function" in vital crucial winter ranges, and even though some modification may be allowed, the location, essential features, and species supported must remain "unchanged." Id. at 6. Habitat function is a quantitative measure of the arrangement of habitat features and the capability of those features to sustain wildlife over time. Id. at **8.**

As stated in the Wyoming Mitigation Policy statement of philosophy, "[b]y adequately dealing with each increment of development, we can avoid or at least forestall the point at which serious cumulative wildlife impacts occur.'' Exhibit 16 at 1. Moreover, in habitats such as crucial winter ranges, which serve as limits on populations of wildlife, and which relate directly to the carrying capacity of the environment, "[d]evelopment activities that affect limiting habitat components must receive priority attention." Id. The WGFD is specifically tasked with making "mitigation recommendations consistent with the Wyoming Game and Fish Department Strategic Plan and this Mitigation Policy." Id. at 2. And while the mitigation measures recommended by WGFD are advisory, it is nevertheless intended that they "be used as local, state, and federal law provides." Id. at 3.

The WGFD Policy specifically recognizes that impacts can be of a secondary nature or indirect. Such impacts include noise and activity, which "may reduce the effectiveness of adjoining habitats, thereby displacing animals." Exhibit 16 at 6. Other secondary impacts can include impacts due to the "workforce" that undertakes a project, and can include vehicle collisions with wildlife and harassment and poaching. To reduce secondary or indirect impacts,

the WGFD is directed to "recommend measures to avoid or minimize these impacts" and if that is not possible, to recommend that the "impacts be mitigated in some manner." Id. **As** will be discussed in more detail below, the Wyoming Mitigation Policy clearly requires considerably more than the standard TLS provides for relative to protection of crucial winter ranges, and BLM has failed to consider, let alone implement, these policies.

b. The Wyoming Department of Game And Fish Strategic Habitat Plan

In addition to the Wyoming Mitigation Policy, the WGFD has a Strategic Habitat Plan (hereinafter, "Strategic Plan"). Exhibit 17. With respect to habitat, the mission of the WGFD is to "[r]estore and/or manage habitat to enhance and sustain wildlife populations in the future." Id. at 3. A goal of the Strategic Plan is to "[m]anage, preserve, and restore habitat for long term sustainable management of wildlife populations." Id. To implement this goal, objectives of the Strategic Plan include implementation of "projects to preserve or restore habitat at the watershed/landscape level," identification of "wildlife habitats where habitat quality should be preserved . . . ," and the development of "guidelines for land managers for restoring, enhancing and managing wildlife habitat." Id. at **4-5.** With respect to this last objective, a specific strategy is to use guidelines to "develop project/management recommendations." Id. at 5. **As** indicated above, the Wyoming Mitigation Policy specifically directs the WGFD to make "mitigation recommendations consistent with the Wyoming Game and Fish Department Strategic Plan and this Mitigation Policy." Exhibit 16 at 2. Thus, the Strategic Plan is a specific component of implementing the Wyoming Mitigation Policy, and a specific component of the Strategic Plan is to develop guidelines for application when management actions such as leasing are taken.

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C. The Wyoming Game And Fish Department's Recommendations Report

The Recommendations Report is a compliment to and component of the Mitigation Policy and the Strategic Plan. It provides detailed guidelines to implement these policies and programs, particularly to ensure there is "no loss of habitat function" in crucial winter ranges.

Among many other things, the Recommendations Report recognizes the ineffectiveness of the standard TLS standing alone for protecting crucial winter ranges. Exhibit **9** at 6. The Recommendations report considers impacts to wildlife due to oil and gas development as occurring at three levels, Moderate, High, or Extreme. Id. at 8-12. These impact thresholds are defined by oil and gas well densities and acres of disturbance per section (640 acres) of land. Id. at 11. For example, on mule deer and pronghorn crucial winter ranges, such as occur on the Crucial Winter Range Parcels, High impacts are defined as occurring when well densities are 5-16 well locations per section and there are 20-80 acres of surface disturbance per section. Id. at 11. Recommendations for mitigation are made accordingly. All three levels of impact "cause loss of habitat function." Id. at 10. Importantly, even one well per section is viewed as causing Moderate impacts to deer and pronghorn crucial winter ranges, meaning there is no level of oil and gas development that does not negatively affect crucial winter ranges. See id. at 10-12. For elk, all impacts from oil and gas development (even from one well) are at least High. Id.

The Recommendations Report makes specific provisions for protecting mule deer, pronghorn, and elk crucial winter ranges, and for overlapping vital habitats. Exhibit **9** at 11-12. In all cases, the Recommendations Report recommends going beyond just the winter drilling timing limitation in the standard TLS to also include a suite of additional standard management practices outlined in Appendix B. Id. at 11-12, 71-76. These recommended additional

management practices on crucial winter ranges include planning to regulate the pattern and rate of development, phased development, cluster development, and minimization of road construction among many other provisions, few if any of which are ensured by the standard TLS that only limits the time during which actual drilling can occur. See id. at 71-76. These WGFD recommendations are specifically not limited to just the five and half month winter period that the standard TLS applies to; they also apply to ongoing operations. Id. In addition to the standard management practices outlined in Appendix B, provisions are made for additional prescriptions as needed and for habitat treatments (e.g., seeding, burning) on or off the drilling site. See id. at 11-12. See also id. at 77-79 (presenting potential wildlife habitat mitigations).

With respect to mule deer and pronghorn crucial winter range, WGFD recommends that well density not exceed 4 well locations per township (the Moderate impact level) "because it is unlikely habitat effectiveness can be maintained at higher densities." Exhibit 9 at 13. Habitat effectiveness can be reduced in an area of approximately 170 acres surrounding each well due to the stress response caused by noise and activity (thus 4 wells would disturb 680 acres, more than the entire area of a 640 acre section), and even human foot traffic can substantially reduce habitat effectiveness in an area of at least 29 acres surrounding each well.. Id. Thus, in the view of the WGFD, there is a need for the standard management practices described in Appendix B and the habitat improvement practices described in Appendix C, in addition to the standard TLS, so as to reduce the area affected by each well and so as to offset impacts. Id.

At High levels of impact (5-16 wells per section; 20-80 acres of disturbance) in mule deer and pronghorn crucial winter range, the level of impact "will impair the ability of animals to use crucial winter ranges and the impact will be much more difficult to mitigate." Exhibit 9 at 14.

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Much more specific recommendations for mitigation are made in the case of High impact areas, ranging from the use of directional drilling to the use of remote monitoring of well conditions. Id. at 14-16. In the case of Extreme impacts, the WGFD policy against loss of function of crucial winter ranges will not be met. Id. at 16. Habitat function and effectiveness would be "severely compromised." Id. The standard TLS does nothing to ensure such impact levels do not occur.

Elk have a "much greater sensitivity" to disturbance than mule deer and pronghorn, and thus protective measures become applicable at even lower levels of disturbance. Exhibit 9 at 11, 22-23. **As** noted, any oil and gas development causes at least High impacts to elk crucial winter ranges. Id. Overlapping crucial winter ranges are habitats that are "exceptionally important wildlife areas." Id. at 28. Consequently special efforts to mitigate impacts are required where there are overlapping crucial winter ranges. Id. **As** noted above, parcels 070 and 071 have overlapping crucial winter ranges for mule deer and pronghorn.

The WGFD recommendations were developed due to the "adverse effects" WGFD anticipates from the "greatly accelerated" pace of fluid minerals "leasing, permitting, and development" in Wyoming. Exhibit 9 at i (emphasis added). They are a programmatic attempt to integrate wildlife protection and mitigation criteria "into the Bureau of Land Management's (BLM's) resource management planning and implementation processes." Id. (emphasis added). They are intended to provide "advanced disclosure of potential wildlife-related concerns." Id. The Recommendations Report specifically provides "Wyoming Game and Fish Department's recommendations for protecting and mitigating wildlife resources affected by oil and gas development." Id. at ii. Moreover, "these oil and gas recommendations" specifically are

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intended to implement the Wyoming Mitigation Policy. Id. at 2.

The Recommendations Report specifically addresses "vital" habitats as defined by the Wyoming Game and Fish Commission Policy, that is, it is intended to address mitigation in crucial winter ranges. See Exhibit 9 at 3. The document recognizes that oil and gas development causes a range of adverse effects, including excavations, roads, facilities, equipment, human activity, and noise, many of which are not solely confined to the time when wells are drilled. See id. at 4. See also id. at 9 (describing other ongoing sources of disturbance). It documents these adverse impacts in detail, and again the impacts are not necessarily confined just to the well drilling period. Id. at 4-6.

The report documents a number of misconceptions about how wildlife responds to oil and gas development. Exhibit 9 at 6-8. It specifically addresses the misconception that "[e]xisting seasonal use stipulations, standard operating procedures, and reclamation practices are adequate consideration for wildlife resources affected by oil and gas development." Id. at 7. The report's analysis regarding the misconception that the standard TLS standing alone is sufficient to ensure the function of crucial winter ranges are maintained states in full:

> Although seasonal restrictions are intended to protect specific habitats (e.g., winter and reproductive habitats) and species (pronghorn, mule deer, elk, sage grouse) at critical times of year, they generally have been most effective during the exploration and drilling phases of oil field development. However, oil and gas operations also disturb and displace wildlife throughout the production phase (up to 40 years and longer). A variety of [other] management and mitigation tools are available to minimize effects of oil field development (Appendix B) and offset unavoidable impacts by providing replacement resources.
>
> In accordance with 43 CFR 3162.5(a) and Section 6 of the standard federal oil and gas lease terms (Form 3100-11), "Lessee shall conduct operations in a manner that minimizes adverse impacts to the land, air, and water, and to cultural, biological, visual, and other resources, and other land uses or users. Lessee shall take reasonable measures deemed necessary by lessor to accomplish the intent of this

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> section." This provision gives BLM the authority to stipulate reasonable protective measures[7] necessary to reduce or mitigate impacts to wildlife habitat. The current interpretation and application of standard lease terms, timing limitations, and reclamation are important mitigation during the initial and final phases of oil and gas development. It is equally important that mitigation measures be applied during the production phase, as production results in substantial. long-term loss of habitat function. Mitigation during the production phase has generally not been required, as noted in past NEPA documents [ ].
>
> Long-term displacement of wildlife from preferred habitats and disruption of migration routes could, in the extreme case, eliminate "migration memory" that required several thousand years to evolve. Each successive cohort of young ungulates learns the locations of suitable winter habitats and migration routes from older, experienced females that lead them [ ]. Extended disruptions of migration or habitat use can result in loss of learned behavior from entire cohorts of young animals, breaking the tradition of migration to the most suitable winter habitats.

Id. at 8 (citations omitted) (emphasis added). In fact, and as noted, "[a]ny level of oil field development potentially causes an impact. It is legitimate to apply management practices and mitigation to reduce or offset the effects of even a single well in crucial habitat." Id.

The Recommendations Report adds great specificity as to what is required to protect the function of big game crucial winter ranges, such as occur on the Crucial Winter Range Parcels. **As** indicated, the recommendations serve as standing recommendations to BLM for the protection of crucial winter range, and they very specifically recommend going beyond utilization of just the standard TLS to protect crucial winter ranges.

The Wyoming Mitigation Policy, Strategic Plan, and Recommendations Report should be read together as constituting the management policies, program, and guidelines of the State of Wyoming relative to crucial winter ranges. As such, BLM must at a minimum consider these

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[7] "to the extent reasonable" or "reasonable" is defined in the Recommendations Report to mean "effective technologies and practices can be applied to avoid, minimize, or mitigate an impact. "Reasonable" is used here in the same context as 43 CFR 3162.5-1(a). We presume the basis for this determination includes technological

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recommendations, and, pursuant to section 202(c)(9) of FLPMA, the Green River and Great Divide RMPs, and the Umbrella and Oil and Gas MOUs adopt such recommendations to the extent possible. BLM has failed to do this.

3, BLM Has Failed to Coordinate Its Oil and Gas Management Activities On The Crucial Winter Range Parcels With The State Of Wyoming's Policies, Programs, and Guidelines Relative To Crucial Winter Ranges And Adopt Such To The Extent Possible

In the Protest the Appellants raised the issues raised here, in particular they argued that BLM must at least consider going beyond the standard TLS so as to meet its obligation to consider, and to the extent possible adopt, the policies, programs, and guidelines of the State of Wyoming relative to crucial winter range in the context of oil and gas leasing. Exhibit 1 at 8-12. And as noted above, BLM's response to this argument was simply that ". . . we coordinated with WGFD and did not receive any objection to issuing the subject parcels for sale. Therefore we do not agree with your allegation that offering the subject parcels is inconsistent with State of Wyoming Policy." Exhibit 2 at 8. And as also noted above, no evidence of any coordination has been presented to date with respect to the Crucial Winter Range Parcels.

But even if BLM did transmit a copy of the preliminary notice of lease sale as claimed, and even if BLM did not receive any "objection" to the sale of the Crucial Winter Range Parcels, this is not enough to meet BLM's responsibilities. See Exhibit 2 at 7-8 (presenting BLM's claims relative to its coordination efforts). The Wyoming Mitigation Policy, Strategic Plan, and especially the Recommendations Report serve as standing input from WGFD regarding what is needed to protect crucial winter ranges, regardless of whether specific comment is made regarding specific lease parcels. See Exhibit 9 at i (stating the WGFD recommendations are intended to provide "advanced disclosure of potential wildlife-related concerns."), ii (stating

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feasibility, applicability, and economic considerations." Exhibit 9 at 4.

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"[t]his version includes [the WGFD's] recommendations for protecting and mitigating wildlife resources affected by oil and gas development."). See also http://af.state.w.us/habitat/index.asp (stating that the Recommendations Report is "A Strategy for Managing Energy Development Consistently with the FLPMA Principles of Multiple Use and Sustained Yield").

The Umbrella and Oil and Gas MOUs were discussed above. The Oil and Gas MOU specifically provides that, "[i]t is essential that information sharing be continuous, current and complete, and that information be readily available between the WGFD and BLM and be fully utilized by BLM in the course of reaching its decisions." Exhibit 15 at unnumbered page 3. In the Umbrella MOU, BLM has agreed to consult with WGFD and coordinate with it "to ensure that all wildlife habitat concerns have been considered in any decisions that may modify terrestrial vegetation or influence aquatic habitat." Exhibit 14 at 9 (emphasis added). BLM is to "[plractice those forms of land management. . . that will give full consideration to wildlife as one of the desirable resources on the public lands." Id. BLM has specifically agreed to:

> (1) prevent the destruction or deterioration of habitat, (2) utilize the best available knowledge and techniques to ensure the balance between wildlife numbers and habitat consistent with multiple use planning, and (3) improve existing wildlife habitat through habitat development and enhancement programs.

Id. at 10.

BLM cannot meet these responsibilities when it ignores the well documented recommendations of the Wyoming Mitigation Policy, Strategic Plan, and Recommendations Report just because WGFD does not specifically call for their inclusion on specific lease parcels. The WGFD has already made it clear these recommendations apply to all management undertakings by BLM, and specifically they apply to all sales of oil and gas lease parcels in crucial winter ranges. If a lease parcel is to be offered in crucial winter range, WGFD's

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recommendations are well known and must be explicitly considered by BLM, and adopted to the extent consistent with BLM policy.

BLM's decision seems to be based on the provision at unnumbered page 9 of the Oil and Gas MOU. That portion of the MOU calls for BLM to submit the preliminary list of lease parcels to the WGFD and to allow it one month to comment on the parcels. Exhibit 15 at unnumbered page 9. BLM and the WGFD are to coordinate with regard to the proposed lease parcels. The MOU states that "[i]n all cases, the concerns and coordination will address reasonable and necessary protective measures and will be documented in writing . . . ." Id.

The Recommendations Report specifically has determined that its provisions, particularly those in Appendix B, should be applied in all cases to the extent reasonable. Exhibit 9 at 10. ~~See also id.~~ at 4 (defining the terms "to the extent reasonable" and "reasonable" which are terms used repeatedly in the Recommendations Report as to when its recommendations apply). WGFD views its recommendations as being reasonable. As discussed above, the Recommendations Report goes into considerable detail as to why its provisions are necessary, including showing the ineffectiveness of the standard TLS standing alone. Id. at 4-17. And there is no doubt the Recommendations Report is a writing. Clearly WGFD has addressed its concerns in writing to BLM with respect to crucial winter range, and the appropriateness of using just the standard TLS on lease parcels located in crucial winter range, including with regard to the Crucial Winter Range Parcels at issue here.

The Oil and Gas MOU then provides that after WGFD has provided its feedback to BLM, if any, the preliminary list of lease parcels "will again be reviewed for correctness and compliance with BLM policy." Exhibit 15 at unnumbered page 9. That is, regardless of any

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specific input by WGFD, BLM has an independent duty to again review the lease parcels it is proposing to offer for sale and ensure they are in compliance with BLM policy. BLM policy in the Rawlins Field Office is that in addition to the standard mitigation guidelines BLM applies, "other special management practices will be used as appropriate to focus management emphasis on important resources or to minimize potential conflicts.'' Exhibit 13. at 45. See also id. at 48 (one of the Standard Mitigation Guidelines for Surface Disturbing activities is the standard TLS). Thus, BLM policy in the Rawlins Field Office is to independently seek out and apply special management practices in areas important to wildlife, which was not done in this case, even though the WGFD Mitigation Policy, Strategic Plan, and Recommendations Report are all readily available to BLM and provide a wide range of "special management practices" that go beyond what the standard TLS provides for.

In the Rock Springs Field Office the policy is that "[t]o the extent possible, suitable wildlife habitat and forage will be provided to support the Wyoming Game and Fish Department 1989 Strategic Plan objectives." Exhibit 12 at 24 (emphasis added). Thus, BLM has specifically committed to attempting to fully abide by the provisions of the Strategic Plan regardless of any specific input on a specific lease from WGFD. And pursuant to the Oil and Gas MOU, BLM must independently determine if the sale of lease parcels are "correct[ ] and [in] compliance with BLM policy," which in the case of the Rock Springs Field Office means it must determine if the sale of the lease parcels supports the WGFD Strategic Plan.

As noted above, the Strategic Plans has objectives of implementing "projects to preserve or restore habitat at the watershed/landscape level," identification of "wildlife habitats where habitat quality should be preserved . . .," and the development of "guidelines for land managers

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for restoring, enhancing and managing wildlife habitat." Exhibit 17 at 4-5. With respect to the last objective, a specific strategy is to use guidelines to "develop project/management recommendations." Id. at 5. Certainly the Recommendation Report represents the development of "project/management recommendations." And thus, pursuant to the policy of the Rock Springs Field Office and the requirements of the Oil and Gas MOU, BLM must independently seek to support the objectives of the WGFD regardless of whether WGFD provides specific input on specific lease parcels—the WGFD has already done that on a standing basis via the Wyoming Mitigation Policy, Strategic Plan, and Recommendations Report.

Furthermore, the policies that BLM must independently seek to ensure are implemented when lease parcels are offered for sale in crucial winter ranges regardless of any specific input by WGFD include the policies in the Umbrella MOU. These include the following. BLM is to "[plractice those forms of land management. . . that will give full consideration to wildlife as one of the desirable resources on the public lands." Exhibit 14 at 9. BLM is to "[rlecognize existing State comprehensive or strategic long-range plans and cooperatively manage toward these goals and objectives." Id. BLM has specifically agreed to:

> (1) prevent the destruction or deterioration of habitat, (2) utilize the best available knowledge and techniques to ensure the balance between wildlife numbers and habitat consistent with multiple use planning, and **(3)** improve existing wildlife habitat through habitat development and enhancement programs.

Id. at 10. These duties are incumbent on BLM regardless of any specific input from WGFD regarding specific parcels in a specific lease sale, and they must be insured when BLM reviews the preliminary list of parcels to ensure they are "correct[ ] and [in] compliance with BLM policy."

Yet as shown, BLM has failed to meet its independent obligations to ensure that the

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policies, programs and land management guidelines of the WGFD are reflected in the Crucial Winter Range Parcels, even if there was no specific comment on the parcels by WGFD. BLM essentially construed any lack of specific response by WGFD as repudiation or nullification of these well documented policies, programs, and recommendations, which of course is absurd. If and when WGFD abandons or modifies the Wyoming Mitigation Policy, Strategic Plan, or Recommendations Report it will make those change of course well known. Until then these provisions represent the standing recommendations to BLM regarding the mitigation measures that should apply in crucial winter ranges, including to the Crucial Winter Range Parcels, and a standing recommendation that BLM go beyond requiring just the standard TLS on parcels that are offered in crucial winter ranges.

Given this, pursuant to section 202(c)(9) of FLPMA, the relevant RMPs, and the Umbrella and Oil and Gas MOUs, BLM was required to consider application of the provisions in the Recommendations Report to the Crucial Winter Range Parcels. It was also required to determine whether the policies of the State of Wyoming could be adhered to by BLM. Specifically BLM was required to determine whether sale of the Crucial Winter Range Parcels with just the standard TLS would meet the policy of the State of Wyoming that there be "no loss of habitat function" in crucial winter ranges; and if some modification to the habitat could occur on parcels subject to just the standard TLS, whether such modification would allow the location, essential features, and species supported to nevertheless remain "unchanged." Exhibit **16** at **6.** Moreover, pursuant to the Strategic Plan BLM was required to determine whether in this case it was possible to "develop project/management recommendations" as part of the objective of developing "guidelines for land managers for restoring, enhancing and managing wildlife

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habitat." Exhibit 17 at 5. Additionally, pursuant to section 202(c)(9) of FLPMA, the Rawlins and Rock Springs Field Offices RMPs, and the Umbrella and Oil and Gas MOUs, BLM was required to adopt these recommendations or abide by these State policies so long as they do not contradict BLM policy. The recommendations and policies of the State of Wyoming certainly are not inconsistent with those of BLM.

The consistency of the State's policies with local BLM policy has been discussed at some length above, and the applicable MOUs and RMPs make it abundantly clear there is no conflict between BLM and State policy—in fact, under the RMPs and MOUs BLM has a policy of abiding by the policies of Wyoming if possible. The State's policies are also consistent with national policy. BLM is required to "incorporate appropriate [Best Management Practices—"BMPs"] into proposed [Applications for Permits to Drill—"APDs"] and associated on and off-lease rights-of-way approvals after appropriate NEPA evaluation." Instruction Memorandum ("IM') No. 2004-194. See also IM 2004-110 Change 1 (extending the requirement to consider the BMPs specified in IM 2004-194 to oil and gas leasing). In fact, WGFD specifically adopted many of the BMPs specified at the BLM website referenced in IM No. 2004-194 as the basis for the recommendations in the Recommendations Report. Exhibit 9 at i (referencing http://www.blm.gov/bmp/). Thus, the policies of WGFD are entirely consistent with those of BLM. And of course, if BLM fails to require additional provisions beyond the standard TLS at the leasing stage, as additional lease stipulations, it will be hard pressed to implement the policies, programs, and guidelines of the State of Wyoming later, at the APD stage of development.[8]

[8] Under BLM's leasing regulations, a lessee has a right to fully develop a lease, unless BLM has limited what may occur through stipulations attached to the lease, or there are limits that apply to a lease due to provisions in non-discretionary statutes, or there are highly limited "reasonable measures" that can still be applied. Thus, BLM cannot

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And pursuant to an Executive Order issued by the President on August 26,2004, national policy and direction is for federal agencies to "facilitate[] cooperative conservation." Exhibit 19 (emphasis added). Cooperative conservation is defined as "actions that relate to use, enhancement, and enjoyment of natural resources, protection of the environment, or both, and that involve collaborative activity among Federal, State, local and tribal governments . . ." Id. Certainly BLM must actively consider, and apply, the State of Wyoming's policies, programs, and guidelines to the maximum extent practical pursuant to this order from the President. **As** discussed at length in this SOR, Wyoming's policies, management programs, and guidelines certainly involve "actions that relate to use, enhancement, and enjoyment of natural resources, protection of the environment, or both," and thus are within the scope of the Executive Order, meaning BLM must facilitate their application to the Crucial Winter Range Parcels, which has not been done.

4. *The Standard Stipulation Will Not* ***Allow*** *Big Game Crucial Winter Range Function to Be Maintained*

It must be emphasized that the need to consider and adopt Wyoming policies, programs, and guidelines regarding means to protect crucial winter ranges is more than academic. Whether additional protections are applied to leases in crucial winter ranges or just the standard TLS is applied will determine whether healthy big game populations are maintained or are lost in much

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fully regulate impacts that occur on a lease unless it reserves that authority in advance. 43 C.F.R. § 3101.l-2. BLM's standard lease form also gives a lessee a right, in fact a duty, to fully develop a lease. Exhibit 18 (giving the lessee the "exclusive right" to develop oil and gas resources on a lease, and in section 4 requiring diligent development of these resources). While the full level of rights retained by BLM, such as through section ***6*** of the standard lease form, can be and have been debated, there is no doubt that issuance of a lease without a no surface occupancy stipulation represents the point of irreversible and irretrievable commitment of resources, and such a lease conveys to the lessee substantial rights to develop a lease and greatly limits BLM's ability to regulate surface disturbance on a lease. See Wyoming Outdoor Council, et al., 157 IBLA 259,275 (2002) (Burski, concurring) ("And I think it fair to say that the thousands of entities which have acquired oil and gas leases . . . would be shocked to hear that those leases merely afforded them a priority in submitting plans to develop those leases and nothing more.")

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of Wyoming. Evidence of this comes from at least three sources: the Recommendations Report, expert scientific opinion, and the scientific literature.

a. The Recommendations Report

The Recommendations Report makes it clear that failure to adopt its recommendations will greatly harm the function of big game crucial winter ranges, such as those on the Crucial Winter Range Parcels. The report points out that, "[d]evelopment of expansive coal, oil, and natural gas deposits that underlie crucial and important wildlife habitats . . . constitutes one of the greatest, contemporary challenges to conservation of western wildlife. The impending, large-scale development of these domestic energy reserves could place sagebrush communities and wildlife at risk on lands overlying BLM-administered minerals." Exhibit 9 at 2.[9] The Recommendations Report mitigation practices are offered so as to "offset or compensate [for these] unavoidable, adverse effects of oil and gas development." Id. at 3. The Recommendation Report identifies in detail the sources and significance of the impacts resulting from oil and gas development, with its recommendations placing emphasis on protecting limiting habitat components and functions, such as crucial winter ranges. Id. at 4-6.

Oil and gas development on crucial winter ranges increases deer density on remaining winter ranges, reduces forage quality, reduces fawn survival, reduces over-winter carrying capacity, forces animals onto poorer quality ranges where adult survival is decreased, and reduces options for coping with extreme environmental conditions. Exhibit 9 at 5-6. Moreover,

[9] This concern is hardly overstated. **As** shown in the recently released Draft Environmental Impact Statement for the Rawlins Resource Management Plan, BLM anticipates 8,822 new wells being drilled in this Field Office under its preferred alternative. Exhibit 20 at ES-7. Reference to the Final Environmental Impact Statement and Proposed Plan Amendment for the Powder River Basin Oil and Gas Project shows that tens of thousands of wells will be drilled in the Powder River Basin in Northeast Wyoming. In the Pinedale Field Office, it is now predicted that a total of 12,872 wells could be drilled by 2020, a dramatic increase from the current number of approximately 3000 wells. Exhibit 21. Reference to any BLM Notice of Competitive Oil and Gas Lease Sale in Wyoming, including that for August 2004, shows that many, perhaps even most, parcels that are being offered for sale are located in

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assertions that wildlife can just relocate to adjacent unaffected habitats, become accustomed to and are not affected by oil and gas development, and are sufficiently protected by the standard TLS are "misconceptions." Id. at 6-8. Thus, the Recommendations Report, a report prepared by probably the lead experts relative to wildlife issues and ecology in the State of Wyoming, makes it abundantly clear that its provisions must not only be considered but in fact adopted if big game crucial winter ranges are to receive sufficient protection from oil and gas development to maintain their function, and that the standard TLS standing alone does not meet this need.

b. The Literature On The Importance Of Crucial Winter Ranges

The popular and scientific literature makes it clear that it is all but guaranteed that there will be loss of habitat function if significant exploration or development occurs on the Crucial Winter Range Parcels subject only to the standard TLS. Perhaps the most significant of these studies is a study conducted by Hall Sawyer and others on big game crucial winter ranges in the Pinedale Anticline oil and gas field near Pinedale, Wyoming. Exhibit 22. The Study is a long-term controlled scientific examination of the potential impacts of energy development on mule deer. Id. at 1. It uses the Pinedale Anticline oil and gas field as the "treatment" area and a nearby area without oil and gas development as a control. Id. The treatment area, the Pinedale Anticline oil and gas field, is composed of a large area of winter range as is the control area. Id. at 3-6. The study shows a striking avoidance of winter ranges that have seen oil and gas development; winter ranges that were formerly receiving high deer use receive much less use after development occurs. Id. at 42-45 (Compare Figures 2.25 to 2.28 with Figures 2.20 to 2.23).

Based on these results, the authors concluded that, "results to date suggest that winter mule deer habitat selection and distribution patterns have been affected by natural gas

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crucial winter ranges.

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development, specifically road networks and well pads." Exhibit 22 at 48. Mule deer "selected habitats away from well pads" immediately and there was "no evidence of acclimatization behavior." Id. It appears "gas development may displace mule deer to less preferred habitats." Id. Concerns expressed by the authors were that there was indirect loss of winter habitat that substantially exceeded direct loss of habitat, and that this could "decrease the carrying capacity of the overall winter range." Id. at 49. While these results are preliminary and direct measurement of changes in survival or reproduction have not been documented yet, the implications of this research regarding the sufficiency of the standard TLS standing alone to maintain crucial winter range function is obvious.

A study by the U.S. Forest Service has documented a number of impacts that result from oil and gas development, many of which are not addressed, or at least fully addressed, by limiting the time during which well drilling can occur. A number of activities associated with oil and gas development besides drilling cause a number of "disruptions" to wildlife. Exhibit 23 at 3-4. Impacts can be primary or secondary, ranging from avoidance and displacement and permanent loss of habitat as primary impacts, to desertion of traditional areas, shifts in range, change in distribution, and use of marginal habitat as secondary impacts. Id. at 9-10. To minimize the negative effects of oil and gas development, temporal restrictions can be used, but "operational management," including many techniques similar to those listed in Appendix B of the Recommendations Report, should also be considered. Id. at 13. Again, it is clear the standard TLS standing alone does not ensure functioning crucial winter range will be maintained.

There are a number of other studies, reports and news articles showing the sensitivity of big game on winter ranges. A study of mule deer and pronghorn responses to oil and gas

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development in the Rattlesnake Hills in Wyoming showed that pronghorn were displaced from winter ranges by oil and gas development and the authors believed the majority of scientific studies show mule deer avoid human-related disturbances. Exhibit 24. Pronghorn avoided oil fields during drilling and well maintenance. Id. A number of other potential effects were also highlighted. Mule deer experts recognize that oil and gas development is severely impacting seasonally critical ranges, and that mule deer survival is negatively affected if they are forced to use marginal habitats, especially on winter ranges. Exhibit 25. Mule deer mortalities in the Big Piney/LaBarge winter range, an area with extensive oil and gas development, have been very high in recent years. Exhibit 26. In Utah, the BLM has determined that oil and gas development results in the loss of habitat and space for wildlife and that it displaces wildlife into other suitable habitats, which may subject the wildlife to crowding, stress, and competition. Exhibit 27. Wildlife also abandons areas surrounding wells. Id. A study of winter ranges in the Big Piney/LaBarge area determined that mule deer were displaced in areas where well recompletions were undertaken, although the deer may tolerate more routine levels of disturbance. Exhibit 28. Human disturbance is an important factor in determining mule deer habitat quality, and on winter ranges mule deer have very small home ranges (less than one-half mile diameter), meaning all needed habitat components must remain present within this limited area. Exhibit 29. BLM in Wyoming has determined that oil and gas development on crucial winter range is "the most serious threat" to pronghorn, this being due to the direct loss of winter range due to surface disturbance from the drilling of wells and their ongoing production. Exhibit 30. While no mule deer crucial winter range was present in the Moxa Arch project area, the drilling and development of wells coupled with associated roads and pipelines physically eliminates large

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areas of habitat. The literature makes it clear that big game crucial winter range function will not be maintained if just the standard TLS is applied to the Crucial Winter Range Parcels.

c. The Declaration Of Erik Molvar

Additional scientific support for the view that the standard TLS standing alone does not protect the function of big game crucial winter ranges is provided in the attached declaration of wildlife biologist Erik Molvar. Exhibit 11. Mr. Molvar's professional opinion is that oil and gas development subject only to the standard TLS has negative effects on the function of big game crucial winter ranges and such effects extend beyond just the time when wells are actually being drilled. Id. ¶ 7. ("These impacts are not limited to the construction/drilling phase, but persist throughout the life of an oil or gas well, and are intensified depending on the number of wells drilled."). His overall professional opinion of the effect of oil and gas wells on big game crucial winter range and the utility of the standard TLS standing alone to protect the function of crucial winter range is that:

> . . . oil and gas development in crucial winter ranges and along migration corridors displaces big game away from preferred habitats and into marginal habitats, resulting in loss of habitat function for affected crucial ranges. Timing stipulations emplaced to prevent construction or drilling activities during the crucial season do not prevent the displacement of wildlife and consequent loss of habitat function. If no compensatory measures are made to fully compensate for this loss of habitat function throughout the life-cycle of a well, the result is a net loss of habitat function for these species.

Id. ¶ 19. His professional opinion is based on his academic training, scientific publications, knowledge of Wyoming landscapes (including specifically the Crucial Winter Range Parcels), and his review and analysis of relevant research conducted in Wyoming on mule deer, pronghorn, and elk. Id.¶¶ 2-6, 8-17.

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5. *Healthy Big Game Populations Are Of Critical Importance To The People Of Wyoming*

The importance of big game in Wyoming and to the State of Wyoming and its residents cannot be overstated. It goes far beyond the somewhat sterile language and terms in section 202(c)(9) of FLPMA, provisions in RMPs and the Umbrella and Oil and Gas MOUs. The issue here is much more profound than ensuring that BLM attempts to "coordinate" with the State so as to ensure that BLM actions are "consistent" with State "management programs" and "management guidelines," and so forth. Big game and big game hunting are of core importance to the economy, "sense of place," aesthetics, ecology, and indeed the culture of Wyoming. Quite simply, a way of life will eventually be lost or gravely damaged if BLM continues to only require the standard TLS on lease parcels in crucial winter range. "Wyoming's wildlife is an important asset to residents and visitors, providing pleasure for viewing and hunting and generating dollars in the state's economy." Exhibit 31 at 1.

According to the U.S. Fish and Wildlife Service's 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, 662,000 people participated in wildlife-related recreation in Wyoming in 2001, in a state with a population of only 377,000, a striking contrast to many if not most states where the total number of participants in wildlife-related recreation does not match, let alone exceed, the State's population. Exhibit 32 at 96-97. Over $ 600,000,000 was spent on wildlife related recreation in Wyoming in 2001. Id. at 98. Over a third of Wyoming's population engages in hunting or fishing. Id. at 102. One-hundred-thirty-three-thousand people hunted in Wyoming in 2002, with over half of them coming from out-of-state. Id. at 103. Of these people, 110,000 thousand, or eighty three percent, engaged in big game hunting. Id. at 104. In Wyoming in 2001, 1,304,000 days of hunting were engaged in with

sixty one percent of that being by in-state residents. Id. at 105. Wildlife in general and big game in particular are clearly a very important part of life in Wyoming.

Over half of the winter range in Wyoming is located on public lands. Exhibit 31 at 2 (Figure 1). Annual expenditures for hunting on public land for mule deer, elk, and pronghorn, which total in the tens of millions of dollars annually, equal or exceed those on private land in Wyoming. Id. at 4 (Figure 3). **A** "Google" search on the key words "big game" and "Wyoming" will turn up literally dozens of'websites,many devoted to the services of big game hunting outfitters. Big game is clearly of an importance to Wyoming's resident's that transcends concepts like ensuring consistency between State and Federal policies, and thus it is critical that the vital habitats that support these species be fully protected by BLM, which has not occurred with respect to the Crucial Winter Range Parcels.

C. The Standard Stipulation Will Lead To Unnecessary Or Undue Degradation Of The Public Lands

The FLPMA requires the BLM to "take any action necessary to prevent unnecessary or undue degradation of the [public] lands." 43 U.S.C. § 1732(b) (emphasis added). This specific, non-discretionary standard requires BLM to ensure that both unnecessary degradation and undue degradation of the public lands does not occur due to oil and gas drilling. Mineral Policy Center v. Norton, 292 F.Supp.2d 30, 41-43 (D.D.C. 2003) (holding this is a two pronged standard). While the "unnecessary" prong of this twofold requirement may relate to the economics of oil and gas drilling and industry standard practices, the "undue" degradation prong relates to impacts that are environmentally excessive. See id. at 42, (finding that "by its plain terms [this provision] vests the Secretary of the Interior with the authority—and indeed the obligation—to disapprove of an otherwise permissible mining operation because the operation, though necessary for

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mining, would unduly harm or degrade the public land."), 43 (determining that "Congress's intent was clear: Interior is to prevent, not only unnecessary degradation, but also degradation, that while necessary for mining, is undue or excessive."). See also Kendall's Concerned Area Residents, 129 IBLA 130, 138 (1994) ("If there is unnecessary or undue degradation, it must be mitigated" and "[i]f unnecessary or undue degradation cannot be prevented by mitigation measures, BLM is required to deny approval of the plan.").

Based on the arguments that have been presented in this SOR, it is clear BLM is failing to meet this mandatory obligation by only attaching the standard TLS to the Crucial Winter Range Parcels, and not requiring the additional protections that application of the State of Wyoming's policies, programs, and guidelines would provide. BLM has failed to take "any" action that is necessary to prevent unnecessary or undue degradation. This SOR has presented substantial, and Appellants believe compelling, evidence showing that protections in addition to the standard TLS are "necessary" to maintain the function of big game crucial winter ranges. Absent these additional protections the function of crucial winter ranges cannot be maintained, which is undue, that is environmentally excessive, degradation since there are many well known and recommended options available from WGFD to eliminate or at least reduce these negative effects.

By failing to require these protections at the leasing stage, the die is cast making it difficult if not impossible to require stricter protections when an APD is filed. Certainly the lessees will have strong arguments that BLM cannot impose additional restrictions. Even assuming BLM is willing and interested in adding further protections at the APD stage to protect crucial winter ranges, which to the best of Appellants' knowledge BLM has never done, the

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lessees can at a minimum make it very difficult for BLM to impose those additional requirements due to the rights that have been given to them by the lease. The time to take any action necessary to prevent unnecessary or undue degradation of the public lands is at the leasing stage when BLM retains the greatest degree of control, not at a later stage when BLM's ability to protect the public lands becomes increasingly problematic and uncertain.

V. CONCLUSION

For the foregoing reasons the Appellants request that this Board reverse BLM's decision to sell and issue the Crucial Winter Range Parcels. BLM should be ordered to explicitly consider the policies, programs, and guidelines of the State of Wyoming relative to crucial winter ranges and be ordered to abide by and adopt these policies, programs and guidelines with respect to the Crucial Winter Range Parcels since they are not inconsistent with BLM policy.

Respectfully submitted for Appellants

BY:

_____

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Dated this _____ day of May, 2005.

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UNITED STATES DEPARTMENT OF THE INTERIOR
OFFICE OF HEARINGS AND APPEALS
BOARD OF LAND APPEALS

Wyoming Outdoor Council, Biodiversity Conservation Alliance,	*	
	*	Dismissal of Protest of the Sale of 97 Oil and Gas Leases
	*	WY-BLM 3100 (921 Mistarka) August 2004 Lease Sale
	*	
Appellants	*	**IBLA No. 2005-147**

REPLY TO ANSWERS

I. PROCEDURAL BACKGROUND

Responding to the Statement of Reasons ("SOR') filed in this matter by the Appellants on May 5,2005, this Board received five Answers. Answers were filed by the U.S. Government on behalf of the Bureau of Land Management ("BLM') (hereinafter, "Government Answer"), Donald B. Anderson, Ltd. (hereinafter, "Anderson Answer"), Questar Exploration and Production Company (hereinafter, "Questar Answer"), EOG Resources, Inc. (hereinafter, "EOG Answer"), and Yates Petroleum Corporation. This Reply to the five Answers is submitted pursuant to this Board's Order dated July 19,2005 allowing the Appellants to submit a Reply to the Answers by August 8,2005.

II. INITIAL MATTERS

Before proceeding to Reply to specific elements of the five Answers, Appellants would like to highlight three matters. First, the SOR attempted to be clear that Appellants believe BLM

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failed its responsibilities in two respects relative to the protections (stipulations) it attached to the lease parcels at issue in this matter, and the policies, plans, and guidelines of the Wyoming Game and Fish Department ("WGFD") with respect to protecting big game crucial winter ranges. BLM failed it responsibilities by not even considering the policies, plans, and guidelines of the State of Wyoming relative to protecting big game crucial winter ranges. It then further failed to meet its responsibilities by not adopting these policies, plans, and guidelines with respect to the lease parcels at issue here because they are not inconsistent with Federal policy. Appellants believe that failure to meet either of these obligations constitutes reversible error. Thus, even if this Board were to conclude that BLM was under no obligation to actually adopt the policies, plans, and guidelines of the State of Wyoming relative to protecting big game crucial winter ranges, Appellants believe that BLM was still under an obligation to at least consider these policies, plans, and guidelines with respect to the lease parcels at issue here, and it failed to meet that obligation.

Second, it is important to emphasize that the WGFD's "Recommendations for Development of Oil and Gas Resources within Crucial and Important Wildlife Habitats" constitute standing recommendations for protecting big game crucial winter ranges from the effects of oil and gas development.' SOR Exhibit 9 at i (noting the Recommendations Report provides "advanced disclosure" of impacts and concerns of the WGFD and mitigation and management options to meet those concerns). Thus, there is no need for WGFD to provided specific, detailed statements relative to the hundreds of lease parcels offered for sale in Wyoming every year; it has already made its concerns well known to BLM in a very detailed fashion. See EOG Answer at Exhibit **A** page 14 of 19 (noting that local BLM personal reviewed and

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supported the Recommendations Report); http://gf.state.wy.us/downloads/pdf/ og.pdf (the Recommendations Report is posted on the Worldwide Web).

Related to the fact that the Recommendations Report constitutes the WGFD's standing recommendations for what is needed to protect big game crucial winter ranges is the fact that it is a piece in the whole of Wyoming's comprehensive position regarding the value of and need for protection of big game crucial winter ranges. In the SOR, considerable discussion was provided regarding how the Recommendations Report is one piece of this overarching policy, with the Wyoming Game and Fish Commission Mitigation Policy constituting the first tier in the policy, the Strategic Habitat Plan the second tier of the policy, and the Recommendations Report the third tier providing specific, concrete recommendations for ensuring there is no loss of function of big game crucial winter ranges. SOR at 17-25; SOR Exhibits 9, 16 and 17.

Thus, the Recommendations Report is not a "free-standing" miscellaneous expression as stated or implied in the Government's Answer and several of the other Answers. It is part of a very well thought out policy based on far more science and evidence than anything the Government or the Intervenors have come forward with, all with the objective of implementing the Wyoming Game and Fish Commission's (the primary policy-setting entity for wildlife issues in the State of Wyoming) official policy of ensuring "no loss of habitat function" in "vital" crucial winter ranges. SOR Exhibit 16 at 5-6. *See also* SOR Exhibit 9 at 29-70, **84-183** (citing literally hundreds of scientific references including an annotated treatment of them, which stands in marked contrast to the Government's science-less and evidence free Answer).

Thus, it is clear that whether the State of Wyoming's position on protecting big game crucial winter ranges is termed a "plan" or a "policy" or a "program" or a "regulation" or

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[1] This report was referred to as the "Recommendations Report" in the SOR, and that terminology **will** be

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"guidelines" or something else, it is all part of a cohesive, well-thought-out whole that the State of Wyoming is actively seeking to implement through the auspices of its agency charged with such efforts, WGFD.[2,3]

Lastly, it is important to emphasize the Appellants are relying primarily on the policies, plans, and guidelines of the WGFD to support their claims that more than the standard timing limitation stipulation ("TLS") prohibiting just actual drilling from November 15 through April 30 is needed to maintain the function of big game crucial winter ranges. The WGFD is clearly an expert agency relative to these matters. Thus, statements like "Appellants charge" the standard TLS standing alone is insufficient to protect big game crucial winter ranges are inaccurate at best; it is as much WGFD making this "charge" as it is the Appellants.[4] See Government Answer at **4** (making this statement).

III. APPELLANTS HAVE DEMONSTRATED WITH OBJECTIVE PROOF ERRORS OF LAW, ERRORS OF FACT, OR A FAILURE TO CONSIDER A SUBSTANTIAL ENVIRONMENTAL QUESTION

The Government in particular advances the notion that the Appellants have not met their burden of proof and that any injury due to BLM's failure to consider and in fact abide by State policies, plans, and guidelines is "speculative." Government Answer at **3-8.** These claims are

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maintained here.

[2] The Government seems to recognize these documents cannot be neatly compartmentalized: "[T]hese policies are merely planning directives . . . ." Government Answer at 10 (emphasis added).

[3] Claims such as those in the EOG and Anderson Answer that the policies, plans, and guidelines of the State of Wyoming are irrelevant because they were not also applied to State oil and gas leases are misplaced. EOG Answer at 4, Anderson Answer at 19-20. State lands are not managed for multiple uses or under the laws BLM lands are subject to; they are subject to a statutory trust obligation that does not require the same management as applies to Federal multiple use lands. *See* Delissa Hayano, Case Note, 5 Wyoming L. Rev. **59** (2005).

[4] In a related claim, many if not all of the Answers attempt to attach significance to the fact WGFD is not party to this appeal. This is of little consequence. It has long been recognized that citizens such as those the Appellants represent serve in the role of "private attorneys general" in matters of environmental protection, stepping into the shoes of the state when the state cannot or will not enforce environmental protections. For the record, counsel for Appellants contacted both the WGFD and the Wyoming Governor's office regarding this appeal in early May, 2005. Neither office raised any objection or expressed any concerns to this appeal being filed.

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largely based on *Western Slope Environmental Resource Council et al.*, 163 IBLA 262,286 (2004). The Government misinterprets this case and attempts to extend if far beyond its holding.

In *Western Slope*, the Appellants challenged a lease sale, just as here. In deciding the case, this Board in no way indicated that Appellants cannot challenge a lease sale unless they can prove with absolute certainty that drilling will occur on a lease, as the Government contends. *See* Government's Answer at 4-6. In fact, in *Western Slope* the Board recognized that issuing a lease constitutes an irreversible and irretrievable commitment "to permit surface-disturbing activity, in some form and to some extent." 163 IBLA at 285 (emphasis added). Thus, the fact that the leases at issue here have been sold and issued means BLM has committed to allow oil and gas drilling in some form and to some extent; it has committed to allow some environmental harm so that oil and gas can be extracted. So the question becomes not whether oil and gas development is certain to occur as advocated by the Government and many of the Intervenors, but rather whether in making the decision to sell and issue the leases at issue here BLM premised the decision on a clear error of law or fact, or decided to sell and issue the leases without considering a substantial environmental question of material significance.[5]

The entire SOR is nothing if not replete with evidence of a substantial environmental harm of material significance (the negative impacts of ongoing oil and gas operations on vital big game crucial winter ranges and the failure of the TLS standing alone to protect against such harms) and legal argument showing BLM failed to consider this issue by failing to consider the

[5] *Western Slope Environmental Resource Council*, 164 **JBLA 329** (Feb. 8,2005) also does not control this matter. In that case, coalbed methane and issues related to strong variation in subsurface geology and produced water were at issue. There was a great deal of uncertainty as to what the levels of environmental impact would be if development occurred, and even whether coalbed methane or another form of methane would be developed. Here, there is no question that the parcels at issue are located in crucial winter ranges, that BLM has no certain retained authority to regulate the impacts of ongoing development on crucial winter ranges, and it is well recognized (by WGFD) that the ongoing effects of oil and gas development harm crucial winter ranges. The harms are far more

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Exhibit 2

A Blueprint for Sage-grouse Conservation and Recovery

Prepared by

Clait E. Braun, Ph.D.

Grouse Inc.
Tucson, Arizona

May 2006

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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 km² to 835,000 km²). 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

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m,id-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 (1-80) across southern Wyoming and only 9 leks were known to occur between 2 and 4 km of 1-80. 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

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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

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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

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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 km² or 1 mi²]) blocks of sagebrush steppe and preferably in excess of 20 cadastral sections [51.8 km² or 20 mi²] in size. These blocks should conserve habitat at the landscape scale with at least 1 large block per Township (36 cadastral sections [93.2 km² or 36 mi²]) throughout the sagebrush steppe. This recommendation is based on personal observations as well on published literature (Toepfer et al. 1990).

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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).

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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 km² (2 miles/mile²) (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.

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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.

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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.

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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.

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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 km²) 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

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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.

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-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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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.

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Appendix

Seasonal Habitat Requirements for Sage-grouse:

Spring, Summer, Fall, and Winter'

(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.)

'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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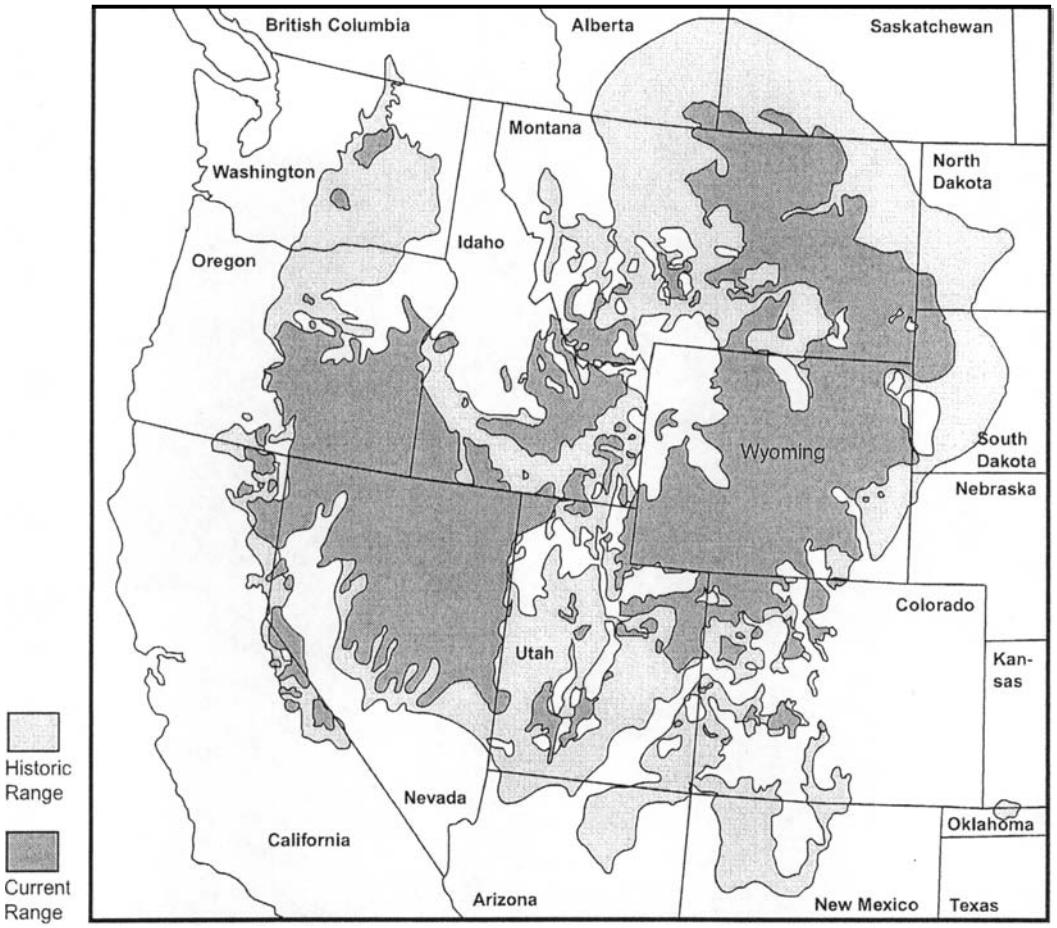

Figure I — Historic and current distribution of sage-grouse (map prepared by M. A. Schroeder)

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 fonds 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 Rraun 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 natura1 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

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Exhibit 3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

JUL 28 2006

Ms. Abigail Dillen
209 South Willson Avenue
Bozeman, Montana 59715

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Dear Ms. Dillen:

This letter is in response to your inquiry regarding applicability of the Scheffe Point Source Screening Tables.

I developed the screening tables in 1988 as a screening test to estimate the contribution to ambient ozone associated with increased non-methane organic carbon (NMOC) emissions arising from new or modified point sources, The tables never achieved a level of EPA certification associated with EPA guideline models and consequently were not endorsed by the Agency. After publication (non peer reviewed literature) of the tables in 1989, the American Petroleum Institute enlisted renowned atmospheric modeling experts, Drs. John Seinfeld and Panos Georgopoulous of the California Institute of Technology, to review the technique. Based on their input and our own analysis, the EPA decided at that time that the tables did not adhere to an adequate level of scientific credibility to be recommended for their intended purpose.

Ozone science has advanced markedly since 1988 with substantial improvements in the characterization of emissions, meteorological, and atmospheric chemistry processes, paralleling an equivalent improvement in computational processing capability, all of which constitute the principal features of a modeling framework. As a result, the Scheffe method, which was deemed "not adequate" in 1989, would be even less adequate today.

Please do not hesitate to contact me (919-477-7955) regarding any further questions.

Sincerely,

Richard D. Scheffe, PhD
Senior Science Advisor
OAQPS, EPA

cc: Richard Long, Region 8
Tom Curran
Valerie Broadwell

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Exhibit 4

Ozone Modeling in the Jonah Infill Development Project Final Environmental Impact Statement

April 8,2006

Technical Report Prepared By
Jana B. Milford, Ph.D., J.D.

Prepared for
Bruce Pendery
Wyoming Outdoor Council

Introduction

This report reviews and assesses the technical validity of the methods BLM used to assess the impacts of the Jonah Infill Development Project on ozone concentrations. The report begins by providing technical background information on the adverse health and welfare impacts of ozone, ozone levels in rural areas of the western United States, ozone chemistry and transport processes, and key components of state-of-the-science ozone models. The report then evaluates BLM's approach to modeling of impacts of the Jonah Project on ozone, examining both the basic method BLM applied – an outdated screening tool known as the "Scheffe method," and BLM's application of that method to the Jonah Project.

Technical Background

Adverse Health Effects of Ozone

Ozone, the main component of photochemical smog, forms in the lower atmosphere when oxides of nitrogen (NOx) and volatile organic compounds (VOCs) react in the presence of sunlight. Because of its serious effects on human health and on vegetation, ozone has been regulated as a criteria pollutant under the Clean Air Act since 1971. In that year, the U.S. Environmental Protection Agency set National Ambient Air Quality Standards for photochemical oxidants, of which ozone is the predominant example. The designation of the indicator for this standard was changed to ozone in 1979.

Breathing ozone at concentrations close to or above the level of the current standard, 0.08 ppm (157 $\mu g/m^3$)[1], can cause a suite of adverse health effects, including decreased lung

[1] Compliance with the federal "8-hour" standard is based on the three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area. For comparison with the standards, ozone concentrations are monitored continuously, with values reported on a 1-hour average basis. The basic process of determining compliance with the standard consists of four steps. First, rolling 8-hour averages are computed from the reported hourly values. Second, the highest of the rolling 8-hour averages for each day are tabulated. Third, these "daily maximum" eight-hour average

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function, particularly in children active outdoors; increased airway responsiveness, and inflammation of the lungs.[2] Epidemiological studies show that elevated ozone concentrations are associated with increased numbers of hospital admissions and emergency room visits for respiratory problems in children and adults with preexisting respiratory diseases such as asthma, and with increased mortality rates.[3] Two large studies in the United States and Europe recently linked total mortality, cardiovascular mortality and respiratory mortality to short term increases in ozone levels.[4]

Children are particularly at risk of adverse respiratory effects from breathing ozone because their lungs are not fully developed and so their airways are narrow, and their respiration rates are higher than those of adults in relation to their size.' Studies conducted in recent years have linked ozone with school absences resulting from sore throats, coughs, and asthma attacks; decreased lung function in girls with asthma; and long-term lung damage in children.[6] A recent study demonstrated that children who use maintenance medication for asthma had an increased likelihood of wheezing and chest tightness when ozone levels increased.[7] One major study associated exposure to ozone with the onset of asthma in children not previously diagnosed with asthma.' In April

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ozone concentrations are ranked in descending order. Finally, the 4" highest eight-hour daily maxima from each of the three preceding years are averaged. This somewhat complicated procedure is used to ensure that the ozone indicator provides a robust measure of "peak" 8-hour average concentrations that is not unduly influenced by unusual meteorological events.

Ozone concentrations are typically reported in units of either parts per million (by volume or equivalently by mole of gas) or micrograms per cubic meter. The conversion between these two systems of units is based on the Ideal gas law. For atmospheric pressure and temperature of 25 °C, the conversion is given as Concentration ($\mu g/m^3$)=Concentration (ppm) x 48 x 40.9, where 48 is the molecular weight of ozone and 40.9 is the numerical value of the other factors in the Ideal gas law relationship. The conversion can be further shortened for ozone by recognizing that 48 x 40.9 = 1963.

[2] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Fact Sheet: Health and Environmental Effects of Ground-Level Ozone, July 17, 1997; American Lung Association, Ozone Air Pollution:What Are Its Health Effects? available at www.lungusa.org/air/envozone.html.

[3] Id.

[4] Bell, M.L.; McDermott, A.; Zeger, S.L.; Samet, J.M.; Dominici, F. (2004) Ozone and Short-term Mortality in 95 US Urban Communities, 1987-2000.J. American Medical Association, 292:2372–2378; Gryparis, A. et al. (2004) Acute Effects of Ozone on Mortality from the "Air Pollution and Health a European Approach" Project. Am. J. Respir. Crit. Care Med. 170: 1080–1087.

[5] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Fact Sheet: Health and Environmental Effects of Ground-Level Ozone, July 17, 1997; American Lung Association, Ozone Air Pollution:What Are Its Health Effects? available at www.lungusa.org/air/envozone.html.

[6] F.D. Gilliland et al., The Effects of Ambient Air Pollution on School Absenteeism Due to Respiratory Illnesses, *Epidemiology* 12 (2001): 43–54; L. Chen et al., Elementary School Absenteeism and Air Pollution, *Inhalation Toxicology* 12 *(2000)*:997–1016; J.M. Peters et al., A Study of Twelve Southern California Communities with Differing Levels and Types of Air Pollution, *American Journal of Respiratory and Critical Care Medicine* 159 (1999): 768-775; T. Frischer et al., Lung Function Growth and Ambient Ozone: A Three-Year Population Study in School Children, *American Journal of Respiratory and Critical Care Medicine* 160 (1999): 390–396.

[7] Gent, J.F., et al. (2003) Association of low level ozone and fine particles with respiratory symptoms in children with asthma, J. American Medical Association 290: 1859–1867.

[8] McConnell, R., et al. (2002) Asthma in exercising children exposed to ozone: a cohort study, Lancet 359: 386–391.

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2005, the California Air Resources Board (CARB) responded to the new science concerning the health effects of ozone at levels below or close to the federal standard, particularly on children's health, by adopting a more protective ozone standard. California's new state ozone standard is set at 0.070 ppm **(137** $\mu g/m^3$) for an eight-hour averaging period, not to be exceeded.'

The **U.S.** Environmental Protection Agency is currently reviewing the adequacy of the existing federal standards based on health studies published over the past decade. As part of this review, the agency recently published the comprehensive, statutorily mandated review of recent science on ozone and its impacts on health and welfare that is known as the Criteria Document. Based on a very large body of scientific evidence, the Criteria Document concludes that there is a causal relationship between short-term ozone exposures and adverse health impacts including inflammatory responses in the lungs" and airway hyper-reactivity, which places asthmatics at greater risk for more prolonged bouts of breathing difficulties.'[1] The Criteria Document review concludes that the scientific evidence supports a causal relationship between short-term ambient O_3 exposures and increased respiratory illness resulting in increased emergency room and hospital visits.[12] The Criteria Document review further concludes that results from recent epidemiologic studies supported by human and animal studies of mechanisms are "highly suggestive that O_3 directly or indirectly contributes to non-accidental and cardiopulmonary-relatedmortality."'[3]

Adverse Effects of Ozone on Vegetation and Air Quality Related Values

In addition to its effects on human health, ozone also has serious environmental effects. Plants are even more sensitive to ozone than are humans. Ozone damage to plants includes visible injury to leaves, premature leaf loss, reduced photosynthesis, and reduced growth.[14] Ozone pollution costs the agriculture industry millions of dollars each year in decreased crop yields.[15] In its new Criteria Document for ozone, the U.S. EPA concludes "Data published since 1996 continues [sic] to support and strengthen the conclusions of previous O_3 AQCDs [Air Quality Criteria Documents] that there is strong evidence that

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[9] The U.S. EPA recently concluded "evidence from newer epidemiologic studies supports the 1996 O_3 AQCD [Air Quality Criteria Document] conclusions that children are more likely at increased risk for O_3-induced health effects. Notably, epidemiologic studies have indicated adverse respiratory health outcomes associated with O_3 exposure in children. In addition, recently published epidemiologic studies also suggest that older adults (aged >65 years) appear to be at excess risk of 03-related mortality or hospitalization. U.S. EPA. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). E-22, U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/004aF-cF, 2006.

[10] U.S. EPA. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). E-14, U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/004aF-cF, 2006.

[11] Id. at E-15.

[12] Id. at E-15 – E-16.

[13] Id. at E-I7 – E-18.

[14] National Park Service (2002) Air Quality in the National Parks, 2d. ed., September.

[15] U.S. EPA, Fact Sheet: ***Health and Environmental Effects of Ground-Level Ozone,*** available at **http://www.epa.gov/ttn/oarpg/naaqsfiin/o3health.html** (last visited **July** 1,2003); National Acid Precipitation Assessment Program, NAPAP Biennial Report to Congress: An Integrated Assessment, 63 (Silver Spring, MD: May 1998).

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current ambient O_3 concentrations cause (1) decreased growth and biomass accumulation in annual, perennial and woody plants, including agronomic crops, annuals, shrubs, grasses, and trees; (2) decreased yield and/or nutritive quality in a large number of agronomic and forage crops; and (3) impaired aesthetic quality of many native plants and trees by increased foliar injury."[16] Due to the phytotoxic effects of ozone on native plants, ozone is prominently discussed as a pollutant that impacts air quality related values in the Federal Land Managers' Air Quality Related Values Workgroup Phase I Report (December 2000).[17]

Ozone also has indirect effects on visual air quality, which is a critical air quality related value in national parks and wilderness areas ("Class I" areas). It does this via chemical reactions that generate secondary organic aerosols and secondary inorganic particles, which degrade visibility by scattering light. When ozone reacts with alkenes (a class of organic compounds) of sufficiently high molecular weight, the low vapor pressure reaction products can partition to the condensed or particle phase. These products of atmospheric conversion, which are known as secondary organic aerosols, degrade visibility by scattering light. Monoterpenes and sesquiterpenes, which are alkenes emitted from vegetation, such as coniferous trees in the forest environments of the Bridger-Teton National Forest, and which react primarily with ozone, are thought to be among the main contributors to secondary organic aerosol concentrations in rural areas. In this case, the biogenic (biologically-generated) emissions of organic compounds may be natural, but the presence of elevated ozone concentrations is not. Additionally, photolysis (i.e., reaction with sunlight) of ozone in the presence of water vapor produces hydroxyl radicals (HO), which are the primary oxidizing agents in the atmosphere. Reactions of hydroxyl radicals with gas-phase sulfur dioxide (from power plants, among other sources) produce particle-phase sulfates. Reactions of hydroxyl radicals with gas-phase nitrogen dioxide produce nitric acid, which can be deposited from the atmosphere into watersheds or in turn can react with ammonia to form particle-phase ammonium nitrate. These secondary inorganic particles, whose formation is linked to the availability of ozone, add to harmful concentrations of fine particles less than 2.5 μm in size and also degrade visibility by scattering light.

Characterization of Ozone Levels and Comparison to the Federal and State Standards

Ozone pollution is common in urban areas, and is mistakenly thought by some people to be only an urban problem. But data from monitors in national parks across the western United States show that it is a regional and rural problem as well. Even in some of the most remote and once unspoiled areas of the West, ozone is approaching or exceeding unhealthy levels. According to a recent study, air-monitoring data reported to the EPA for 2002 through 2004 show that numerous areas of the Interior West where ozone is monitored, including 14 national parks and monuments, would not meet California's 8-

[16] U.S. EPA. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). E-28, U.S Environmental Protection Agency, Washington, DC, EPA/600/R-05/004aF-cF, 2006.
[17] Available at http://www2.nature.nps.gov/air/Pubs/pdf/flag/FlagFinal.pdf.

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hour ozone health standard of 0.070 ppm, not to be exceeded." These areas meet the federal 8-hour standard of 0.08 ppm, measured by the 3-year average of the 4th highest daily maximum values, but come close to violating it. Levels of ozone pollution at Yellowstone, Canyonlands, Zion, Rocky Mountain, Mesa Verde, and Grand Canyon national parks would violate the California health standard. Similarly, rural communities such as Campbell County, Wyoming, and San Juan County, New Mexico, violate California's health standard for ozone. In all, ozone levels in **32** areas in the West for which monitoring data are reported exceeded California's health standard more than 1,600 times from 2002 through 2004.

Atmospheric Chemistry and Transport of Ozone

Ozone forms in the lower atmosphere through atmospheric reactions involving volatile organic compounds (VOCs) and nitrogen oxides (NOx). Nitrogen oxides are produced through high temperature combustion processes, including in wildfires and prescribed burns as well as in power plants and internal combustion engines, such as those used in the most significant sources of emissions in the gas fields including trucks, drill rigs and compressor stations. Volatile organic compounds are released into the atmosphere from evaporation of liquid fuels and organic solvents, incomplete combustion of fuels and other materials containing organic compounds, and from vegetation. Carbon monoxide (CO), another product of incomplete combustion, is also an important "precursor" of ozone.

Because it forms through atmospheric reactions and is generally not emitted directly, ozone is known as a "secondary" air pollutant. The atmospheric chemistry leading to ozone formation is complex and nonlinear, and is highly sensitive to a large number of factors, including the intensity of sunlight, atmospheric temperature, pressure, and humidity, and the quantity and detailed chemical composition of the volatile organic compounds and nitrogen oxides that contribute to ozone formation. The term "VOC" refers to all gas- or vapor-phase organic compounds present in the atmosphere, and includes alkanes, alkenes, aromatics, aldehydes, alcohols, and halogenated organic compounds. Hundreds of different volatile organic compounds and several different nitrogen oxides are present in the atmosphere in both rural and urban areas; each of them reacts at a different rate and through different chemical pathways in contributing to ozone formation, as well as to the formation of other oxidants such as peroxy acetyl nitrate (PAN), and hydrogen peroxide (H_2O_2).

The only significant reaction in the lower atmosphere that leads directly to ozone formation is the photolysis (i.e., reaction with sunlight) of nitrogen dioxide (NO_2). This reaction breaks off an oxygen atom from the NO_2 molecule. The oxygen atom can then combine with molecular oxygen (O_2) to form ozone (O_3). Most emissions of nitrogen oxides are in the form of nitric oxide (NO), which must be oxidized to NO_2 before ozone can form. Oxidation of NO to NO_2 occurs through two distinct pathways with very

[18] Center for Energy Efficiency and Renewable Technologies, Environmental Defense, and Western Resources Advocates, Clearing California's Coal Shadow from the American West, 2005. Available at http://www.environmentaldefense.org/documents/4890_CAcoalShadow.pdf.

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different implications. In the first pathway, NO reacts with O_3 to form NO_2. No net accumulation of ozone results when NO_2 is produced by this route and then photolyzes to form O_3. On the other hand, the second oxidation pathway involves the reaction of NO with peroxy radicals (e.g., the hydroperoxy radical, HO_2), which in turn are formed through the oxidation of volatile organic compounds and carbon monoxide. When this pathway is active, the ozone formed in the subsequent NO_2 photolysis reaction can accumulate, because it is not destroyed in the next cycle of NO oxidation. This same basic process of ozone formation occurs throughout the troposphere, in urban, rural, and remote settings, as long as nitrogen oxides and VOCs and/or carbon monoxide are present. Ozone and its precursors cease to participate in photochemical cycles with direct impacts on local and regional-scale air pollution when they are converted to stable forms (e.g., CO_2 in the case of organic compounds) or removed from the troposphere by deposition to the surface.

Nitrogen oxides, volatile organic compounds, carbon monoxide and the photochemical oxidants they produce are present in remote and rural areas as well as urban ones, for three main reasons.[19] First, natural sources of these compounds may be present. In particular, vegetation is a significant source of VOCs in rural and vegetated remote areas. Soil, lightning, and natural fires are all sources of nitrogen oxides in rural and remote areas. Second, anthropogenic sources of VOCs, carbon monoxide and nitrogen oxides, including industrial facilities and internal combustion engines, are also common in rural areas. Finally, nitrogen oxides, volatile organic compounds, carbon monoxide and their intermediate reaction products may be transported from more urban locations. The lifetimes of volatile organic compounds in the atmosphere range from minutes in the case of some highly reactive alkenes, to years, in the case of slowly reacting alkanes like methane.[20] Nitrogen oxides (NOx) have lifetimes of a few hours to a few days due to conversion to nitric acid.[21] At cold temperatures (during winter or in the upper troposphere) organic nitrates such as PAN formed from nitrogen oxides can serve as reservoir species, storing nitrogen oxides for weeks as they are transported in the upper

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[19] An additional source of ozone in rural and remote areas on some occasions and at some locations is "intrusion" of ozone from the stratosphere, the region of the atmosphere above about 10 – 15 km in elevation. Ozone forms in the stratosphere from photolysis of molecular oxygen (O_2). Mixing ratios of ozone in the stratosphere are in the parts per million range. Under certain meteorological conditions, which occur most often in late winter and early spring at temperate latitudes, the height of the tropopause can dip significantly, bringing air from the upper atmosphere down closer to the surface. As discussed in the recent Criteria Document for ozone, "This imported stratospheric air contributes to the natural background of O_3 in the troposphere, especially in the free troposphere [the region of the troposphere from about 1 km to 10 km above the surface]… Stratospheric intrusions that reach the surface are rare. Much more common are intrusions which penetrate only to the middle and upper troposphere." U.S. EPA. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). 2-8, U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/004aF-cF, 2006. As EPA's Criteria Document also notes, "Substantial photochemical production of O_3 in the troposphere also begins in late winter and early spring; therefore, it cannot be assumed that O_3 present at these times is only stratospheric in origin." Id.

[20] National Research Council (1991) Rethinking the Ozone Problem in Urban and Regional Air Pollution, 122-123, National Academy Press.

[21] U.S. EPA. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). AX2-13, U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/004aF-cF, 2006.

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troposphere, then returning them to an active role in ozone production when warmer temperatures are encountered.[22]

The scale of impacts of ozone and its precursors extends from distances of a few kilometers out to distances of over a thousand kilometers.[23] The scale of impacts of ozone and its precursors is reflected in the size of nonattainment areas for ozone, which EPA commonly designates to encompass whole "airsheds," defined either by the outer boundaries of developed areas where emissions occur or by natural topographic boundaries. For example, the airshed for the Denver-area Early Action Compact encompasses 11 counties covering much of the South Platte Valley in northeastern Colorado.[24] The scale of ozone production is also reflected in EPA's regional approaches to ozone management, including the NOx SIP call[25] EPA issued to address ozone transport across **23** eastern states and the Clean Air Interstate Rule the Agency issued to address ozone transport across 25 states.[26]

The rate at which ozone forms depends in part on the chemical mixture present, and in part on meteorological conditions. The intensity of sunlight is an especially important variable, as it controls the rate of photolysis reactions like the NO_2 photolysis reaction that leads to ozone production. Temperature is also an important variable, because the rates of many atmospheric reactions increase with temperature. Finally, relative humidity is important, because water vapor (H_2O) participates in several key reaction pathways.

Ground-level ozone concentrations are critically dependent on the amount of vertical mixing that occurs in the atmosphere and on the amount of transport that occurs from upwind regions that are sources of ozone precursors. Stagnant meteorological conditions that limit vertical mixing tend to favor the local build up of ozone, whereas windier conditions accompanied by sunlight can promote long-range transport of ozone and its precursors. During the summertime, slow moving high pressure systems are commonly associated with elevated ozone levels, as sinking air in these systems traps pollutants near the surface, while strong sunlight supports active chemistry. These high-pressure systems are large-scale systems, covering regions of hundreds of miles or more, so conditions favorable to ozone formation often cover multi-state regions and can continue for days.[27]

In cases where long-range transport is important, high ozone levels may be associated with relatively high wind speeds that carry ozone and precursors over long distances. Both types of ozone episode (local formation and long-range transport) may affect the same locale at different times. And local ozone formation may combine with simultaneous long-range transport to produce concentrations that exceed ozone standards. **A** thorough review of the state of scientific understanding of ozone formation recently

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[22] Id. at AX2-14.
[23] Kasibhatla, P., Chameides, W.L. (2000) Seasonal modeling of regional ozone pollution in the eastern United States. Geophys. Res. Lett. 27: 1415-1418.
[24] See http://www.raqc.org/ozone/EAC/ozone-eac.htm.
[25] 70 Fed. Reg. 57356 (October 27, 1998).
[26] 70 Fed. Reg. 25162 (May 12,2005).
[27] U.S. EPA. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). 2-10, U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/004aF-cF, 2006.

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stated "Instead of reflecting a single spatial scale, peak concentrations have been found to arise from a complex and probably nonlinear interaction between O_3 formation occurring on all spatial scales as well as transport of O_3 and its precursors from one area to another and from one region to another. Further complications arise from the fact that the relative contributions from each scale and process can vary from one episode to another and from one region to another.""

Ozone concentrations respond to changes in precursor concentrations in a nonlinear fashion. Where NOx concentrations are relatively low (most commonly in rural areas not near significant anthropogenic sources), the net production of ozone increases as NOx emissions increase. At the other extreme, if NOx is present in abundance compared to VOCs, the direct reaction of NO with O_3 can dominate the chemistry so that increased NOx emissions lead to locally reduced ozone concentrations. This situation is further complicated by the dynamics of chemistry and transport. As air parcels are transported away from high NOx settings (e.g., power plant plumes or other dense source areas) they may switch over to a low NOx regime, so that the same NOx molecule that originally consumed ozone is recycled and ends up producing ozone somewhere downwind. Rural areas are often, though not always "NOx-limited" because VOCs from vegetation (i.e., biogenic VOCs) are more abundant than NOx in these areas. The NARSTO Assessment quoted above summarized this point by noting that "VOC and NOx limitation is not uniquely defined by location or emissions; it is, rather, a chemical characteristic of an air parcel that varies dynamically with transport, dispersion, and photochemical aging."[29]

One important implication of nonlinearity in ozone chemistry is that the effects of emissions from new sources cannot be assumed to be simply additive. One cannot generally assess the effect of each new source or unit of emissions in isolation and then add the results together to assess the net effect. For example, the effect of the Jonah Infill cannot be predicted in isolation – the existing background chemical conditions must be factored into the calculation through a chemistry and transport model that accounts for mixing and chemical interactions between the new emissions and the VOCs, NOx, carbon monoxide, ozone and chemical intermediates that are already present in the locale or are being transported into the region. Likewise, a cumulative assessment would need to perform modeling that accounts for chemical interactions between all the new and existing emissions that are anticipated – it would not work to model each new project separately and then try to sum the results. This could lead to inaccurate predictions.

The nonlinearity of ozone formation distinguishes it from other pollutants like sulfur dioxide, nitrogen dioxide, and primary particulate matter (PM) for which concentrations resulting from a new source can be calculated in isolation, and then added to baseline concentrations attributable to other sources to estimate the total concentration at a particular receptor. Although nitrogen dioxide is largely a secondary pollutant (some NO_2 is emitted directly but more is formed in the atmosphere from oxidation of emitted NO), concentrations of NO_2 are commonly approximated as increasing linearly with emissions

[28] NARSTO (2000) An Assessment of Tropospheric Ozone Pollution —A North American Perspective,, Available at http://www.narsto.com/.
[29] Id.

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of NOx. For example, BLM performed its near-field analysis of NO_2 impacts from the Jonah Infill project using AERMOD, which treats NO, concentrations due to a source as directly proportional (linearly related) to NOx emissions from the source. BLM then estimates maximum NO_2 concentrations from the maximum NOx concentration by multiplying by *0.75*, which maintains the proportionality to emissions.[30]

A second critical implication of the nonlinearity of ozone formation is that impacts of new sources must be assessed across a range of downwind distances. It does not suffice to look at the impacts of emissions on ozone at a nearby receptor and assume that because the receptor is close to the source it represents the worst effect. Concentrations must be modeled over distances reflecting long-range transport and the chemical evolution of air parcels as transport proceeds. In the context of ozone formed by emissions from the Jonah Infill project, local communities and nearby Class I national parks and wilderness areas ("mid"' and "far-field" areas) might well have greater ozone concentrations than occur in the Jonah field itself due to these factors, at least under some atmospheric conditions and emission scenarios.

Modeling the Effects of New Emissions on Downwind Ozone Concentrations

The VOC, NOx and CO emissions that would be produced by the Jonah Infill and other oil and gas development projects occurring in western Wyoming are released into a complex regional soup of emissions that interact in a nonlinear fashion. To provide an accurate assessment, the impact of these projects on ozone at near-, mid- and far-field locations must be assessed using a comprehensive chemistry and transport modeling system that accounts for dynamic interactions between projected new emissions and the background mixture of pollution affecting the region. As shown in the following figure, the **U.S.** EPA identified the key elements of such a modeling system in its recent Criteria Document for ozone.[31] The elements shown in the figure are included in state-of-the-science photochemical grid models, including EPA's Models-3/CommunityMulti-scale Air Quality (CMAQ) modeling system (the model recommended for multi-source ozone analyses in the agency's Guideline on Air Quality Models)[32] and the Comprehensive Air-quality Model with Extensions (CAMx).[33] Several of the key elements are not components of Scheffe's (1988) method, which was employed by BLM in its Jonah Infill project ozone modeling and analysis.

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[30] TRC Environmental Corporation, Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement (Volume 1 of 2), 31, January 2006, available at **http://www.wy.blm.gov/nepa/pfodocs/jonah/28FAQTSDvolI.pdf.**

[31] U.S. EPA. Air Quality Criteria for Ozone and Related Photochemical Oxidants (Final). Figure 2-9, U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/004aF-cF, 2006. Note that cloud aqueous processes and aerosol chemistry and microphysics are sometimes omitted from models that are applied in situations where gaseous ozone, rather than particle-phase species like sulfate, are of principle interest.

[32] 40 CFR Part 51, Appendix W section 5.2.1. as revised. 70 Fed. Reg. 68,218 (November **9,** 2005).

[33] Morris, R.E., Yarwood, G., Emery, C.A., Wilson, G.M., Recent Advances in Photochemical Air Quality Modeling Using the CAMx Model: Current Update and Ozone Modeling of Point Source Impacts, Paper # **43** 180, Air and Waste Management Association, 2002. See also www.camx.com.

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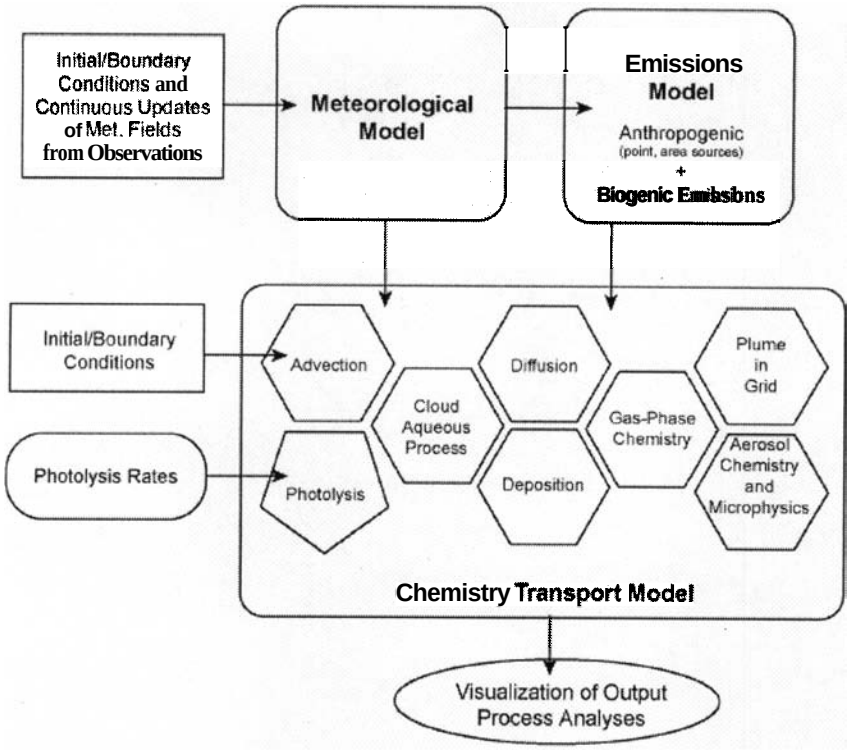

Figure 1. Main Components of an Atmospheric Chemistry Modeling System.[34]

[34] Id.

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Models such as Models3-CMAQ and CAMx that replicate the photochemical reactions occurring in the atmosphere are called "grid" models because the region being modeled is sub-divided into stacked cells or "grids", as shown in Figure 2. Mass balance equations describing transport and chemistry in the atmosphere are solved simultaneously for each grid, accounting for interactions between them as pollutants are transported from one grid cell to another.

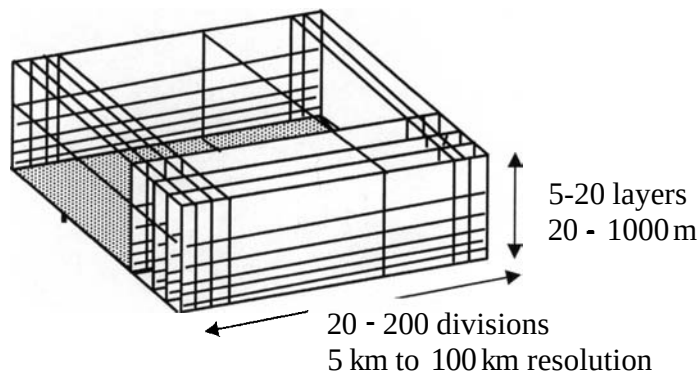

Figure **2.** Schematic of subdivision of a modeling domain in a photochemical grid model.

Photochemical grid models have been used for more than three decades to model ozone in urban nonattainment areas, and for more than twenty years to model ozone over regional scale domains that include rural areas. Recent versions of these models are currently being used in attainment demonstrations for ozone in numerous urban areas.[35] Regional planning organizations have applied and continue to apply them to assess strategies for reducing regional haze (current photochemical models are capable of predicting concentrations of visibility-impairing particulate matter as well as ozone).[36] They are also being used to predict and understand the sources of ozone in more rural communities. For example, the CAMx model is being applied to predict the effect of emissions from oil and gas production activities on ozone concentrations in the Four Corners area of Arizona, Colorado, New Mexico, and Utah.[37] Photochemical grid models represent the current state of the art for the purpose of predicting expected ozone concentrations that will result from adding new sources of NOx and VOCs to a regional airshed.

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[35] ***See for example*** the modeling documents associated with the Denver Early Action Compact, where CAMx was used (available at http://www.raqc.org/ozone/EAC/ozone-eac.htm); the Dallas-Fort Worth nonattainment State Implementation Plan, using CAMx (available at http://www.tceq.state.tx.us/implementation/air/airmod/data/dfw1.html#docs; the San Francisco Bay Area nonattainment State Implementation Plan, using CAMx (available at http://www.baaqmd.gov/pln/plans/ozone/2003_modeling/).

[36] *See for* ***example*** the regional haze modeling performed for the Western Regional Air Partnership, using Models3-CMAQ (available at http://www.wrapair.org/forums/aqmf/index.html); and the regional haze modeling performed for the Central Regional Air Planning Association, using Models3-CMAQ (available at http://www.cenrap.org/modeling_document.asp#).

[37] ***See*** http://www.nmenv.state.nm.us/aqb/ozonetf/Executive_Summary_01.14.04.pdf.

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The grids in photochemical grid models typically have dimensions of 4 km by 4 km or larger. In a pure grid model, emissions are immediately dispersed to fill the cell into which they are released. For large stationary sources such as power plants, this treatment can overestimate the rate of mixing of fresh emissions with the surrounding air, which in turn may introduce errors into the modeled chemistry. To address this problem, grid models such as CAMx and Models3-CMAQ provide "plume-in-grid" modules that treat the mixing of a fresh plume of emissions with the pollutants in the surrounding air more realistically. Additionally, state-of-the-art models can incorporate a finer-scale "nested" grid in areas where greater resolution of emissions and/or resulting concentrations is needed.[38] Whether it is necessary to use plume-in-grid or nested-grid treatments depends on the distribution of emissions and the focus of the modeling study. Where emissions are relatively uniformly distributed over an area comparable to the size of a model grid (typically 4 km x 4 km or larger), or where ozone concentrations several grid lengths or more downwind of the release point are of interest, use of a plume-in-grid or nested-grid treatment may be deemed unnecessary.

Scheffe's (1988) method, which BLM applied to predict ozone impacts from the Jonah Infill, is not a photochemical grid model but rather is a look-up table method that was developed more than 25 years ago by running a "reactive plume model" called RPM-II, for a limited number of pre-set meteorological and chemical conditions.[39] In contrast to plume-in-grid models that place a dispersing, reacting stationary source plume within an urban or regional scale grid-model, simple reactive plume models treat dispersion and chemistry within a stationary source plume without detailed treatment of emissions, transport and conditions in the surrounding atmosphere.[40] Pollutant concentrations in the surrounding "ambient" atmosphere must be specified externally or based on a separate model calculation, because they are not computed simultaneously with the pollutant concentrations in the plume. This is problematic because it is very difficult to specify pollutant concentrations for the surrounding air that are sufficiently detailed and consistent to provide an accurate representation as the plume moves downwind.

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[38] See Morris, R.E., Yarwood, G., Emery, C.A., Wilson, G.M., Recent Advances in Photochemical Air Quality Modeling Using the CAMx Model: Current Update and Ozone Modeling of Point Source Impacts, Paper # 43180, Air and Waste Management Association, 2002.

[39] Scheffe's method was meant to be a "screening technique." EPA's modeling guidance defines these techniques as follows. "There are two levels of sophistication of models [screening and refined]. The first level consists of relatively simple estimation techniques that generally use preset, worst-case meteorological conditions to provide conservative estimates of the air quality impact of a specific source, or source category. These are called screening techniques or screening models. The purpose of such techniques is to eliminate the need of more detailed modeling for those sources that clearly will not cause or contribute to ambient concentrations in excess of either the National Ambient Air Quality Standards (NAAQS) or the allowable prevention of significant deterioration (PSD) concentration increments." 40 CFR Part 51, Appendix W, subsection 2.2. (November 2005).

[40] Plume models are one form of a "Lagrangian" model, which is a technical name for a pollutant transport model that follows a pollution-laden air parcel as it is carried along with the wind, rather than establishing a fixed, underlying grid and tracking pollution as it moves through that grid. Plume models are distinct because they focus on the plume from a single source, whereas some other Lagrangian models track pollution from multiple sources with the assumption that the pollution has mixed together into a single parcel of air.

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EPA Guidance on Ozone Modeling Calls for Use of Photochemical Grid Models

EPA guidance on ozone modeling reflects the complexities discussed above, in calling for the use of photochemical grid models to simulate ozone formation. Appendix W to 40 CFR Part 51 – Guideline on Air Quality Models (2005) gives the following guidance with regard to ozone modeling.

> 5.2.1 Models for Ozone
> a. *Choice of Models for Multi-source Applications.*
> Simulation of ozone formation and transport is a highly complex and resource intensive exercise. Control agencies with jurisdiction over areas with ozone problems are encouraged to use photochemical grid models, such as the Models-3/Community Multi-scale Air Quality (CMAQ) modeling system, to evaluate the relationship between precursor species and ozone. Judgement [sic] on the suitability of a model for a given application should consider factors that include use of the model in an attainment test, development of emissions and meteorological inputs to the model and choice of episodes to model. Similar models for the 8-hour NAAQS and for the 1-hour NAAQS are appropriate.
> b. *Choice of Models to Complement Photochemical Grid Models.*
> As previously noted, observational models, Lagrangian models, or the refined version of the Ozone Isopleth Plotting Program (OZIPR) may be used to help guide choice of strategies to simulate with a photochemical grid model and to corroborate results obtained with a grid model. Receptor models have also been used to apportion sources of ozone precursors (*e.g.*, VOC) in urban domains. EPA has issued guidance in selecting appropriate techniques.
> c. *Estimating the Impact of Individual Sources.*
> Choice of methods used to assess the impact of an individual source depends on the nature of the source and its emissions. Thus, model users should consult with the Regional Office to determine the most suitable approach on a case-by-case basis (subsection 3.2.2).

40 CFR Part 51, Appendix W (citations omitted).

As discussed in more detail below, BLM has not used a photochemical grid model in its analysis of the ozone impacts of the Jonah Infill Development Project. Instead, BLM has used an outdated look-up table approach which is based on a set of model runs performed with a reactive plume model. Because it is not a photochemical grid model, nor even based on one, Scheffe's (1988) method would not qualify under subsection 5.2.1.a as a preferred model for a multi-source situation, such as the Jonah Infill.

Scheffe's method is also not one of the types of models listed in subsection 5.2.1.b. Although Scheffe (1988) used a reactive plume model, which is a type of Lagrangian model, to develop his look-up tables, the tables themselves do not constitute a Lagrangian model, because they do not account for the specific chemical and meteorological conditions applicable in the Jonah field, as a Lagrangian model would. Rather, they are developed from model runs for a limited set of pre-specified conditions.

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To be approved as an alternative method for either a multi-source situation or for modeling ozone from an "individual source" under subsection 5.2.1.c, Scheffe's method would have to meet EPA's criteria for approval of an alternate model. Subsection 3.2.2 gives the following guidance on selection of an alternative model.

> 3.2.2 Recommendations
> a. Determination of acceptability of a model is a Regional Office responsibility. Where the Regional Administrator finds that an alternative model is more appropriate than a preferred model, that model may be used subject to the recommendations of this subsection. This finding will normally result from a determination that (1) a preferred air quality model is not appropriate for the particular application; or (2) a more appropriate model or analytical procedure is available and applicable.
> b. An alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use. There are three separate conditions under which such a model may normally be approved for use: (1) If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model; (2) if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A; or (3) if the preferred model is less appropriate for the specific application, or there is no preferred model. Any one of these three separate conditions may make use of an alternative model acceptable. Some known alternative models that are applicable for selected situations are listed on EPA's SCRAM Internet Web site (subsection 2.3). However, inclusion there does not confer any unique status relative to other alternative models that are being or will be developed in the future.
> .
> .
>
> e. Finally, for condition (3) in paragraph (b) of this subsection, an alternative refined model may be used provided that: i. The model has received a scientific peer review; ii. The model can be demonstrated to be applicable to the problem on a theoretical basis; iii. The data bases which are necessary to perform the analysis are available and adequate; iv. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and v. **A** protocol on methods and procedures to be followed has been established.

40 CFR Part 51, Appendix W (citations omitted).

BLM has not presented any evidence in the record that Scheffe's (1988) method produces equivalent concentrations to the estimates obtained using a photochemical grid model, or that it performs better than a photochemical grid model, as required to meet the first two

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conditions in 3.2.2b. If BLM contends that there is no preferred ozone model for the Jonah Field application (i..e., following 3.2.2c), then it must still meet the requirements of subsection 3.2.2.e to claim that the modeling it has performed is sufficient to provide a final assessment. However, as discussed below, BLM has not, and most likely cannot demonstrate that Scheffe's method satisfies the tests in subsection 3.2.2.e for an alternative model.

At best, Scheffe's method might have been viewed as a screening tool, which is meant to be applied "to eliminate the need of more detailed modeling for those sources that clearly will not cause or contribute to ambient concentrations in excess of . . . the National Ambient Air Quality Standards.'" However, Scheffe's method also fails as a screening technique, because it is scientifically flawed and out of date, and because BLM has applied it in a manner that violates the requirement that such screening techniques "provide conservative estimates of the air quality impact of a specific source, or source category."[42] In fact, if Scheffe's method had been properly applied, by the terms of the method, and assuming that it could serve as a screening technique, large exceedances of the ozone NAAQS would have been predicted. **A** faithful application of Scheffe's method would have shown that BLM needed to go beyond a rough screening approach to assess the expected ozone impacts of the Jonah Infill using a photochemical grid model.

<u>Deficiencies in BLM's Assessment of the Impacts of the Jonah Infill on Ozone</u>

BLM's analysis of the impacts of the Jonah Infill Development Project (JIDP) on ozone is limited to an assessment of a small part of the project emissions on "in-field" or "near-field" ozone. This assessment is inadequate in several respects.

1) Ozone impacts are not limited to near-field effects, and in fact at times will be more severe further downwind, as chemical reactions proceed and where sensitive and critical receptors may be located.
2) BLM has no justification for limiting its analysis to a small fraction of the emissions expected from the JIDP. Greater impacts on ozone would be expected if full project emissions are considered, and still greater impacts if emissions from the JIDP are combined with those from other reasonably foreseeable development in western Wyoming.
3) BLM has used a scientifically flawed and out-of-date method, which it calls the "Scheffe method" to estimate the partial near-field ozone impacts it did try to assess, and additionally has applied that method incorrectly. These issues are addressed below.

Scheffe's Method is Scientifically Flawed and Out-of-Date

In the Final Environmental Impact Statement for the Jonah Infill Development Project (JIDP),[43] BLM uses the so-called "Scheffe method" to attempt to estimate the effects of

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[41] 40 CFR Part 51, Appendix W, subsection *2.2.* (November *2005).*
[42] Id.
[43] TRC Environmental Corporation; Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement (Volume 1 of 2), January *2006,* available at **http://www.wy.blm.gov/nepa/pfodocs/Jonah/28FAQTSDvolI.pdf.**

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the project on near-field ozone concentrations. The copy of the Scheffe (1988) report included in BLM's FEIS is labeled a draft (see pages 9 and 10); to my knowledge, it was never finalized by the author, and never accepted by any expert air quality management agency. In addition, the approach is fundamentally unsound as a means of predicting the impacts of significant emissions increases from oil and gas development on ozone air quality. To estimate how much ozone would be formed in plumes with varying amounts of VOC and NOx emissions, Scheffe (1988) ran the now-outdated Reactive Plume Model, Version II (RPM-II) for a limited number of hypothetical scenarios based on two "environments" characterized by estimates of urban and rural background concentrations made in the mid 1980's.[44] The results of these modeling runs are presented in look-up tables, from which estimates of ozone production due to the new emissions can be read, given the annual mass emissions rates of VOCs and NOx and the daily maximum emissions rate for non-methane organic compounds (NMOC). Because ozone chemistry is nonlinear and highly sensitive to background chemistry and meteorology, as discussed above, these pre-set scenarios are totally inadequate for projecting the impact of multiple new pollution sources in the real world. BLM's reliance on this method is thus fundamentally flawed.

Scheffe's method was intended to be used only as a first screening step, leading to further analysis unless an insignificant impact was predicted. The draft documentation of the method provided in Appendix **A** to the *Air Quality Impact Assessment Protocol, Jonah Infill Drilling Project* states "this technique is not intended to be substituted for a realistic photochemical modeling analysis, rather it is to be used only in the context of a first-step procedure which potentially can preclude further resource-intensive analysis."[45]

Scheffe's method is identified as a screening tool because of the following limitations:

1. It estimates ozone impacts of a point source of NOx and VOC emissions introduced into a single, preset background environment – either a default "urban" environment or a default "rural" environment – with the chemical descriptions of these background environments based on "crude" estimates of urban and rural background concentrations of ozone, NOx, VOC and intermediate chemical species made in the mid-1980s.[46]
2. The default rural environment, on which BLM improperly relied for the JIDP analysis, uses spatially and temporally invariant background concentrations, which is highly unrealistic.
3. The default urban environment, which by the terms of Scheffe (1988) should have been used by BLM, as explained below, uses time-varying background concentrations, but unrealistically assumes the concentrations do not vary with

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[44] R.D. Scheffe, VOC/NOx point source screening tables, U.S. EPA, Office of Air Quality Planning and Standards, September 1988.

[45] See R.D. Scheffe, VOC/NOx point source screening tables, **3,** U.S. EPA, Office of Air Quality Planning and Standards, September 1988, included in TRC Environmental Corporation, Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement (Volume 1 of 2), *Air Quality Impact Assessment Protocol, Jonah Infill Drilling Project*, Appendix A, January 2006, available at http://www.wy.blm.gov/nepa/pfodocs/jonah/28FAQTSDvolI.pdf.

[46] Id. at 22.

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location, and hence cannot reflect the different conditions a plume would encounter as it moves downwind.

4. Another limitation acknowledged by Scheffe (1988) is that default chemical speciation profiles (i.e., which of the many hundreds of volatile organic compounds and nitrogen oxides are actually present in the emissions and in which relative proportions) are used for point source emissions of VOC and NOx, even though emissions speciation profiles in reality are highly source-specific. As Scheffe says "parameters describing background chemistry, episodic meteorology, and source emissions speciation affect actual ozone impacts produced by a point source."[47]

Scheffe's (1988) report acknowledges the importance of these limitations, stating "a major difficulty in applying a model such as RPM-II is specifying background concentrations because the model is particularly sensitive to ambient air quality. Hydrocarbon and NOx composition vary spatially and temporally through out any region."[48] (Emphasis added.)

Beyond the important variables that affect ozone chemistry that Scheffe acknowledges his method does not account for, the method is also inadequate because it (naturally) omits important processes and new information on chemical reactions that have been recognized since the method was written in 1988. For example, one important scientific advance that has occurred since the late 1980's is a greater understanding of the role of biogenic VOC emissions, which are ubiquitous in both rural and urban environments in the United States.[49] Scheffe's background conditions omitted these compounds entirely.

Scheffe's method is further flawed due to the limitations of the underlying RPM-II model he used to model his hypothetical plumes. The RPM model was developed in the late 1970's and was updated twice in the next two decades. The latest version of the model of which I am aware, RPM-IV, was published in 1993.[50] Thus even RPM-IV is more than a decade out-of-date. The RPM-II model Scheffe used to develop his look-up tables was published in 1980.[51] This version of the model does not reflect advances in understanding of atmospheric chemistry made over the past two and a half decades, including significant modifications in reaction rate and/or product estimates for alkenes, aromatic compounds and nitric acid formation.[52] **As** noted above, the various versions of the RPM models collectively suffer from the limitation that they do not adequately model

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[47] Id. at 7.
[48] Id. at 13.
[49] See for example, Trainer, M., Williams, E.T., et al., (1987) Models and observations of the impact of natural hydrocarbons on rural ozone, Nature, 329:705-707; Chameides, W.L., Lindsay, R.W., Richardson, J., Kiang, C.S. (1988) The role of biogenic hydrocarbons in urban photochemical smog: Atlanta as a case study, Science 241:1473-1475.
[50] Environmental Protection Agency, 1993. Reactive Plume Model IV (RPM-IV) User's Guide. EPA Publication No. EPA-454/B-93-012. U.S. Environmental Protection Agency (ESRL), Research Triangle Park, NC. (NTIS No. PB 93-217412).
[51] SAI (1980) User's Guide to the Reactive Plume Model – RPM II, Systems Applications Inc., San Rafael, CA.
[52] For details, ***see*** R. Atkinson (2000) ***Atmospheric Chemistry of*** *VOCs and NOx* Atmos. Environ. 34,2063.

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emissions, chemistry and transport in the air surrounding the plume on which they focus. In contrast, "plume-in-grid" models simulate the chemistry and transport in the plume from a point source as it disperses and mixes with the surrounding air, while simultaneously modeling the emissions, chemistry and transport going on in the background air using an "Eulerian grid framework." Models that are currently widely used and recommended for predicting ozone impacts for regulatory purposes, including the Comprehensive Air Quality Model (CAMx) and the Community Multiscale Air Quality model (CMAQ) have this capability.[53] And, unlike Scheffe's (1988) approach, these models can account for the interacting suite of variables that actually determine how much ozone would be produced from a new source of emissions.

Scheffe's (1988) method is not mentioned in EPA's Guideline on Air Quality Models, either as a preferred model, an alternative model or a screening technique. The method does not meet EPA's published guidance on requirements for alternative models. The selection of a model must follow section 3.2.2 (e) of EPA's guidelines.[54] Scheffe's method fails the criteria presented there, because there is no evidence of its having received a scientific peer review and no evidence of performance evaluations having been conducted. The model has also not been shown to be applicable to the problem on a theoretical basis, because there has been no showing that the chemical conditions of the default background environments match those of the Jonah field.

Scientific peer review, as required in EPA's guidelines, is important for reviewing the theoretical (or "face") validity of air quality models, ensuring that the underlying physical and chemical concepts are sound, model equations accurately describe these concepts, and computational methods used to solve the model equations are as accurate as feasible. The term "performance evaluation" refers to testing a model by running it for a particular historical situation, and comparing model results to actual pollutant concentrations measured in the ambient air during that same situation. The models EPA recommends for ozone modeling, e.g., CMAQ and CAMx, have undergone extensive performance evaluations through application to not just one but many historical cases.

Although Scheffe (1988) claims that his method was developed as a screening tool, using "assumptions which lead to conservative (high ozone) ozone increment predictions,"[55] it actually is not clear whether the results would be conservative for this application in the Jonah field. Scheffe's method assumes what its author characterizes as "reasonable worst-case"[56] conditions of strong sunlight, low wind speed, high temperature, and moderate dispersion. If the ozone standard were a long-term average standard, then producing model results for meteorological conditions that are likely to lead to relatively high concentrations, but only on a short-term basis, would clearly be conservative. But here, the standard is based on near-peak short-term (8-hour average) values, which

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[53] User's Guide: Comprehensive Air Quality Model with Extensions (CAMx) Version 4.10s, Environ International Corp., August 2004. Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. EPA/600/R-99/030, March 1999.
[54] 40 CFR Part 51, Appendix W (November 2005).
[55] R.D. Scheffe, VOC/NOx point source screening tables, 3, U.S. EPA, Office of Air Quality Planning and Standards, September 1988.
[56] Id. at 14.

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typically result from conditions of strong sunlight, low wind speed, high temperature, and moderate dispersion, conditions similar to those assumed in Scheffe's analysis. Thus it is unclear how conservative Scheffe's assumptions are, compared to conditions that are conducive to peak or near-peak ozone production in western Wyoming.

Furthermore, in applying Scheffe's method to the Jonah Infill, BLM has made three critical assumptions that are not authorized by Scheffe's description of his method and are clearly not "conservative" (i.e., BLM's assumptions do not tend to err on the side of ensuring that human health and the environment are protected) in the case of the JIDP application. These assumptions significantly offset any conservatism that was meant to be built into the method. First, BLM has assumed only a fraction of the JIDP VOC and NOx emissions would contribute to near-field ozone concentrations. Second, BLM has used Scheffe's table for a rural background environment, even though the stated conditions for using that table are not met. Third, BLM has unjustifiably added the 8-hour increases in near-field ozone concentrations it predicted with its modification of Scheffe's method to a *long-term* average background ozone concentration, which is much lower than the 4th highest 8-hour average concentration that should have been used.

BLM has No Credible Technical Basis for Limiting its Analysis to a Small Fraction of JIDP Emissions

BLM's analysis of the near-field impacts of the JIDP on ozone is limited to emissions from a single one square-mile "patch" of 128 production wells and the Jonah compressor station, which together account for 2433.9 tons per year of VOC emissions and 87.1 tons per year of NOx.[57] In contrast, BLM estimates the annual VOC and NOx emissions from the whole JIDP (3100 wells distributed over 30,500-acre project area) would total approximately 14,000 tons per year and 700 tons per year, respectively.[58] The designation of this "patch" to represent emissions from the entire project area is completely contrary to an approach based on the best currently available science. **As** discussed above, ozone and its precursors are transported and react on spatial scales of tens to hundreds of kilometers and time scales of minutes to days. Emissions from the entire Jonah field will mix over these time scales and combine to produce ozone downwind.

For BLM's approach to have any validity, the patch of sources on which it focuses would have to be isolated from other emissions sources. BLM has not shown that emissions from a one square-mile patch of wells would be isolated in their impacts on ozone from other wells and equipment in the Jonah field or from wells and equipment in other developments in western Wyoming. Given the close proximity of the 3100 wells in the Jonah field, it is highly unlikely the plume from a patch of 128 wells would be isolated from the emissions from the other wells and equipment, even under relatively stagnant conditions.

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[57] TRC Environmental Corporation, Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement (Volume 1 of 2), **33,** January 2006.
[58] TRC Environmental Corporation, Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement (Volume 1 of 2), 14, January 2006.

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Of note, if a "point source" emitting 14,000 tons per year of VOC and 700 tons per year of NOx was evaluated using the Scheffe method, it would be predicted to produce 0.129 ppm of additional ozone (1-hour average) based on the rural table, and 0.208 ppm of additional ozone (1-hour average) based on the urban table – exceeding the old 1-hour ozone NAAQS of 0.12 ppm all on its own. This source would also be estimated to exceed the current 8-hour ozone NAAQS all on its own, if BLM's factor of 0.7 is used to convert from 1-hour average to 8-hour average values. Multiplying 0.129 ppm (1-hour) by 0.7 yields an estimated 8-hour average value of 0.090 ppm and multiplying 0.208 ppm (1-hour) by 0.7 yields an estimated 8-hour average value of 0.146 ppm, in both cases exceeding the 8-hour standard of 0.08 ppm.

BLM Misapplies Scheffe's Method by Its Own Terms Because it Improperly Uses the Rural Table

In its assessment of ozone impacts from the Jonah Infill, BLM has used Scheffe's table for a rural background environment, even though the stated conditions for using that option are not met. Scheffe (1988) states that the following criteria should guide the selection of the appropriate table (urban or rural):

> "(1) If the source location and downwind impact area can be described as rural and where ozone exceedances have never been reported, choose the rural area table.
> (2) If the source location and downwind impact area are of urban character, choose the urban area table.
> (3) If an urban based source potentially can impact a downwind rural area, or a rural based source can potentially impact a downwind urban area, use the highest value obtained from applying both tables."[59]

Ozone exceedances have been reported at or near the Jonah field,[60] so the rural table is inappropriate, according to Scheffe (1988).

This error is important because use of the alternative urban table would lead to much higher predicted ozone concentrations from the Jonah project. Although BLM offers no reasoned basis for isolating a square-mile "patch" of 128 production wells and the Jonah compressor station, if we were to assume that the relevant emissions from the entire project were in fact **2433.9** tons per year of VOC emissions and 87.1 tons per year of NOx,[61] it is straightforward to apply Scheffe's approach using the urban table in place of the rural table. The first calculation required is to determine the ratio of annual VOC and NOx emissions, which is 28:1. This ratio takes us to the first column of the urban Scheffe table. The annual VOC emissions total of 2433.9 tons per year places the Jonah

[59] R.D. Scheffe, VOC/NOx point source screening tables, 3, U.S. EPA, Office of Air Quality Planning and Standards, September 1988.
[60] At least four exceedances of the 8-hour ozone standard have been reported at or near the Jonah field in 2005 and 2006. These include values of 0.098 ppm on February 3, 2005, 0.089 ppm on February 26,2005, and 0.091 ppm on February 27,2006 at the Jonah monitoring site. On February 20,2005, a value of 0.088 ppm was reported at the Boulder station, located 15-20 miles north of the Jonah field.
[61] TRC Environmental Corporation, Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement (Volume 1 of 2), 33, January 2006.

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project between the corresponding VOC emissions in the 9th and 10th rows of the table, which are 2000 and 3000 tons per year, respectively. Reading from the table, the urban-based ozone increment is from 7.1 to 9.5 pphm, or 0.071 to 0.095 ppm, for a 1-hour average. Linear interpolation between the values in the table and application of BLM's factor of 0.7 to estimate 8-hour average concentrations from one-hour average concentrations results in a value of 0.057 ppm, as the estimated 8-hour ozone concentration attributable to the Jonah Infill project.

BLM has Added Results from Scheffe's Method to an Inappropriately Low Background Ozone Value

The third major error BLM has made in its application of Scheffe's method is that BLM has significantly underestimated the "background" ozone concentration to which ozone from the Jonah Infill project should be added. BLM has unjustifiably added the predicted 8-hour increases in near-field ozone concentrations it obtained from its modification of Scheffe's method for the segment of the JIDP project it analyzed to a ***long-term*** average background ozone concentration from the Green River Basin Visibility Study. Instead, BLM should have added the predicted 8-hour concentrations to observed near-peak 8-hour ozone concentrations in the region, as the 4th maximum daily 8-hour average form of the NAAQS dictates.[62] The long-term average value BLM used was 75.2 $\mu g/m^3$ (0.038 ppm)[63] whereas the value BLM reports as representing near-peak 8-hour average background concentrations is 147 $\mu g/m^3$ (0.075 ppm).[64] BLM's choice of the long-term average value makes all the difference, because had BLM used the 8-hour higher value it would have predicted an exceedance of the 8-hour ozone NAAQS.

BLM attempts to explain its use of a low long-term average concentration by asserting that it would be "overly conservative" to combine results from Scheffe's look-up tables with background concentrations that reflect close-to-peak values, but this reasoning is not sound. As discussed above, the 8-hour NAAQS is a short-term standard specifically because exposure to high ozone concentrations for short periods (8 hours or less) is associated with serious health effects. Also as discussed above, meteorological conditions that lead to high ozone levels typically cover large regions, with spatial scales of hundreds of kilometers or more. Consequently, BLM must be concerned with the likely situation that the same type of high-ozone producing meteorological conditions treated in Scheffe's method would occur simultaneously with meteorological conditions that would lead to high concentrations at the background site. BLM's contrary assumption, that high-ozone producing conditions at the Jonah field would be accompanied by conditions that produce only average background ozone levels upwind, runs counter to what is known about ozone formation and introduces a significant non-conservative bias to the predictions. Moreover, to the extent that Scheffe's method is conservatively biased, BLM has not provided any estimate of the magnitude of the bias, nor could it, since no performance evaluation of Scheffe's approach has been conducted.

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[62] Jonah Infill Drilling Project, Final Environmental Impact Statement, J-3 (Table J-6).
[63] TRC Environmental Corporation, Final Air Quality Technical Support Document for the Jonah Infill Drilling Project Environmental Impact Statement (Volume 1 of 2), **34,** January 2006.
[64] Jonah Infill Drilling Project, Final Environmental Impact Statement, **3-8** (Table **3.7).**

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Given this, BLM's substitution of a long-term average as the background concentration of ozone for estimating net effects of the JIDP is without any scientific foundation, and violates the best scientific understanding of ozone formation.

In summary, for the three reasons discussed above, any "conservatism" that Scheffe thought he was building into his method relative to estimating ozone concentrations (i.e., to provide ozone concentration estimates that tend to err on the high side, so as to be sure to protect human health) has been greatly reduced or eliminated entirely by the assumptions and approaches BLM has applied to this particular application of Scheffe's results.

To Obtain Scientifically Defensible Results, BLM Must Apply a Photochemical Grid Model that Reflects the State of the Science

To adequately model ozone impacts from the JIDP, BLM must include emissions from all sources that will be operating over the whole project area. The fact that the Jonah field encompasses hundreds of wells and compressor stations that emit VOC and NOx emissions over an area of 30,500 acres indicates that it must be treated as a "multi-source" modeling problem. EPA's Appendix W modeling guidelines provide clear guidance on the models to use in this situation – "photochemical grid models such as the Models-3/CommunityMulti-scale Air Quality (CMAQ) modeling system."[65] Another widely used photochemical grid model that EPA has accepted for regulatory applications is the CAMx model. The viability of using a photochemical grid model is demonstrated by the fact that the CAMx model is being applied to estimate the impacts of oil and gas development (along with other sources) in the San Juan basin in the Four Corners Region. In applying a grid model to western Wyoming for environmental impact assessment purposes, BLM could isolate the impacts of JIDP emissions by performing sensitivity tests with and without these emissions (so-called "zero out" modeling). For better resolution of near-field impacts, a nested-grid could be applied to the immediate vicinity of the Jonah field, inside the larger grid of the full modeling domain. For large stationary sources such as large compressors, BLM could also have employed the plume-in-grid modules available in CAMx and CMAQ. These approaches represent application of the best available science as recognized in EPA's Guideline on Air Quality Models for ozone modeling in a multi-source environment where ozone exceedances are being observed. The Scheffe method is wholly inappropriate for this application, especially when BLM has applied it in a way that undercuts any conservatism it was meant to have by modeling only a small number of wells in the Jonah field, improperly using the rural table, and substantially underestimating background ozone levels.

Mid- to Far-field Effects of the JIDP and Other Oil and Gas Development Projects in Western Wyoming are Likely to be Significant

Like SO_2, NO_2, PM10, PM2.5, regional haze and deposition of acid precursors (nitrogen and sulfur compounds), ozone has mid-field and far-field impacts. In the case of ozone, these impacts can be observed over scales of hundreds of kilometers. BLM performed

[65] **40** CFR Part 51, Appendix W (November 2005).

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mid- and far-field analyses for the other pollutants and effects, but not for ozone. In response to the public comment that it should also assess "mid-field" to "far-field" impacts of ozone, BLM responded that ozone models other than Scheffe's method would be too expensive and time-consuming to apply and that "the data and analyses provided in the EIS and AQTSD are adequate for assessment."[66] The fact that application of photochemical grid models listed by EPA in the Guideline on Air Quality Models is feasible and appropriate in this situation is demonstrated by their extensive use in other settings, including for analysis of the cumulative impacts of emissions increases from oil and gas development. The January 2006 Air Quality Technical Support Document also states "the models that are available for estimating ozone formation are applicable for urban areas where high temperature, summertime, stagnant conditions can persist and are conducive to ozone formation." To the extent that this statement was meant to imply that these models are not applicable to rural areas, or conditions like those found in western Wyoming, the statement is simply incorrect. As discussed above, photochemical grid models can be and have been applied to domains ranging from the size of an urban area to the scale of a state or continent, encompassing both rural and urban conditions.

Finally, photochemical grid models also carry the significant advantage that they are the appropriate tool for projecting the effects on ozone of not only the JIDP but also the cumulative impacts on ozone of all of the oil and gas development projects occurring in western Wyoming, northwestern Colorado, northeastern Utah and southeastern Idaho.

Conclusion

There is no indication that Scheffe's method has ever been evaluated or received peer review, or was ever even finalized. It has not been approved by EPA as a preferred model or an alternative model for any application. Nor has BLM even attempted to make the showings that would be necessary for EPA to approve the method as an alternative model.

Scheffe's method is not scientifically defensible because it either fails to represent or only crudely represents many of the variables known to be major factors influencing ozone formation. BLM has compounded the problems with Scheffe's original approach by applying it in a manner that violates the instructions Scheffe (1988) provides, and that ignores without justification most of the relevant emissions from the Jonah Infill project. BLM's tortured application of Scheffe's method violates the requirement of NEPA that assessments of a project's impact on the environment be based upon sound science.

At best, Scheffe's method was intended to serve as a screening model, "to be used only in the context of a first-step procedure which potentially can preclude further resource-intensive analysis."[67] If Scheffe's method had been properly applied, by its own terms,

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[66] Comment Analysis Report, Part 11: Substantive Comments Received During Public Comment Analysis Process of the Jonah Infill Drilling Project, Table III-B, **3,** available at http://www.wy.blm.gov/nepa/pfodocs/jonah/index.htm.

[67] R.D. Scheffe, VOC/NOx point source screening tables, **3,** U.S. EPA, Office of Air Quality Planning and Standards, September 1988.

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and assuming that it could serve as a screening model to determine whether a more refined modeling assessment is needed, it would have predicted that emissions from the Jonah Infill project would cause large violations of the NAAQS. Based on results obtained from a proper application of the method, BLM must undertake a comprehensive assessment of expected ozone impacts using the tools currently approved by EPA as representing the most reliable scientifically validated method for modeling ozone.

Modern photochemical grid models, which are listed as the preferred modeling methods in subsection 5.2.1.a of the EPA Guideline on Air Quality Models, represent the state of the modeling art for the purpose of predicting future ozone concentrations in and downwind from the Jonah Field. As noted above, they are the appropriate tool for projecting the effects on ozone of not only the JIDP but also the cumulative impacts of all of the oil and gas development projects occurring in the region.

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Exhibit 5

00123

Report to WESTAR Technical Committee
September 20, 2006

The CMAQ Visibility Model Applied To Rural Ozone In The Intermountain West

Patrick Barickman
Tyler Cruickshank (Perl Programming)
Dave Strohm (HYSPLIT)

Department of Environmental Quality *Division of Air Quality*

Are the CMAQ model results a useful guide for rural ozone analysis?

"Model Performance Evaluation" (MPE) answers this question

Is the model providing good estimates of hourly ozone production and depletion?

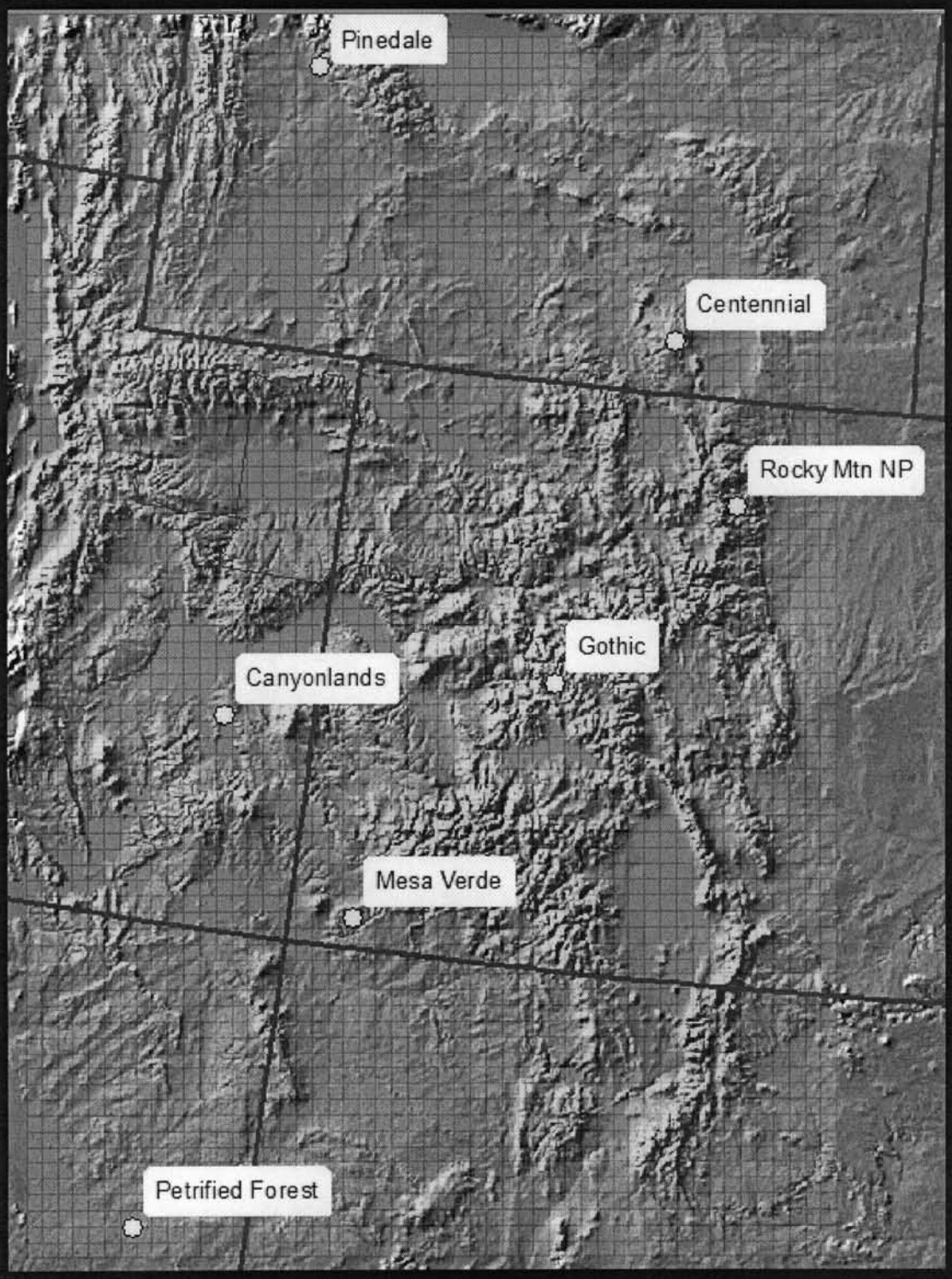
Compare observed ozone at the 6 monitors in the domain with model estimates

- Statistical metrics
  - Mean normalized bias
  - Mean normalized error
- Time series charts

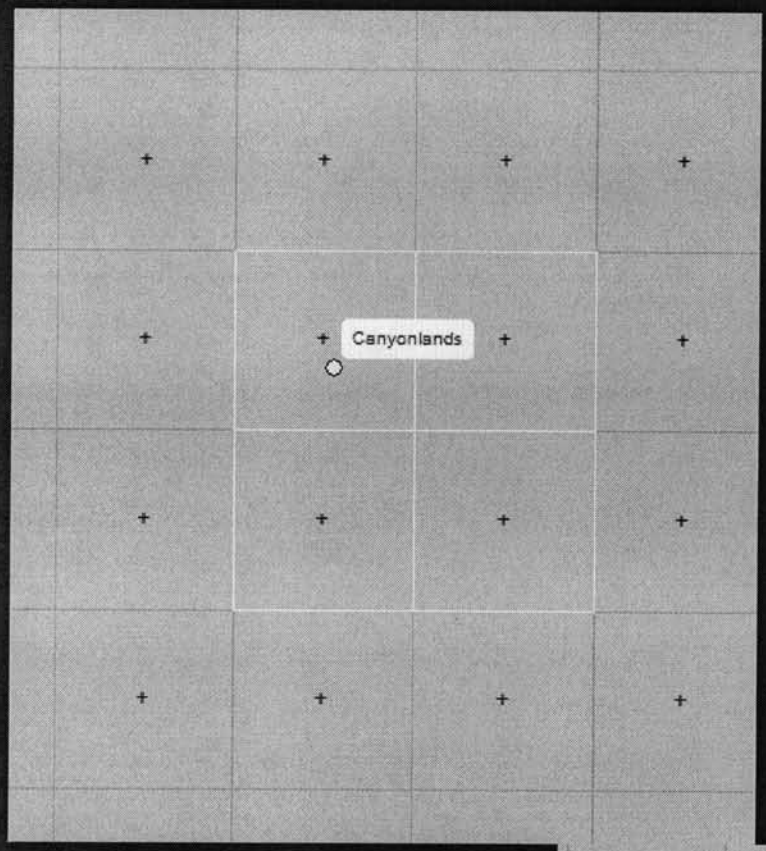
Tools used

- GIS
- Perl programming
- Additional scripts from the RMC
- HYSPLIT

Model Sub-domain 12 km CMAQ Domain

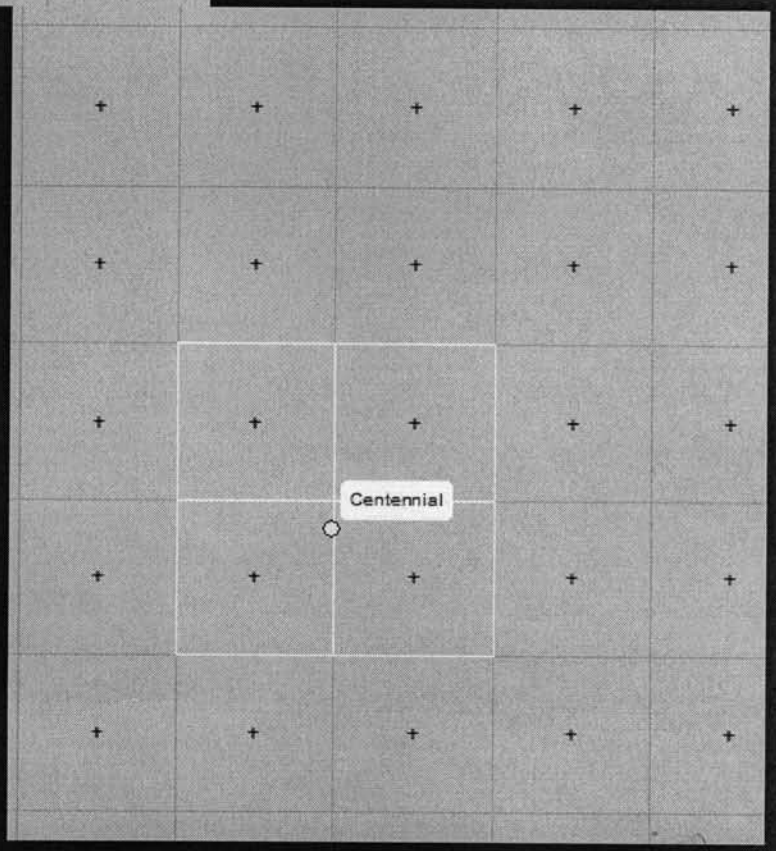


Establishing model value for comparison



Bilinear interpolation 4-cell window around each monitor

Weighted average of 4 cells based on distance of cell center to monitor location



Mean Normalized Bias (MNB): A value of zero would indicate that the model over predictions and model under predictions exactly cancel each other out.

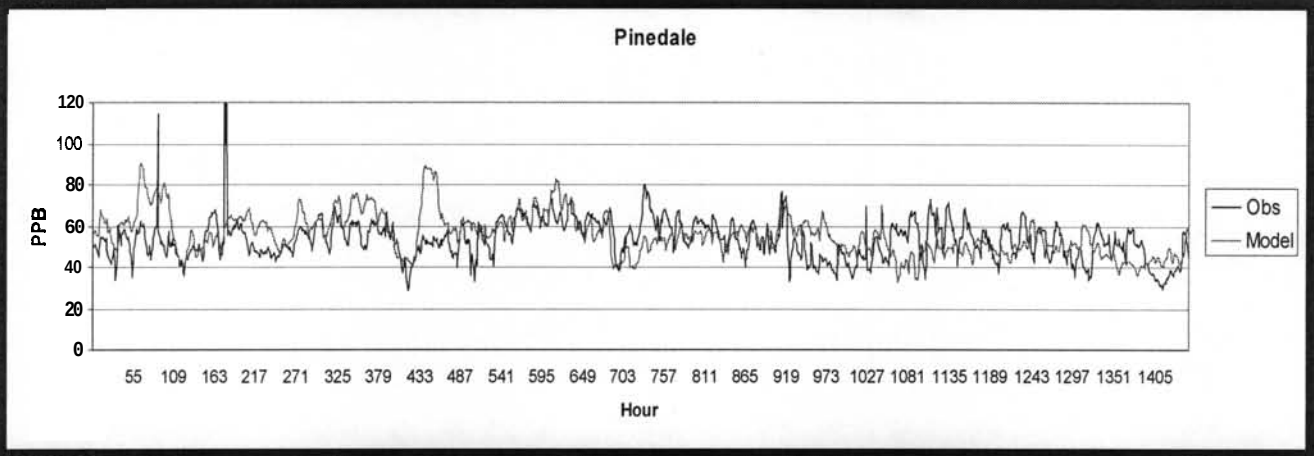
Mean Normalized Gross Error (MNGE): A value of zero would indicate that the model exactly matches the observed values at all points in space/time.

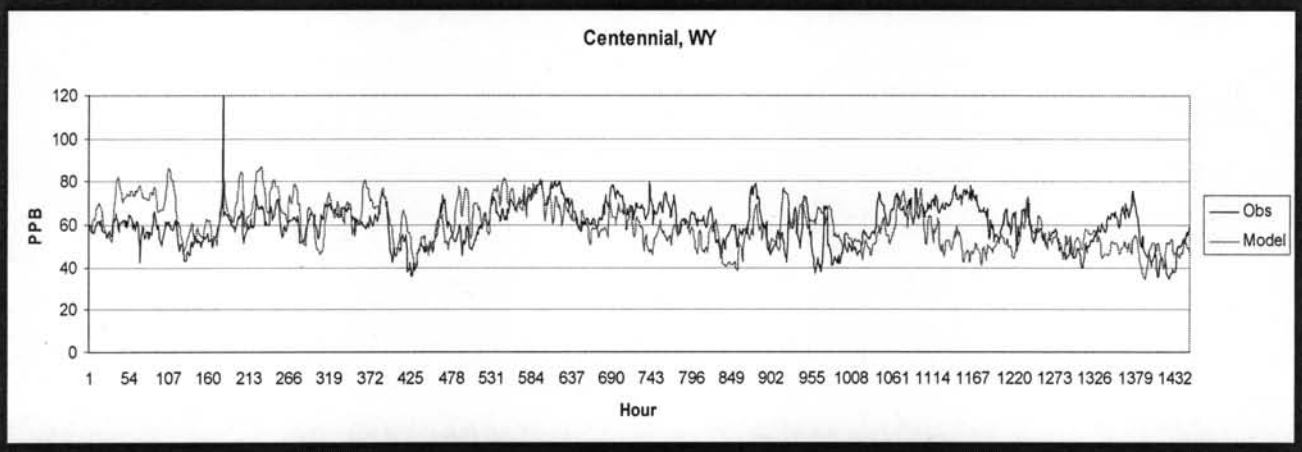
Previous guidance in the modeling community set a goal of: MNB <= 15% and MNGE of <= 25%. This was based on the experience of actual model performance over the years.

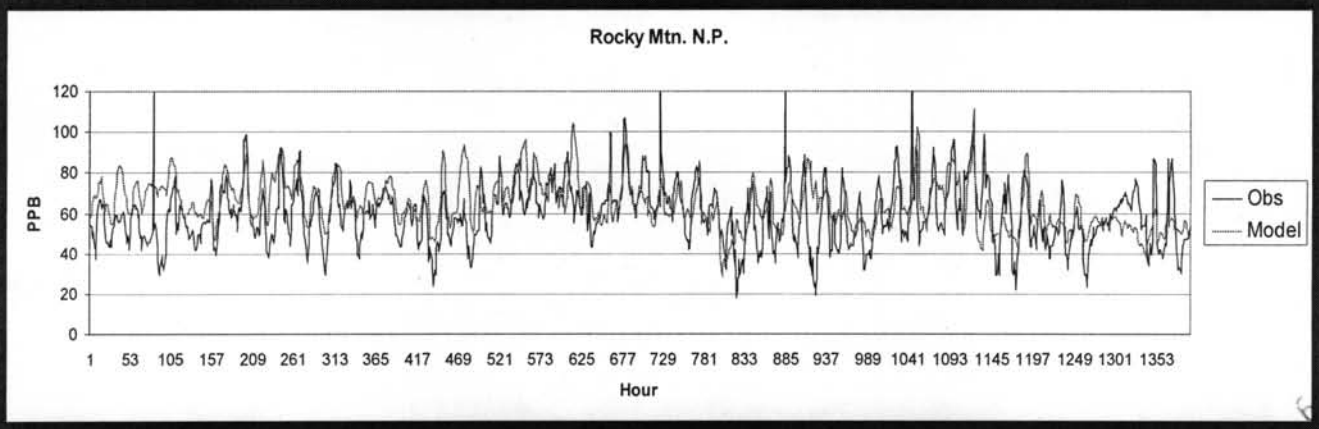
Goal	<= 15%	<= 25%
Monitor	MNB	MNGE
Rocky Mountain N.P.	4%	16%
Mesa Verde N.P.	3%	14%
Centennial, WY	-4%	10%
Pinedale, WY	-2%	13%
Gothic, CO	7%	17%
Canyonlands N.P.	-3%	12%

Mean Normalized Bias (MNB)
Mean Normalized Gross Error (MNGE)
Minimum cutoff 50 ppb – only hours with observations > 50 used in bias and gross error calculations

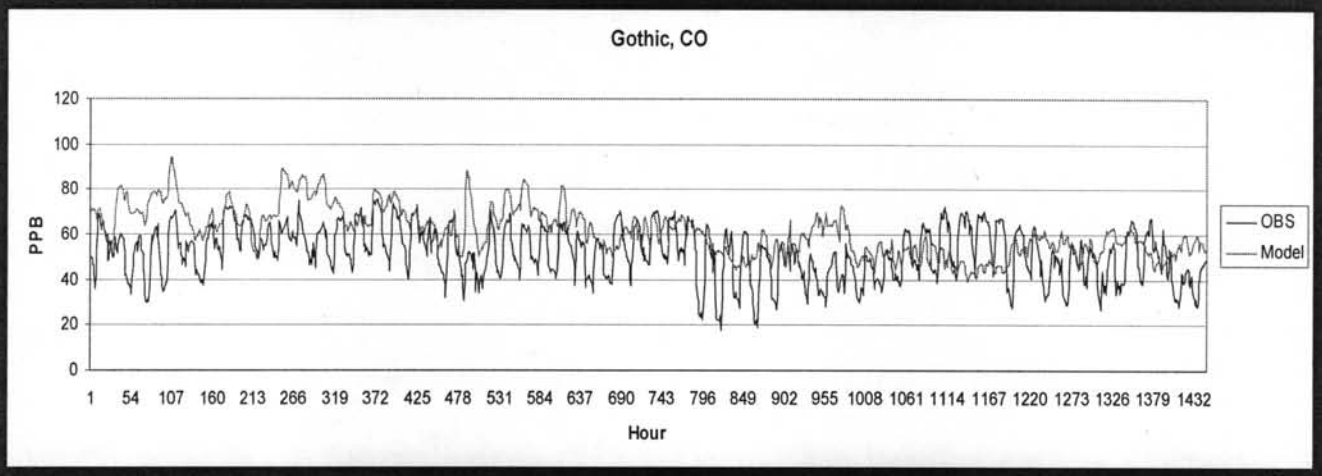
Time Series Charts (North to South)
June 1 – July 31, 2002

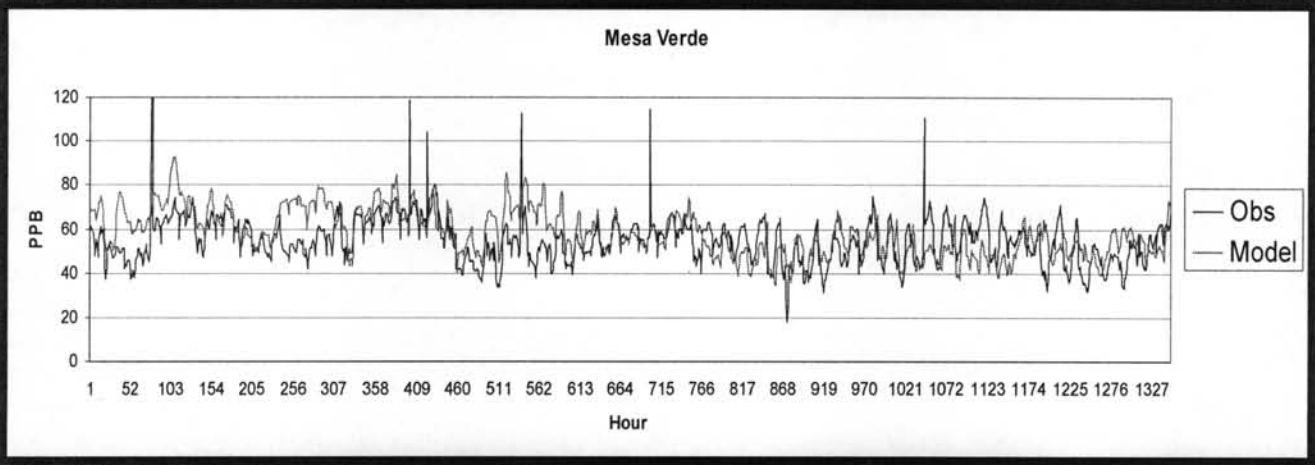


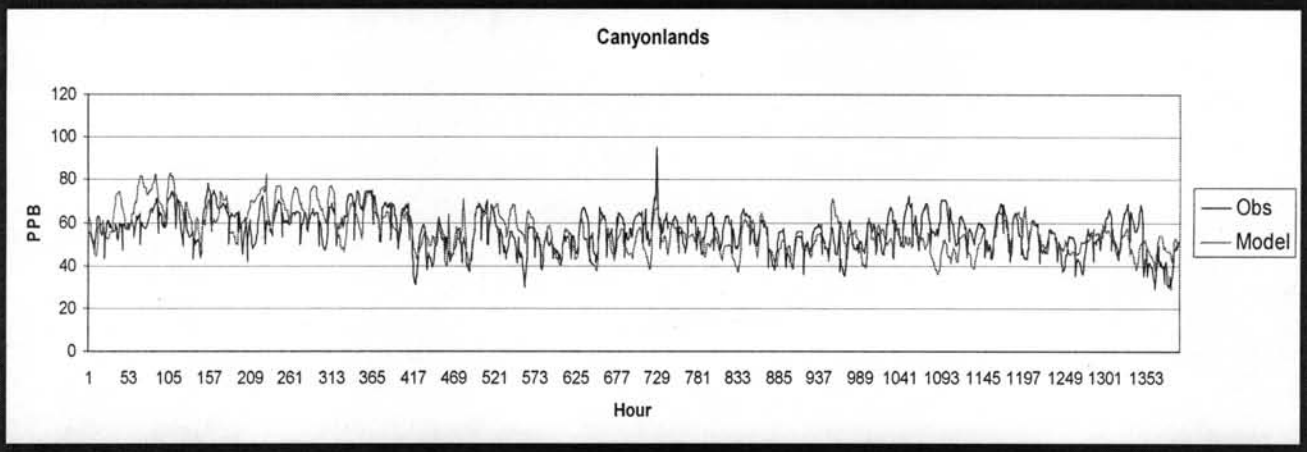


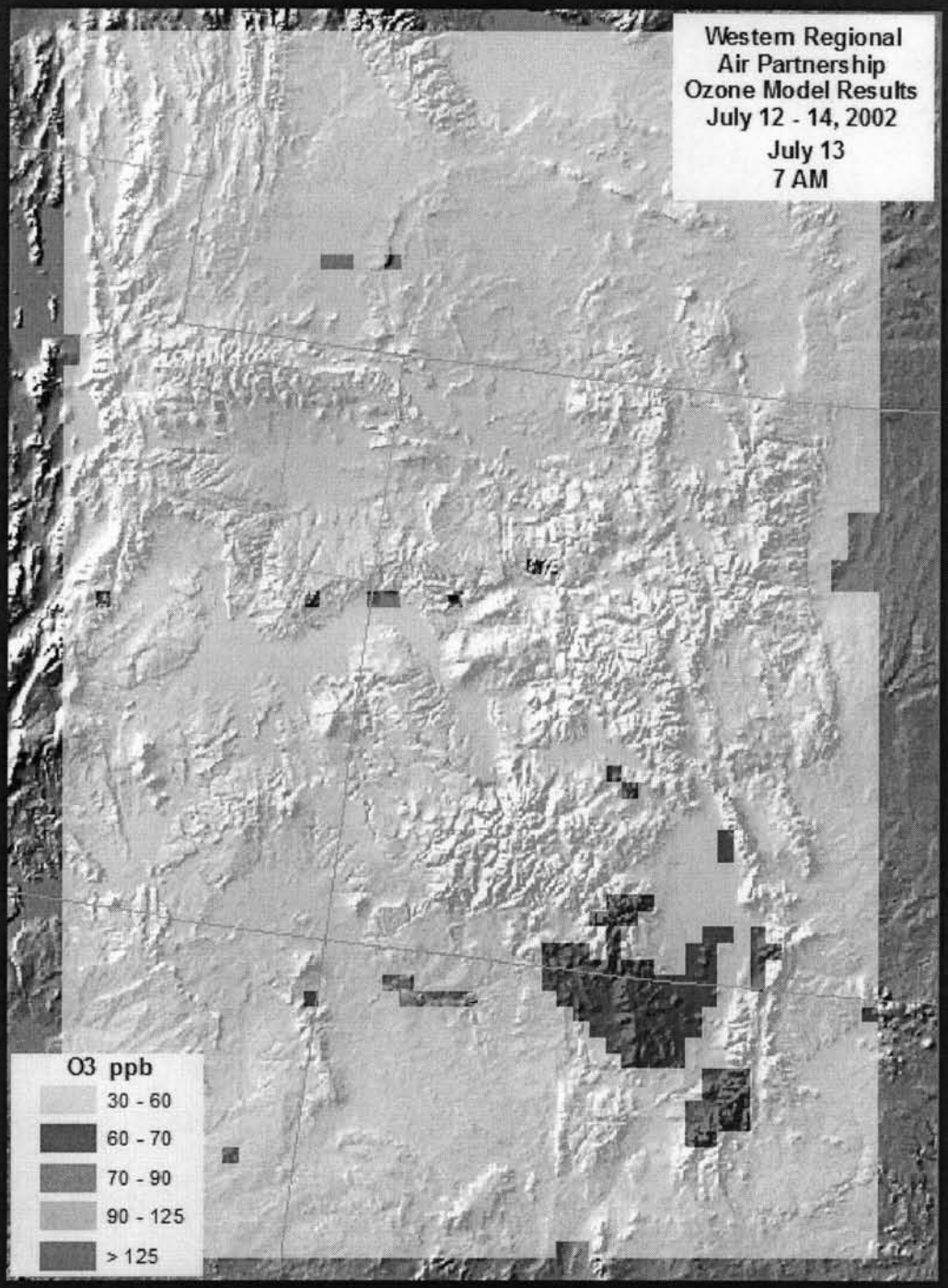


Time Series Charts (North to South)









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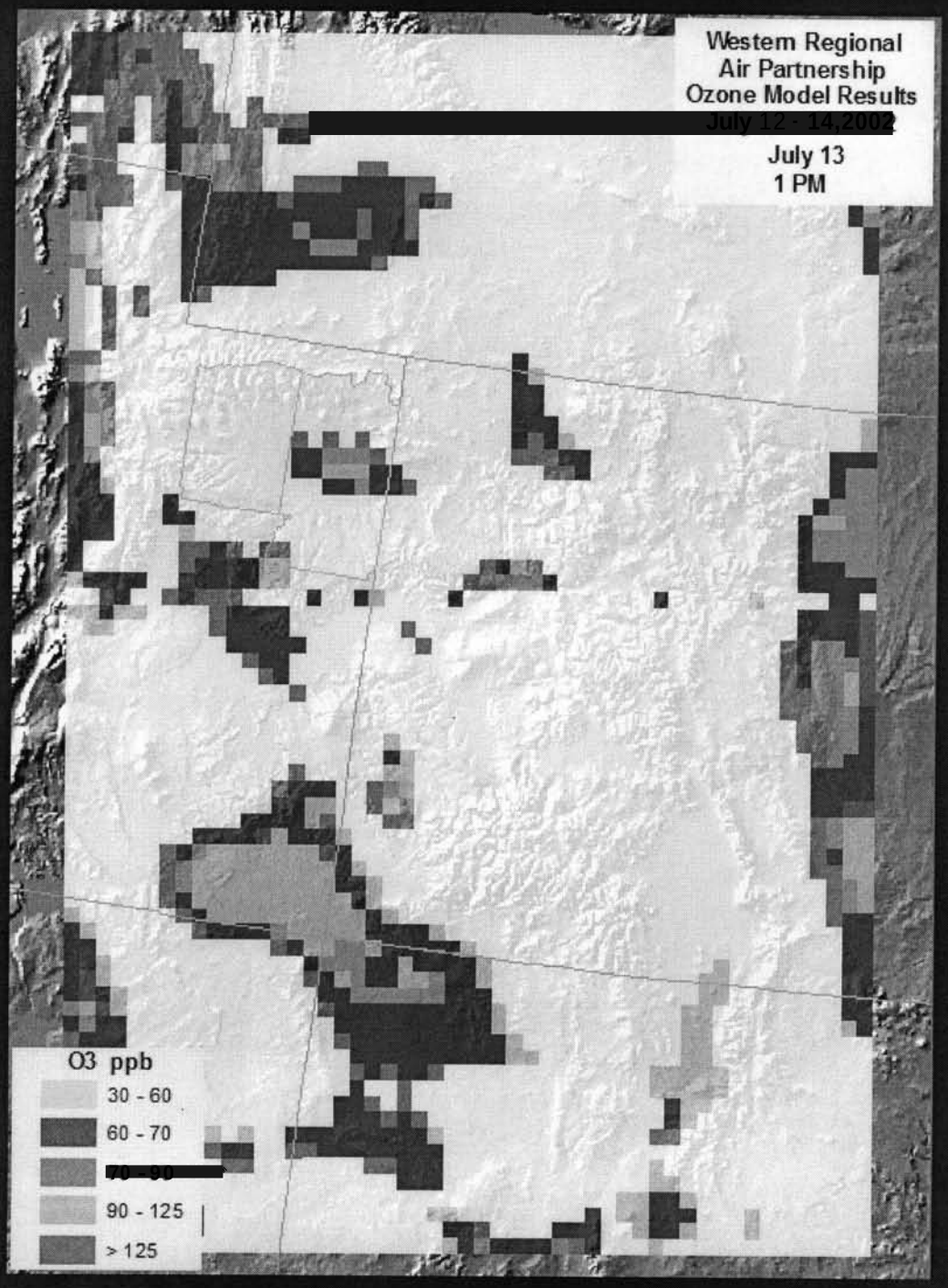

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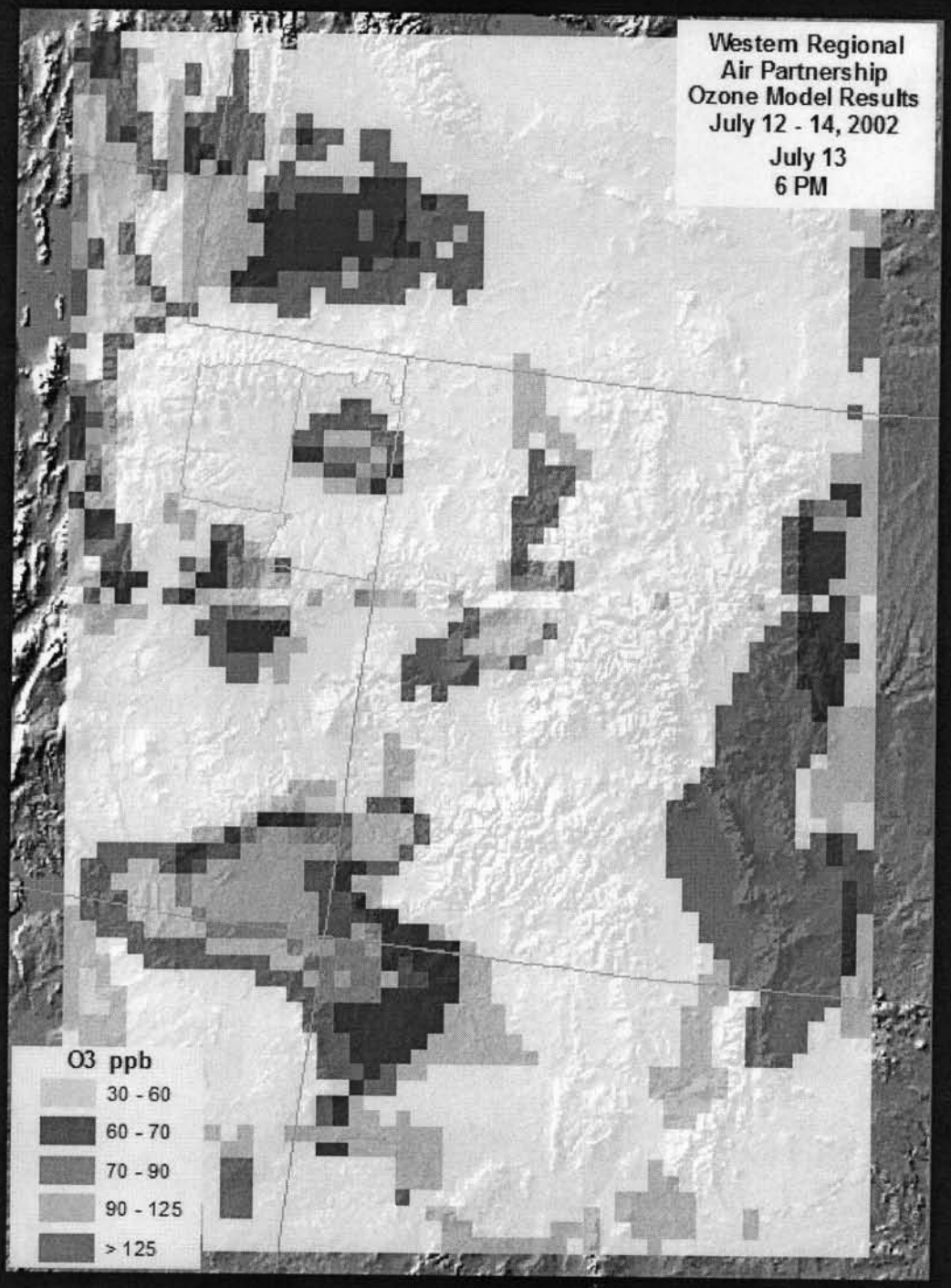

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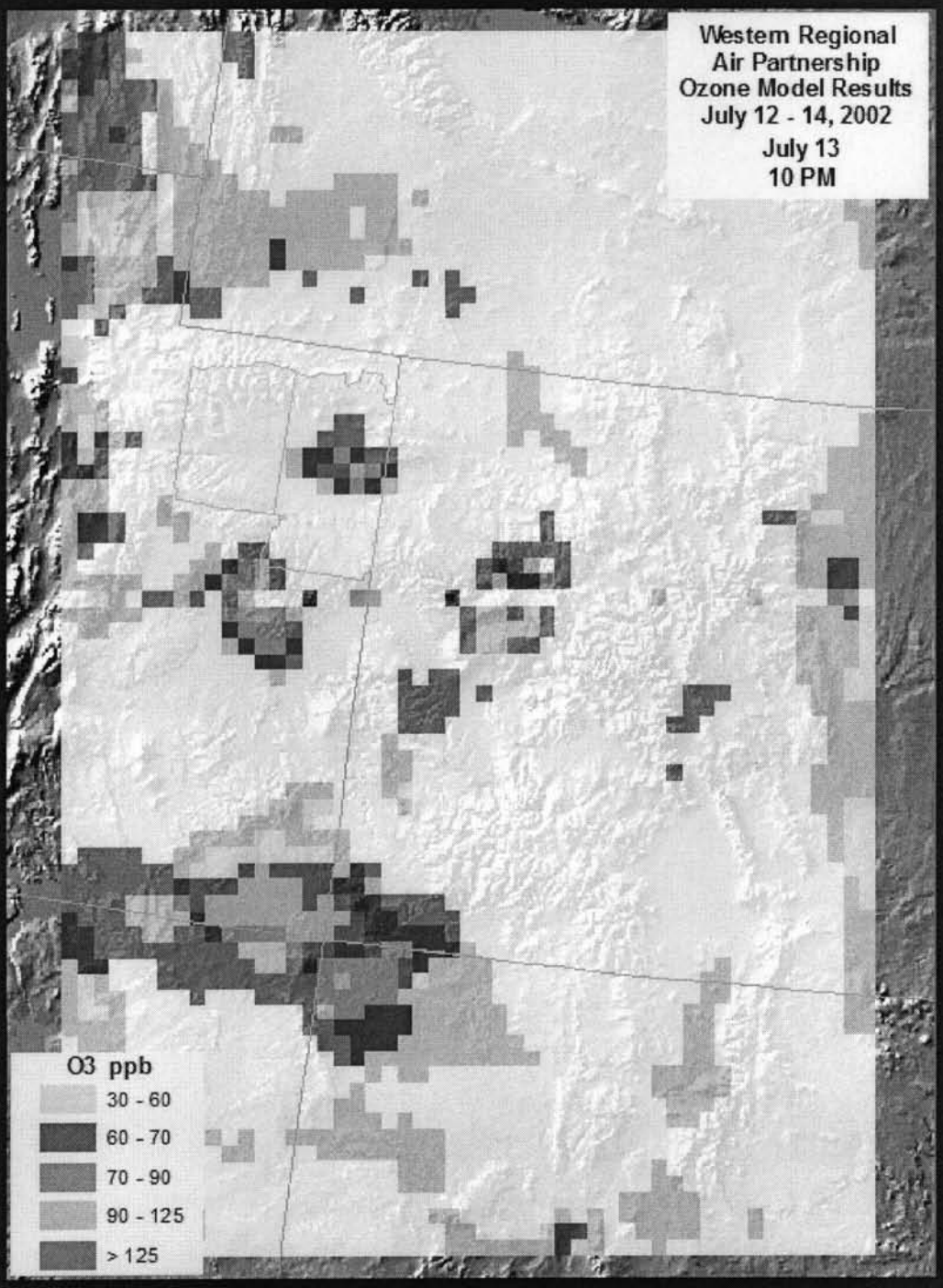

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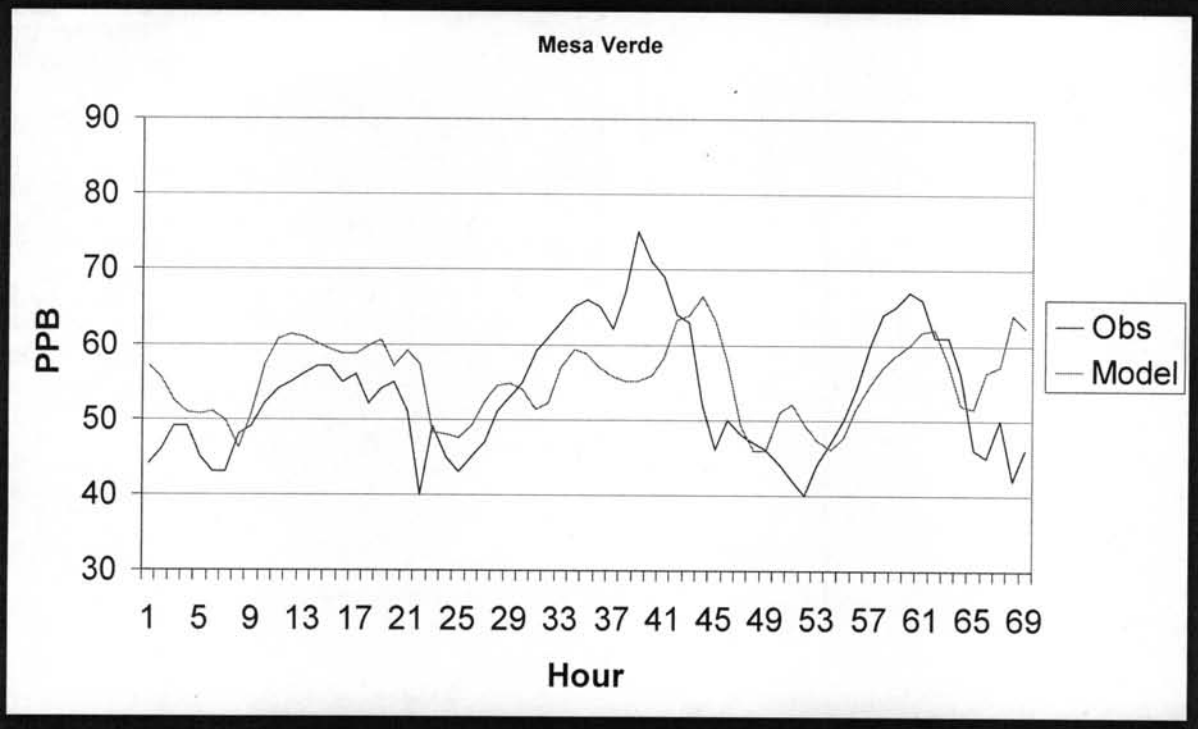

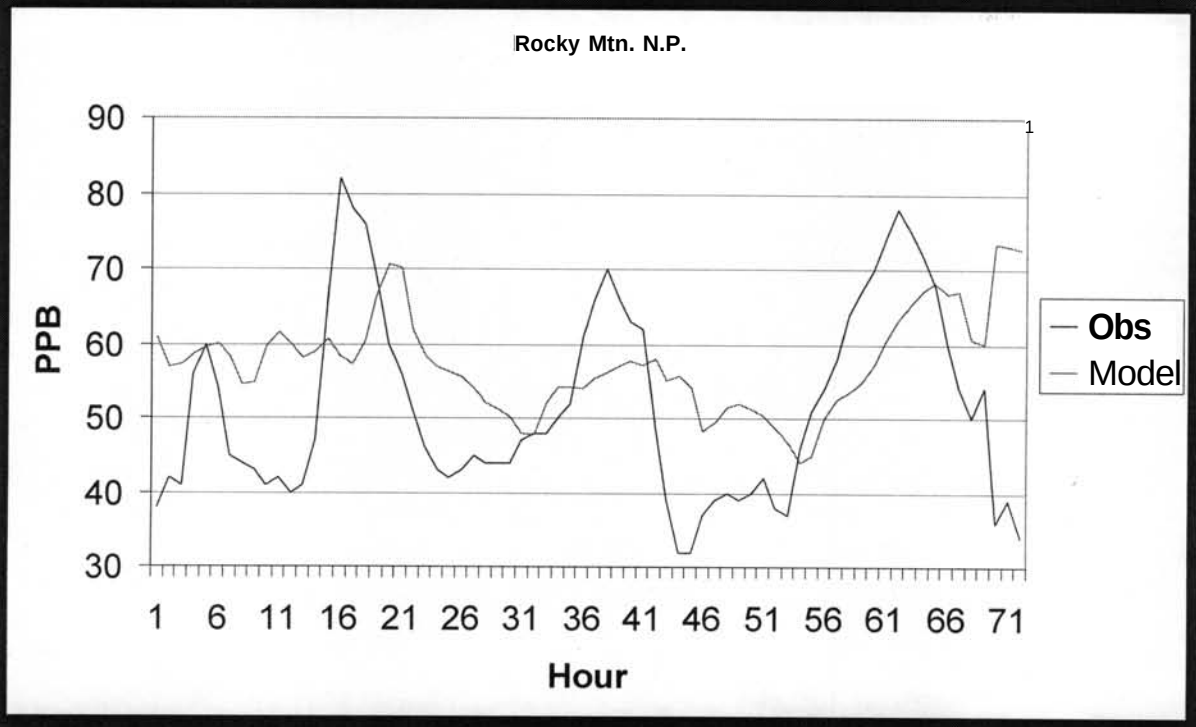

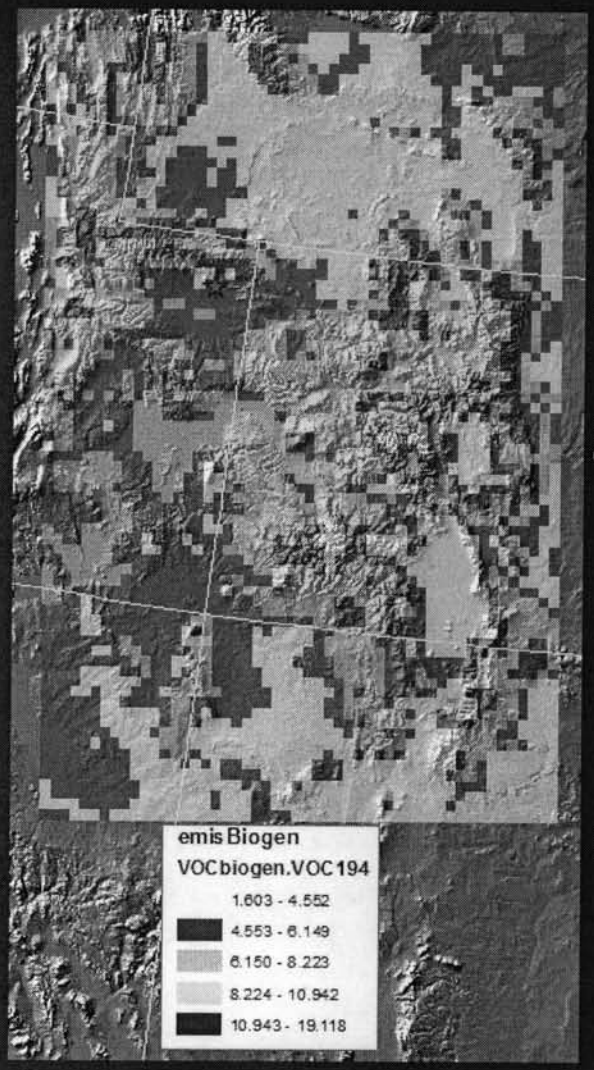

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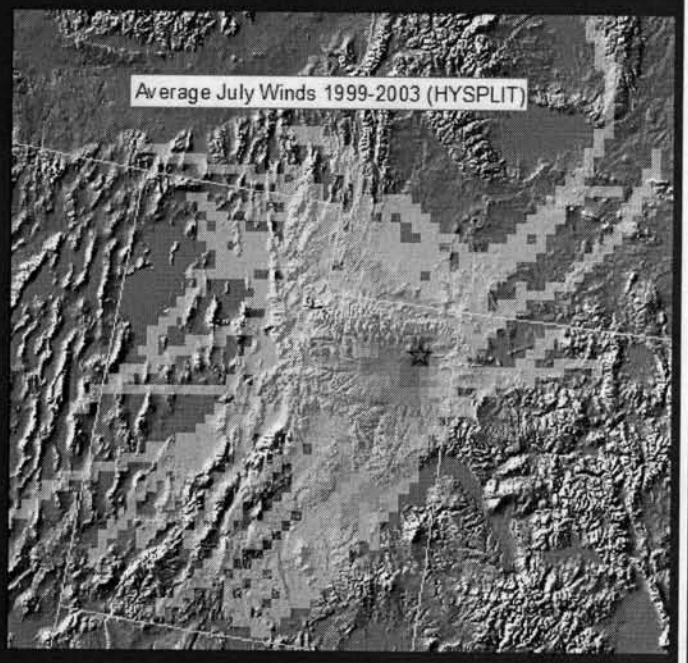

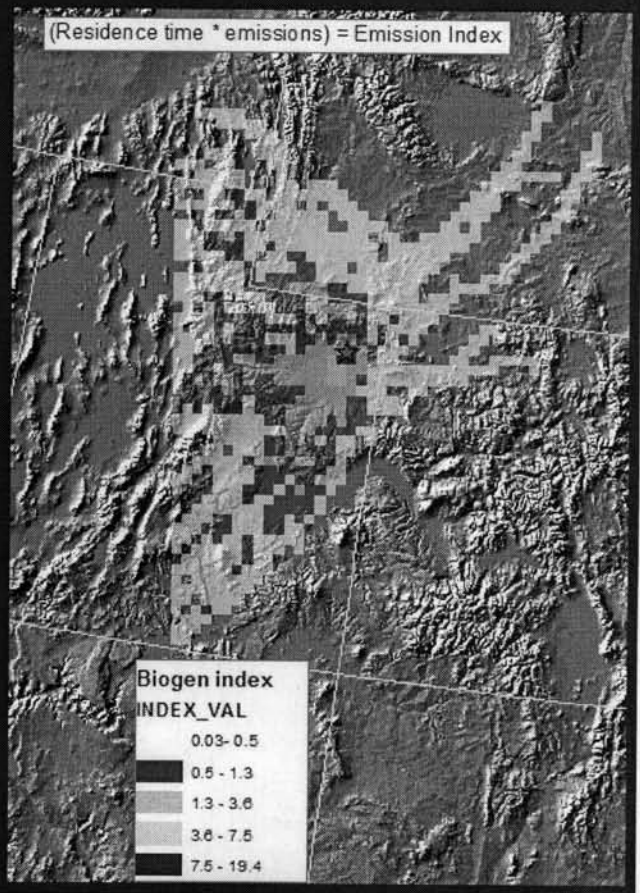

Gridded emissions + HYSPLIT creates an alternative view of average emissions transport to a specific area

Conclusions

- Model performs well for rural ozone predictions
- Good model performance increases confidence in the meteorology and emissions inputs
- Emissions inventory, meteorology, and AQ model have been under continuous development for the past six years and are useful for a variety of issues

Exhibit 6

00123

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DOI: 10.1126/science.1128834

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RESEARCH ARTICLES

Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

A. L. Westerling,[1,2*] H. G. Hidalgo,[1] D. R. Cayan,[1,3] T. W. Swetnam[4]

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Western United States forest wildfire activity is widely thought to have increased in recent decades, yet neither the extent of recent changes nor the degree to which climate may be driving regional changes in wildfire has been systematically documented. Much of the public and scientific discussion of changes in western United States wildfire has focused instead on the effects of 19th- and 20th-century land-use history. We compiled a comprehensive database of large wildfires in western United States forests since 1970 and compared it with hydroclimatic and land-surface data. Here, we show that large wildfire activity increased suddenly and markedly in the mid-1980s, with higher large-wildfire frequency, longer wildfire durations, and longer wildfire seasons. The greatest increases occurred in mid-elevation, Northern Rockies forests, where land-use histories have relatively little effect on fire risks and are strongly associated with increased spring and summer temperatures and an earlier spring snowmelt.

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Wildfires have consumed increasing areas of western U.S. forests in recent

years, and fire-fighting expenditures by federal land-management agencies now regularly exceed US$1 billion/year (1). Hundreds of homes are burned annually by wildfires, and damages to natural resources are sometimes extreme and irreversible. Media reports of recent, very large wildfires (>100,000 ha) burning in western forests have garnered widespread public attention, and a recurrent perception of crisis has galvanized legislative and administrative action (1–3).

Extensive discussions within the fire-management and scientific communities and the media seek to explain these phenomena, focusing on either land-use history or climate as primary causes. If increased wildfire risks are driven primarily by land-use history, then ecological restoration and fuels management are potential solutions. However, if increased risks are largely due to changes in climate during recent decades, then restoration and fuels treatments may be relatively ineffective in reversing current wildfire trends (4, 5). We investigated 34 years of western U.S. (hereafter, "western") wildfire history together with hydroclimatic data to determine where the largest increases in wildfire have occurred and to evaluate how recent climatic trends may have been important causal factors.

Competing explanations: Climate versus management. Land-use explanations for increased western wildfire note that extensive livestock grazing and increasingly effective fire suppression began in the late 19th and early 20th centuries, reducing the frequency of large surface fires (6–8). Forest regrowth after extensive logging beginning in the late 19th century, combined with an absence of extensive fires, promoted forest structure changes and biomass accumulation, which now reduce the effectiveness of fire suppression and increase the size of wildfires and total area burned (3, 5, 9). The effects of land-use history on forest structure and biomass accumulation are, however, highly dependent upon the "natural fire regime" for any particular forest type. For example, the effects of fire exclusion are thought to be profound in forests that previously sustained frequent, low-intensity surface fires [such as Southwestern ponderosa pine and Sierra Nevada mixed conifer (2, 3, 10, 11)], but of little or no consequence in forests that previously sustained only very infrequent, high-severity crown fires (such as Northern Rockies lodgepole pine or spruce-fir (1, 5, 12)].

In contrast, climatic explanations posit that increasing variability in moisture conditions (wet/dry oscillations promoting biomass growth, then burning), and/or a trend of increasing drought frequency, and/or warming temperatures have led to increased wildfire activity (13, 14). Documentary records and proxy reconstructions (primarily from tree rings) of fire history and climate provide evidence that western forest wildfire risks are strongly positively associated with drought concurrent with the summer fire season and (particularly in ponderosa pine–dominant forests) positively associated to a lesser extent with moist

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conditions in antecedent years (13–18). Variability in western climate related to the Pacific Decadal Oscillation and intense El Niño/La Niña events in recent decades along with severe droughts in 2000 and 2002 may have promoted greater forest wildfire risks in areas such as the Southwest, where precipitation anomalies are significantly influenced by patterns in Pacific sea surface temperature (19–22). Although corresponding decadal-scale variations and trends in climate and wildfire have been identified in paleo studies, there is a paucity of evidence for such associations in the 20th century.

We describe land-use history versus climate as competing explanations, but they may be complementary in some ways. In some forest types, past land uses have probably increased the sensitivity of current forest wildfire regimes to climatic variability through effects on the quantity, arrangement, and continuity of fuels. Hence, an increased incidence of large, high-severity fires may be due to a combination of extreme droughts and overabundant fuels in some forests. Climate, however, may still be the primary driver of forest wildfire risks on interannual to decadal scales. On decadal scales, climatic means and variability shape the character of the vegetation [e.g., species populations and their drought tolerance (23) and biomass (fuel) continuity (24), thus also affecting fire regime responses to shorter term climate variability]. On interannual and shorter time scales, climate variability affects the flammability of live and dead forest vegetation (13–19, 25).

High-quality time series are essential for evaluating wildfire risks, but for various reasons (26), previous works have not rigorously documented changes in large-wildfire frequency for western forests. Likewise, detailed fire-climate analyses for the region have not been conducted to evaluate what hydroclimatic variations may be associated with recent increased wildfire activity, and the spatial variations in these patterns.

We compiled a comprehensive time series of 1166 large (>400 ha) forest wildfires for 1970 to 2003 from federal land-management units containing 61% of western forested areas (and 80% above 1370 m) (26) (fig. S1). We compared these data with corresponding hydroclimatic and land surface variables (26–34) to address where and why the frequency of large forest wildfire has changed.

Increased forest wildfire activity. We found that the incidence of large wildfires in western forests increased in the mid-1980s (Fig. 1) [hereafter, "wildfires" refers to large-fire events (>400 ha) within forested areas only (26)]. Subsequently, wildfire frequency was nearly four times the average of 1970 to 1986, and the total area burned by these fires was more than six and a half times its previous level. Interannual variability in wildfire frequency is strongly associated with regional spring and summer temperature (Spearman's correlation of 0.76, $P < 0.001$, $n = 34$). A second-order polynomial fit to the

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regional temperature signal alone explains 66% of the variance in the annual incidence of these fires, with many more wildfires burning in hotter than in cooler years.

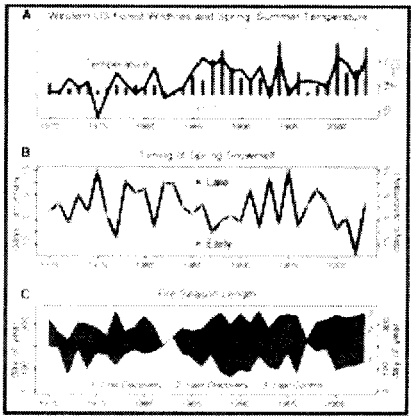

Fig. 1. (**A**) Annual frequency of large (>400 ha) western U.S. forest wildfires (bars) and mean March through August temperature for the western United States (line) (26, 30). Spearman's rank correlation between the two series is 0.76 ($P < 0.001$). Wilcoxon test for change in mean large–forest fire frequency after 1987 was significant ($W = 42$; $P < 0.001$). (**B**) First principle component of center timing of stream-flow in snowmelt dominated streams (line). Low (pink shading), middle (no shading), and high (light blue shading) tercile values indicate early, mid-, and late timing of spring snowmelt, respectively. (**C**) Annual time between first and last large-fire ignition, and last large-fire control. [View Larger Version of this Image (52K GIF file)]

The length of the wildfire season also increased in the 1980s (Fig. 1). The average season length (the time between the reported first wildfire discovery date and the last wildfire control date) increased by 78 days (64%), comparing 1970 to 1986 with 1987 to 2003. Roughly half of that increase was due to earlier ignitions, and half to later control (48% versus 52%, respectively). Later control dates were no doubt partly due to later ignition dates, given that the date of the last reported wildfire ignition increased by 15 days, but a substantial increase in the length of time the average wildfire burned also played a role. The average time between discovery and control for a wildfire increased from 7.5 days from 1970 to 1986 to 37.1 days from 1987 to 2003. The annual length of the fire season and the average time each fire burned were also moderately correlated with the regional spring and summer temperature (Spearman's correlations of 0.61 ($P < 0.001$) and 0.55 ($P < 0.001$), respectively.

The greatest increase in wildfire frequency has been in the Northern Rockies, which account for 60% of the increase in large fires. Much of the remaining increase (18%) occurred in the Sierra Nevada, southern Cascades, and Coast Ranges of northern California and southern Oregon ("Northern California," in fig. S2). The Pacific Southwest; the Southern Rockies; the Northwest; coastal,

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central, and southern California; and the Black Hills each account for 11%, 5%, 5%, <1%, and <1%, respectively. Interestingly, the Northern Rockies and the Southwest show the same trend in wildfire frequency relative to their respective forested areas. However, the Southwest's absolute contribution to the western regional total is limited by its smaller forested area relative to higher latitudes.

Increased wildfire frequency since the mid-1980s has been concentrated between 1680 and 2590 m in elevation, with the greatest increase centered around 2130 m. Wildfire activity at these elevations has been episodic, coming in pulses during warm years, with relatively little activity in cool years, and is strongly associated with changes in spring snowmelt timing, which in turn is sensitive to changes in temperature.

Fire activity and the timing of the spring snowmelt. As a proxy for the timing of the spring snowmelt, we used Stewart and colleagues' dates of the center of mass of annual flow (CT) for snowmelt-dominated streamflow gauge records in western North America (*32*–*34*). The annual wildfire frequency for the region is highly correlated (inversely) with CT at gauges across the U.S. Pacific Northwest and interior West, indicating a coherent regional signal of wildfire sensitivity to snowmelt timing (Fig. 2). The negative sign of these correlations indicates that earlier snowmelt dates correspond to increased wildfire frequency. Following Stewart *et al.*, we used the first principal component (CT1) of CT at western U.S. streamflow gauges as a regional proxy for interannual variability in the arrival of the spring snowmelt (Fig. 1) (*26*, *32*). This signal had its greatest impact on wildfire frequency between elevations of 1680 and 2590 m (Fig. 2), with a nonlinear response at these elevations to variability in snowmelt timing. Overall, 56% of wildfires and 72% of area burned in wildfires occurred in early (i.e., lower tercile CT1) snowmelt years, whereas only 11% of wildfires and 4% of area burned occurred in late (i.e., upper tercile CT1) snowmelt years.

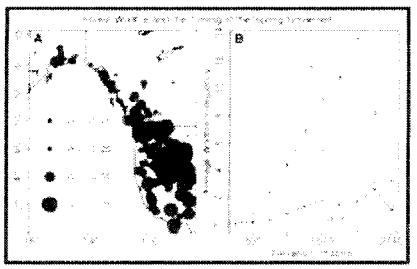

Fig. 2. (**A**) Pearson's rank correlation between annual western U.S. large (>400 ha) forest wildfire frequency and streamflow center timing. *x* axis, longitude; *y* axis, latitude. (**B**) Average frequency of western U.S. forest wildfire by elevation and early, mid-, and late snowmelt years from 1970 to 2002. See Fig. 1B for a definition of early, mid-, and late snowmelt years. [View Larger Version of this Image (28K GIF file)]

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Temperature affects summer drought, and thus flammability of live and dead fuels in forests through its effect on evapotranspiration and, at higher elevations, on snow. Additionally, warm spring and summer temperatures were strongly associated with reduced winter precipitation over much of the western United States (Fig. 3). The arrival of spring snowmelt in the mountains of the western United States, represented here by CT1, is strongly associated with spring temperature (26). Average spring and summer temperatures throughout the entire region are significantly higher in early than in late years (Fig. 3), peaking in April. The average difference between early and late April mean monthly temperatures in forested areas was just over 2°C, and it increased with elevation.

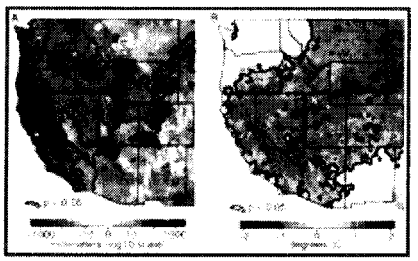

Fig. 3. Average difference between early and late snowmelt years in average precipitation from October through May (**A**) and average temperature from March through August (**B**). Contours enclose regions in which a *t* test for the difference in mean between 11 early and 11 late years was significant ($P < 0.05$). The null hypothesis that precipitation from October through May is normally distributed could not be rejected using the Shapiro-Wilk test for normality ($P > 0.05$ for more than 95% of 24,170 grid cells, $n = 49$ for precipitation; $P > 0.05$ for more than 95% of 24,170 grid cells, $n = 50$ for temperature). See Fig. 1B for a definition of early, mid-, and late snowmelt years. [View Larger Version of this Image (76K GIF file)]

Snow carries over a substantial portion of the winter precipitation that falls in western mountains, releasing it more gradually in late spring and early summer, providing an important contribution to spring and summer soil moisture (35). An earlier snowmelt can lead to an earlier, longer dry season, providing greater opportunities for large fires due both to the longer period in which ignitions could potentially occur and to the greater drying of soils and vegetation. Consequently, it is not surprising that the incidence of wildfires is strongly associated with snowmelt timing.

Changes in spring and summer temperatures associated with an early spring snowmelt come in the context of a marked trend over the period of analysis.

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Regionally averaged spring and summer temperatures for 1987 to 2003 were 0.87°C higher than those for 1970 to 1986. Spring and summer temperatures for 1987 to 2003 were the warmest since the start of the record in 1895, with 6 years in the 90th percentile—the most for any 17-year period since the start of the record in 1895 through 2003—whereas only 1 year in the preceding 17 years ranked in the 90th percentile. Likewise, 73% of early years since 1970 occurred in 1987 to 2003 (Fig. 1).

Spatial variability in the wildfire response to an earlier spring. Vulnerability of western U.S. forests to more frequent wildfires due to warmer temperatures is a function of the spatial distribution of forest area and the sensitivity of the local water balance to changes in the timing of spring. We measured this sensitivity using the October-to-September moisture deficit—the cumulative difference between the potential evapotranspiration due to temperature and the actual evapotranspiration constrained by available moisture—which is an important indicator of drought stress in plants (*24*). We used the percentage difference in the moisture deficit for early versus late snowmelt years scaled by the fraction of forest cover in each grid cell to map forests' vulnerability to changes in the timing of spring (Fig. 4) (*26*). The Northern Rockies and Northern California display the greatest vulnerability by this measure—the same forests accounting for more than three-quarters of increased wildfire frequency since the mid-1980s. Although the trend in temperature over the Northern Rockies increases with elevation, vulnerability in the Northern Rockies is highest around 2130 m, where the greatest increase in fires has occurred. At lower elevations, the moisture deficit in early years is increasing from a high average value (i.e., summer drought tends to be longer and more intense at lower elevations), whereas at higher elevations the longer dry season in early years is still relatively short, and vegetation is somewhat buffered from the effects of higher temperatures by the available moisture.

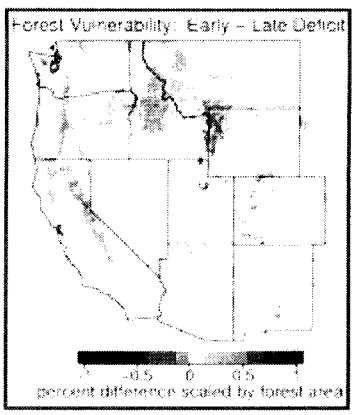

Fig. 4. Index of forest vulnerability to changes in the timing of spring: the percentage difference in cumulative moisture deficit from October to August at each grid point in early versus late snowmelt years, scaled by the forest-type vegetation fraction at each grid point, for 1970 to 1999 (*26*). See fig. S3 for a map of forest vulnerability for 1970 to 2003 over a smaller spatial domain. See Fig. 1B for a definition of early, mid-, and late snowmelt years. [View Larger Version of this Image (45K GIF file)]

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Discussion. Robust statistical associations between wildfire and hydroclimate in western forests indicate that increased wildfire activity over recent decades reflects sub-regional responses to changes in climate. Historical wildfire observations exhibit an abrupt transition in the mid-1980s from a regime of infrequent large wildfires of short (average of 1 week) duration to one with much more frequent and longer burning (5 weeks) fires. This transition was marked by a shift toward unusually warm springs, longer summer dry seasons, drier vegetation (which provoked more and longer burning large wildfires), and longer fire seasons. Reduced winter precipitation and an early spring snowmelt played a role in this shift. Increases in wildfire were particularly strong in mid-elevation forests.

The greatest absolute increase in large wildfires occurred in Northern Rockies forests. This sub-region harbors a relatively large area of mesic, middle and high elevation forest types (such as lodgepole pine and spruce-fir) where fire exclusion has had little impact on natural fire regimes (*1*, *5*), but where we found that an advance in spring produces a relatively large percentage increase in cumulative moisture deficit by midsummer. In contrast, changes in Northern California forests may involve both climate and land-use effects. In these forests, large percentage changes in moisture deficits were strongly associated with advances in the timing of spring, and this area also includes substantial forested area where fire exclusion, timber harvesting, and succession after mining activities have led to increased forest densities and fire risks (*10*, *11*). Northern California forests have had substantially increased wildfire activity, with most wildfires occurring in early years. Southwest forests, where fire exclusion has had the greatest effect on fire risks (*2*, *3*), have also experienced increased numbers of large wildfires, but the relatively small forest area there limits the impact on the regional total, and the trend appears to be less affected by changes in the timing of spring. Most wildfires in the Southern Rockies and Southern California have also occurred in early snowmelt years, but again forest area there is small relative to the Northern Rockies and Northern California. Thus, although land-use history is an important factor for wildfire risks in specific forest types (such as some ponderosa pine and mixed conifer forests), the broad-scale increase in wildfire frequency across the western United States has been driven primarily by sensitivity of fire regimes to recent changes in climate over a relatively large area.

The overall importance of climate in wildfire activity underscores the urgency of ecological restoration and fuels management to reduce wildfire hazards to human communities and to mitigate ecological impacts of climate change in forests that have undergone substantial alterations due to past land uses. At the same time, however, large increases in wildfire driven by increased temperatures and earlier spring snowmelts in forests where land-use history had little impact on fire risks indicates that ecological restoration and fuels

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management alone will not be sufficient to reverse current wildfire trends.

These results have important regional and global implications. Whether the changes observed in western hydroclimate and wildfire are the result of greenhouse gas–induced global warming or only an unusual natural fluctuation is beyond the scope of this work. Regardless of past trends, virtually all climate-model projections indicate that warmer springs and summers will occur over the region in coming decades. These trends will reinforce the tendency toward early spring snowmelt (*36*, *37*) and longer fire seasons. This will accentuate conditions favorable to the occurrence of large wildfires, amplifying the vulnerability the region has experienced since the mid-1980s. The Intergovernmental Panel on Climate Change's consensus range of 1.5° to 5.8°C projected global surface temperature warming by the end of the 21st century is considerably larger than the recent warming of less than 0.9°C observed in spring and summer during recent decades over the western region (*37*).

If the average length and intensity of summer drought increases in the Northern Rockies and mountains elsewhere in the western United States, an increased frequency of large wildfires will lead to changes in forest composition and reduced tree densities, thus affecting carbon pools. Current estimates indicate that western U.S. forests are responsible for 20 to 40% of total U.S. carbon sequestration (*38*, *39*). If wildfire trends continue, at least initially, this biomass burning will result in carbon release, suggesting that the forests of the western United States may become a source of increased atmospheric carbon dioxide rather than a sink, even under a relatively modest temperature-increase scenario (*38*, *39*). Moreover, a recent study has shown that warmer, longer growing seasons lead to reduced CO_2 uptake in high-elevation forests, particularly during droughts (*40*). Hence, the projected regional warming and consequent increase in wildfire activity in the western United States is likely to magnify the threats to human communities and ecosystems, and substantially increase the management challenges in restoring forests and reducing greenhouse gas emissions.

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Supporting Online Material

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Materials and Methods

Figs. S1 to S3

References

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PERSPECTIVES

CLIMATE CHANGE:
Is Global Warming Causing More, Larger Wildfires?

Steven W. Running*

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On 3 April 2006, the U.S. weekly news magazine *Time* ran a report on global warming with the cover title "Be worried, be very worried." Similar coverage of global warming has emerged in other general-interest magazines in recent months, triggered by scientific studies that are finding evidence for adverse impacts of global warming occurring today, not merely projected for future decades. These adverse impacts--from higher probabilities of category 4 and 5 hurricanes (1, 2) to higher rates of sea-level rise (3)--are found not in some distant unpopulated region, but rather right in our own back yards.

On page 940 of this issue, Westerling *et al.* (4) come to a similarly discomforting conclusion for wildfires. They show that warmer temperatures appear to be increasing the duration and intensity of the wildfire season in the western United States. Since 1986, longer, warmer summers have resulted in a fourfold increase of major wildfires and a sixfold increase in the area of forest burned, compared to the period from 1970 to 1986. A similar increase in wildfire activity has been reported in Canada from 1920 to 1999 (5).

Westerling *et al.* used the most comprehensive data set of wildfire occurrences yet compiled for the western United States to analyze the geographic location, seasonal timing, and regional climatology of the 1166 recorded wildfires with an extent of more than 400 ha. They found that the length of the active wildfire season (when fires are actually burning) in the western United States has increased by 78 days, and that the average burn duration of large fires has increased from 7.5 to 37.1 days. Based on comparisons with climatic indices that use daily weather records to estimate land surface dryness, Westerling *et al.* attribute this increase in wildfire activity to an increase in spring and summer temperatures by ~0.9°C and a 1- to 4-week earlier melting of mountain snowpacks. Snow-dominated forests at elevations of ~2100 m show the greatest increase in wildfire activity.

The hydrology of the western United States is dominated by snow; 75% of

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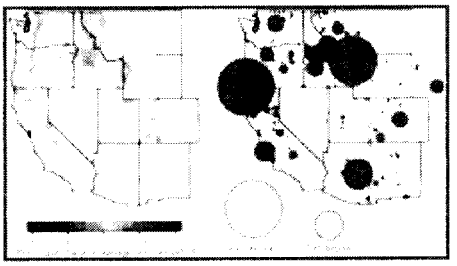
annual stream-flow comes from snowpack. Snowpacks keep fire danger low in these arid forests until the spring melt period ends. Once snowmelt is complete, the forests can become combustible within 1 month because of low humidities and sparse summer rainfall. Most wildfires in the western United States are caused by lightning and human carelessness, and therefore forest dryness and hot, dry, windy weather are the necessary and increasingly common ingredients for wildfire activity for most of the summer. Snowpacks are now melting 1 to 4 weeks earlier than they did 50 years ago, and stream-flows thus also peak earlier (6, 7).

Westerling *et al.* found that, in the 34 years studied, years with early snowmelt (and hence a longer dry summer period) had five times as many wildfires as years with late snowmelt. High-elevation forests between 1680 and 2690 m that previously were protected from wildfire by late snowpacks are becoming increasingly vulnerable. Thus, four critical factors--earlier snowmelt, higher summer temperatures, longer fire season, and expanded vulnerable area of high-elevation forests--are combining to produce the observed increase in wildfire activity.

The fires in Yellowstone Park in 1988 (see the first figure) seemed to inaugurate this new era of major wildfires in the western United States. The fires lasted more than 3 months, burning 600,000 ha of forest, and--despite the investment of $120 million and deployment of 25,000 firefighters--were only extinguished when snow began to fall in mid-September (8).



Less moisture--more fires. Between 1970 and 2003, spring and summer moisture availability declined in many forests in the western United States (**left**). During the same time span, most wildfires exceeding 1000 ha in burned area occurred in these regions of reduced moisture availability (**right**). [Data from (4)]

The Yellowstone fires exemplify a common statistic of wildfires: Less than 5% of all wildfires account for more than 95% of the area burned. A small fraction of fires get very large and become uncontrollable despite human efforts to suppress them, regardless of money expended. Such efforts can cost more than $20 million per day, and seasonal expenditures by governmental agencies in recent years have reached $1.7 billion.

Fire is an important process for recycling dead biomass in the arid west, where natural decomposition rates are extremely slow (historical repeat photography has shown untreated wooden fenceposts still intact after 100 years). However, this benefit is balanced by the annual damages in the western United States from wildfires that have exceeded $1.0 billion in 6 of the past 15 years (9).

In 2002, the U.S. Departments of Agriculture and the Interior embarked on a controversial new land management policy called "Healthy Forests," whose stated objective is to clean out dead and dying trees in the west to reduce the risk of wildfires. This initiative blames increasing wildfire activity in the western United States solely on increasing stand density and the buildup of dead fuel as a result of fire exclusion policies; it does not acknowledge any role of changing

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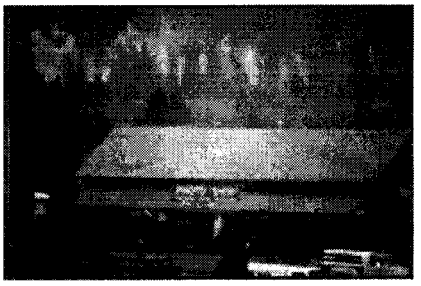
climate in recent wildfire trends. In contrast, the analysis of Westerling *et al.* suggests that observed increased wildfire activity is at least partially the result of a longer wildfire season acting over a larger forested area. This increased wildfire trend correlates with observed higher temperatures and reduced moisture availability (see the second figure).



Too close for comfort. Wildfire is seen approaching Old Faithful Village, Yellowstone National Park, in 1988.

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As part of the upcoming 4th Assessment of the Intergovernmental Panel on Climate Change (IPCC) (10), seven general circulation models have run future climate simulations for several different carbon emissions scenarios. These simulations unanimously project June to August temperature increases of 2° to 5°C by 2040 to 2069 for western North America. The simulations also project precipitation decreases of up to 15% for that time period (11). Even assuming the most optimistic result of no change in precipitation, a June to August temperature increase of 3°C would be roughly three times the spring-summer temperature increase that Westerling *et al.* have linked to the current trends. Wildfire burn areas in Canada are expected to increase by 74 to 118% in the next century (12), and similar increases seem likely for the western United States.

Wildfires add an estimated 3.5×10^{15} g to atmospheric carbon emissions each year, or roughly 40% of fossil fuel carbon emissions (13). If climate change is increasing wildfire, as Westerling *et al.* suggest, these new sources of carbon emissions will accelerate the buildup of greenhouse gases and could provide a feed-forward acceleration of global warming.

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Exhibit 9

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Fire and Restoration of Sagebrush Ecosystems

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Abstract

*Wildlife managers often resort to prescribed fire to restore sagebrush (*Artemisia *spp.) ecosystems thought to have been affected by fire exclusion. However, a fire mosaic of burned and unburned areas may be tolerated by certain wildlife but can be detrimental to sagebrush obligates. This article assesses evidence about the historical frequency and pattern of fire in sagebrush ecosystems and the need for prescribed fire. Fire-scar data from nearby forests require adjustment to estimate fire rotation, the time required to burn once through a sagebrush landscape. Estimates from forests require correction for unburned area and because sagebrush burns less often than forests. Recovery time also might indicate fire rotation. Mountain big sagebrush (*Artemisia tridentata *ssp.* vaseyana*) recovers within about 35–100 or more years after fire, and Wyoming big sagebrush (*A. t. *ssp.* wyomingensis*) requires 50–120 or more years. Fire rotation in other ecosystems is 2 or more times the recovery period. Together, the evidence suggests fire rotations may be a minimum of 325–450 years in low sagebrush (*A. arbuscula*), 100–240 years in Wyoming big sagebrush, 70–200 years or more in mountain big sagebrush, and 35–100 years in mountain grasslands with a little sagebrush. Given these long rotations, fire exclusion likely has had little effect in most sagebrush areas. If maintaining and restoring habitat for sagebrush-dependent species is the goal, fire should be suppressed where there is a threat of cheatgrass (*Bromus tectorum*). Elsewhere, fire does not need to be reintroduced until native understory plants can be restored, so that sagebrush ecosystems can fully recover from fire.* (WILDLIFE SOCIETY BULLETIN 34(1):177–185; 2006)

Key words

Artemisia *spp., fire history, fire rotation, prescribed fire, sagebrush.*

Sagebrush (*Artemisia* spp.) ecosystems and the species dependent upon them are under threat in western North America (Knick et al. 2003). Sagebrush has been viewed as a pest and eradicated using fire and other means but also has been converted to agriculture, overgrazed by domestic livestock, and invaded by non-native plants (Vale 1974, Knick and Rotenberry 1997, Knick et al. 2003). In this context, fire may be a double-edged sword in perpetuating and restoring sagebrush landscapes and their associated wildlife. Invasion by cheatgrass (*Bromus tectorum*) has led to a grass–fire cycle in which increasing cheatgrass promotes large fires that allow cheatgrass to increase further, eroding and fragmenting remaining stands of sagebrush (Whisenant 1990, Knick and Rotenberry 1997, Knick 1999). Fire also may have been reduced or excluded in some areas due to loss of fine fuels to overuse by livestock, landscape fragmentation, and intentional fire suppression (Wrobleski and Kauffman 2003). Are sagebrush landscapes suffering from too much fire or too little? Should fire be suppressed or restored? Answers to these questions depend on the situation but also on our understanding of the historical role of fire before EuroAmerican settlement.

How fire is managed may have significant implications for wildlife, as a mosaic of burned and unburned areas is characteristic of modern sagebrush fires, and the pattern and extent of patchiness influences wildlife. Small prescribed fires may directly decrease habitat for sagebrush obligates, such as Brewer's sparrows (*Spizella breweri*) and sage thrashers (*Oreoscoptes montanus*) (Castrale 1982, Kerley and Anderson 1995). At the landscape scale, the fire mosaic may have adverse impacts if unburned areas are too small, as these birds are favored by large, unfragmented sagebrush areas (Kerley and Anderson 1995, Knick and Rotenberry 1995). However, if unburned areas are large, these birds may be little affected (Petersen and Best 1987).

Earlier studies suggested that sage-grouse (*Centrocercus* spp.) might be favored by a burn mosaic (Klebenow 1973). However, sage-grouse may be adversely affected by a landscape mosaic of adjacent young burns, as these burns may all lack good nesting habitat (Nelle et al. 2000) and do not meet the habitat requirements of sage-grouse at other seasons (Wambolt et al. 2002). Brood-rearing habitat for sage-grouse may not be enhanced by fire in xeric sagebrush areas, even if a mosaic is created, as forbs and insects may not increase (Fischer et al. 1996). Overall, small infrequent fires may have a slight positive effect, but large, frequent fires (e.g., every 17 years) can cause extinction of grouse populations (Pedersen et al. 2003).

Similarly, generalist small mammals (e.g., deer mice [*Peromyscus maniculatus*]) are not adversely affected by either a patchy spring fire or an extensive stand-replacing autumn fire, but more specialized small mammals (e.g., jumping mice [*Zapus princeps*]) cannot survive extensive stand-replacing fires (McGee 1982). Regeneration of sagebrush after fire is probably enhanced by dispersal of seed from unburned plants (Wrobleski 1999, McDowell 2000, Longland and Bateman 2002). When all sagebrush plants are burned, recovery is very slow, as seed does not spread far from mature plants (Welch and Criddle 2003). Thus, large fires that lead to extensive loss of sagebrush cover may have negative effects on sagebrush obligate and more specialized species and may delay sagebrush recovery after fire (Longland and Bateman 2002).

Given these effects, have sagebrush ecosystems actually been affected by fire exclusion or an increase in fire? Winward (1991) suggested that most sagebrush stands were $\geq$60 years of age, which he thought implied that fire intervals have lengthened. Wrobleski and Kauffman (2003) suggested that fire suppression and overgrazing by livestock have lengthened fire intervals, leading to increased dominance of sagebrush. Junipers (*Juniperus* spp.), pinyons (e.g., *Pinus edulis*, *P. monophylla*), and Douglas-fir (*Pseudotsuga menziesii*) are thought to have invaded former

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sagebrush areas due to fire exclusion (Arno and Gruell 1983, Miller and Rose 1999).

Fire likely has increased in sagebrush areas where cheatgrass has become common. Wildfires in former sagebrush areas now dominated by cheatgrass are burning at short fire rotations. Fire rotation is the time required to burn once through an area, equal to the size of a particular study area (Baker and Ehle 2001). About 26% of cheatgrass-dominated lands in the Salt Lake District of the Bureau of Land Management burned in 11 years (Roberts 1990), a fire rotation of 42 years. Fires burned 45% of the Snake River Birds of Prey Area in southern Idaho over a 7-year period, where over 50% of this landscape is dominated by cheatgrass, leading to a fire rotation of about 15.5 years (Pellant 1990). Former sagebrush areas now dominated by cheatgrass may have a fire rotation too short to allow re-establishment of sagebrush (Whisenant 1990). Large, high-intensity cheatgrass fires leave fewer and smaller unburned patches of sagebrush, that are especially vulnerable to further cheatgrass invasion (Whisenant 1990, Knick and Rotenberry 1997).

Threats to the sagebrush ecosystem and the declining status of sage-grouse and other species have led to interest in ecosystem restoration. Some restoration proposals call for use of prescribed fire, others suggest it is better to suppress fires, especially where cheatgrass is a threat (Hemstrom et al. 2002, Bunting et al. 2003). Moreover, there are competing ideas about how often fire historically burned these ecosystems (Winward 1991, Welch and Criddle 2003), and there is little understanding of the pattern produced by natural fires in sagebrush landscapes. Also, standard measures of fire frequency do not provide estimates of the rate at which fire burned across landscapes, and a reassessment is warranted (Baker and Ehle 2001).

The purpose of this article is to review and reassess evidence about fire history, fire rotation, and the pattern of fire across sagebrush landscapes and from this evidence suggest the most promising directions for restoration. Sagebrush taxa that have been the subject of fire-history research include mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), Wyoming big sagebrush (*A. t.* ssp. *wyomingensis*), and low sagebrush (*A. arbuscula*).

Fire Intensity and the Fire Mosaic

Fire intensity in sagebrush in the modern era has varied over a 7-fold range due to variation in fuel loads, shrub density, fuel moisture, wind speed, and other factors (Sapsis and Kauffmann 1991, Pyle and Crawford 1996). Low fire intensity, however, does not usually increase sagebrush survival; when flames reach sagebrush, mortality is nearly complete and the fire is "stand-replacing" (e.g., Blaisdell 1953, Britton and Clark 1985, Acker 1988, Sapsis and Kauffmann 1991). Britton and Clark (1985:23) report: "it is relatively unimportant how fast the fire moves, how hot the fire is, or what the fire intensity is . . . if a fire front passes through an area, the sagebrush will be killed." However, silver sagebrush (*A. cana*) and three-tip sagebrush (*A. tripartita*) may be killed, but often will re-sprout (White and Currie 1983, Shariff 1988).

Fires, thus, do not thin sagebrush stands or lower their density by killing a certain fraction of sagebrush throughout a stand as was implied in the past (Winward 1991). Fire exclusion cannot be a cause of increased density in a particular patch of existing sagebrush (Wrobleski and Kauffman 2003), brought on by an absence of thinning fires, as thinning fires did not occur.

Table 1. Percentage of area that is unburned within a fire perimeter in sagebrush. Studies reviewed include all studies conducted in North American over the last century.

Sagebrush species Author(s)	Prescribed fires (%)	Wildfires (%)
Low and black sagebrush		
Boltz (1994)	—	57
Wyoming big sagebrush		
Boltz (1994)	—	
"Loamy 7–10"" ecological site		18[a]
"Loamy 8–10"" ecological site		12[a]
"Loamy 10–13"" ecological site		28[a]
Clifton (1981)	85–90	
Fischer et al. (1996)	43	
Petersen and Best (1987)	55	
Mountain big sagebrush		
Boltz (1994) ">12"" ecological site		21[a]
Raper et al. 1985		
West slope	40	
East slope	60	
Wrobleski (1999)	53 (36–62)	
Basin big sagebrush		
Boltz (1994) "Sand 8–12" ecological site		4[a]

[a] Estimates are derived by interpolating from a bar graph (Boltz 1994, fig. 2). Numerical ranges for Boltz's ecological sites are annual precipitation. Ecological sites that now contain significant cheatgrass and, thus, have less unburned area are omitted (e.g., "Loamy 10–12"").

Fire instead creates and controls the pattern and extent of a mosaic of burned and unburned areas. Unburned areas can result from 1) low sagebrush cover, 2) insufficient loading of fine fuels, 3) high fuel moisture, and 4) variable winds. A minimum of about 20% sagebrush cover and 300 kg/ha of herbaceous fuel might be required to carry fire in sagebrush (Britton and Clark 1985), but wind speed can significantly affect the fuel requirement (Brown 1982). Nonetheless, areas with low sagebrush density or little fine fuel can have mosaic burns (Ralphs and Busby 1979, Wright et al. 1979, Smith and Busby 1981). Lower fine-fuel production during droughts also may contribute to patchy burns (Hosten 1995, West and Yorks 2002). More unburned area also is common in cooler or moister parts of landscapes or during cooler or wetter conditions, as in early spring (Clifton 1981, Kuntz 1982, Boltz 1994, Colket 2003). Warmer, drier conditions, unless these reduce fine-fuel production, may lead to nearly complete sagebrush mortality and few or no islands of unburned sagebrush (Kuntz 1982, McGee 1982).

It is, thus, logical to suspect that pre-EuroAmerican fires in sagebrush landscapes left less unburned area in a mosaic, than is observed in modern prescribed fires (Wrobleski and Kauffman 2003), due to higher fine-fuel amounts, greater fuel continuity, and drier burning conditions. Modern fires often are burning through sagebrush that has reduced fine fuels due to overuse by domestic livestock. Today's summer wildfires seem to have less unburned area than do spring and autumn-prescribed fires, supporting the idea that hotter summer fires in the pre-EuroAmerican era would have left less unburned area (Table 1). Unfortunately, nothing is known directly about the extent and pattern of a fire mosaic in sagebrush in the pre-EuroAmerican era.

Table 2. Scar-based studies of fire history in forests and woodlands near sagebrush in the western United States.[a]

Author(s)	Location	Sample trees	Sagebrush	Crossdated fire scars?	Spread among sample stands?	Elevation (m)
Arno and Gruell (1983)	Southwest Mont.	Douglas-fir	Mt. big sagebrush	No	Not studied	Unknown
Burkhardt and Tisdale (1976) Low sagebrush	Southwest Id.	Western juniper	Mt. big sagebrush	Yes	Not studied	1,580–2,073
Houston (1973) Lodgepole pine	Northwest. Wyo.	Douglas-fir	Mt. big sagebrush	No	Yes	1,500–2,600
Miller and Rose (1999) Low sagebrush	South Cent. Oreg.	Ponderosa pine	Mt. big sagebrush	Yes	Yes	1,450–1,875
Young and Evans (1981) Low sagebrush	Northeast. Calif.	Western juniper	Wyo. big sagebrush	No	Not studied	1,350–1,430

[a] Gruell (1995) is not included because only 2 scarred trees were sampled and cross-dating was not used. This is an inadequate sample for determining fire history (Baker and Ehle 2001).

A mosaic pattern has been reported in some cases for several sagebrush taxa (Table 1). In low and black sagebrush (*A. nova*), fire is rare, due to sparse fuels, and often goes out (Beardall and Sylvester 1976, Britton and Ralphs 1979, Clifton 1981, Blaisdell et al. 1982, Bunting et al. 1987, Boltz 1994). Fuels also may be sparse or patchy in Wyoming big sagebrush, and unburned areas also are common after prescribed fires (e.g., Beardall and Sylvester 1976, Ralphs and Busby 1979, Petersen and Best 1987, Kerley and Anderson 1995, Fischer et al. 1996). Yet, unburned areas also are common after prescribed fires in mountain big sagebrush where fine fuels often are more abundant (Blaisdell 1953, McGee 1982, Raper et al. 1985, Nelle et al. 2000). Unburned islands are even found after hotter wildfires in both Wyoming (Hosten 1995) and mountain big sagebrush (Martin 1990). Unfortunately, few estimates of unburned area are available (Table 1), and it is unclear to what extent unburned area varies among sagebrush communities.

Evidence of Fire Rotation in Sagebrush

Fire Rotation and the Mean Composite Fire Interval

Fire rotation is the appropriate parameter for understanding and managing fire because fire rotation is a consistent measure of the rate of burning (Baker and Ehle 2001). If the fire rotation is 100 years, for example, on average a fire will burn across the whole landscape once per 100 years, and in so doing, fire also will reach each point in the landscape once every 100 years on average (Baker and Ehle 2001). The fire rotation is calculated by adding the areas of individual fires in a particular area over some period of time, and dividing this time period by the fraction of the area burned (Baker and Ehle 2001).

Because fire does not leave scars on sagebrush, evidence of fire in sagebrush comes from scarred trees within or near sagebrush. The most common parameter for comparing fire-scar data is the mean composite fire interval (mean CFI), which is the mean interval between fires in a composite list of all fires found on scarred trees within a small area of forest. Mean CFI, however, declines as more area or more scarred trees are sampled (Arno and Petersen 1983), an undesirable property. Mean CFI is simply the mean interval between fires anywhere within a sample area (Dieterich 1980), and many of these fires are small (Baker and Ehle 2001). Thus, mean CFI must be adjusted to estimate the fire rotation.

Correcting Mean Composite Fire Interval for Unburned Area and Adjacency

Since fire scars only record that a fire occurred but do not provide an estimate of the area burned in the fire, it is appropriate to correct scar-based estimates of mean CFI for several things to estimate fire rotation. The first needed correction is for unburned area, and the appropriate correction is as follows: fire rotation = mean CFI/(1.0 – mean fraction of unburned area). For example, if fires typically burned at a mean CFI of 50 years, but each fire on average leaves 40% of the area unburned, the fire rotation estimate is 83.3 years (50/1.0 – 0.4). The best available estimates of unburned area are from modern wildfires (Table 1).

Fire-scar evidence from forests also requires adjustment because a fire on a nearby tree may not always have burned the sagebrush (Wambolt et al. 2002). The most compelling evidence that fire burned through sagebrush is a specific fire documented in sample areas on both sides or scattered across a large sagebrush area. To show this, the fire must be cross-dated (the year verified by comparing tree rings with a known chronology), to document that the same fire year is found in locations that span the sagebrush. Only the Miller and Rose (1999) study, commonly cited as a study of sagebrush fire history, has cross-dated evidence of spread across a large area from a set of distinct sample stands (Table 2). This study likely was in a former grassland, not sagebrush, a point discussed later. In the only other study, commonly cited as evidence of fire spread through sagebrush, cross-dating was not completed (Houston 1973). All that is known is that some fires at distinct locations occurred within a few years of each other. If these fires cross-dated to different years, they were small spot fires that did not burn across much sagebrush. If they cross-dated to the same year, they likely were large, extensive fires that spread across the sagebrush. Neither possibility can be excluded. However, this study also is likely a study of a former grassland, not a former sagebrush area, as explained below.

Less compelling evidence of fire in sagebrush comes from single sample sites adjacent to sagebrush (Burkhardt and Tisdale 1976, Young and Evans 1981, Arno and Gruell 1983, Gruell 1995). It is likely that not all fires documented at a single forest location spread into or across the sagebrush; a single sample site really provides no evidence these fires did spread across the sagebrush (Welch and Criddle 2003), although some probably did.

Fire is documented from modern fire records to actually be less

likely to be ignited and burn in sagebrush than in forests. The ignition ratio, which is the number of lightning strikes per fire start, is 144 in sagebrush–grass but only 42 in Douglas-fir and 24 in ponderosa pine (*Pinus ponderosa*), based on data from Idaho (Meisner et al. 1994). This suggests fires are much more likely to start in forests than in sagebrush, given the same amount of lightning. The ignition rate, which is the number of fires per 400,000 ha per year, is only 3.6 in sagebrush–grass, but is 25.5 in Douglas-fir and 81.9 in ponderosa pine, based on historical fire records from Colorado (Fechner and Barrows 1976). This also suggests that fires are less common in sagebrush than in forests.

If ignition ratios and rates were proportional to fire rotation, sagebrush would burn at rotations that are 3.4–6 times as long (based on ignition ratio) or 7.1–22.8 times as long (based on ignition rate) as in nearby forests. Other factors also affect fire rotation, but these data and arguments are evidence that fire burns at rotations that are longer in sagebrush than in adjoining forests, and a correction is needed when using fire-scar records from adjacent forests. It is not possible to estimate the necessary correction at present. I arbitrarily use 2.0 times mean CFI. This is likely an overly conservative, low estimate given the much larger numbers presented above and the fact that mean CFI underestimates fire rotation in the forest itself (Baker and Ehle 2001). Nonetheless, if the mean CFI in the forest is 50 years, this adjacency correction results in an estimated 100-year fire rotation in adjacent sagebrush.

A third problem that requires correction is that all the fire-scar studies (Table 2) use targeted sampling, which means that areas containing concentrations of scarred trees were sought, and trees with multiple fire scars were selected in these areas (Baker and Ehle 2001). However, these sampling areas and multiple-scarred trees may be those that have the most fire, while areas and trees with little evidence of fire are not sampled (Baker and Ehle 2001). For example, pinyon–juniper woodlands adjoining sagebrush in southwestern Colorado contain no fire scars or other evidence of surface fire, and instead burn in stand-replacing fires at about 400-year rotations (Floyd et al. 2000, 2004). Corrected for adjacency, this implies that fire plays a very minor role (fire rotation = 800 years) in these sagebrush stands. Because stands like these, that lack fire scars, are commonly not sampled, available estimates of fire rotation in sagebrush are likely too short. The magnitude of the targeting correction cannot be estimated now, but available fire rotation estimates are likely for parts of these ecosystems where fire was more frequent. Thus, the estimates that are derived by correcting estimates of mean CFI are low estimates.

Corrected Estimates of Fire Rotation from Scar-Based Studies of Adjacent Forests

Some initial sorting of the fire-scar studies (Table 2) is required before corrections are made. Three of the 5 fire-scar study sites often cited as evidence of fire frequency in sagebrush were primarily grassland, not sagebrush, prior to EuroAmerican settlement, and grasslands commonly are thought to burn more frequently than sagebrush. Arno and Gruell (1983:336) indicated that "on the widely distributed loamy soils where most of the fire history work was done, ten early photographs suggest that prior to 1900, sagebrush was restricted to small patches or widely spaced plants." Houston (1973:1115) suggested that "the conspicuous increase of fire-sensitive *Artemisia tridentata* in the steppe ... would certainly be reversed if fire were reintroduced ..." He showed a picture of a grassland in A.D. 1885 that was dominated by sagebrush in A.D. 1970, although a single photograph does not provide much evidence of the original character of the vegetation. Miller and Rose (1999:558) reported that "mean fire intervals of less than 15 years were adequate to inhibit western juniper [*Juniperus occidentalis*] encroachment and probably limit sagebrush cover allowing the herbaceous layer to dominate the landscape."

Fire intervals in these former grasslands now dominated by mountain big sagebrush were summarized as <15 years (Miller and Rose 1999), 20–25 years (Houston 1973), and less than 35–40 years (Arno and Gruell 1983). Sagebrush could be found as scattered shrubs or small patches in these grasslands, given these reported mean fire intervals, but sagebrush did not dominate these sites. Corrections for adjacency and unburned area are not known for grasslands, but if the figures for mountain big sagebrush (2.0 correction for adjacency; 21% unburned area, Table 1) are used, the fire rotation estimates are <38 years (from Miller and Rose 1999 data), 51 years (from Houston 1973 data), and less than 89–101 years (from Arno and Gruell 1983 data) on these sites. A range of about 35–100 years is suggested by these estimates of pre-EuroAmerican fire rotation in grasslands with small amounts of mountain big sagebrush.

Given that only a few studies are of sites that predominantly supported sagebrush in the pre-EuroAmerican era (Burkhardt and Tisdale 1976, Young and Evans 1981, and the low-sagebrush part of Miller and Rose 1999), what do these remaining scar-based studies reveal about how often fires burned in ecosystems dominated by particular sagebrush taxa? Only one study separately analyzed low sagebrush areas, and in this case a single fire interval of 138 years was found (Miller and Rose 1999). This interval comes from cross-dated scars in more than one location spanning the sagebrush, so it does not need adjustment for forest adjacency but does require correction for unburned area. If the only estimate of unburned area (Boltz 1994) is used (57%, Table 1), the corrected fire rotation estimate is 321 years [138/(1.0 – 0.57)]. In the Young and Evans (1981) study, low sagebrush and Wyoming big sagebrush burned in 3 fires, leading to a mean fire interval of about 95 years, but these estimates are from adjacent forests, and a correction of 2.0 (see above) leads to a fire rotation estimate of 190 years in the sagebrush itself. After adjustment for unburned area, the fire rotation estimate is 442 years. Thus, corrected, rounded estimates of the fire rotation in low sagebrush may be approximately 325–450 years.

In Wyoming big sagebrush, there is one study (Young and Evans 1981). Their estimated interval of 95 years from 3 fires also requires correction for adjacency (a factor of 2.0, so 190 years) and unburned area. Using the mean of the estimates for unburned area in wildfires in Wyoming big sagebrush (Table 1, 19.33%), the estimated fire rotation is 236 years. Thus, this one estimate suggests the fire rotation in Wyoming big sagebrush may be about 235 years.

Burkhardt and Tisdale (1976) is the only study of a former mountain big sagebrush site, and fire intervals were not explicitly calculated. They reported (1976:478): "fires at intervals of 30–40

yr could maintain a sagebrush-bunchgrass community free of juniper. The data in Table 1 indicate that fires were probably more frequent than this." Given a 2.0 correction for forest adjacency and using Boltz's (1994) estimate of 21% unburned area, the fire rotation on mountain big sagebrush sites might have been somewhat less than 75–100 years. Waichler et al. (2001) has been cited (Crawford et al. 2004) as providing data suggesting mean CFI >200 years in xeric mountain big sagebrush on sandy soil in eastern Oregon. These data could not be located in Waichler et al. (2001), but these estimates, after correction for adjacency and unburned area, suggest the fire rotation in some mountain big sagebrush areas could be much longer than 75–100 years, perhaps several hundred years.

Past summaries of mean CFI in sagebrush did not recognize the limitations of these data and need for corrections to estimate fire rotation. Many summaries suggest that fires burned in some or even many mountain big sagebrush stands at intervals of 10 to somewhat less than 40 years (Winward 1985, 1991; Whisenant 1990, Miller 2002, United States Department of Interior 2002, Crawford et al. 2004), not recognizing that these short intervals are uncorrected mean CFI estimates for sites that were primarily grasslands, not sagebrush, in the pre-EuroAmerican era. Other summaries (Pellant 1990, Whisenant 1990) have used the "adjusted interval" of 32–70 years from table 1 in Houston's (1973) study, but this is also an uncorrected estimate from areas that were predominantly grasslands in the pre-EuroAmerican era. Summaries of mean fire interval for Wyoming big sagebrush have included 50 or 60 years on the low end (e.g., Miller 2002, United States Department of Interior 2002) or even 12–50 years for some stands (Miller 2002). However, there are no scar-based studies that support these short intervals. Moreover, all these intervals require correction for adjacency and unburned area and, once corrected, would still be low estimates, due to targeted sampling.

Evidence of Fire Rotation from Sagebrush Recovery Rate

The rate that sagebrush returns following fire is thought to be an indicator of fire frequency (Wright and Bailey 1982) and might also be used to estimate the fire rotation. Estimates of recovery time come from analysis of chronosequences of stands varying in time since fire (Fig. 1). Sagebrush density data are shown (Fig. 1), where cover data were not reported, but density is an insufficient measure of recovery, as it only indicates that shrubs are present, not that they are mature and have cover comparable to that in unburned control areas. Livestock grazing may hasten sagebrush recovery after fire (Pechanec and Stewart 1944), and more intense wildfires may decrease recovery, sometimes leading to fewer post-fire seedlings (Blaisdell 1953, Champlin 1983, Martin 1990). Unfortunately, there are insufficient data to allow analysis of the effects of these factors on sagebrush recovery rates.

In 2 studies, mountain big sagebrush recovered within about 35 years after fire to the same cover as sagebrush in unburned control areas (Fig. 1*a*). Welch and Criddle (2003) projected it would require 70 years or more just to get mountain big sagebrush back into the interior of a burn in Idaho, which is not recovery to full density, much less full cover. Perhaps a reasonable low estimate, then, is 35–100 years or more for recovery of mountain big sagebrush.

For Wyoming big sagebrush, the required recovery period is less certain, as available data are meager after about 20 years of recovery (Fig. 1*b*). Very little recovery within the first 20 years is generally consistent among studies (Fig. 1*b*). The Wisdom sites in southwestern Montana (Walhof 1997, Wambolt et al. 2001) are exceptional, as they averaged about 96% recovery of cover 9 years after fire. Walhof (1997:60) reported: "These 2 sites may be atypical, and their responses are clearly not similar to other published data ..." Watts and Wambolt (1996) documented recovery to 76% of control area cover within 30 years, consistent with 72% recovery after 32 years at their Exclosure site in southwestern Montana (Walhof 1997, Wambolt et al. 2001). However, Colket (2003) found that, in southeastern Idaho, only 3 of 17 plots had recovered fully in density within 53 years, while full density recovery had been reached by 92 years on 16 of 17 plots. Colket (2003:58) reported that "... well over 53 years are required for big sagebrush to return to its pre-fire abundance." Another few decades beyond density recovery may be required for plants to mature and cover values to recover. Together these limited data suggest that full recovery of Wyoming big sagebrush may be quite variable but generally requires 50–120 or more years. In exceptional cases, recovery may occur within a decade (e.g., Wisdom sites).

The relationship between recovery period and fire rotation in other vegetation types suggests that fire rotation may be a multiple of the recovery period. In pinyon–juniper woodlands, for example, where documented fire rotations are 400–480 years (Baker and Shinneman 2004), the time to recover to a mature, closed-canopy condition is about 200 years (Tress and Klopatek 1987, Mehl 1992, Goodrich and Barber 1999), about half the fire rotation. Similarly, in lodgepole pine (*Pinus contorta*) and spruce–fir (*Picea–Abies*) forests, where fire rotations are about 300 years (Buechling and Baker 2004), a closed-canopy mature condition is reached in about 150 years, also about half the fire rotation (Despain and Romme 1991). Interior chaparral in southern California recovers within 20–30 years after fire, but fire rotations prior to about 1950, when fire regimes were less influenced by people, averaged about 80 years among nine counties (Keeley et al. 1999). These comparisons suggest the fire rotation may be twice or more the recovery period. Thus, fire rotations would be 70–200 years or more in mountain big sagebrush and 100–240 years or more in Wyoming big sagebrush. These estimates, which are imprecise, are at least similar in magnitude to scar-based estimates.

Conclusions

Combining the fire-scar and recovery evidence, the best available estimates of fire rotation are 325–450 years in low sagebrush, 100–240 years in Wyoming big sagebrush, 70–200 years or more in mountain big sagebrush, and 35–100 years in mountain grasslands where sagebrush is a minor component. These estimates are likely low estimates because they could not be corrected for targeted sampling and they use a conservative estimate of adjacency correction, but fire rotation in sagebrush cannot be estimated more precisely at this time using available data.

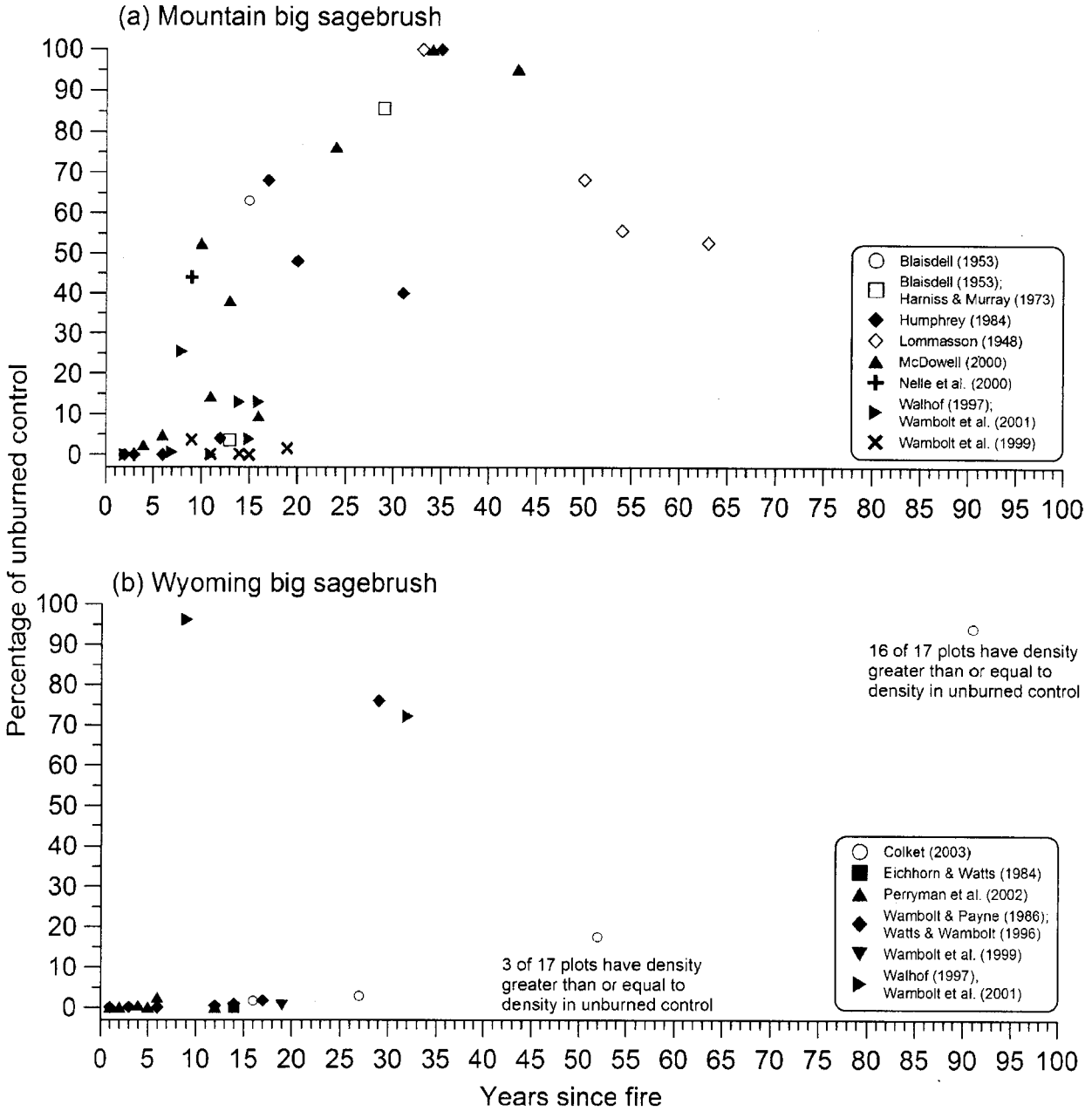

Figure 1. Sagebrush abundance versus time since fire, relative to unburned control areas, for (a) mountain big sagebrush and (b) Wyoming big sagebrush. These graphs include different measures of sagebrush abundance–density is shown as open symbols, cover as closed symbols. When authors did not specify the abundance in an unburned control area, the percentage is of the maximum value during the period covered by the study. When more than one value was reported for a particular time since fire, the mean was used. Many other studies that report recovery only within the first 10 years after fire (e.g., Pechanec and Stewart 1944, Acker 1988) are omitted. Lommasson (1948) does not identify the subspecies of big sagebrush, but it was likely mountain big sagebrush, based on the high elevation of the site. Studies reviewed include all studies conducted in North America over the last century.

Sagebrush has been assumed by some to be a fire-dependent vegetation type, requiring periodic renewal by fire (Winward 1991), although evidence challenging this fire dependence has been presented (Connelly et al. 2000, Welch and Criddle 2003). Fire is an important natural disturbance in sagebrush but does not occur as often as suggested in the past and is only one of many agents. Sagebrush density and cover are also diminished by droughts, insect outbreaks, and competition with native bunchgrasses, and may increase again during wet periods (Lommasson 1948, Maier et al. 2001, Anderson and Inouye 2001, Welch and Criddle 2003).

Given the long rotations that characterized pre-EuroAmerican fires in sagebrush, fire exclusion likely has had little effect in most sagebrush communities. A national assessment of fire regimes and fire-related condition classes (Schmidt et al. 2002) placed sagebrush mostly within fire regime II (stand replacement at 0–35-year frequency) and fire regime III (mixed severity at 35–100-year frequency). The source of these estimates is not documented,

but they are interpreted to mean that sagebrush has commonly missed several fires since EuroAmerican settlement and, thus, requires prescribed burning for restoration. However, the evidence presented here shows that these fire regimes underestimate the fire rotation, and there is no evidence of mixed-severity fire in sagebrush. Sagebrush instead generally belongs in fire regime V (long rotation, stand replacement). Where cheatgrass now dominates, sagebrush is likely in condition class 3 (fire regimes significantly altered from historical range), with too much fire. Sagebrush that has not entered a cheatgrass–fire cycle should remain in condition class 1 (fire regimes within historical range), not having missed much, if any, fire at this point. Similarly, the invasion of junipers, pinyons, and Douglas-fir into sagebrush areas (Arno and Gruell 1983, Miller and Rose 1999) is likely not generally due to fire exclusion, but to other factors (e.g., overgrazing).

Particularly in Wyoming big sagebrush, a program of prescribed burning is unwarranted or inadvisable if maintaining and restoring sagebrush landscapes and sagebrush-dependent species is the goal. Correcting for fire exclusion by reintroducing fire is likely not a common sagebrush restoration need. Also, little is known about the pattern of a mosaic created by pre-EuroAmerican fires or the importance of particular aspects of this mosaic to viability of wildlife populations (Longland and Bateman 2002). There is, thus, insufficient basis for prescribed burning to restore a mosaic thought to be important for wildlife. For example, in mountain big sagebrush, prescribed burning, even at modest fire rotations (e.g., 55 years in Idaho, Nelle et al. 2000), can adversely impact sage-grouse if the landscape mosaic is not just right (Nelle et al. 2000). A fire mosaic can also increase the ability of cheatgrass to further destroy sagebrush (Knick and Rotenberry 1997).

Burning sagebrush does not assure restoration of a healthy sagebrush ecosystem, and may delay or prevent restoration, since sagebrush itself does not recover for 35 or more years (Figure 1). Restoration of native plants may not require sagebrush thinning (Anderson and Inouye 2001), but if thinning is thought to be needed, fire is inappropriate, as it does not thin sagebrush, but kills it in patches. If fire occurs, successful recovery of the sagebrush ecosystem is enhanced by abundant, healthy native plants (Anderson and Inouye 2001). Restoring native plants is an essential goal before fire is reintroduced or even allowed to continue, if further conversion to cheatgrass is to be avoided (Bunting et al. 2003). Intentional fire suppression is appropriate, at least in Wyoming big sagebrush and the lower elevations of mountain big sagebrush where replacement by cheatgrass is possible (Wambolt et al. 2002). Restoration requires enough solution to the cheatgrass problem to allow some re-seeding or passive re-invasion and increase of native plants, followed by decades of rest or reduced livestock grazing, some fortuitous wet periods, and considerable patience (Anderson and Inouye 2001). Sagebrush ecosystems did not historically burn often or recover quickly, but can be destroyed quickly if we fail to stop the cheatgrass–fire cycle and if we do not focus on restoring the native plants that are essential to maintaining a sagebrush ecosystem that can recover after fire.

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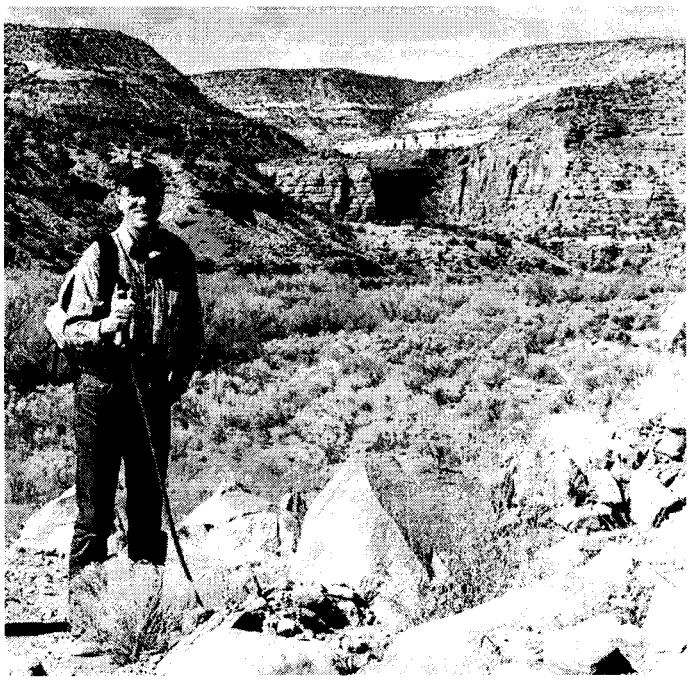

William L. (Bill) Baker (photo) has been a professor at the University of Wyoming since 1990. He received a B.S. in botany from Oregon State University, a Master's in botany from the University of North Carolina, and a Ph.D. in geography from the University of Wisconsin. His primary research interests are fire history and ecology, landscape ecology, and conservation biology.

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Exhibit 10

Exhibit 7

Post-Wildfire Logging Hinders Regeneration and Increases Fire Risk

D. C. Donato,[1*] J. B. Fontaine,[2] J. L. Campbell,[1] W. D. Robinson,[2] J. B. Kauffman,[3] B. E. Law[1]

Recent increases in wildfire activity in the United States have intensified controversies surrounding the management of public forests after large fires (*1*). The view that postfire (salvage) logging diminishes fire risk via fuel reduction and that forests will not adequately regenerate without intervention, including logging and planting, is widely held and commonly cited (*2*). An alternate view maintains that postfire logging is detrimental to long-term forest development, wildlife habitat, and other ecosystem functions (*1*). Scientific data directly informing this debate are lacking.

Here we present data from a study of early conifer regeneration and fuel loads after the 2002 Biscuit Fire, Oregon, USA, with and without postfire logging. Because of the fire's size (~200,000 ha), historic reforestation difficulties in the region (*3*), and an ambitious postfire logging proposal, the Biscuit Fire has become a national icon of postfire management issues. We used a spatially nested design of logged and unlogged plots replicated across the fire area and sampled before (2004) and after (2005) logging (*4*).

Natural conifer regeneration on sites that experienced high-severity fire was variable but generally abundant, with a median stocking density of 767 seedlings per hectare, primarily of Douglas fir (*Pseudotsuga menziesii*) (Fig. 1A). Such density exceeds the regional standards for fully stocked sites, suggesting that active reforestation efforts may be unnecessary. Postfire logging subsequently reduced regeneration by 71% to 224 seedlings per hectare (Fig. 1A) due to soil disturbance and physical burial by woody material during logging operations. Thus, if postfire logging is conducted in part to facilitate reforestation, replanting could result in no net gain in early conifer establishment.

Postfire logging significantly increased both fine and coarse downed woody fuel loads (Fig. 1B). This wood was composed of unmerchantable material (e.g., branches), and far exceeded expectations for fuel loads generated by postfire logging (*4*, *5*). In terms of short-term fire risk, a reburn in logged stands would likely exhibit elevated rates of fire spread, fireline intensity, and soil heating impacts (*6*).

Postfire logging alone was notably incongruent with fuel reduction goals. Fuel reduction treatments (prescribed burning or mechanical removal) are frequently intended after postfire logging, including in the Biscuit plan, but resources to complete them are often limited (*7*). Our study underscores that, after logging, the mitigation of short-term fire risk is not possible without subsequent fuel reduction treatments. However, implementing these treatments is also problematic. Mechanical removal is generally precluded by its expense, leaving prescribed burning as the most feasible method. This will result in additional seedling mortality and potentially severe soil impacts caused by long-duration combustion of logging-generated fuel loads. Therefore, the lowest fire risk strategy may be to leave dead trees standing as long as possible (where they are less available to surface flames), allowing for aerial decay and slow, episodic input to surface fuel loads over decades.

Our data show that postfire logging, by removing naturally seeded conifers and increasing surface fuel loads, can be counterproductive to goals of forest regeneration and fuel reduction. In addition, forest regeneration is not necessarily in crisis across all burned forest landscapes.

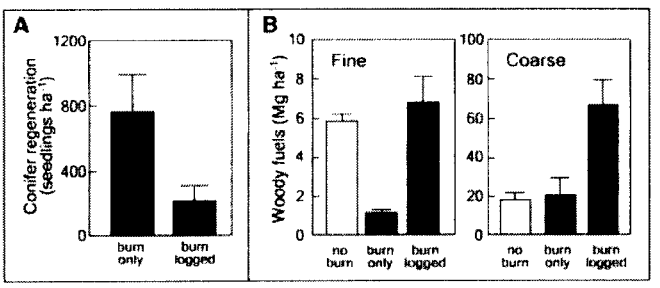

Fig. 1. **(A)** Natural conifer regeneration and **(B)** surface woody fuel loads before and after postfire logging of the Biscuit Fire, Oregon, USA. (A) shows that regeneration was abundant after the fire. Postfire logging significantly reduced seedling densities ($P < 0.01$, Wilcoxon signed rank test) from 767 seedlings per hectare to 224 seedlings per hectare. (B) shows that postfire logging significantly increased downed fine ($P < 0.01$) and coarse ($P < 0.05$) woody fuel loads (Mg ha^{-1}) relative to burn-only fuel loads by Wilcoxon signed rank test. To provide context, fuel data from unburned stands are shown as reference for prefire conditions (fuel loads in burn-logged stands were at or well above prefire levels). Graphs of seedling densities and fine (≤7.62 cm) and coarse (>7.62 cm) surface woody fuels are medians ± SE; sample size $n = 8$ stands for no burn, $n = 9$ for burn-only and burn-logged (*4*).

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4. Materials and methods are available as supporting material on *Science* Online.
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Supporting Online Material

www.sciencemag.org/cgi/content/full/1122855/DC1
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SOM Text
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TECHNICAL COMMENTS

Response to Comments on "Post-Wildfire Logging Hinders Regeneration and Increases Fire Risk"

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We reported that postfire logging 2 to 3 years after the 2002 Biscuit Fire was associated with significant mortality in natural conifer regeneration and elevated potential fire behavior in the short term as a result of increased surface fuel loads. We underscore the strength of our study design and statistical conclusions, provide additional details of the research setting and scope, and address comments pertinent to forest development and fire ecology.

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Although Newton *et al.* (1) and Baird (2) provide no compelling evidence to refute our findings, we are pleased with the opportunity for dialogue and to expand on our article (3). We respond by underscoring the strength of our study design, providing additional details of the research setting and scope, and addressing comments pertinent to forest development and fire ecology.

Study background. We reported that postfire logging (salvage) 2 to 3 years after the 2002 Biscuit Fire was associated with significant mortality in natural conifer regeneration and elevated potential fire behavior in the short term due to increased surface fuel loads (3). Our study design has robust inferential power (4), and the data strongly support these straightforward conclusions, as verified by independent statistical evaluations (5, 6).

Our scope of inference (3) is the salvage of the Biscuit Fire [see (4) for study details]. Areas sampled were typical of portions of the Biscuit Fire designated for salvage (4). Responses to postfire logging may vary between and within fires, forest types, and

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technique/timing of logging. Similar patterns of seedling damage/reduction resulting from postfire logging operations have been documented across a range of conditions (7–11), which may be because postfire logging is often conducted under the presumption of negligible natural regeneration and is therefore not designed to protect it. The logging techniques on which we reported (handfelling with helicopter yarding >2 years postfire) occur on public lands throughout the western United States.

The hypothesis that prompt postfire logging could have different effects merits study. Currently, there are no data comparing effects of early versus delayed logging operations (12) and, to date, the few relevant studies of prompt postfire logging have also reported reductions in seedling densities (7, 8). More field data are needed to elucidate the range of potential effects under different conditions and prescriptions.

Short-term data from well-designed studies, such as (3), are important in providing benchmarks for long-term studies and isolating the mechanisms through which management affects forest processes. To date, the few longer term studies of postfire logging (13) have been confounded by multiple postfire treatments (e.g., logging, fuel treatment, replanting). A review of postfire management studies (12) states, "when treatments involve logging as well as other site preparation measures, it is impossible to distinguish the specific causative factor behind any observed vegetation change." We maintain that research on postdisturbance management effects will be most valuable when each treatment is studied as a distinct variable [e.g., (3, 14)].

Early regeneration. Although various reforestation practices after live tree harvest in southwest Oregon have been well studied (1, 15), natural post-wildfire regeneration remains far less studied in the region. Postfire conditions differ substantially from conditions following live tree harvest in several important ways [e.g., (16, 17)], including seedbed qualities, legacy structure, and stress seed crops. Thus, we caution against extrapolating knowledge from postharvest studies to natural post-wildfire regeneration.

Early regeneration data provide insight into important processes, including seed production, dispersal, germination, and early survival. The relation between short-term effects of postfire logging on these processes (3) and long-term recruitment patterns (1, 18, 19) is key to understanding the legacy of logging effects on stand development. Conifer regeneration following wildfires can be limited during two phases: (i) initial establishment due to seed source deficiency in large burned areas, and (ii) subsequent competition, survival, and release. We reported on the former, not the latter. This is important in light of uncertainties regarding the degree to which this first phase would occur in high-severity portions of the Biscuit Fire (20, 21). We did not draw further conclusions about long-term effects of postfire logging (3). Relevant long-term data from replicated experiments do not exist (12).

Postfire succession in mixed-evergreen forests of the Klamath-Siskiyou region (which covers much of southwest Oregon and northwest California), is characterized by a period during which broadleaf vegetation forms a substantial overstory component (19). Several authors have suggested that, in the presence of shrub competition, early conifer establishment is especially important in attaining eventual conifer dominance (15, 20, 22). Alternatively, current studies indicate a variable, protracted conifer regeneration period in this region, with peak establishment generally within 5 years of fire and persistence in the

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presence of broadleaf species (18). Under either scenario, establishment of seedlings 2 to 3 years after fire represents an important period of succession in the Klamath-Siskiyou region. Subsequent competition from broadleaf vegetation has been shown to occur with or without postfire logging (13) and is therefore a related but separate issue from the results of our study (3).

With respect to regional stocking standards (23), we followed federal definition M, which states that a suitable tree (capable of meeting forest management objectives) "may qualify as a component of the stand by having survived at least one growing season in the field." The vast majority of seedlings we reported had been present for at least two growing seasons by 2005 (24). Regional stocking standards include prescriptions for density and distribution (1, 23). We reported data pertinent to density standards, quantified at the hectare scale using an effective method (4) and assessed for variability at the treatment scale (across logging units) rather than within each logging unit. Traditional stocking surveys (1) were not our intent. We indicated that the median density we quantified exceeded that found in adequately stocked sites per the Biscuit management plan [since sites must be stocked at a minimum density (23)]. This was a benchmark for comparison and not a conclusion regarding stocking per se, which is quantified differently. Because much of the Biscuit salvage was planned in land use allocations for which very low densities and variable spacing were prescribed (25), we suggest that stand level density is an important parameter relative to other stocking standards.

Fuel dynamics. Although fuel composition, arrangement, and continuity are all important variables contributing to potential fire behavior, a predominant factor affecting behavior of the flame front is the mass of fine downed wood (26, 27). We reported an increase by a factor of about 5 in fine downed wood as a result of postfire logging (3), which suggests that salvaged environments are predisposed to fires of greater intensity than unsalvaged sites in the near term. Fire behavior modeling of different salvage/fuel-treatment scenarios, parameterized with field data, will best characterize potential fire behavior in postfire settings. However, standard fire behavior models [e.g., (26)] do not include fuel continuity as an independent variable and therefore assume similar connections between fuel loads and fire behavior.

One of the primary purposes of the Biscuit management plan was to reduce the "risk" of high intensity and/or stand replacement fire (21); thus, we presented our results relative to this objective (28). Prescriptions also called for broad ranges of downed wood levels for soil function and habitat (21). Our observation was that downed wood levels following logging were variable relative to prescriptions, often as much a function of inherent, localized felling and handling practices as they were reflective of any specific prescription. Regardless, our research quantified higher postsalvage fuel loads, which are associated with higher potential fire behavior, thus adding empirical field data to what has only been modeled thus far (29).

Given the observed pulse of surface fuels after logging and its potential effects on surface fire behavior, our suggestion that leaving woody material (dead trees) standing could result in lower fire hazard is a reasonable hypothesis. Surface fuel loads derived from fire-killed trees are determined by the dynamic balance between inputs (from the canopy) and outputs (decomposition). As such, no scenario produces a larger pool of fine (up to

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7.62 cm) and 1000-hour [7.62 to 20.32 cm (19)] fuels than a single one-time input from clearfelling shortly after a fire. Long-term interactions between these inputs and live fuel succession are poorly understood, especially for the largest fuel size classes. As we stated in (3), hypotheses regarding long-term fire potentials merit study [see (30)].

Statistical analysis. All appropriate, conservative methods for analyzing our data yield robust, biologically and statistically significant effects (3, 5, 6). These methods employ either nonparametric analyses that do not require normality or equal variance, or a common transformation ($\log_e$) to more closely meet assumptions of parametric tests [Fig. 1 and (31)]. Parametric tests on untransformed data, as in (2), are prone to spurious results due to substantial departure from normality and unequal variance (Fig. 1).

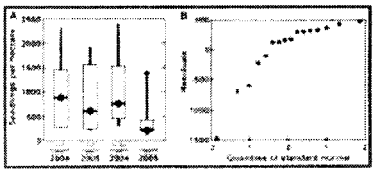

Fig. 1. (**A**) Box-and-whisker plots of Biscuit Fire seedling data (seedlings per hectare) from (3) and (**B**) residuals from parametric test [analysis of variance (ANOVA)] on interannual changes in untransformed seedling data, as in (2). (A) shows tendency toward positive skewness (typical for ecological count data) for all groups and unequal variance, as well as marked difference between the 2005-logged sample compared with other samples. Dot within box is the median; box edges are the 25th and 75th percentiles; whiskers represent the data range; points beyond 1.5 times the interquartile range from the quartiles are drawn as horizontal lines across the whisker. Shapiro-Wilk normality test (32) indicates lack of normality: W = 0.7173, P = 0.0023 for 2005-logged plots. (B) shows that parametric ANOVA tests on untransformed data, as in (2), are prone to spurious results for the seedling data due to substantial departure from normality (Shapiro-Wilk normality test: W = 0.7226, P = 0.0026 for annual change in density between years in logged plots). Analyses after data transformations or nonparametric analyses are highly preferred (31). [View Larger Version of this Image (17K GIF file)]

Baird's (2) description of our analysis is misleading. Repeated measures are irrelevant because we did not assume independence of 2004 and 2005 measurements within each plot (Table 1). We intended to quantify annual change within plots. In addition, our descriptive estimate of the sample-wide change in logged plots between years was a 71% decline in the sample median, which does not arise from analysis of any particular plot. Rather, the median is a conservative measure of central tendency for the entire sample before and after logging, providing descriptive information at the broader, treatment-wide level.

Table 1. Seedling densities for each of the 16 burn plots before and after logging treatment. The following are test statistics and one-tailed P values from multiple analytical

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methods of testing the hypothesis that the reduction in seedling density in logged plots exceeded interannual variation in unlogged plots. Rank sum test on percentage change in each plot: W = 53, $P = 0.006$; rank sum test on untransformed (raw) changes: W = 60, $P = 0.045$; two-sample t test on percentage change in each plot: $t_{14} = 3.15$, $P = 0.004$; two-sample t test on changes in $\log_e$-transformed densities: $t_{14} = 2.70$, $P = 0.009$; two-sample t test on untransformed (raw) changes: $t_{14} = 1.52$, $P = 0.075$ [to our understanding this is equivalent to the analysis of Baird (2); see also Fig. 1B]. One-tailed tests are logically appropriate because, given the time frame of study as well as the timing of logging relative to the interannual and seasonal timing of regeneration, the immediate effect of logging on seedling densities (if different from zero) would be a reduction (7–10).

Seedlings per hectare

Plot	2004	Treatment	2005
1	298	logged	164
2	471	logged	221
3	767	logged	454
4	576	logged	141
5	407	logged	217
6	1534	logged	224
7	2423	logged	349
8	1697	logged	1388
9	1137	logged	646
10	288	unlogged	220
11	622	unlogged	747
12	300	unlogged	260
13	888	unlogged	584
14	1448	unlogged	1566
15	1425	unlogged	626
16	2349	unlogged	1924

Because the sample of unlogged plots showed no consistent or statistically significant pattern in changes in seedling density over time (Fig. 2 and Table 1) (3, 6), and new in-seeding as well as mortality was occurring [see (18)], the statistically significant change in logged plots was attributed to logging. Analyses that include the variation observed in the unlogged sample also yield findings of significant logging effects that differ only in the point estimate of effect magnitude (Table 1) (5, 6).

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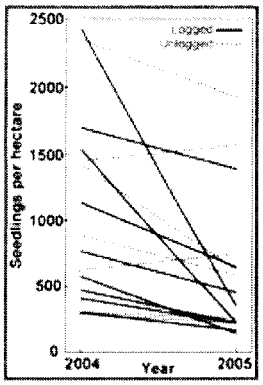

Fig. 2. Changes in seedling densities between 2004 and 2005 for logged and unlogged plots, with logging occurring between measurement periods. Equivocal variation between years can be seen in the unlogged plots (no consistent trend), whereas logged plots all show marked declines. [View Larger Version of this Image (28K GIF file)]

Independent statistical evaluations of our data support the conclusions of significant effects of postfire logging on seedling regeneration and fuels (*5*, *6*). As stated in one such review, "Although there can be differences of opinion on methods of analysis, all reasonable methods will lead to congruent conclusions" (*5*).

The study design, results, and conclusions presented in (*3*) are strong, relevant, and straightforward. Newton *et al.* (*1*) and Baird (*2*) present different perspectives, but provide no data or evidence from other studies to contradict our findings and conclusions. A short-format paper such as ours is not intended to review or explore every angle but to present key data that will stimulate discussion and further research. We hope our research findings and comments provide direction for future studies and management.

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33. This manuscript benefited from reviews by statisticians L. L. Conquest, A. Gitelman, E. A. Housworth, M. M. P. Huso, P. Murtaugh, and F. L. Ramsey, as well as several colleagues and five anonymous reviewers. This work was supported by the Joint Fire Science Program and DOE grant DE-FG02-04ER63917. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

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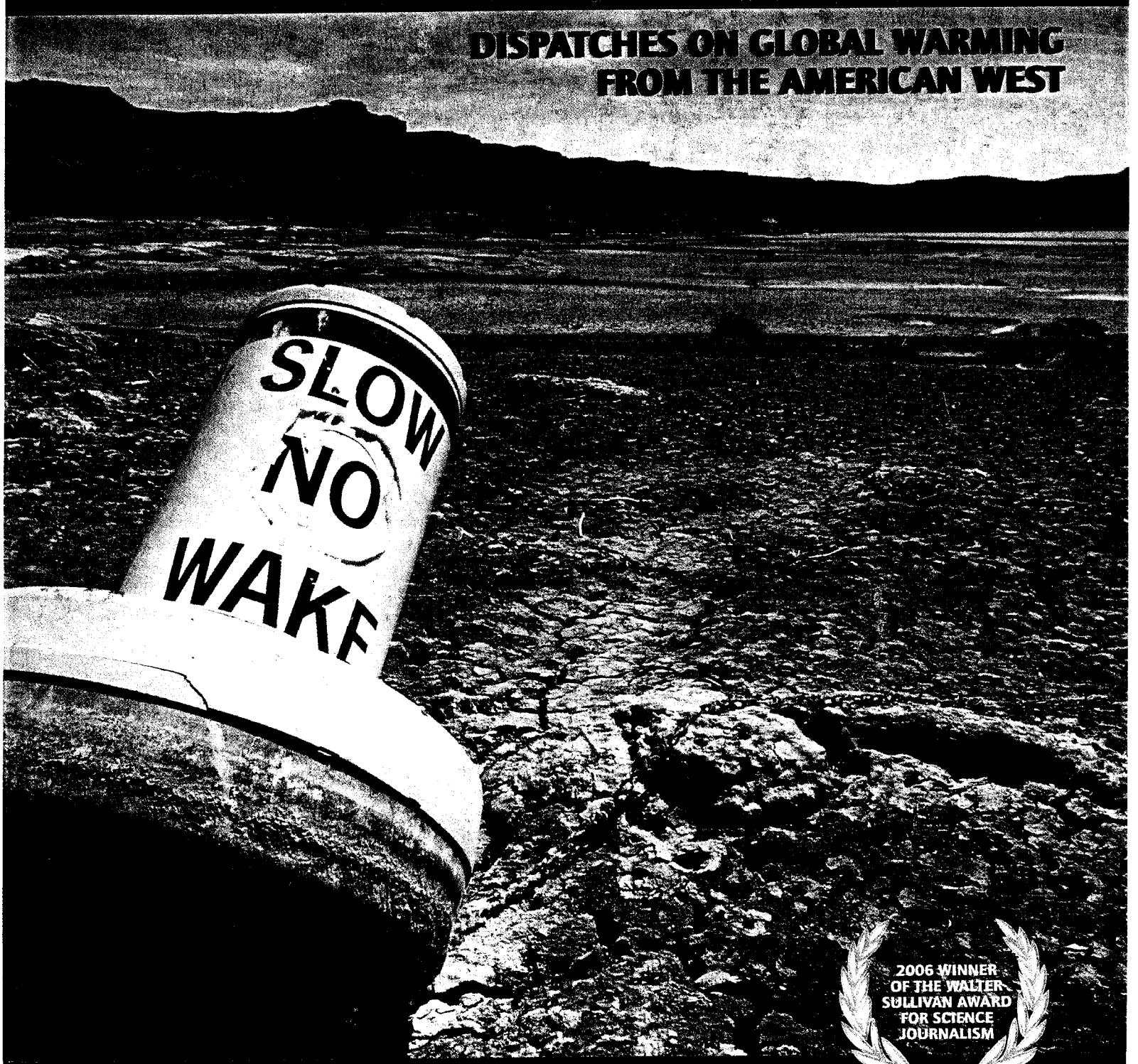

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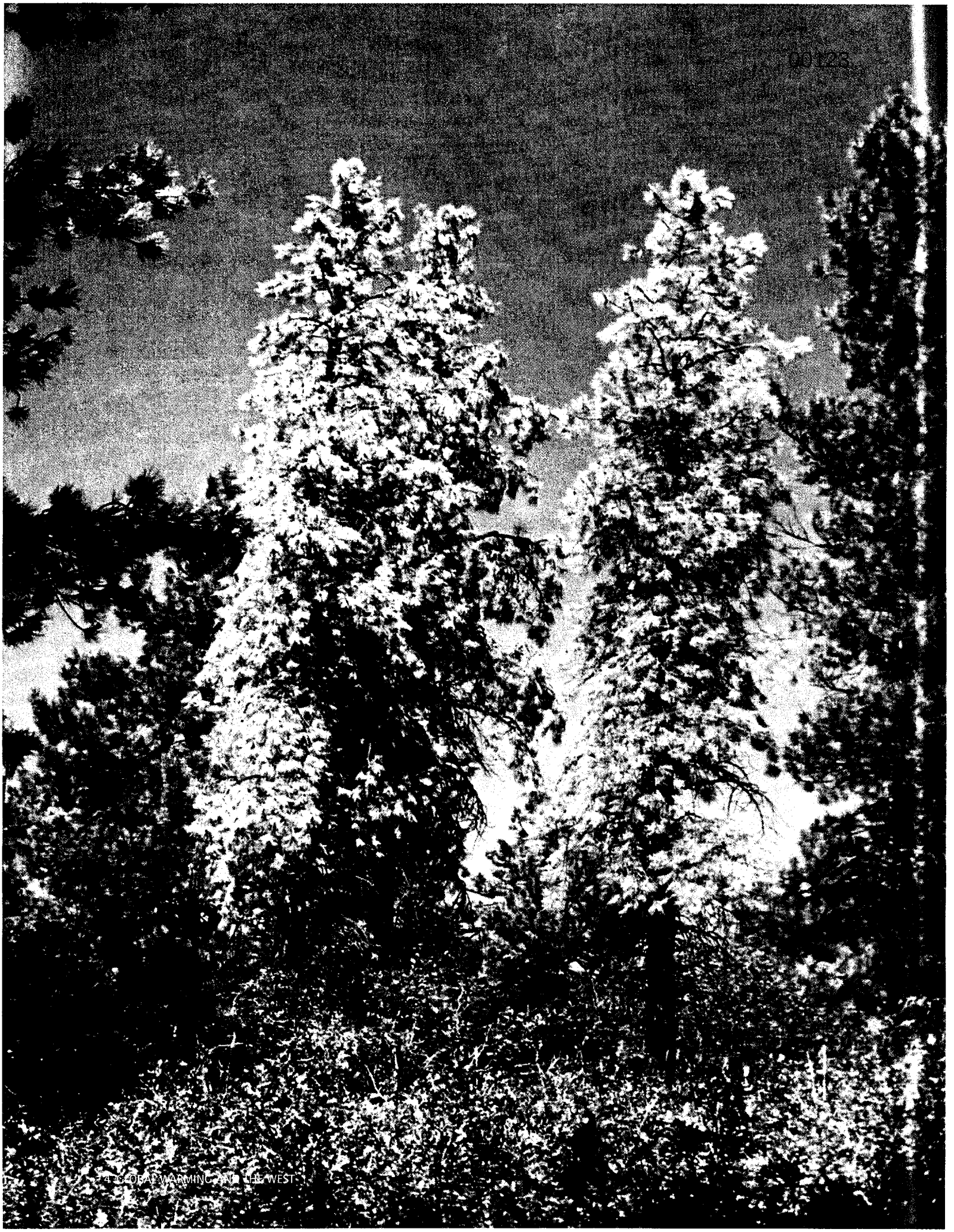


BY MICHELLE NIJHUIS

Attack of the Bark Beetles

The West is heating up — and bark beetles are moving in for the kill

STANLEY, IDAHO

The lodgepole pines are dying. Inside the bark of the trees, tens of millions of beetles are tunneling, birthing, hatching, maturing. In early May 2004, when Forest Service researcher Jesse Logan drives through the Stanley Valley to inspect the damage, more than half the lodgepole pines display dull red foliage — the signal flag of beetle victory. This summer, says Logan, these forested slopes will glow a brilliant rusty orange. In just a few more years, these broad bands of mature lodgepoles will be nothing but weathered snags, their supplies of water and nutrients choked off by a beetle no larger than a fingernail. Mountain pine beetles are one of the most industrious members of the genus *Dendroctonus* — loosely translated as "tree killers" — and every outbreak confirms the aptness of their grim scientific handle.

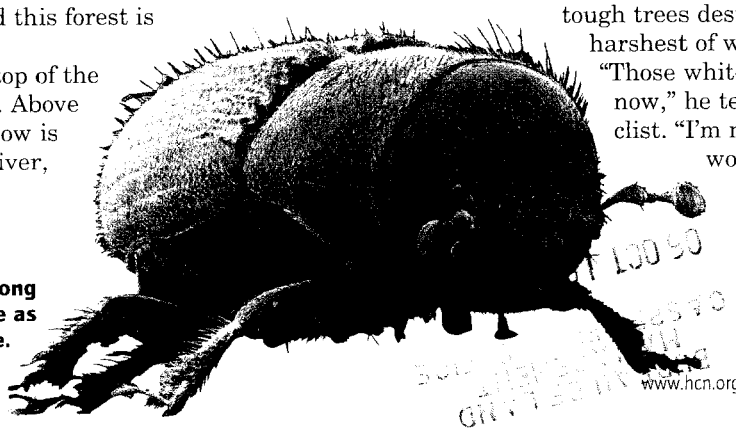
In lodgepole forests like this one, these tiny murderers anchor a familiar cycle. The ghostly, beetle-killed stands act as fuel for forest fires, and the fires kick-start a new generation of lodgepole pines. It could take these 150,000 acres of forest a century or so to fully regenerate, says Logan, but he's not too worried about their long-term future. During the past decade, lodgepole pines have started to bounce back in burned areas of Yellowstone National Park, and this forest is probably just as resilient.

From Galena Summit, at the top of the valley, Logan pauses to look back. Above are steep mountain slopes; far below is the winding cord of the Salmon River, edged with green meadows and the red, beetle-killed swaths of pines. When a passing motorcyclist stops to suss out the scenery, he soon discovers that Logan is a beetle expert. "Wow, I'm *really* glad I ran into you," he says with enthusiasm. Massive beetle outbreaks, it seems, turn entomologists into minor celebrities.

The motorcyclist points down the valley, shaking his head, then peers at Logan through mirrored sunglasses. "I've lived here for 30 years, and I've never seen anything like this," he says. "I just keep thinking, 'Wasn't there something we could have done?' "

For Logan, this is an old question. He explains the cycle of devastation and regeneration, emphasizing that humans can't — and probably shouldn't — do much to stop this natural process. The frosty Stanley Valley was long thought to be too cold for a major outbreak, so these particular red trees are something of a scientific curiosity. Still, he says, they don't give us any real cause for panic. "These lodgepoles and the mountain pine beetle, they've got an understanding — even if we don't fully understand it ourselves," says Logan. "They've worked out a deal."

Logan then points upward, to the serrated peaks of the Sawtooth Mountains. The narrow ridgelines are fringed with squat, bushy shapes, tough trees designed for the harshest of winter conditions. "Those whitebark pines, now," he tells the motorcyclist. "I'm not so sure they've worked out a deal."



Two dying lodgepole pines stand among still-healthy trees, left. A bark beetle as seen through an electron microscope.

When Logan leaves the inquisitive motorcyclist, he crosses Galena Summit and zigzags into the next drainage. He's entering the Sun Valley area, the former home of Ernest Hemingway and the posh retreat of many a modern-day gazillionaire. Logan, however, isn't thinking about stargazing. Just a few hundred yards past the summit, he pulls over and grabs his binoculars, training them on the forest above. On the highest ridgeline is a solid line of whitebark pine, all flying the red flag of the mountain pine beetle.

Logan drops the binoculars and shakes his head. "Wow, that is amazing to me," he says, pausing to find the words. "There's a *lot* of mortality up there. That is ... that is just astounding."

It's not easy to surprise Logan, at least when it comes to the mountain pine beetle. He's a research entomologist for the Forest Service's Rocky Mountain Research Station in Logan, Utah, which has been studying mountain pine beetles and other bark beetles for more than three decades. Logan has worked with the research station's Interior West Bark Beetle Project on and off through much of his career, which has included stints on the faculty of Colorado State University and Virginia Polytechnic Institute; he joined the bark beetle project full-time in 1992. His closest collaborator, entomologist Barbara Bentz, started working for the research station as a seasonal technician in the early 1980s and now, two graduate degrees later, leads the project.

Sure enough, as temperatures warmed, beetles at these sites shifted from a two-year to a one-year life cycle — just as the model had predicted.

Together, Logan and Bentz helped shift their agency's attitude toward bark beetle management. For much of the last century, the Forest Service treated beetle outbreaks like plagues, clobbering them with heavy (and mostly useless) doses of pesticides. In those days, Forest Service scientists concentrated largely on slowing beetle damage to timber. But Logan and Bentz recognized that bark beetle outbreaks were part of a natural process. They convinced their bosses to let them rewrite the mission of their research project, moving it away from beetle police work and toward longer-term ecological studies. "Our major focus was on natural disturbance — and how we can live with it," says Logan.

Project researchers have long collected detailed data on the life history of bark beetles, particularly the widespread mountain pine beetle. In recent years, Bentz, Logan, entomologist Jim Vandygriff, and a crew of other researchers have monitored sensitive weather stations and temperature data collectors at various study sites, postholing through snowbanks in the early spring and fighting off swarms of mosquitoes in the summer. They peel off samples of tree bark throughout each year, noting how the beetles' development responds to variations in climate. These data, they hope, will help them understand the elaborate ecological machinery that runs a beetle outbreak.

Early on, they found that temperature had a powerful influence on the mountain pine beetle, so powerful that Logan wondered about the effect of global warming on beetle outbreaks. Not many shared his concern: Ten years ago, he raised the issue during a presentation at a scientific meeting in Hawaii. "The response was, 'That's an interesting idea, but it would be better if you'd do something that actually mattered,' " he remembers.

But Logan persisted with his questions. Along with Utah State University mathematician Jim Powell and Canadian entomologist Jacques Régnière, Logan used the station's field data and other research to create a computer model of beetle behavior. The model showed that, most of the time, mountain pine beetles just couldn't get it together at very high elevations. The cold temperatures made it impossible for them to complete their life cycle in one year, forcing them to confront a second winter at a vulnerable point in their development. The adult beetles also couldn't synchronize their emergence and flight from their birthplaces. With so few beetles attacking new trees at any one time, healthy trees could defend themselves by drowning the tiny beetles in resin. Under these conditions, beetles could only kill diseased and otherwise weakened trees.

Logan and his collaborators then plugged some new numbers into their model. The United Nations-sponsored Intergovernmental Panel on Climate Change (IPCC), widely considered the world authority on climate change science, predicted in 1990 that global mean temperatures would rise 4.5 degrees Fahrenheit by 2030, assuming humans took no major action to reduce carbon dioxide levels in the atmosphere. Curious about the effect of this change on mountain pine beetle outbreaks, the researchers gradually stepped up temperatures in their model. When temperatures hit 3.6 degrees Fahrenheit higher than the average conditions at one of their whitebark pine study sites, prospects for the beetles improved dramatically. Beetles raced through a one-year life cycle at higher elevations. They also synchronized their emergence, allowing them to join forces and overwhelm tree defenses. High-mountain mass attack — and mass tree death — suddenly became possible.

These results were reassuringly theoretical until about five years ago, when Logan and Bentz started hearing about a new round of beetle attacks. This time, it seemed, the mountain pine beetles weren't as interested in the lodgepole forests. They were outbreaking in the whitebark pines.

Whitebark pines form the roofbeam of our mountain landscapes. These thick-trunked trees, found at high elevations throughout the Northern Rockies, support a wide web of animal dependents. Known as "stone pines," the trees store heavy, fatty seeds inside stubbornly closed cones. The Clark's nutcracker, a cousin to crows and jays, harvests the cones each year; it eats some seeds and hides the rest, recovering the caches in late winter in order to feed its young. The seeds it leaves in the ground become the next crop of whitebark pines. In his book *Made for Each Other*, biologist Ronald Lanner sums up this elegant relationship: "Working in concert, the Clark's nutcracker and the whitebark pine build ecosystems."

Red squirrels also collect whitebark pine cones, stockpiling their booty throughout the forest. In the fall and early spring, when other food is hard to find, grizzly bears plow up these hidden high-fat meals. When whitebark pine seeds are scarce, grizzlies head for lower elevations, where they often run into humans. Biologist David Mattson, who has studied Yellowstone grizzlies and their ecosystem since 1979, documented a several-fold increase in grizzly-human interactions during years of low whitebark cone production. Because of these encounters, he says, humans kill nearly twice as many grizzlies during poor cone years.

Mountain pine beetles are not unknown in the whitebark pine zone — in fact, there were several intense outbreaks during the previous century. In the past, however, the beetles have behaved more or less politely, outbreaking occasionally in healthy stands but sticking mostly to trees weakened by drought, disease, or other stresses. When Logan and his colleagues got news of the fresh outbreaks, they feared the beginning of a very different phenomenon.

The beetle researchers set up a new study site on Snowbank Mountain in southeastern Idaho, where healthy whitebark pine had started dying from bark beetle attacks. They started watching beetles march through whitebark pine on Galena Summit in the Sawtooth Mountains. Last year, even their highest-elevation study site got hammered: The whitebark pine on 10,000-foot-high Railroad Ridge, an area that Logan and his coworkers have monitored for more than a decade, was hit hard by the mountain pine beetle. Sure enough, as temperatures warmed, beetles at these sites shifted from a two-year to a one-year life cycle — just as the model had predicted.

Reliable data on the extent of previous mountain pine beetle outbreaks are difficult to come by, but the current outbreaks in the whitebark pine zone "seem to be broader" than outbreaks in past decades, says Ward McCaughey, who studies whitebark pine communities as a research forester for the Forest Service. "In the 1980s, it hit very intensively in isolated areas," he says. "Now, we're seeing outbreaks across the spectrum."

Diana Six, a University of Montana entomologist who studies whitebark pine in Idaho, Montana, and Yellowstone National Park, says beetles at all of her 12 study sites have adopted a one-year life cycle. What's more, she says, outbreaks now move even faster at high elevations than in the beetles' more familiar lodgepole pine territory. In the past, beetle outbreaks in whitebark were often helped along by spillover from the lodgepole zone, but that assistance is no longer necessary. "Instead of moving up from lodgepole pine, mountain pine beetles are starting in whitebark pine, and building up huge populations," she says. "They're producing four to seven times more brood in whitebark than they do in lodgepole."

While lodgepole forests only need a few human generations to recover from similar outbreaks, whitebark pines aren't designed for quick action. The trees mature slowly, and can live for centuries. For Logan, long acquainted with whitebark pines through decades of research and backcountry ski trips, these newest outbreaks have a tragic aspect.

Forest Service researcher Jesse Logan has found that increasing temperatures dramatically improve the prospects of the mountain pine beetle. PHOTO COURTESY JESSE LOGAN

"When I see outbreaks intensify in the lodgepole pine, it's an interesting ecological event," says Logan. "When I see a 700-year-old whitebark pine go down, I have a completely different reaction. It breaks my heart."

Overall temperatures in the Rockies — and around the world — are rising dramatically. The Intergovernmental Panel on Climate Change reports that global mean surface temperature increased by more than 1 degree Fahrenheit over the 20th century. In the Northern Hemisphere, the warming was greater than in any other century for the last 1,000 years, and the 1990s were the warmest decade of the entire millennium. The IPCC, which issued its most recent assessment report in 2001, now predicts that global mean temperatures will rise anywhere from 2.5 to 10.4 degrees Fahrenheit between 1990 and 2100 — a rate of

warming very likely without precedent in the last 10,000 years. If Logan's model is correct, even a few uninterrupted years of these widespread, unusually high temperatures will unleash bark beetles as never before.

Logan and his colleagues can't say whether the warmer temperatures we've been experiencing result from our affection for fossil fuels. That's not their job. But other respected researchers say the connection is difficult to deny. The IPCC stated in its 2001 assessment that the concentration of carbon dioxide in the atmosphere increased by about 30 percent in the past 250 years, and that the current rate of increase is unprecedented in the last 20,000 years. "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities," the panel said. The National Academy of Sciences also states that "temperatures are, in fact, rising," and adds that the observed warming over the past several decades is "likely mostly due to human activities." For scientists, who tend to be a cautious crowd, these are blistering words.

Combine Logan's model with the conclusions of the IPCC and other authorities, and the story is stark. We're performing a gigantic experiment on the planet, and today's unusual beetle outbreaks are part of the result.

This isn't a Hollywood disaster movie — no tidal waves or giant ice sheets here — but news from the world of beetle behavior is, in its own way, just as worrisome as anything you might have seen in the recent global-warming scare flick *The Day After Tomorrow*. In British Columbia, says Canadian Forest Service ecologist Allan Carroll, "We have the largest outbreak ever recorded currently on the go." A forest survey conducted in 2003 found that more than 10 million acres of lodgepole pines — an area the size of Switzerland — had been killed the previous year. The outbreak's reach has been almost doubling every year since 1998.

Carroll has studied 40 years of forest health surveys by the Canadian Forest Service, and he's found that the mountain pine beetle is spilling over the northern margin of its historical range. "In the past, the beetle has collapsed when it's run out of food," says Carroll. "Now, we're seeing new areas opening up in front of it." This expansion could have innumerable impacts on northern ecosystems; woodland caribou in northern British Columbia, for instance, depend on lichen that grow beneath lodgepole pine stands. There's never been an infestation recorded in these stands, but now the mountain pine beetle is headed in their direction. As these lodgepole pines go, so go the lichen and the caribou.

Though Canadian outbreaks haven't ventured into the whitebark pine zone, the beetles have a new food

Mountain pine beetle galleries.
LADD LIVINGSTON, IDAHO DEPARTMENT OF LANDS

source in their path. Carroll says the beetles are now between 60 and 120 miles from the nearest stand of jack pine, a species not previously acquainted with mountain pine beetles. Experimental evidence suggests that the beetles will thrive in jack pine, an important timber species that extends through much of Canada. The Great Plains have long been considered an insurmountable barrier to the mountain pine beetle, but once the beetle hits this new host, nothing would stop it from plowing eastward into stands of eastern white pine and cruising south all the way to the loblolly pine forests of the Southeastern United States. This would add up to a supersized sweep of outbreaks, beginning in the U.S. Southwest, stretching across the southern half of Canada, and curving down the Eastern Seaboard of the United States into southern Texas. "The shortest route from Logan, Utah, to Nacogdoches, Texas," says Logan, "might be through Ontario, Canada."

These pines define landscapes — and, in some cases, economies. Imagine a swath of standing dead snags stretching from British Columbia to New England to the Deep South. Imagine hundreds of busted logging and mill towns, unable to process all the timber before it began to rot. Imagine the cloud of carbon dioxide these decaying — or burning — trees would ultimately release into the atmosphere. Regeneration of the forests would take at least a century, and it might not happen at all; if temperatures stayed high, the beetles could just keep coming.

"We saw the beetles building up, and these incredible summer beetle flights like something out of an Alfred Hitchcock movie."

—Edward Berg, Alaskan ecologist

The mountain pine beetle has a huge extended family, and its relatives are also responding to the warming climate. More than a decade ago, on the outskirts of Homer, Alaska, ecologist Edward Berg watched spruce beetles take down the thick spruce stands around his house. "We saw the beetles building up, and these incredible summer beetle flights like something out of an Alfred Hitchcock movie," he says. The kill eventually spread to 4 million acres, covering the Kenai Peninsula and overflowing into other parts of south-central Alaska; on color-coded maps of spruce beetle outbreaks, the peninsula sticks out of the state's southern coast like a bloodied thumb. It wasn't long before a logging rush got under way.

"Suddenly, the landowners were thinking 'Good God, all the trees are dying, they're all going to fall down and create a mess,' " says Berg. "But Realtors loved it. They described all the beetle-killed properties as having 'emerging views.' "

Berg, for his part, abandoned his newly exposed acreage and moved into town. As a researcher for the Kenai National Wildlife Refuge, he also looked into the reasons for the spectacular beetle kill. When beetles open up space in a spruce forest, the surviving trees react with a growth spurt, and the spurts show up as wide rings inside tree trunks. So Berg looked for prolonged "growth pulses" in the tree-ring record. This evidence, combined with historical observations, showed that the Kenai Peninsula had experienced a beetle outbreak of some size about once every half-century for the last 250 years. Though rainfall and stand density probably affected beetle behavior, says Berg, the historical outbreaks are most closely linked with higher temperatures.

"The gun has to be loaded, and something has to pull the trigger," he says. "The loading is having a lot of mature trees. The run of warm summers is the trigger."

The latest warm spell is the longest yet. Summers in Alaska warmed up the late 1980s, and Berg says temperatures have been "on overdrive" ever since. The long, hot summers allowed the beetles to complete their life cycle in one year instead of two, and, Berg says, "the beetles just grew exponentially." While cooler temperatures knocked back past outbreaks after a year or two, there was nothing to stop the most recent infestation. Nothing, that is, except the near-total exhaustion of the food supply.

"Essentially, they ate themselves out of house and home," says Berg. Summer temperatures remain above the historical mean, he says; if there were still trees to be attacked in his neighborhood, the spruce beetles would still be hard at work.

Unlike many residents of the Lower 48, Alaskans already see plenty of anecdotal evidence of global warming. "It's a fact of life here," says Berg. "We can see the treeline going up, the glaciers retreating, and the roads buckling because the permafrost is melting." The idea that rising global temperatures also amp up beetle outbreaks doesn't surprise him — or his neighbors. "I always considered it kind of an obvious thing," he says. "I had one neighbor who told me that they just needed someone like me with a Ph.D. to come along and make it official."

In the Southwestern United States, beetle damage is also reaching Hollywood proportions, but it's not as clear that global warming is the culprit. Mike Wagner, an entomologist at Northern Arizona University in Flagstaff, estimates that bark beetles killed 20 million ponderosa pines and 50 million piñon pines in New Mexico and Arizona in 2002 and 2003. "We're seeing entire watersheds — blocks in excess of several thousand acres — where 80 to 90 percent of the trees have been killed," says Wagner. In the Southwest, the mountain pine beetle gets help from related species such as the Mexican pine beetle, the roundheaded pine

beetle, and several types of ips beetle.

The extent of the recent beetle attack is "unprecedented," says Wagner, but he warns there's no solid evidence that the region's warming temperatures are behind the outbreaks. The pine forests of the Southwest are weak from years of drought; between 1994 and 2004, eight years were drier than normal in the region, and tree-ring scientists say 2002 was the driest single year in northern Arizona in the last 1,400 years. (Drought is one possible outcome of increasing carbon dioxide levels, but tree-ring scientists say there's also a long tradition of severe, long-lasting droughts in the Southwest; so far, the current drought appears to be part of this tradition.) Wagner says the ponderosa pine forests have also changed substantially over the past century, with stand densities tripled or quadrupled by fire suppression and an unusually wet period in the 1970s and '80s. "These changes are more than sufficient to explain the outbreaks," he says. "We don't need to invoke the concept of global change." Wagner calls Allan Carroll's work in British Columbia "convincing," but he says it's impossible to use results from such distant forests to explain the beetle attacks in the Southwest.

In many areas of southern Colorado, the one-two punch of drought and beetles has killed 90 percent of mature piñon stands.

The region is full of unanswered questions. Craig Allen, an ecologist with the U.S. Geological Survey who's worked in northern New Mexico for most of his career, documented what he calls a "massive forest dieback" in the Jemez Mountains in recent years. Piñon populations increased during the wet decades of the 1970s and '80s, and the drought that began in the '90s began to "squeeze the excess out of the system," he says. In 2002, however, the piñons started dying wholesale, killed either by the direct effects of drought or by an associated invasion of piñon ips, another relative of the mountain pine beetle. By March 2003, most of the piñon pines in Allen's study area — even the seedlings — were dead. Piñon populations are crashing throughout the region; in many areas of southern Colorado, the one-two punch of drought and beetles has killed 90 percent of mature piñon stands.

Though the current drought in the Southwest hasn't yet lasted as long as a previous severe drought in the 1950s, Allen says its effects on the Jemez Mountains piñon pine forests already outstrip those observed in that earlier dry spell. "The magnitude of mortality is pretty astounding right now," he says. "Arguably, this drought is more stressful because it's warmer." Unlike the mountain pine beetle, which hits some high-value timber species and has been studied for decades, no one has paid much attention to the piñon ips. "It does make sense that (the ips outbreaks) are temperature-driven," says Northern Arizona University entomologist Neil Cobb, "but there are a lot of holes in the knowledge."

So has this beetle been helped along by thicker piñon forests? The drought? The warming climate? Or all three? It's nearly impossible to untangle these factors, but Allen and other researchers hypothesize that, here as well, warming temperatures play a major role.

Hang around with ecologists for a little while, and you notice their fear of sweeping proclamations. There's always more to study and consider before they reach a simple conclusion. It's not hard to see why: The systems they work in are so complex, so variable in space and time, that what they see on one hillside may be quite different from what they see in the next watershed. The drought-addled forests of the Southwest, for instance, are different from the somewhat moister forests of the Northern Rockies, or the still-wetter stands of Southern Alaska. The types of trees, the species of beetles, and the forests' relationship with fire vary tremendously throughout the Western half of the continent. And though oddly enormous beetle outbreaks seem to be pervading the region, there are exceptions. In the mountains of Colorado, says University of Colorado ecologist Tom Veblen, "We don't see any evidence that spruce beetle outbreaks are outside the range of outbreaks over the last few hundred years." Temperatures at high elevations in the state, says Veblen, also don't show the same clear warming trend as other areas in the West.

So the outbreaks are a typical scientific puzzle: The closer you look, the blurrier the picture seems to get. But even many ecologists admit that a couple of general statements are in order here. The number of red — and dead — trees in the region is breaking records. So are thermometer readings. "We're seeing changes in (mountain pine beetle) activity from Canada to Mexico," says Logan, "and the common thing is warming temperatures."

This news complicates an already fearsome set of management dilemmas. Land managers have only recently accepted beetle kills as a natural process, rather than a crisis requiring large-scale logging or armies of seasonal workers armed with backpack sprayers. But just as they've learned to work on nature's terms, we've drastically changed the terms. Understanding this new reality, let alone reacting to it, means another venture into the unknown.

It's not as if managers have a lot of spare time for exploration. The current sweep of beetle outbreaks is increasing public fear of wildfires, leading to new pressure to pull trees out of Western forests. "There's a lot of public expectation that we're going to cut and remove every red tree," says Jim Rinehart, who, as forester for the Sawtooth National Forest in Idaho, is overseeing some 2,500 acres of thinning projects near towns and developed areas in the Stanley Valley. Clear-cuts and widespread logging, he says, aren't part of his forest's response to the

outbreak: "We're just trying to live with it."

The Bush administration-backed Healthy Forests Restoration Act, passed by Congress and signed into law in 2003, strengthened the political push for logging in beetle-killed stands. Some ecologists, however, are calling for a more subtle approach. "We need to recognize that lodgepole pine forests are very different from ponderosa pine forests, that ponderosa pine-type thinning prescriptions are not appropriate in piñon pine," says Colorado State University fire ecologist Bill Romme. The new legislation, he says, "treats all forest types alike."

Romme and other scientists sent a letter to Interior Secretary Gale Norton after the passage of the Healthy Forests act, arguing that beetle outbreaks in the piñon pine forests of the Southwest may reduce, not increase, the danger of large, intense fires in the tree canopy. When piñon needles drop to the ground, Romme explained, the tops of the trees are less likely to burn. "We urge managers to resist pressures to launch ambitious salvage or tree-removal operations in the mistaken assumption that the dead trees constitute a serious fire hazard," he wrote. It's the ecologist's constant reminder: Every forest is a little different from its neighbor; every year is a little different from the last. Everything is a lot more complicated than we think.

USDA FOREST SERVICE, ROCKY MOUNTAIN REGION ARCHIVES

Whitebark pine seedling

The whitebark pine — the sentinel of the high mountains, the supporter of ecosystems — confronts an especially fierce predicament. It's dealing with multiple serious threats: The suppression of forest fires has interrupted the regular handoff between sun-loving whitebark pines and shade-loving spruce-fir communities, allowing spruce and fir to dominate. White pine blister rust, a fatal disease, has spread throughout the range of the whitebark pine and related tree species since it was introduced to North America from Europe around 1900. The Forest Service, in cooperation with university researchers, has begun a painstaking effort to find and breed rust-resistant trees; that work, however, is now jeopardized by the mountain pine beetle.

"Our main worry is that trees resistant to blister rust are not resistant to mountain pine beetles," says Diana Tomback, a professor at the University of Colorado at Denver and a longtime whitebark pine researcher. "Here you have the cornerstone of a restoration program, and they can be killed by mountain pine beetles in a year." Rust-resistant trees can be protected from beetles with insecticides, or with pheromone traps that draw beetles away from the trees. But these labor-intensive measures are impractical on a broad scale.

For the whitebark pine, fire suppression, blister rust and mountain pine beetles may turn out to be the least of its problems. Beetles aren't the only organisms responding to warming temperatures, of course; their short lifespan just allows them to react more quickly to changing conditions. Under most climate-change scenarios, forest types are predicted to shift uphill, implying that the forest that regenerates after a modern-day beetle kill may look very different from the one that came before it. In a 1991 study of whitebark pine communities in Yellowstone National Park, ecologist Romme found that the lower limit of the whitebark pine zone would move up about 1,500 feet if the concentration of carbon dioxide in the atmosphere were to double. That scenario may sound far-fetched, but the IPCC now says that, under certain conditions, the atmospheric carbon dioxide concentration in the year 2100 could be anywhere from 1.5 to 2.6 times greater than it was in the year 2000. Romme says that whitebark, usually found just below treeline, would then be "crowded into smaller and smaller portions of the landscape" on mountaintops. Where there's nowhere to go but up, the effects of a warming planet will be speedy and cruel.

Scientists and managers who think about climate change often talk about managing for "resilience," about helping natural processes withstand major climate shifts and other stresses. In extreme cases, like that of the whitebark pine, resilience may be a good idea come much too late. Even in less dire situations, managing for resilient forests, grasslands or tundra requires a specialized — and very rare — sort of knowledge. "For my forest, I think I know what makes it stable and resilient," says Nate Stephenson, a researcher at Sequoia-Kings Canyon National Park in California. "But I've been here 25 years."

Westerners are notorious for frontier nostalgia, but we no longer have to look to the past — or, for that matter, to Hollywood blockbusters — for thrills. We're on the edge of a very real, and very daunting, modern frontier. During a recent conference of climate scientists on the shores of Lake Tahoe, Swiss scientist Harald Bugmann commented on the now-visible effects of rising temperatures on Western mountains. "I am sorry for where you are," he said in German-accented English. Then, he pointed out one bright spot: Beetle outbreaks and other unsettling phenomena may finally grab the public's attention.

In the West, Bugmann explained with a small smile, we don't have to wait to witness the consequences of global warming. Today, he said, *is* the day after tomorrow.

Jesse Logan Forest Service, Rocky Mountain Research Station, 435-755-3573

Whitebark Pine Ecosystem Foundation www.whitebarkfound.org

Intergovernmental Panel on Climate Change www.ipcc.ch

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SCIENCE FROM

THE WILDERNESS SOCIETY

00123

Wildlife at a Crossroads:

Energy Development in Western Wyoming

EFFECTS OF ROADS ON HABITAT IN THE UPPER GREEN RIVER VALLEY

By
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THE WILDERNESS SOCIETY

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This science report is one of a series that stems from conservation research studies conducted by The Wilderness Society's Ecology and Economics Research Department. Other reports in the series that focus on issues relevant to this report include:

- **Fragmenting Our Lands:** The Ecological Footprint from Oil and Gas Development (A Spatial Analysis of a Wyoming Gas Field)
- **Energy & Western Wildlands:** A GIS Analysis of Economically Recoverable Oil and Gas
- **Ecological Effects of a Transportation Network on Wildlife:** A Spatial Analysis of the Upper Missouri River Breaks National Monument
- **Protecting Northern Arizona's National Monuments:** The Challenge of Transportation Management

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Preface

Wyoming's Upper Green River Valley, an undulating expanse of sagebrush hemmed by scenic mountain ranges, harbors a wildlife resource of national significance. It is the winter destination for some of the largest and longest-migrating bands of mule deer and pronghorn in the nation, as well as a year-round home for Greater Sage-Grouse, one of the West's signature game birds and a species whose future is far from certain.

Yet the vast reservoir of natural gas that lies beneath this vital habitat means that these species must share their home with the infrastructure of a natural gas boom. In the past decade the valley has been punctured by thousands of wells and crisscrossed by a sprawling web of roads and pipelines. With the recently approved and pending permits for natural gas drilling, industrial development and road construction will surely accelerate in the years to come.

The Wilderness Society's report, *Wildlife at a Crossroads: Energy Development in Western Wyoming*, examines the effect of the transportation network on four of the Upper Green River Valley's signature species: mule deer, pronghorn, elk, and Greater Sage-Grouse. Authors Dr. Janice Thomson, Nada Culver, and Peter Aengst, in collaboration with Tim Schaub of CommEn Space, have generated a spatial analysis to demonstrate the impact of these roads on wildlife. Their findings provide compelling evidence that transportation routes, many of them associated with natural gas development, have already carved the landscape into disparate fragments of habitat.

The Bureau of Land Management, which oversees much of the land and even more of the subsurface mineral rights in the valley, is currently preparing a land-use plan that will guide the management of this area over the next 15 to 20 years. The planning process presents a significant window of opportunity for the conservation community. Our influence on the final plan may help decide whether some of America's world-class wildlife populations remain viable or not.

The authors have presented detailed recommendations to guide the agency as its planning process moves forward. Their comprehensive list of strategies includes specific criteria for closing and reclaiming some roads and restricting traffic on others in order to enhance species protection. The steps outlined herein point the way toward achieving a balanced solution for Wyoming's magnificent Upper Green River Valley, where profitable energy development and healthy wildlife populations can coexist far into the future.

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Acronyms and Abbreviations

ACEC	Area of Critical Environmental Concern
BLM	Bureau of Land Management
EIS	Environmental Impact Statement
FLPMA	Federal Land Policy and Management Act
GIS	Geographic Information System
NEPA	National Environmental Policy Act
ORV	Off-road vehicle
RMA	Resource Management Area
RMP	Resource Management Plan
WGFD	Wyoming Game and Fish Department

Report Highlights

The Bureau of Land Management (BLM) is currently revising a Resource Management Plan (RMP) that will shape management of the Pinedale Resource Management Area (RMA), in western Wyoming, over the next 15 to 20 years. The Pinedale RMA includes the Upper Green River Valley, winter habitat for over 100,000 pronghorn, mule deer, elk, bighorn sheep, moose, and other big game. The valley also contains winter habitat and mating, nesting, and brood-rearing areas favored by Greater Sage-Grouse, one of the West's signature game birds and a species whose future is far from certain.

In its RMP revision, the BLM faces the delicate task of balancing the needs of the world-class wildlife populations of the Upper Green River Valley with development of some of the nation's most productive onshore natural gas fields, which occur in the same area. Scientific studies have shown that the infrastructure of natural gas development — wells, drill pads, roads, pipelines, and other features — can harm wildlife populations, displacing them from preferred areas, making them more vulnerable to predation, and reducing the effectiveness of habitat for forage, breeding, or other life functions. While the direct effects of oil and gas drilling may be limited to the physical footprint of roads and well pads, the complex web of these structures across the landscape causes indirect and cumulative effects on habitat quality and connectivity that extend well beyond the physical structures and can last long after gas extraction is completed.

In this report, we present a spatial analysis of the existing transportation network in a 2.9-million-acre area of the Pinedale RMA where both the crucial habitat for big game and Sage-Grouse and the area's largest natural gas fields are concentrated. This analysis, which uses Geographic Information System (GIS) route datasets provided by the BLM, reveals that the Upper Green River Valley's crucial habitat is already severely fragmented by transportation routes. Findings suggest that the current level of development is sufficient to have a negative impact on the four wildlife species assessed — pronghorn, mule deer, elk, and Sage-Grouse. Key findings include:

- The lower-elevation lands in the Pinedale RMA that are most important for wintering big game and wintering and breeding Sage-Grouse have the highest route densities, smallest core areas, and shortest average distance-to-route values in the study area.
- The current transportation network is most extensive within the oil and gas fields, particularly the Jonah Field, which is the most heavily developed field with 95 percent of its area having route densities greater than 2 mi/mi^2.
- Eighty percent of pronghorn crucial winter range has route densities higher than 1 mi/mi^2, which is suggested by the BLM to adversely affect this species.
- Sixty-six percent of elk crucial winter habitat has route densities greater than 1 mi/mi^2, a level of development that has been suggested to severely restrict elk habitat in open landscapes.
- All Greater Sage-Grouse leks (courtship/mating areas) in the study are within 3 miles of a road, the distance from surface disturbance recommended for seasonal closures to preserve breeding functions.

Given the rapid recent development of new roads and infrastructure for oil and gas development in the Upper Green River Valley, and the likelihood that the transportation network will increase as development proceeds in the coming years, the BLM is now at a critical juncture in deciding the long-term fate of key habitat for the nationally significant wildlife populations found there. We urge the BLM to adopt,

▼ The Upper Green River Valley's crucial winter habitat is already severely fragmented by transportation routes. ▲

through its upcoming RMP revision, a responsible transportation plan that will improve the Pinedale RMA's long-term ecological health and integrity while providing for balanced public access and use of the landscape and its resources.

The analysis used to create this report and the results generated can and should be used by the BLM to make sound, science-based decisions in revising the Pinedale RMP, in designating or limiting areas for further development, and in determining those areas where roads should be closed or subject to limited use. A number of specific recommendations are derived from the spatial analysis conducted in the present study:

- Develop and implement route closure and reclamation plans to restore and maintain critical big-game habitat and habitat linkages:
  - Mule deer: Increase the amount of core area greater than 1,542 feet from a route within crucial winter range and along migration corridors.
  - Pronghorn: Increase the amount of core area greater than 3,168 feet from a route and reduce route densities below 1 mi/mi^2 within crucial winter range and along migration corridors.
  - Elk: Reduce route densities below 1 mi/mi^2 within crucial winter range and along migration corridors.
- Prohibit drilling and surface occupancy in big-game wintering areas between November 15th and April 30th.
- Implement seasonal traffic restrictions on all roads within 656 feet of Sage-Grouse winter habitat (9:00 am to 5:30 pm, mid-November through March), within 3 miles of breeding and nesting areas (9:00 am to 5:30 pm, March through mid-May), and in brood-rearing areas (9:00 am to 5:30 pm, June through mid-July). Impose a speed limit of 30 miles per hour during non-restricted hours.

These species-specific recommendations should be combined with more general provisions to benefit all wildlife species in the area, such as requiring directional drilling and cluster development; planning for staged development of energy resources; restricting new roads and energy development; allowing few exceptions to temporal occupancy restrictions; designating Areas of Critical Environmental Concern (ACECs); imposing rigorous standards for ecological restoration of closed routes; and continuing to research the effects of the transportation network on wildlife species and using this knowledge in adaptive management. Profitable natural gas extraction and healthy wildlife populations can coexist in the Pinedale RMA, but only if the BLM adopts measures to close and reclaim unnecessary transportation routes and regulate the remaining ones to minimize their impacts on wildlife.

▼
A responsible transportation plan will improve the Pinedale RMA's long-term ecological health and integrity while providing for balanced public access.
▲

1. Introduction

The Upper Green River Valley in western Wyoming contains a prime example of the vital and threatened sagebrush ecosystem of the western United States (Knick et al. 2003, Wyoming Game and Fish Department (WGFD) 2004). Sagebrush steppe and grassland habitats in the lower elevations of the valley are surrounded by the forested slopes of the Wyoming Range to the west, the Wind River Range to the east, and the Gros Ventre Range to the north. Much of the valley falls within the Bureau of Land Management's (BLM) 4.8-million-acre Pinedale Resource Management Area (RMA) (Figure 1).

The Upper Green River Valley contains crucial habitat for big-game species including pronghorn (*Antelocarpa americana*) (Figure 2), mule deer (*Odocoileous hemionus*) (Figure 3), elk (*Cervus elaphus*) (Figure 4), bighorn sheep (*Ovis canadensis*), and moose (*Alces alces*). Wyoming has by far the greatest concentration of pronghorn of any North American state or province, and the Green River Valley holds the highest concentration of this animal in Wyoming (BLM 2000).

Over 100,000 big-game animals winter in the Upper Green River Valley (Berger 2004a), the largest block of publicly owned winter range for big game in the 19-million-acre Greater Yellowstone Ecosystem. The valley also contains birthing areas used by pronghorn and mule deer.

The Upper Green River Valley contains important big-game migration routes. Round-trip migration distances documented in the valley range from 62 miles for moose and 137 miles for elk to 186 miles for mule deer and 311 miles for pronghorn (Berger 2004b). The annual journey of herds of mule deer and pronghorn from Grand Teton National Park and nearby national forest lands to snow-free areas of the Upper Green River Valley containing crucial winter forage represents North America's longest big-game migration outside the Arctic (Sawyer and Lindzey 2000, Berger 2004a). Archaeological evidence indicates that the pronghorn migration has continued uninterrupted for more than 6,000 years (Sawyer and Lindzey 2000). Berger (2004a) has proposed formally designating a national migration corridor to acknowledge and protect this unique phenomenon.

The Pinedale RMA also contains one of the largest populations of Greater Sage-Grouse (*Centrocercus urophasianus*) in the western United States (Braun 1998). This species has recently declined throughout western North America and in Wyoming in particular (Braun 1998, Connelly and Braun 1997). The BLM has demonstrated its concern for the species by establishing a National Sage-Grouse Habitat Conservation Strategy, a comprehensive approach to the management of Sage-Grouse habitat on public lands.

Because sagebrush is slow to regenerate following disturbance, conservation of sagebrush habitat is critical for the success of Sage-Grouse (Knick et al. 2003). Sage-Grouse are a meaningful indicator

IMAGE PROVIDED BY SKYTRUTH

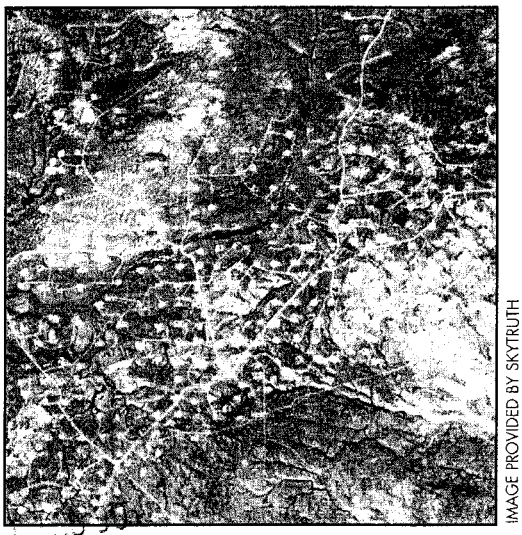


IMAGE PROVIDED BY SKYTRUTH

Landsat satellite images of the Jonah Gas Field in 1999 (left) and 2002 (right) illustrate the rapid expansion of new roads and infrastructure for oil and gas development that has been occurring in the Pinedale RMA.

PHOTO BY JON CATTON

The Upper Green River Valley of western Wyoming provides crucial breeding and wintering habitat for Sage-Grouse, as well as wintering and birthing areas for big-game species such as mule deer, elk, and pronghorn. Ancient big-game migration routes crisscross the valley, at times passing through bottlenecks or "pinch points" where physiographic constrictions force herds to travel along relatively narrow corridors. Additional road-building or other human activity at these pinch points could sever big-game migration routes and jeopardize populations of these species.

of the ecological health of sagebrush steppe habitat because they depend on sagebrush throughout their life processes. During the winter months, for example, Sage-Grouse are totally dependent on sagebrush for food and cover (Lyon 2000). The Pinedale RMA provides important winter habitat for Sage-Grouse, with wind-scoured slopes and ridge tops that ensure year-round sagebrush exposure. The Pinedale RMA also contains important complexes of Sage-Grouse breeding habitat, the availability of which limits populations of Sage-Grouse in many areas (WGFD 2004). Sage-Grouse habitat and lek (courtship/mating area) locations in the Pinedale RMA are shown in Figure 5.

In addition to its importance for wildlife species, the sagebrush ecosystem in Wyoming also supports the region's cultural heritage; scientific research; hiking, hunting and other recreational pursuits; and the local economy. Notably, wildlife-associated spending is Wyoming's second-largest source of income, bringing in $500 million annually (WGFD 2004).

However, the same Upper Green River Valley lands that provide this outstanding wildlife habitat and important cultural values also contain some of the largest and most productive onshore natural gas fields in the nation. With escalating pressures to develop domestic energy supplies, oil and gas production in southwestern Wyoming has grown rapidly. Over 8,500 well sites have already been drilled on public lands in the region, and another 10,000 to 15,000 are forecast over the next decade (Berger 2004a). In fact, energy production in the Pinedale RMA is further accelerating due to Presidential Order 13212, which requires federal agencies to expedite permitting and other reviews for approval of energy development projects (Berger 2003).

Substantial infrastructure and human activity are associated with energy development in the Pinedale RMA. For example, the Environmental Impact Statement (EIS) for the Pinedale Anticline Natural Gas Project (BLM 2000) projects that up to 276 miles of roads will be built or upgraded during development of the Pinedale Anticline Field. The EIS estimates traffic at 702 round trips per well over the 80-day drilling and construction phase, followed by 100 trips per year during the production life of the well, or 168 trips per day for the entire field of 500 wells. Similarly, the Jonah II Natural Gas Project EIS projects up to 180 miles of new or upgraded access roads, with 421 round trips per well during construction and another 739 trips over each well's production life (or a total of 521,900 trips for the 450-well field over its 20-year life) (BLM 1998). The road mileage for the Jonah Field is expected to increase substantially under a new development plan in preparation at the time this report went to press.

Surface ownership of the lands in the Pinedale RMA is held by a variety of entities. The higher-elevation lands are primarily managed by the U.S. Forest Service, while the lower-elevation areas are a patchwork of BLM and private ownership, with limited state holdings. However, across surface ownerships, the BLM controls substantial portions of the subsurface mineral rights and the development of oil and gas resources in the Pinedale RMA.

The BLM has a responsibility to manage the landscape for wildlife, energy development, and many other purposes. The agency is in the process of revising its Resource Management Plan (RMP) for the Pinedale RMA, which will set the terms for management over the next 15 to 20 years. The planning process will require the BLM to assess various alterna-

tives for management and use of the public lands within the Pinedale RMA, and is guided by the BLM's obligations under the Federal Land Policy and Management Act (FLPMA) and the National Environmental Policy Act (NEPA).

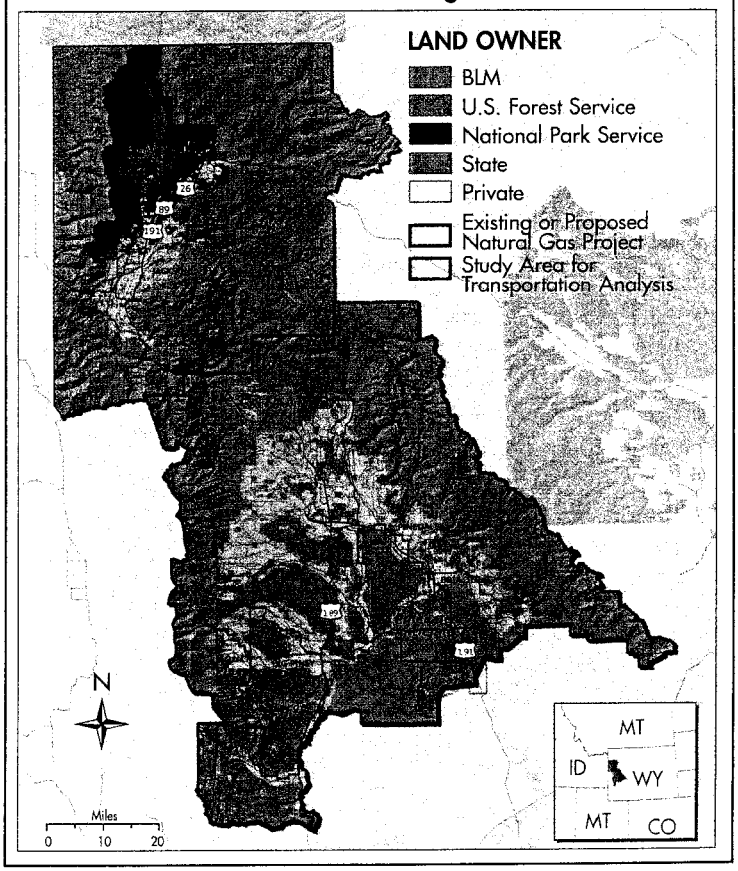
FLPMA requires the BLM to "manage the public lands under principles of multiple use and sustained yield," in a manner that will "minimize adverse impacts on the natural, environmental, scientific, cultural, and other resources and values (including fish and wildlife habitat) of the public lands involved."[1] In developing management plans, the BLM must take into account physical, biological, economic, and other sciences; give priority to the designation and protection of Areas of Critical Environmental Concern (ACECs); and give consideration "to the relative values of the resources and not necessarily to the combination of uses that will give the greatest economic return."[2] NEPA dictates that the BLM take a "hard look" at the environmental consequences of a proposed action, and the requisite environmental analysis "must be appropriate to the action in question."[3] The impacts and effects of a proposed action, such as oil and gas development, that the BLM is 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."[4]

Oil and gas development in the Upper Green River Valley could threaten wildlife populations by fragmenting and causing disturbance in the crucial winter habitat, birthing areas, and migration corridors of big-game species, and in the winter habitat, lekking areas, nesting sites, and rearing areas for Sage-Grouse. For example, compromising winter habitat for big game in the valley could affect ungulate populations in five surrounding western Wyoming mountain ranges (Sawyer et al. 2004). Migration corridors are also vulnerable, particularly at "pinch points" where physiographic constrictions force herds through relatively narrow corridors (Berger 2004a). Loss of habitat continuity due to human activity along migration routes would severely restrict the seasonal movements necessary to maintain healthy big-game populations (Sawyer and Lindzey 2000, 2001). In addition, unguided energy development will further depress declining Sage-Grouse populations throughout the West. However, prudent management that limits habitat fragmentation and disturbances from human activity along roads could give the species an opportunity to maintain if not increase its numbers.

However, the direct and indirect impacts of energy development on

FIGURE 1.

Surface Ownership Within the Pinedale Resource Management Area



1 43 U.S.C. §1732.

2 43 U.S.C. § 1712; 43 C.F.R. § 1601.0-5(f).

3 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).

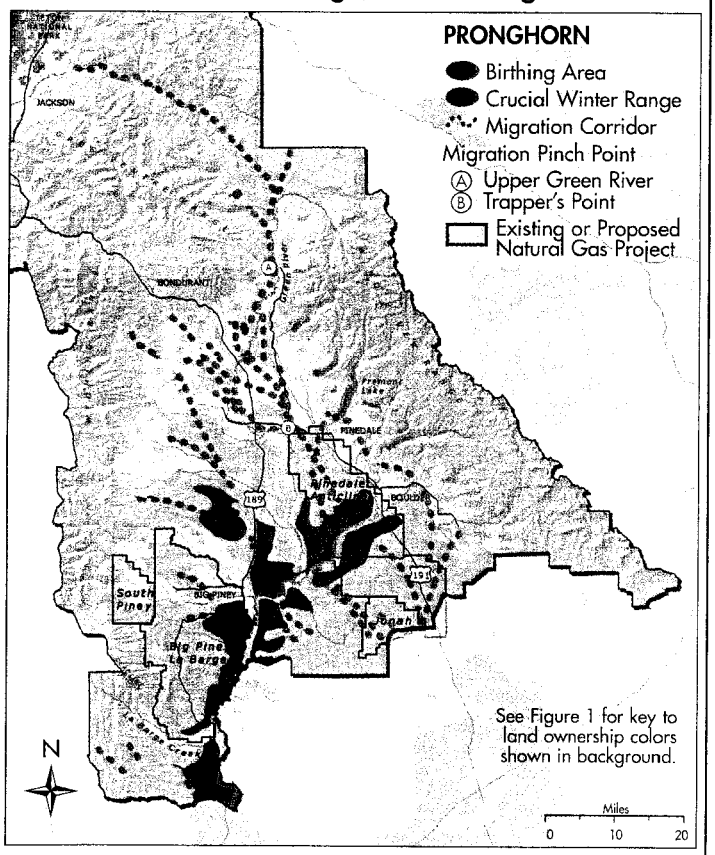
4 40 C.F.R. § 1508.8.

wildlife are poorly understood (Sawyer and Lindzey 2004). Continued research and monitoring by wildlife management agencies, the BLM, and biologists at other institutions will be critical to designing a sustainable wildlife management strategy for the Pinedale RMA.

This report documents the intensity, extent, and spatial arrangement of wildlife impacts of the transportation network associated with oil and gas development in the Pinedale RMA. While the direct impacts from oil and gas drilling may be limited to the physical footprint of roads and well pads, the complex web of these structures across the landscape causes much broader, indirect effects on habitat quality and connectivity. Thus, a full understanding of the impact of oil and gas development on the region's wildlife requires an assessment of the spatial distribution of roads and other transportation routes (in both the areas subject to BLM management and the areas outside the agency's jurisdiction), combined with the latest wildlife research on the effects of roads and other infrastructure on specific wildlife species.

FIGURE 2.

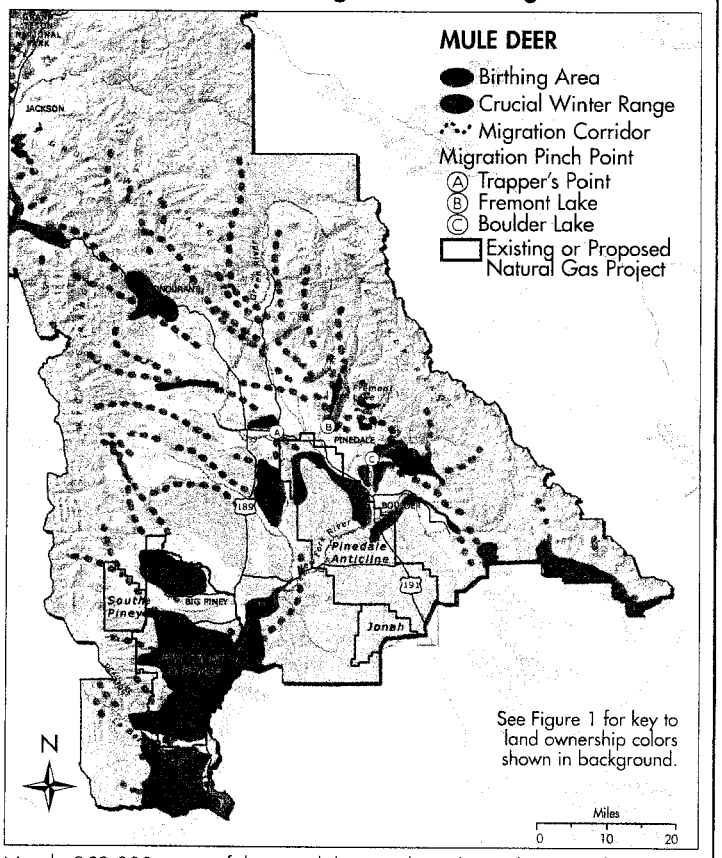
Pronghorn in the Pinedale Resource Management Area: Migration Corridors, Crucial Winter Range, and Birthing Areas



Over 170,000 acres of the Pinedale RMA have been designated as pronghorn crucial winter range by the Wyoming Game and Fish Department. More than 125,000 acres of that winter range fall on BLM lands. Another 23,000 acres of the RMA are designated as birthing areas, of which 22,000 acres fall on BLM lands.

FIGURE 3.

Mule Deer in the Pinedale Resource Management Area: Migration Corridors, Crucial Winter Range, and Birthing Areas



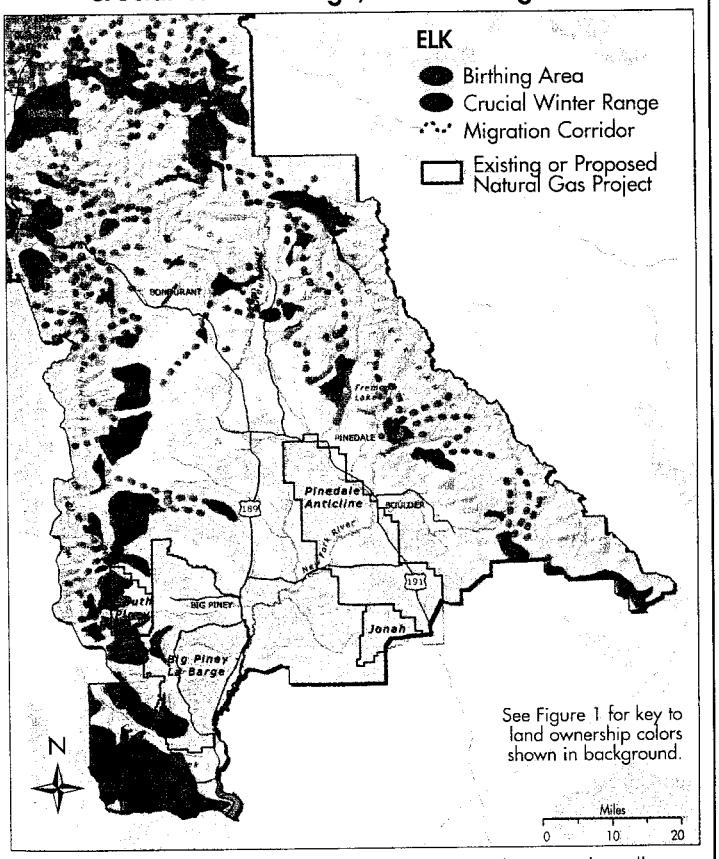
Nearly 350,000 acres of the Pinedale RMA have been designated as mule deer crucial winter range by the Wyoming Game and Fish Department. Over 200,000 acres of crucial winter range fall on BLM lands. More than 80,000 acres in the RMA serve as birthing areas, with 14,000 of those acres on BLM lands.

The methods and results of this report represent one of the major topics of information needed to design future management strategies in the Pinedale RMA. This report details a recommended process for assessing the ecological impact of roads on big game and Sage-Grouse, shows the feasibility of performing such an analysis as part of the Pinedale RMP revision, and demonstrates the importance of using the results in evaluating management alternatives.

The Pinedale RMA was selected for this spatial evaluation of the impacts of energy development on wildlife because of its abundant and actively studied wildlife populations, its highly developed oil and gas fields, and the ongoing public planning process that will set the terms for energy development over the next 15 to 20 years. The analysis used to create this report and the results generated can and should be used by the BLM in revising the Pinedale RMP, in designating or limiting areas for further development, and in determining those areas where transportation routes should be closed or subject to limited use. The methods should also serve as an example for other energy development sites.

FIGURE 4.

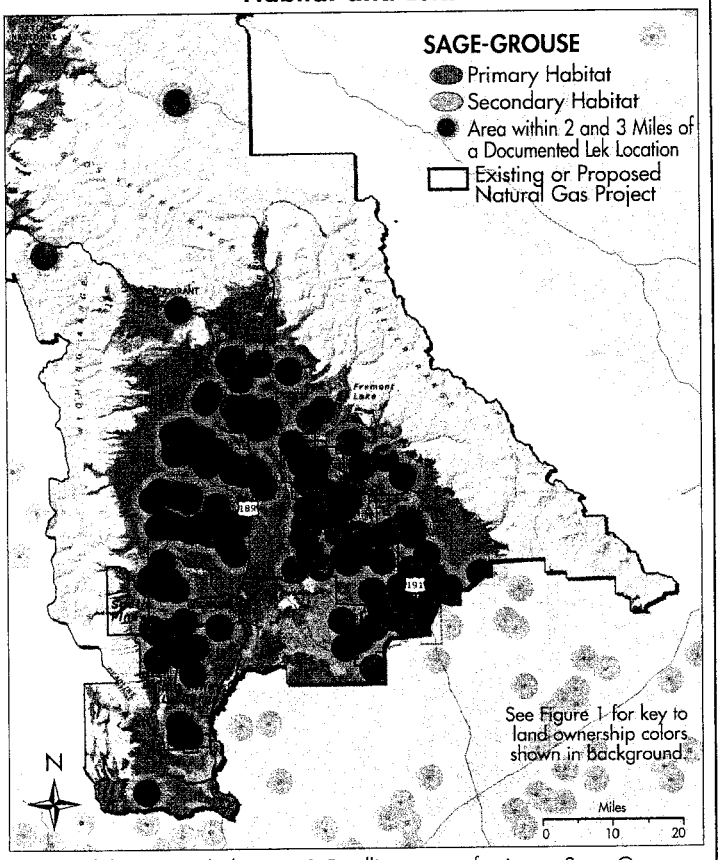
Elk in the Pinedale Resource Management Area: Migration Corridors, Crucial Winter Range, and Birthing Areas



Over 198,000 acres of the Pinedale RMA have been designated as elk crucial winter range by the Wyoming Game and Fish Department. More than 105,000 acres of that winter range fall on BLM lands. Another 354,000 acres of the RMA are designated as birthing areas, of which 62,000 acres fall on BLM lands.

FIGURE 5.

Sage-Grouse in the Pinedale Resource Management Area: Habitat and Leks



The Pinedale RMA includes over 1.5 million acres of primary Sage-Grouse habitat and about 200,000 acres of secondary habitat. Forty-nine of the 151 documented lek locations in the area fall within the Pinedale Anticline and Jonah gas field boundaries. In addition, over 470,000 acres of BLM land in the area are within 2 miles of a lek, and 595,000 acres of BLM land are within 3 miles of a lek.

Defining a "Road"

In this report, the terms "routes" and "transportation routes" refer to all linear features used by motorized vehicles, including "roads." However, the term "road" holds a precise legal definition with important management implications. Many but not all routes in the BLM's transportation dataset used in this analysis meet the definition of a road.

Within the Pinedale RMA, roads must meet criteria established in Title 43, Part 19.2(e) of the Code of Federal Regulations — "an improved road that is suitable for public travel by means of four-wheeled, motorized vehicles intended primarily for highway use." In addition, the legal definition of a road, according to the U.S. Department of the Interior, is derived from the definition of "roadless" in the legislative history of FLPMA: "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)).

2. Methods

Study Area

This study focuses on the impact of roads and other transportation routes on wildlife in the lower-elevation areas of the Pinedale RMA that encompass most BLM surface ownership. The study area is roughly the southern half of the Pinedale RMA, which includes what residents and land managers consider the "Upper Green River Valley." The study area accounts for about 2.9 million acres of BLM, U.S. Forest Service, state, and private lands within the 4.8-million-acre Pinedale RMA. It encompasses the portion of the Pinedale RMA within Lincoln, Sublette, and Fremont counties. The full Pinedale RMA, the study area boundaries, and surface ownership patterns within the Pinedale RMA are shown in Figure 1. The acreage of surface lands by ownership type within the study area is shown in Table 1.

The BLM has subsurface management authority, and thus authority over energy development, over 1.2 million acres of the study area. This includes the 992,370 acres that the agency manages at the surface, as well as additional "split estate" lands managed by state or private entities at the surface and by the BLM for subsurface energy development. Gas fields evaluated in this study include Jonah, Pinedale Anticline, and South Piney. These three gas fields are the current focus of industry development. They are either recently permitted or, in the case of South Piney, soon to be permitted.

Data Collection

Data representing the transportation network in the Pinedale RMA were obtained from the BLM Pinedale Field Office. This dataset is an updated version of the TIGER[5] road dataset and includes additional routes digitized by Geographic Information System (GIS) staff at the BLM. Significant edits were made to the BLM dataset to remove duplicate records. The dataset is in the process of being updated by the BLM. Because this dataset includes roads and some, but not all, additional transportation routes that may not legally be considered "roads," we will use the more inclusive term "routes" or "transportation routes" when discussing this dataset. (See sidebar, page 8: Defining a "Road.") Though the agency has digitized some user-created two-tracks and other routes, this dataset has not been completed, and thus our analysis represents a conservative assessment of the actual transportation network. Additional administrative data were collected from the Pinedale BLM Field Office including the field office boundary, surface ownership boundaries, and gas field development area boundaries.

All data for big-game species originated from the Wyoming Game & Fish Department (WGFD). Winter range boundaries were used directly as supplied by the WGFD. Big-game birthing areas and migration routes were updated with guidance from a local wildlife biologist with experience in the Pinedale area. The locations of occupied Sage-Grouse leks were collected by the WGFD, and predicted distribution of Sage-Grouse habitat originated from the Wyoming Gap Analysis Project, an interagency mapping effort. While these data layers were the best available at the time this work was conducted, the WGFD will continue to refine many of the habitat boundaries. The statistics documenting the impacts of transportation routes and habitat fragmentation on specific wildlife species that were used to guide our spatial analysis were

[5] Topologically Integrated Geographic Encoding and Referencing (TIGER) data are geographic data for transportation routes from the U.S. Census Bureau.

collected from the scientific literature and will be cited throughout this document.

Habitat Fragmentation Metrics

Fragmentation of habitat affects the ecological composition, structure, and functions of a landscape. Habitat fragmentation has been defined as the "creation of a complex mosaic of spatial and successional habitats from formerly contiguous habitat" (Lehmkuhl and Ruggiero 1991). Although fragmentation can be difficult to measure, we have chosen three landscape metrics to show the degree of fragmentation and the condition of the landscape, and applied them to available data regarding the distribution of wildlife and habitat.

The metrics below were calculated for the entire landscape, as well as within specific surface ownership types, gas fields, and critical wildlife habitat areas. Wildlife habitat boundaries were also used to calculate some basic habitat acreage figures and, for Sage-Grouse, acreages within two and three miles of leks.

Route Density

Route density is a measure of the number of miles of transportation routes per unit area and is a common metric in quantitative assessments of ecological impacts of development from a landscape perspective. The density calculation involves measuring the length of linear transportation features in a given sub-area at regular intervals. For this analysis, the BLM transportation dataset was used to construct a "continuous" measure of route density across the Pinedale RMA. A sample spacing of 1,500 feet was used to measure route length within a 4-square-mile circular sub-area. The result is a grid of density measurements where the value in each 1,500-by-1,500-foot cell is the total length of all routes in the nearest 4 square miles, divided by 4 square miles. Route density distribution curves were plotted to document the percent of the landscape with route densities greater than or equal to any given route density value. Density measurements are reported as miles of routes per square mile (mi/mi^2).

Core Area

In order to characterize the degree of habitat fragmentation, the distribution of unroaded areas, or core areas, was measured for the entire Pinedale RMA. Core areas are defined as land beyond a given distance, or effect zone (Forman 1999), from transportation routes. Different wildlife species respond to disturbances related to a transportation network at varying distances. Thus, the size distribution of core areas was determined for effect zones of 100 ft, 500 ft, 1/4 mile, 1/2 mile, and 1 mile from all routes in our dataset. A map of core areas was then plotted for one of these effect zones, 500 ft.

PHOTO BY PETER AENGST

A plan currently under consideration by the BLM may allow an additional 3,000 wells to be drilled in the Jonah Gas Field, a heavily developed area where wildlife habitat is already severely fragmented.

Distance to Route

Wildlife-related restrictions on road or infrastructure construction and use are commonly given in terms of the distance the feature or activity must be separated from a given wildlife habitat of interest. Measuring the amount of land within a given distance to a transportation route (or route effect zone) is the reverse of measuring core areas. These two habitat fragmentation metrics complement one another and will be discussed together in later sections. To illustrate the amount of land that lies within various distances from transportation routes in the

TABLE 1.

Study Area Land Ownership

	U.S. Forest Service	BLM	Private	State
Area (acres)	1,252,815	922,370	609,134	86,501
Percent of Study Area	44%	32%	21%	3%

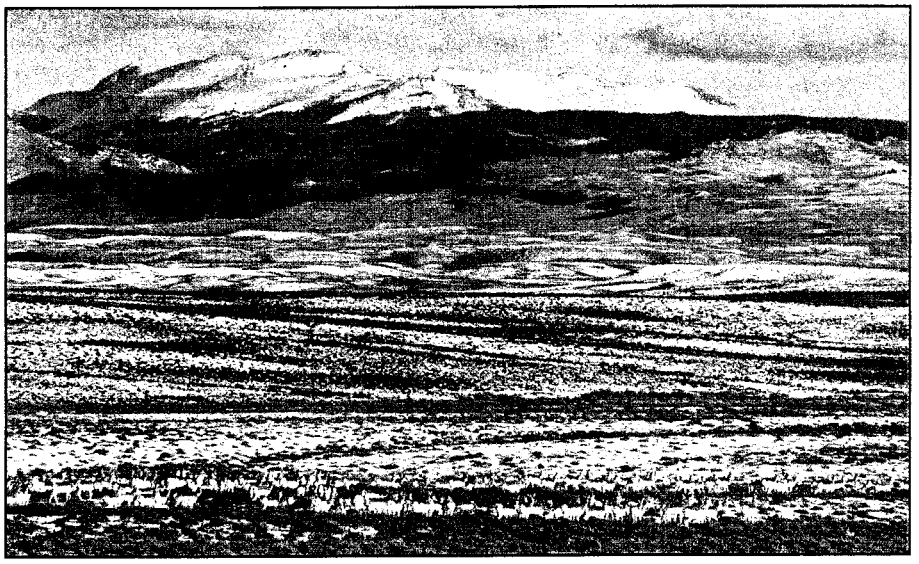


PHOTO BY LINDA BAKER

The Upper Green River Valley represents some of the nation's most important habitat for pronghorn, the only remaining wild ungulate to have evolved in North America and the continent's swiftest land animal.

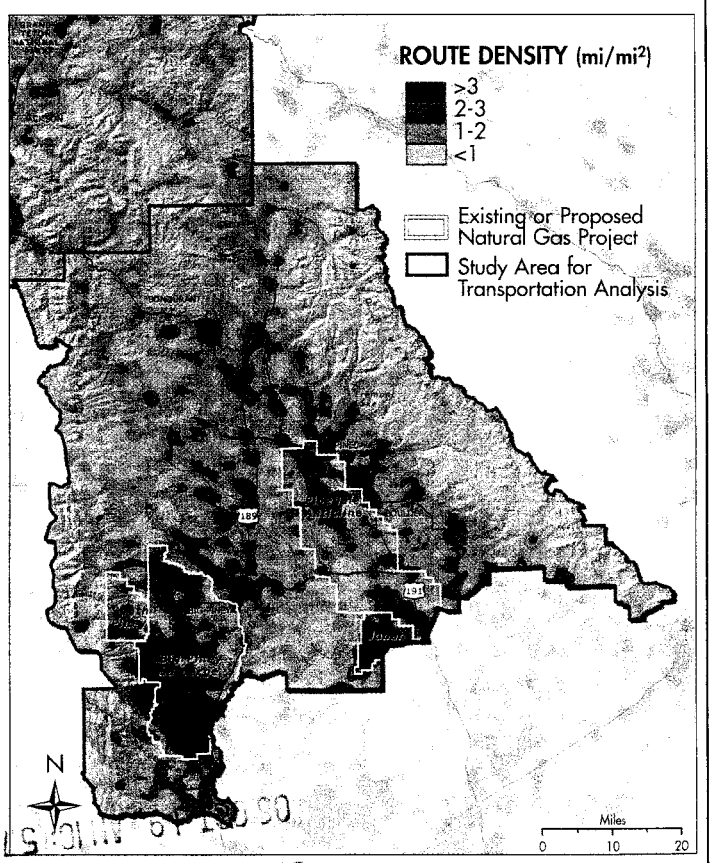
Pinedale RMA, we generated cumulative distance-to-route distribution curves for specific surface ownership types, gas fields, and wildlife habitat areas.

Other Considerations

Note that all measures of habitat fragmentation in this report are conservative because they do not take into account all of the undocumented routes visible in digital air photos of the landscape (Weller et al. 2002), other human infrastructure (e.g., well pads, pumping stations, pipelines, power lines) or natural breaks in the landscape (e.g., steep topography, rivers or washes, breaks in vegetation types). Actual infrastructure densities are likely higher and core area sizes and distances to routes are lower than those captured in this analysis.

In addition, the varying speeds and volumes of traffic on different roads were not taken into account because these attributes were not available for the BLM route dataset. These factors do affect wildlife and are reflected in recommendations in this report. Similarly, seasonal access restrictions were not addressed in the analysis because this information was not in the GIS data and because of imperfect enforcement of and exemptions granted to restrictions. For example, the WGFD has noted, "Seasonal stipulations are only effective if actually applied on the ground. To date, these stipulations have been inconsistently applied among BLM resource areas. Exceptions are routinely granted by some BLM resource areas, at times under what our Department believes are inappropriate circumstances" (WGFD 2004). Specific access restrictions are suggested in the recommendations section.

FIGURE 6.
Transportation Route Densities in the Pinedale Resource Management Area



Eighty percent of BLM lands in the Pinedale RMA have route densities greater than 1 mi/mi². Over 35 percent of BLM lands have densities greater than 2 mi/mi².

3. Results

Route Density Analysis

Route densities vary considerably within the Pinedale RMA (Figure 6). A few key statistics characterize the differences in route densities across various land ownership types. The distribution of route densities is similar for state, private, and BLM lands, but route densities are markedly lower on U.S. Forest Service lands (Figure 7). Eighty percent of BLM lands have route densities over 1 mi/mi^2, and 36 percent of BLM lands have route densities over 2 mi/mi^2. By contrast, only 17 percent of U.S. Forest Service lands have route densities over 1 mi/mi^2.

Route densities within the crucial winter ranges of different ungulate species vary (Figure 8). For example, 66 percent of elk crucial winter range has route densities greater than 1 mi/mi^2. In addition, 80 percent of pronghorn and 89 percent of mule deer crucial winter range have route densities greater than 1 mi/mi^2.

The size and permit year of the Jonah, Pinedale Anticline, and proposed South Piney natural gas fields are summarized in Table 2. Route densities vary among the three fields. The Jonah Field, a fully developed gas field that is being considered for further "in fill" drilling, has the highest route densities. Already 95 percent of its area has route densities greater than 2 mi/mi^2. Route densities

FIGURE 7.

Transportation Route Densities by Land Ownership Type

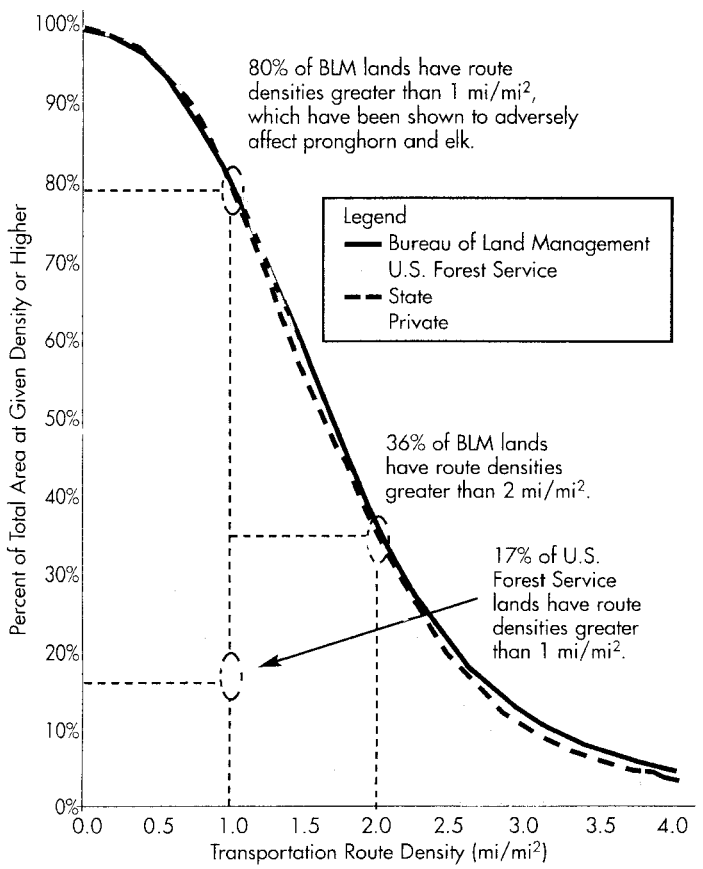
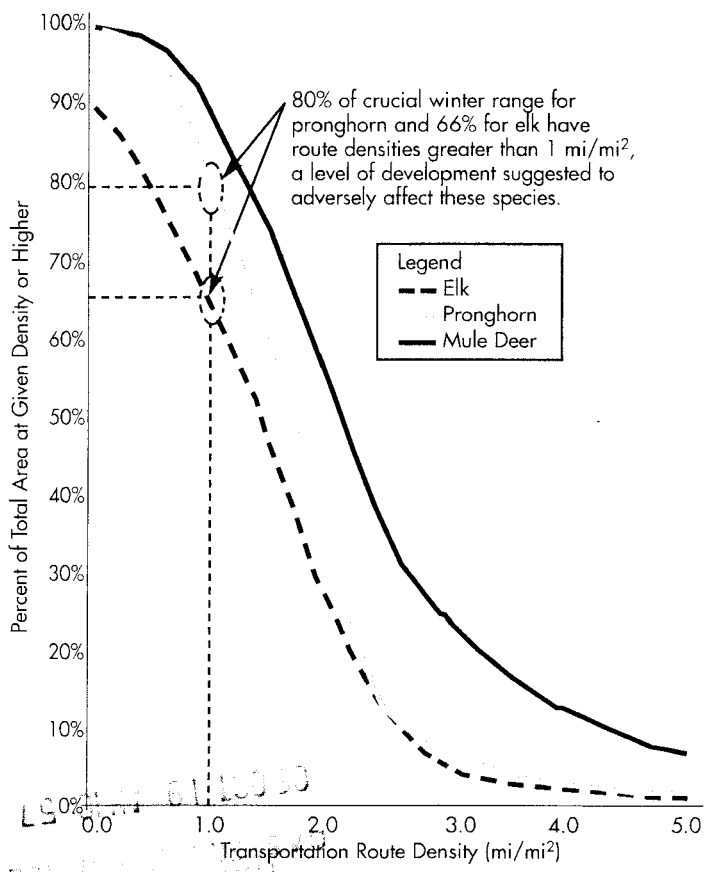


FIGURE 8.

Transportation Route Densities in Pronghorn, Mule Deer, and Elk Crucial Winter Ranges



are lower in the Pinedale Anticline and proposed South Piney gas fields (Figure 9). The Pinedale Anticline is a recently permitted gas field (2000 Record of Decision) where fewer than half the wells permitted have been drilled and half the new miles of road permitted have been bladed to date. The South Piney project is a proposed new gas field that to date has experienced only limited exploratory drilling. An EIS is currently being prepared to evaluate and potentially permit full field development. In both the Pinedale Anticline and South Piney fields, about 45 percent of the development area has route densities greater than 2 mi/mi^2.

TABLE 2.

Gas Field Permit Year and Size

Gas Field	Year Permitted	Field Size (Acres)
Jonah	1998	47,000
Pinedale Anticline	2000	200,000
South Piney	Pending*	30,000

* Permit still pending at time of production of this report.

Core Area Analysis and Distance to Route

The size of core areas — that is, wildlife habitat away from the disturbance of routes — varies substantially across the Pinedale RMA. State, private, and BLM lands are generally much closer to routes and have smaller core areas than Forest Service lands (Figures 10 and 11). About 63 percent of BLM

FIGURE 9.

Transportation Route Densities in Three Gas Fields

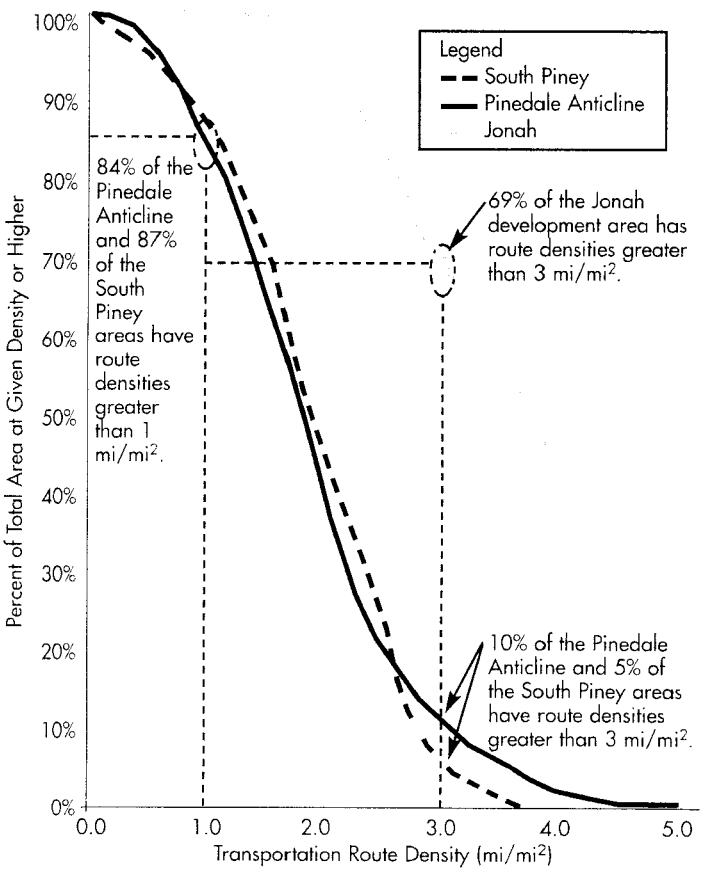
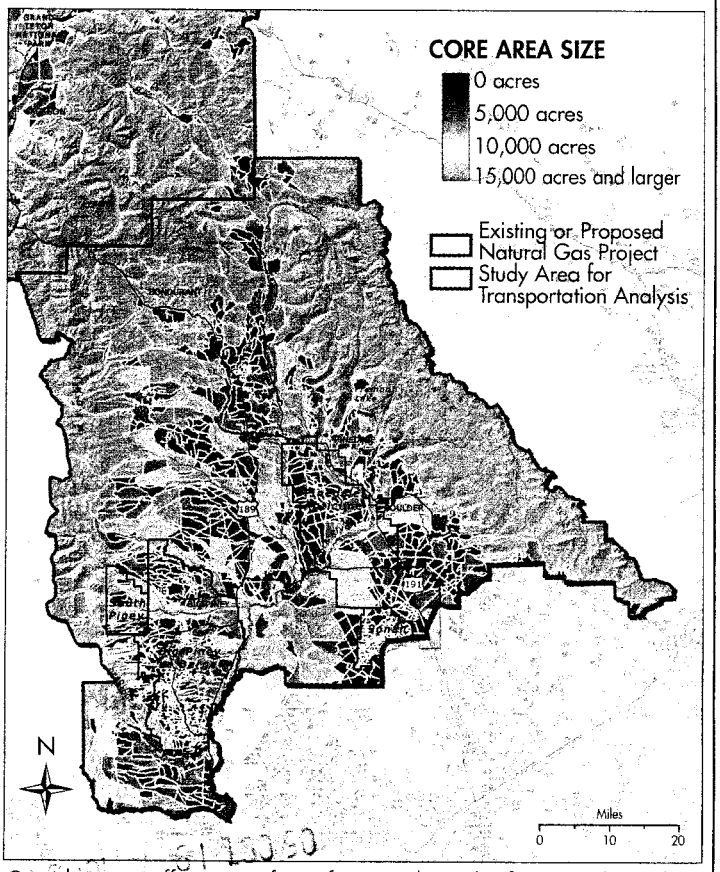


FIGURE 10.

Core Habitat Areas Outside a 500-Foot Transportation Route Effect Zone



Considering an effect zone of 500 feet on either side of a route, the study area is fragmented into 2,021 "unroaded" core areas on BLM lands. These core areas have an average size of just over 300 acres.

land within the study area is closer than $^1/_4$ mile to a route. Less than 20 percent of Forest Service land lies within this same proximity to a route. Notably, 87 percent of BLM land is within $^1/_2$ mile of a route.

Statistics relating to core areas as defined by various route effect zone widths on BLM lands within the study area are shown in Table 3. For example, assuming that effects on wildlife extend 100 feet from a route, 90 percent of the landscape falls within the 2,596 core areas with a maximum patch size of 20,925 acres. Assuming that impacts on wildlife species extend 1 mile from a route, only 2 percent of the landscape falls within the 50 core areas with a maximum patch size of just 5,384 acres. A route effect zone of 500 feet is illustrated graphically in Figure 10, where BLM lands in the study area are fragmented into 2,021 core areas.

TABLE 3.

Characteristics of Core Areas as Defined by Different Route Effect Zone Widths

	Route Effect Zone Width				
Core Areas	100 ft	500 ft	$^1/_4$ mi	$^1/_2$ mi	1 mi
Number	2,596	2,021	1,105	430	50
Max. Acres	20,925	16,268	13,277	7,886	5,384
Min. Acres	<1	<1	<1	<1	<1
Mean Acres	318	305	305	282	323
Total Area in Acres	826,172	616,685	336,526	121,380	16,163
Total Area as Percentage of Study Area	90%	67%	36%	13%	2%

Core area habitat is limited in ungulate crucial winter range (Figure 12). For example, 90 percent of elk crucial winter range is within 1 mile of a route. Eighty-nine percent of pronghorn and 90 percent of mule deer crucial winter habitat are within $^1/_2$ mile of a route. The study also shows little core area in the vicinity of Sage-Grouse leks. Less than 30 percent of Sage-Grouse leks fall within core areas farther than $^1/_4$ mile from a route, and only about 5 percent are farther than $^1/_2$ mile from a route.

Core area habitat is most severely restricted within the study area's gas fields (Figure 13). The Jonah Field is most heavily affected by routes, with about 70 percent of its total area within 600 feet of a route and nearly all of the field within $^1/_2$ mile of a route. In the

IMAGE PROVIDED BY SKYTRUTH

IMAGE PROVIDED BY SKYTRUTH

Landsat satellite images of the Pinedale Anticline Gas Field from 1999 (left) and 2002 (right) show how quickly energy development can transform a landscape.

FIGURE 11.

Cumulative Distributions of Distance to Routes by Land Ownership Type

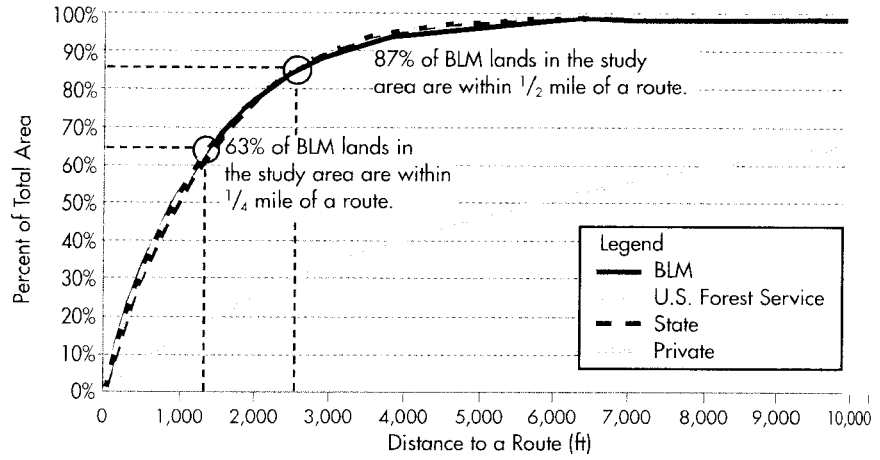


FIGURE 12.

Cumulative Distributions of Distance to Routes in Pronghorn, Mule Deer, and Elk Crucial Winter Ranges

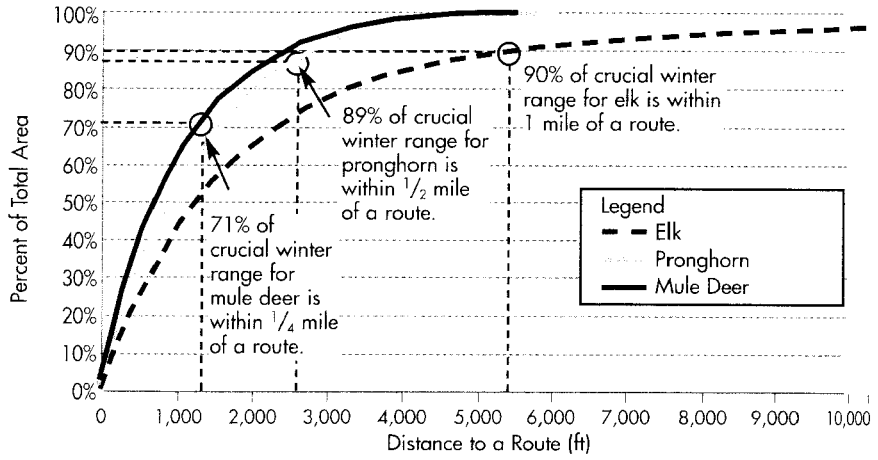
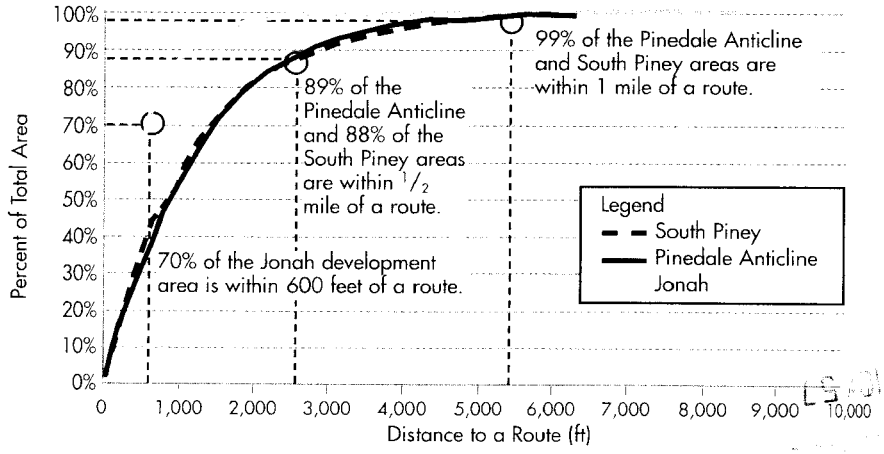


FIGURE 13.

Cumulative Distributions of Distance to Routes for Three Gas Fields



Pinedale Anticline and South Piney fields, nearly 40 percent of the total area is within 600 feet of a route, and just under 90 percent is within 1/2 mile of a route.

4. Implications for Management and Conservation

The nationally significant (WGFD 2004) and locally treasured (Blevins 2004) wildlife populations of the Upper Green River Valley are threatened by habitat loss and fragmentation from roads constructed for energy development. The BLM inventoried a substantial network of roads and other transportation routes, many directly associated with energy development, that fragment wildlife habitat in the Pinedale RMA.

Increasingly, scientists are assembling reviews of the effects of roads, other types of routes, and associated human activities on wildlife (Gucinski et al. 2001, Gains et al. 2003). However, literature on this topic remains relatively scarce for rangeland landscapes. The Wyoming Game and Fish Department has recently completed a report containing guidelines for wildlife protection in areas of energy development (WGFD 2004). It includes a review of the literature on the impacts of roads, other infrastructure, and human activities associated with energy development on sagebrush and grassland habitats and their associated wildlife species in Wyoming.

Many studies have found that the effects of roads and other infrastructure extend well beyond the physical footprint of the feature (Lyon and Christensen 2002, Lutz et al. 2003, WGFD 2004). The effects on terrestrial and aquatic wildlife include mortality from collisions, modifications of animal behavior (and effects on energetics), disruption of the physical environment, alteration of the chemical environment, fragmentation of connected habitats, spread of exotic species, and changes in human use of lands and water (Trombulak and Frissell 2000, Lutz et al. 2003).

More specifically addressing the infrastructure of energy development, the Wyoming Game and Fish Department

PHOTO BY JOHN FANDEK

Elk that winter in the Upper Green River Valley face reduced habitat effectiveness from the current network of roads and energy development.

report states: "As densities of wells, roads, and facilities increase, the effectiveness of adjacent habitats can decrease until most animals no longer use the habitat. Although vegetation and other natural features may remain unaltered within areas near oil and gas features, wildlife make proportionately less use of these areas than their availability. Animals attempting to forage inside the affected zones are also subjected to increased physiological stress. The avoidance/stress effect impairs the function by reducing the capability of wildlife to use the habitat effectively" (WGFD 2004).

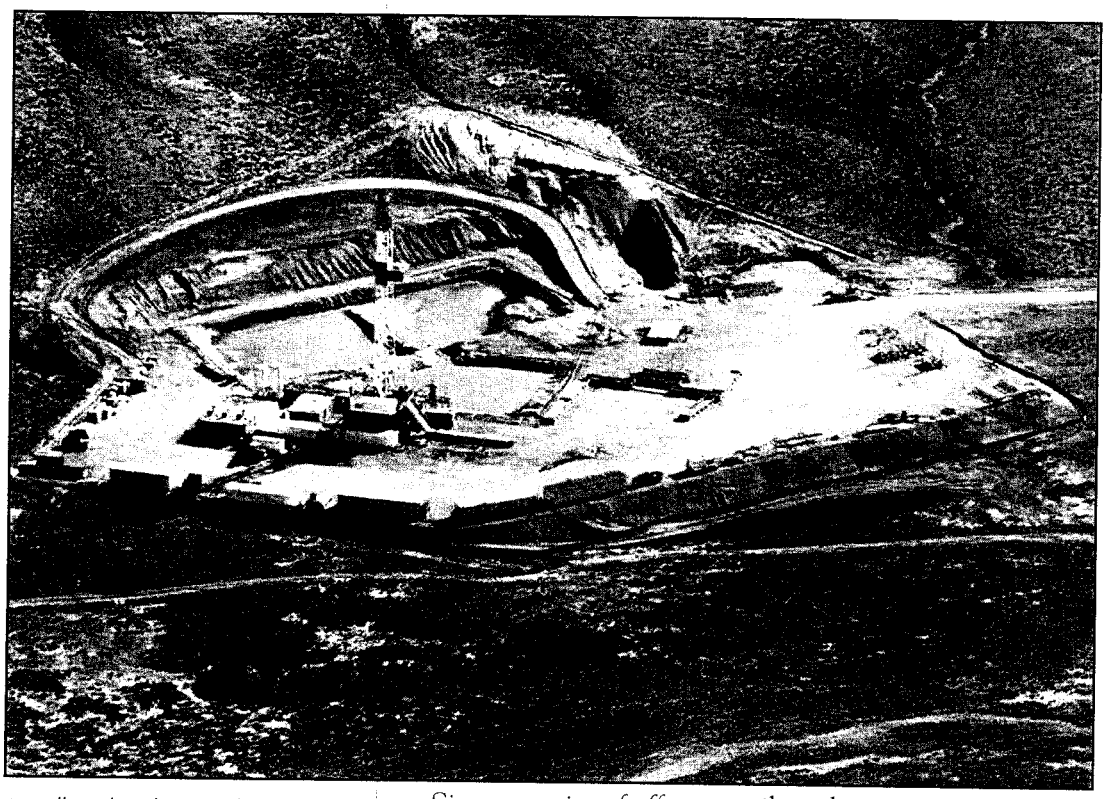


PHOTO BY LLOYD DORSEY/WYOMING WILDLIFE FEDERATION/LIGHTHAWK

A well pad in the Pinedale Anticline Field shows that the impact of natural gas development on habitat is not limited to drill rigs alone. Along with the rigs come waste ponds, spur roads, compressors, storage tanks, and other features — which continue to have effects on wildlife long after natural gas extraction is completed and require substantial reclamation efforts.

Six categories of effects attributed specifically to oil and gas development by the Wyoming Game and Fish Department are: "1) direct loss of habitat, 2) physiological stress to wildlife, 3) disturbance and displacement of wildlife, 4) habitat fragmentation and isolation, 5) introduction of competitive and predatory organisms, and 6) secondary effects created by work force assimilation, growth of service industries, etc." (WGFD 2004).

Implications of Habitat Fragmentation for Wildlife Species

In the present study, the highest route densities and lowest distance-to-route values (i.e., the smallest core areas) are found on the BLM, state, and private lands within the study area (Figures 7 and 11). In fact, route densities and distance-to-route values are very similar for these three land ownership classes. Route densities are lower and distance-to-route values higher on the U.S. Forest Service lands on the east, north, and west edges of the study area. Yet these less-fragmented lands cannot be expected to provide needed habitat for many of the wildlife species on BLM lands because these lands are higher in elevation, provide substantially different vegetative habitat, and experience snow depths that prohibit use by many species during the winter months. The concentration of more-fragmented lands at the lower elevations critical for big-game and Sage-Grouse populations makes evaluating the impact of energy development and managing for sustainable habitat exceedingly important.

While the degree of impact of roads on wildlife is not fully understood, our results indicate that route densities are high enough and distance-to-route values low enough in the BLM route inventory to adversely affect the four wildlife species studied. Comparison of wildlife habitat areas (Figures 2, 3, 4, and 5) with the route density map (Figure 6) and the core area map (Figure 10) illustrates graphically just how abundant routes are in ungulate winter range,

birthing areas, and migratory corridors, as well as around Sage-Grouse leks.

Mule Deer

Energy development has the potential to directly and indirectly impact mule deer and their habitat, possibly leading to reductions in survival and reproductive capacity and potentially limiting the population's ability to sustain itself (Lutz et al. 2003). These effects can extend well beyond the area of the development and continue past the time period of the development (Lutz et al. 2003).

Thirty-five to 77 percent of crucial winter range may be close enough to a road to cause mule deer to alert to or move away from associated human activities.

Rost and Baley (1979) used mule deer pellet counts in north-central Colorado as an indication of winter habitat use, reporting lower density of deer in open, mixed shrub and forest habitat compared to sites with more forest cover. Their data show that deer were three times more likely to occur 984–1,312 feet from a road than 328 feet from a road. Within our study area in the Pinedale RMA, 23 percent of BLM land and 29 percent of mule deer crucial winter range are closer than 328 feet to a route, and thus likely to show relatively reduced use by mule deer.

Another study of female mule deer in sagebrush winter range in north-central Colorado observed response distances to people on foot and on snowmobiles (Freddy et al. 1986). Mule deer were observed to alert to persons on foot and on snowmobiles at 1,096 feet and 1,542 feet, respectively, and to move away from these disturbances at distances of 627 feet and 436 feet. Measuring these response distances relative to routes in the Pinedale RMA reveals that mule deer could be affected by activities on roads in 35 percent to 77 percent of their crucial winter range habitat. This suggests human activity around drill pads in the winter could affect mule deer movements. The WGFD used the alert distance of 1,542 feet to calculate that there is a 29-acre area of reduced habitat effectiveness around each drill pad (WGFD 2004).

While data on mule deer response specifically to energy development are minimal (Lutz et al. 2003), mule deer have been shown to avoid human activity associated with roads and energy production facilities. A study in a North Dakota energy development area observed that active deer used habitat within 316 feet of a road less than its availability, while bedded deer avoided habitat within 158 feet of a road (Fox 1989).

An ongoing study by Sawyer et al. (2004) of Global Positioning System (GPS)-collared deer in the Pinedale Anticline Field found that deer utilized habitat progressively farther from roads and well pads over three years of increasing gas development and showed no evidence of acclimating to energy-related infrastructure. The effects of development were immediate, and areas of "high probability of use" before gas development were used substantially less after development, suggesting that deer may be displaced to less-preferred habitat (Sawyer et al. 2004). Lutz et al. (2003) agree that mule deer can be pressured into using less-preferred or lower-quality habitat, and that this could negatively affect an individual's energy balance "and ultimately decrease population productivity, especially on winter range." Sawyer et al. (2004) further suggest that direct loss of habitat from road and pad construction, combined with indirect loss from changes in habitat quality, may reduce winter range carrying capacity. To date, NEPA-

based monitoring of the impacts of energy development on mule deer has not been sufficient to add to needed knowledge and has not been published in peer-reviewed literature (Sawyer and Lindzey 2004).

Pronghorn

Pronghorn are likely to be affected by the same types of human disturbance as mule deer, but are known to have a more sensitive flight response (WGFD 2004). Based on preliminary results from on ongoing study by Berger and Beckmann (2004) in the Jonah and Pinedale Anticline fields, the WGFD (2004) concludes that migrating pronghorn avoid areas of dense energy development. BLM documents indicate that pronghorn are adversely affected at road densities of 1 mi/mi^2 (BLM 1999). Eighty percent of BLM lands and 80 percent of pronghorn crucial winter range in the study area have road densities greater than 1 mi/mi^2.

Eighty percent of BLM lands and 80 percent of the crucial winter range for pronghorn have route densities higher than those shown to adversely affect this species (1 mi/mi^2).

A study in central Arizona showed that pronghorn generally exhibited a weak avoidance of areas within 3,168 feet of a maintained road, as well as areas near non-maintained dirt roads and four-wheel-drive trails (Ockenfels et al. 1994). Ninety-two percent of BLM lands and 94 percent of pronghorn crucial winter range in the study area fall closer than 3,168 feet to a route. Additionally, pronghorn may be more strongly affected by the noise and activity associated with a road than by the road bed itself (Ockenfels et al. 1994), suggesting that temporal occupancy restrictions are particularly important. Also, an ongoing pronghorn study in the Pinedale area shows that the configuration and density of well pads and other surface disturbances further affect pronghorn use and that there may be a threshold beyond which habitat utilization no longer occurs (Berger and Beckmann 2004).

Elk

In a major volume reviewing elk ecology and management, Lyon and Christensen (2002) state, "Access — mainly that facilitated by roads — is perhaps the single most significant modifier of elk habitat and a factor that will remain central to elk management on public and private lands."

Eighty percent of BLM lands and 66 percent of elk crucial winter range have route densities greater than those suggested to severely restrict elk habitat in open landscapes (1 mi/mi^2).

Research by Lyon (1983) in forested habitat indicates that elk habitat effectiveness is reduced by 25 percent at road densities of 1 mi/mi^2, and by 50 percent at densities of 2 mi/mi^2. Eighty percent of the BLM lands in our study area have route densities greater than 1 mi/mi^2, and 36 percent have densities greater than 2 mi/mi^2. A study on elk habitat effectiveness in a forested area of north-central Wyoming found that few elk used areas with road densities greater than 0.5 mi/mi^2 (Sawyer et al. 1997). Ninety-five percent of BLM lands and 80 percent of elk crucial winter range in the study area of the Pinedale RMA have route densities greater than 0.5 mi/mi^2.

The above numbers are conservative, because the studies by Lyon (1983) and

Sawyer et al. (1997) were conducted in forested landscapes, and road avoidance by wildlife is increased in open landscapes, such as in the study area, where one finds reduced habitat security (Perry and Overly 1976, Morgantini and Hudson 1979, Rost and Bailey 1979, Lyon 1979). A study in open habitat at Jack Morrow Hill in Wyoming observed that elk avoid areas within 1.2 miles of roads and active oil and gas wells in the summer and within 0.6 miles of these features in the winter (Powell 2003). It is possible that in areas with no cover, road densities less than 1 mi/mi^2 may eliminate effective habitat (Lyon 1979). In our study area, 80 percent of BLM lands and 66 percent of elk crucial winter range have route densities greater than 1 mi/mi^2.

Additionally, Phillips and Aldredge (2000) observe that human disturbance during the calving season reduces elk calving success rates and recommend maintaining "disturbance-free" areas during the calving season, based on work in alpine areas in Colorado. A radio-telemetry study by Edge and Marcum (1991) measured only a 5 percent probability of elk using lands within 0.6 mi of a road during calving season. In our study area, 82 percent of the 62,000 acres of elk birthing areas on BLM lands fall within 0.6 miles of a route.

Note that the role of elk winter feedgrounds is not addressed by the present study. State and federal agencies have made a substantial effort to protect ranchers' stored and feed hay from elk since the early 1900s (Dean et al. 2004). Since the 1970s, they have also endeavored to separate elk from cattle in order to minimize the spread of the ungulate disease brucellosis (Dean et al. 2004). These actions greatly complicate management strategies for elk. However, they do not negate the need to manage for high-quality elk winter range, birthing areas, and migration routes in the Upper Green River Valley.

Sage-Grouse

Research indicates that activities associated with gas field development — including road construction — can cause declines in nearby Sage-Grouse populations (Braun 1998). Habitat used for wintering, lekking, nesting, and brood rearing are of most concern in our study area. Because roads constructed for gas exploration and development result in permanent travel routes to previously inaccessible regions, the negative impacts on Sage-Grouse are not limited to the initial development phase of an oil or gas field. Landscapes with less habitat fragmentation, better shrub structure, and a diverse understory of grasses and forbs are more secure for prey animals such as Sage-Grouse (Braun 2002). The construction of fences, powerlines, and other infrastructure as well as the associated decreases in patch sizes and diversity benefit Sage-Grouse predators (Braun 2002).

Forty-nine percent of BLM lands are closer to a route than the average distance (879 feet) associated with unsuccessful raising of Sage-Grouse chicks. All leks in the study area are within 3 miles of a route, which is the distance from surface disturbance recommended for seasonal closures to preserve breeding functions.

Work by Lyon (2000) indicates that traffic disturbance has a long-term negative impact on breeding hens. The study, conducted in the region of the Pinedale Anticline Field, involved documenting nest-initiation and brood-rearing success rates of 48 hens from six leks in the area. The nest-initiation rate over a 2-year period was 55 percent for hens from the three leks in close proximity to a road

(average distance of 2,382 feet to a road). Hens from the three leks farther removed from roads (average distance of 7,742 feet) had a nest-initiation rate of 82 percent over the same period. Following the same hens through early brood rearing, Lyon determined that the hens that were most successful at raising chicks nested farther from roads (an average of 3,734 feet) than hens whose broods did not survive the first 3 weeks after hatching. Unsuccessful brood-rearing grounds averaged 879 feet from the nearest road. Forty-nine percent of BLM lands in the study area are within this distance of a route.

A recent field study by Holloran and Anderson (2004) measured the influence of natural gas development on Sage-Grouse in the Pinedale Anticline and Jonah fields between 1998 and 2004. Results showed 32-percent mean annual declines in the maximum number of males at leks within 2 miles of a drilling rig and 19-percent declines within 1,640 feet of a road. The authors also state, "Although lek attendance, male and female survival, and female demographics varied depending on lek-to-drilling-rig and nest-to-drilling-rig distances, the data suggest that the presence of a drilling rig within 5.5 kilometers [3.4 miles] directly and indirectly influenced sage-grouse."

PHOTO BY LLOYD DORSEY/WYOMING WILDLIFE FEDERATION/LIGHTHAWK

Drill rig on the New Fork River, south of Pinedale, Wyoming.

The Wyoming Game and Fish Department (2004) recommends that where Sage-Grouse habitat has already been fragmented (as we have documented for this study area of the Pinedale RMA), future development "should completely avoid remaining habitats." The agency proposes a series of guidelines for development within 2 miles of a lek or nesting and rearing habitat and recommends no roads or other infrastructure within 656 feet of identified winter habitat. To protect breeding areas, a number of authors (Braun 2002, Connelly et al. 2000, Braun et al. 1977) have suggested that areas within 3 miles of leks should be free of road disturbance during breeding and brood rearing. All BLM lands within the study area are within 3 miles of a route. In fact, 98 percent of BLM lands are within 1 mile of a route. This suggests that most of the leks identified by the Wyoming Game and Fish Department (Figure 5) may lie within habitat sufficiently fragmented and potentially open to disturbance during the breeding season as to have reduced breeding functions already.

Additional Route Impacts to Wildlife

Beyond the fragmentation effects discussed above, transportation routes directly affect these wildlife species by blocking migration paths. Natural and man-made bottlenecks or "pinch points" in the 40- to 150-mile migration corridors for pronghorn and mule deer in the Pinedale RMA have been documented by Sawyer and Lindzey (2000, 2001) and Berger (2004a). Severing migration routes at these pinch points through additional road building for energy development or other purposes would threaten the fall and spring migrations, and thus maintenance of healthy populations, of these species (Western EcoSystems Technology, Inc. 2003). According to

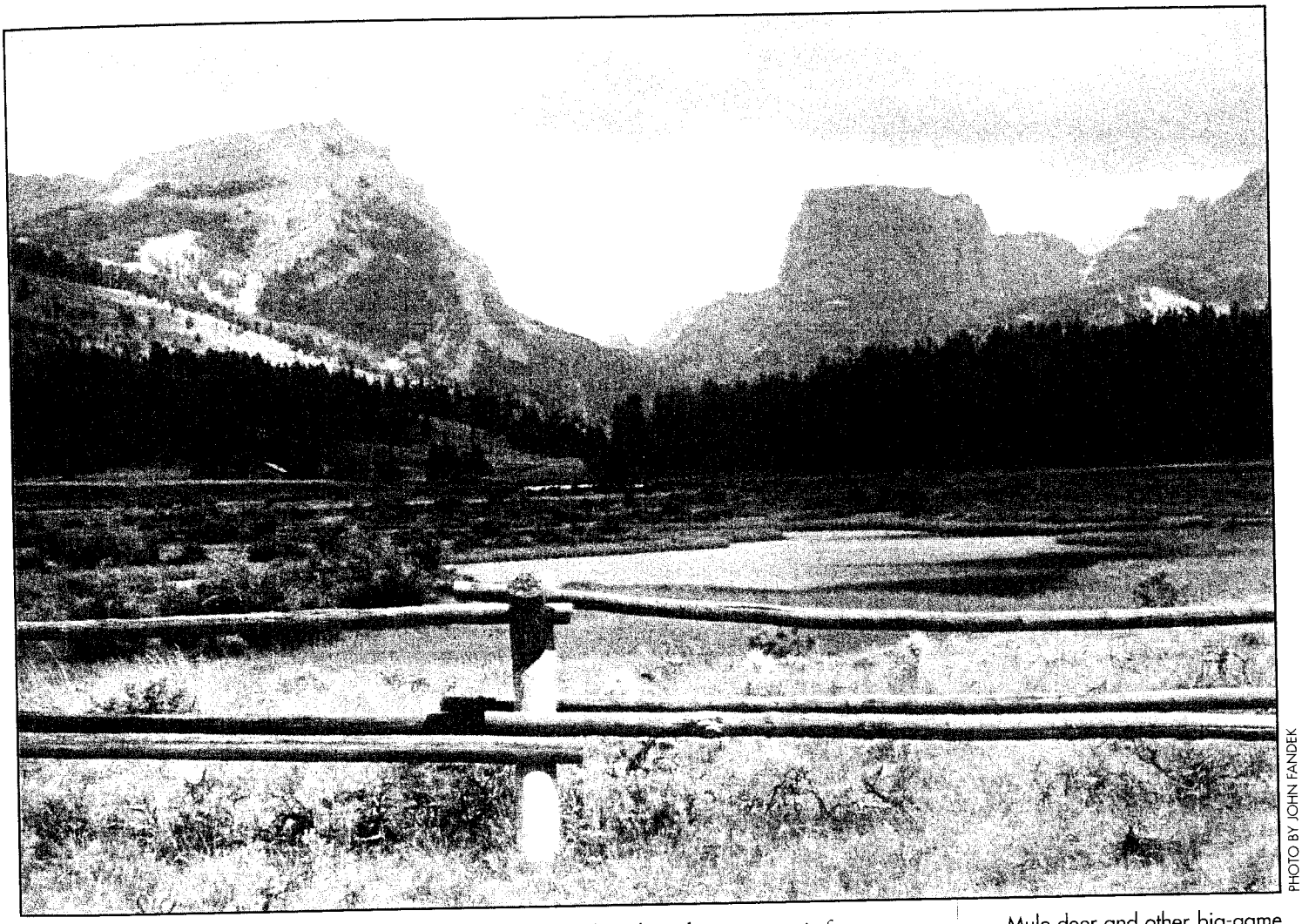


PHOTO BY JOHN FANDEK

Mule deer and other big-game species seek winter forage in the shadow of Square Top, one of the most distinctive peaks in the Wind River Range.

the WGFD (2004), "long term displacement of wildlife from preferred habitats and disruption of migration routes could, in the extreme case, extirpate 'migration memory' that required several thousand years to evolve."

Additionally, vehicle traffic and other human activities along roads can tax animals' limited energy reserves during the winter months. Increased stress and activity required to avoid roads (or other infrastructure) are likely associated with many roads in our study area within ungulate crucial winter range.

Limitations of This Assessment and Future Research Needs

Most importantly, additional monitoring is needed to understand the specific direct, indirect, and cumulative effects of roads, well pads, other energy infrastructure, and related human activities on wildlife species in the Upper Green River Valley. Citations from the biological literature included in this report, while not exhaustive, are some of the best available but fall short of what is needed. Nevertheless, our comparison of landscape measures of route density and distance-to-route values with scientific literature on the responses of wildlife to such infrastructure indicates that substantial caution is warranted in the permitting of additional energy roads and infrastructure.

Further, because the Resource Management Plan currently in preparation will likely guide activities in the Pinedale RMA for 15 to 20 years, it is reasonable to expect an increase in pro-

posed roads and infrastructure, and a corresponding increase in impacts to wildlife, over that time. Still, additional research is vital to understanding the effects of this development. In particular, research is needed on species-specific impacts from different types, levels, and times (of day and season) of road use as well as activity levels and times of use on drill pads.

Our analysis is based on the best available GIS data for transportation routes and for the habitat boundaries for the targeted wildlife species. However, no GIS dataset is ever entirely complete and accurate, and many of the data layers used in this study will continue to be updated by various land-management and wildlife-management agencies. As stated earlier, the GIS route data available from the BLM at the time of our assessment did not include seasonal restriction information, and consequently this information was not incorporated into our analysis.

There are several additional caveats. This study likely underestimates actual habitat fragmentation in the study area because it only addresses fragmentation resulting from transportation routes. That is, it does not account for other features that fragment the landscape such as other human infrastructure (e.g., pipelines, fences), natural topographic barriers, and natural vegetation breaks. In addition, the BLM route dataset did not capture all transportation routes. Nor does the study address habitat connectivity, variations in scale, differences in types of transportation features, and habituation to hunting regulations or other human activities. When these

▼
Severing big-game migration routes at "pinch points" through additional road building would threaten the fall and spring migrations.
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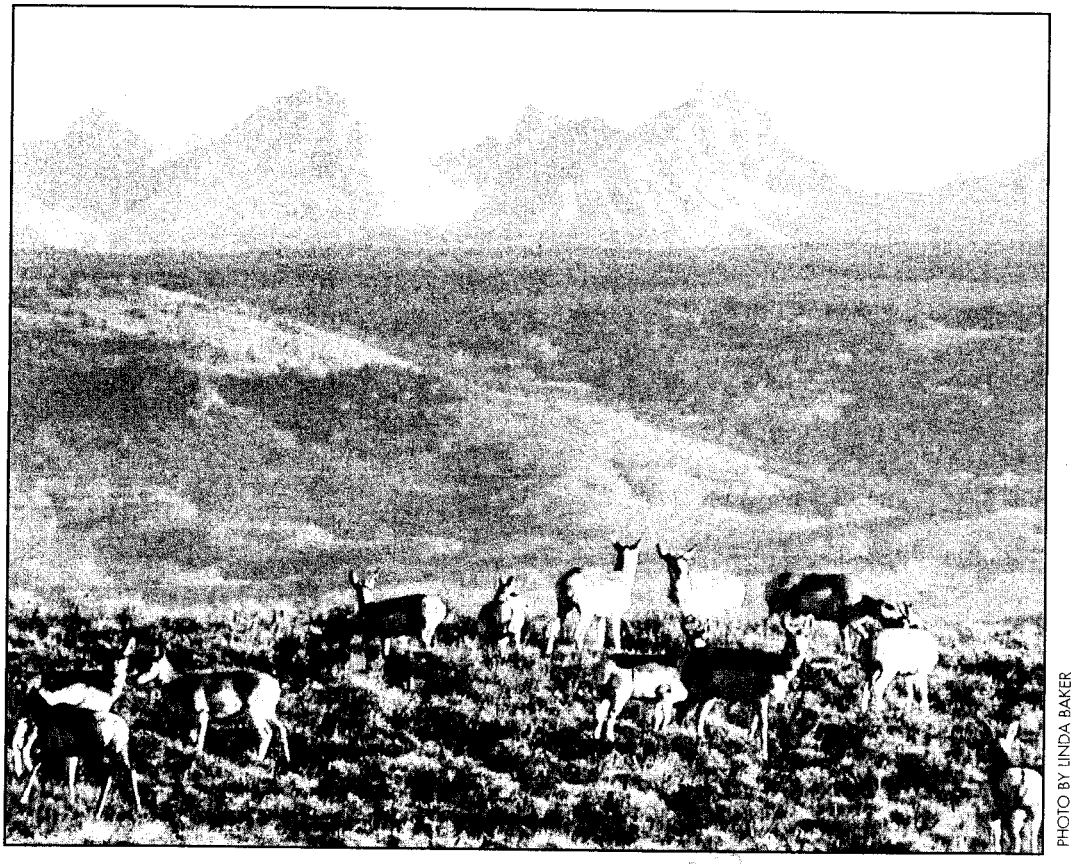

PHOTO BY LINDA BAKER

West of the Wind River Range, 40,000 pronghorn winter in the Upper Green River Valley. These animals disperse into five surrounding mountain ranges every summer. Some migrate to Grand Teton National Park, a 311-mile round-trip trek that is North America's longest big-game migration outside the Arctic.

factors are considered, it may well be that even less optimal habitat remains than we have estimated here. With additional field research, a more comprehensive assessment of fragmentation metrics for each species or set of species could be generated.

Finally, the study does not address additional fragmentation and wildlife impacts from routes that have been permitted but not yet built. In the Pinedale Anticline Field, for example, many miles of roads, drill pads, and related infrastructure will be built in the coming years under the limits established in the 2000 Environmental Impact Statement Record of Decision.

5. Recommendations and Conclusions

This report demonstrates the feasibility of spatial analysis and its applicability to the decisions that will be made during the Pinedale Resource Management Plan revision. Transportation routes and associated energy development infrastructure have a range of effects — direct, indirect, and cumulative — on the landscape. Informed decision-making requires state-of-the-art tools such as spatial analysis to provide critical information and gauge the potential negative effects of these routes on ecosystems.

As noted earlier, 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. In addition to field monitoring, spatial analysis is an appropriate way to take that hard look, particularly in relation to the impacts of roads and all energy development infrastructure on wildlife. We believe the BLM must apply these techniques to meet the requirements of NEPA.

The results of our spatial analysis suggest that the existing transportation route network in the Pinedale RMA is endangering wildlife populations through fragmentation and destruction of habitat. As noted above, the pressures on wildlife from development are likely to increase during the RMP's applicability over the next 15-20 years. Therefore, accurately assessing the effects of transportation routes on wildlife and taking action to ameliorate these impacts through RMP revision and other efforts are essential.

We recommend that the BLM employ the spatial analysis techniques used in this report to carefully evaluate the impacts of the existing transportation network on other species and natural and cultural resources, in order to assess the need for closure and other limitations on the use of existing roads (and other routes) and to develop and thoroughly evaluate alternative transportation networks. We also recommend that the BLM continue to update data on the distribution and quality of wildlife habitat. Under the Data Quality Act, the BLM is required to use information that is of high quality and that is objective, useful, and verifiable by others.[6] The agency must also use "sound statistical and research" methods.[7]

Especially in the absence of adequate data, science cannot always provide clear and certain answers to important questions about potential environmental impacts in a timely fashion. Lack of accurate boundaries for wildlife habitats and an incomplete understanding of the impacts of roads and other types of routes on wildlife are real problems that demand additional research.

However, such gaps in knowledge must not stop or delay decisions to protect wildlife resources by reducing the number and mileage of transportation routes across a landscape. Substantial numbers of published scientific studies suggest that roads and other transportation routes and their associated human activities can negatively affect wildlife at route density and distance-to-route values like those measured in the present study. We recommend that management planning, using the best available data,

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6 Treasury and General Government Appropriations Act for Fiscal Year 2001, Pub.L.No. 106-554 § 515. See also Bureau of Land Management "Information Quality Guidelines," available at http://www.blm.gov/nhp/efoia/data_quality/guidelines.pdf.

7 Ibid.

techniques, and results such as those presented in this report, should proceed — with an emphasis on reductions in road densities and increases in the number and size of core habitat areas in ungulate wintering grounds and along migration corridors, and in Sage-Grouse wintering, lekking, nesting, and rearing areas.

A key step in achieving these goals is implementing a consistent approach to identifying roads and other routes for closure and reclamation. We recommend that the BLM identify and schedule for closure routes that do not have a specific ongoing use (i.e., those that are not associated with active energy development or do not provide access to a publicly recognized destination) and those providing redundant access.[8]

In addition, we recommend that the BLM identify routes that impact wildlife habitat or increase the likelihood of noncompliance with existing conservation mandates, such as the Endangered Species Act, and then consider closing those routes or otherwise mitigating their identified impacts, including by rerouting, seasonal closures, or limitations on use. For those roads and routes that will be closed, the BLM should adopt obliteration and reclamation standards that will restore the area.

Our recommendations are in concert with the "precautionary principle" of conservation biology, which states that precautionary measures should be taken when a certain activity or inactivity threatens to harm human health or the environment, even when science has not fully established cause-and-effect relationships (Meffe and Carroll 1994, Noss and Cooperrider 1994). This principle is rooted in the recognition that scientific understanding of ecosystems is complicated by numerous factors, including dynamic ecosystem processes and the various effects of human activities. Put simply, it is easier to prevent harm to biodiversity than to attempt to repair it later. This prevention of harm is critical for ungulate winter range and migratory routes and for Sage-Grouse wintering, lekking, nesting, and rearing areas in the Pinedale RMA.

Specific Wildlife Recommendations

Our analysis indicates that the existing transportation network identified by the BLM severely fragments wildlife habitat across the Pinedale RMA and is sufficiently likely to cause negative effects on all four of the wildlife species studied that constraints on road use and energy development are warranted. We did not assess the potential impacts of the transportation network on other wildlife species in this analysis. However, the study area contains numerous additional species that would also be subject to the effects of transportation routes and their use. We recommend that the BLM take several actions to alleviate these effects.

- **Ensure that plans are developed and implemented so that the scientifically derived standards listed below for reducing the impact of transportation routes on the four wildlife species addressed in this report are met.** These standards should be met by closing and reclaiming routes not associated with active energy development or other specifically designated uses, routes providing redundant access, and routes excessively impacting habitat; and by mitigating the

[8] We note that closure and reclamation of unnecessary, unused, or redundant routes or facilities is recommended by the BLM for restoring and enhancing habitat and habitat connectivity in its *National Sage-Grouse Habitat Conservation Strategy*, "*Guidance for the Management of Sagebrush Plant Communities for Sage-Grouse Conservation*," November 2004, pp. 18, 20.

impacts of transportation routes through seasonal activity restrictions.

a. **Mule Deer:** Increase the amount of core area greater than 1,542 feet (Freddy et al. 1986) from a road or other transportation route within mule deer crucial winter range and along migration routes. Allow no drilling or surface occupancy between November 15th and April 30th (WGFD 2004) within crucial winter range.

b. **Pronghorn:** Increase the amount of core area greater than 3,168 feet (Ockenfels et al. 1994) from a road or other transportation route and reduce route densities below 1 mi/mi^2 (BLM 1999) within pronghorn crucial winter range and along migration routes. Allow no drilling or surface occupancy between November 15th and April 30th (WGFD 2004) within crucial winter range.

c. **Elk:** Reduce road or other transportation route densities below 1 mi/mi^2 (Lyon 1979) within elk crucial winter range and along migration routes. Allow no drilling or surface occupancy between November 15th and April 30th (WGFD 2004) within crucial winter range.

d. **Sage-Grouse:** Implement seasonal restrictions on traffic on all roads and other transportation routes within 656 feet (WGFD 2004) of winter habitat (9:00 am to 5:30 pm, mid-November through March), within 3 miles of leks (Braun 2002, Connelly et al. 2000, Braun et al. 1977) or breeding and nesting areas (9:00 am to 5:30 pm, March through mid-May), and in brood-rearing areas (9:00 am to 5:30 pm, June through mid-July) (Braun personal communication). Set a maximum speed limit of 30 miles per hour during restricted seasons during unrestricted hours (Braun personal communication).

- **Allow few exceptions to temporal occupancy restrictions.** Temporal restrictions allow the BLM to fulfill its mandate to manage lands for multiple use and to prevent undue and unnecessary degradation of the land. Only short-term exceptions to temporal occupancy restrictions should be allowed and only in limited cases, which are identified in the RMP. Per the BLM's Handbook on Planning for Fluid Minerals, "[a]ll circumstances for granting a waiver, exception, or modification must be documented in the plan." [9] BLM regulations also emphasize the importance of limiting exemptions from stipulations, stating: "[a] stipulation included in an oil and gas lease shall be subject to modification or waiver only if the authorized officer determines that the factors leading to its inclusion in the lease have changed sufficiently to make the protection provided by the stipulation no longer justified or if proposed operations would not cause unacceptable impacts."[10] Also, a 30-day public review and comment period should be provided for modification or waiver of a stipulation prior to lease issuance if the stipulation involves an issue of major concern to the public and subsequent to lease issuance if the modification or waiver is deemed "substantial."[11]

- **Ensure directional drilling and cluster development.** In its revision of the Pinedale RMP, the BLM should

[9] H-1624 at IV.C.3.

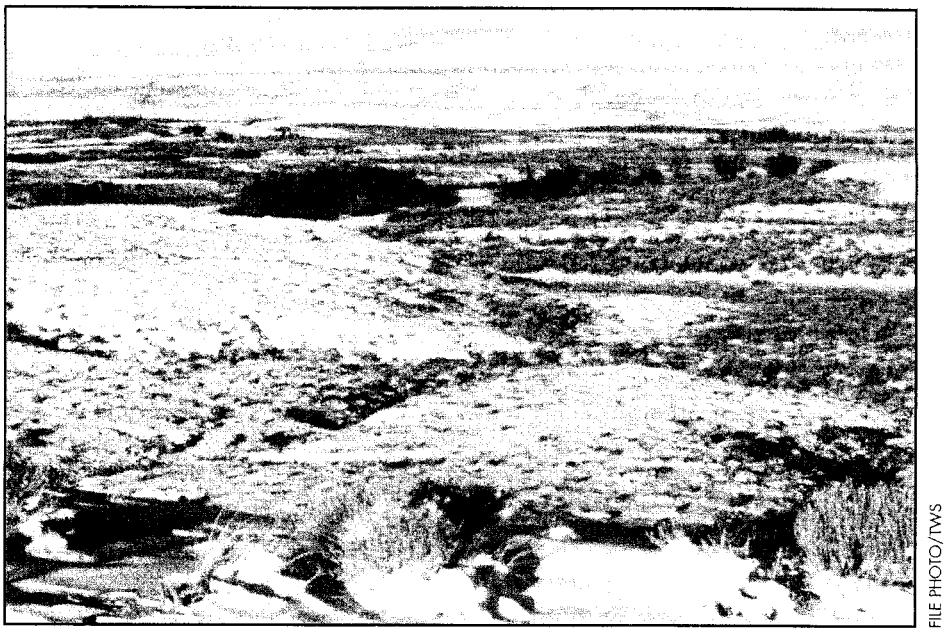
[10] 43 C.F.R. § 3101.1-4.

[11] 43 C.F.R. § 3101.1-4.

establish guidelines and requirements for operators to use directional drilling techniques and clustering of drill holes and other infrastructure on a single pad (Upper Green River Valley Coalition 2004). Such techniques can reduce the physical footprint of energy development and the impacts on wildlife (Molvar 2003, WGFD 2004) and reflect best management practices endorsed by the BLM to mitigate the impacts of oil and gas development.[12]

- **Implement a plan for staged development for potential future energy development.** The revision of the Pinedale RMP should lay out a staged leasing strategy in which some areas of the landscape are open for development while others are temporarily withdrawn. The staged leasing should be designed to ensure that critical winter range, birthing areas, and migration corridors for ungulates and winter habitat, breeding grounds, and nesting and rearing areas for Sage-Grouse are not intensely developed all at once. This will not only disperse wildlife impacts over time and allow economic benefits to last longer but will also allow time for the monitoring and evaluation of development impacts on wildlife.

- **Restrict new roads and energy development.** The revision of the Pinedale RMP should not allow any new energy development, expansion of existing development, or road construction within big-game crucial winter range or at the pinch points of migration routes. Directional drilling should be required for any extraction of natural gas under these areas, with no surface disturbance or road construction allowed.



FILE PHOTO/TWS

Wind-scoured slopes and ridge tops in the Upper Green River Valley ensure year-round exposure of sagebrush and thus provide prime habitat for Sage-Grouse, which rely entirely on sagebrush for winter food and cover.

- **Designate ACECs.** Designate the lands comprising winter range and/or migration route pinch points for multiple big-game species as ACECs, subject to management prescriptions that will protect their use for big-game winter range and/or migration. The prescriptions should include: no creation of new routes, no expansion of existing routes, no new leasing (unless "no surface occupancy"), no new energy development, no cross-country travel, limitation of off-road vehicle use to designated routes, and closure of unnecessary routes. The new ACECs should include those nominated by various groups in a joint 2002 petition to the BLM during the RMP scoping period (Defenders of Wildlife et al. 2002) and addressed in the "Responsible Energy Development" proposal submitted to the BLM by the Upper Green River Valley Coalition (2004): Trapper's Point Mule Deer and Pronghorn Migratory Bottleneck, Cora Butte Mule Deer and Pronghorn Transition Range, Fremont Lake Mule Deer Migratory Bottleneck, Green

[12] Instruction Memorandum No. 2004-194, *Integration of Best Management Practices into Application for Permit to Drill Approvals and Associated Rights-of-Way.*

River Crossing Area, LaBarge Creek Native Elk Winter Range, and the Wind River Front area currently off-limits to leasing. We also recommend including ACEC designation for the Wyoming Range front proposed for no leasing or leasing with no surface occupancy by the Upper Green River Valley Coalition (2004). Sage-Grouse winter habitat is not yet fully documented. This habitat needs to be mapped and at least 90 percent should be designated as ACECs, with the implementation of management strategies that would preserve cover and forage required for winter months (Braun 2002).

The above recommendations are based on the best available research about wildlife-road interactions and the distribution of habitat for the targeted species. As better data become available from agency and academic sources, the above recommendations can and should be adjusted and improved through an adaptive management process.

General Recommendations for Protection of Wildlife

- **Apply the analysis used to create this report and the results generated to inform the Pinedale RMP revision and to create a responsible travel management plan as part of the current planning process.** The BLM is legally required to designate areas and routes, avoid impairment of the public lands, and protect wildlife and other resources through its land-use planning process.[13] A spatial analysis of the impact of roads, other transportation routes, and other infrastructure on wildlife is also a key component of creating a comprehensive travel plan for the Pinedale RMA. In the Pinedale RMA, rapid expansion of roads to support gas exploration and development has been occurring and is projected to continue at a similar pace, heightening the adverse impacts on wildlife and, as a consequence, the corresponding importance of addressing these impacts through travel planning.

- **Adopt a Resource Management Plan that includes significant route decommissioning and restoration of the landscape's ecological health and integrity.** Specific procedures, protocols, and priorities should be defined and implemented to close and reclaim roads and other transportation routes, including: a schedule for closure and reclamation of specific roads and routes; requirements for immediate reclamation of unused areas and commencement of initial reclamation if no production activities have taken place for six months; requirements for submission and approval of reclamation plans with applications for permit to drill; requirements that reclamation plans include decompaction of soils, restoration of original contour and drainage, replanting of native vegetation, obliteration of visual evidence, and use of specified seed, fill, and other materials and methods as appropriate; monitoring of compliance with reclamation plans; and institution of scientifically based standards to assess when reclamation has been achieved (over and above simple re-seeding requirements).

- **Use our landscape fragmentation metrics to guide any and all management decisions regarding transportation routes.** Calculate route density, core area, and distance-to-route (or

[13] A more detailed discussion of the BLM's legal obligations to create a travel management plan and to use the analytical methods set out in this report as the best available and appropriate standards for data analysis and planning decisions, and a process for developing a compliant and responsible transportation plan, are included in Appendix A, A Responsible Travel Management Plan.

route effect zone) metrics in accordance with scientific literature on wildlife species and evaluate the likely impacts of potential road networks on wildlife species and other resources the BLM is required to protect under relevant laws and policies. Goals should include reductions in road density and increases in core areas to provide greater habitat security.

- **For all new roads that are built, follow the road construction guidelines of the Wyoming Game and Fish department (WGFD 2004) to minimize the effect of routes on wildlife.** (See Appendix B.)

- **Include clear enforcement mechanisms in the revision of the Pinedale RMP so that impacts of energy development on wildlife are minimized.** These mechanisms should include a plan for enforcing permanent road closures, temporary/seasonal road closures, limits on off-road travel in designated areas or times of year, limits on road and well pad construction in critical habitats, and requirements for directional drilling and cluster development.

- **Continue to evaluate the impacts of routes on wildlife (and other resources) as part of the travel management planning process and subsequent ongoing adaptive management.** Ongoing NEPA-related monitoring of wildlife impacts from routes, well pads, and related human activities such as that described by Sawyer and Lindzey (2004) should be defined in the final RMP and implemented over the course of the development. The BLM must apply landscape fragmentation analysis to design a plan that meets its responsibility to protect all of the region's resources for multiple use and sustained yield, and give priority to designation and protection of ACECs.

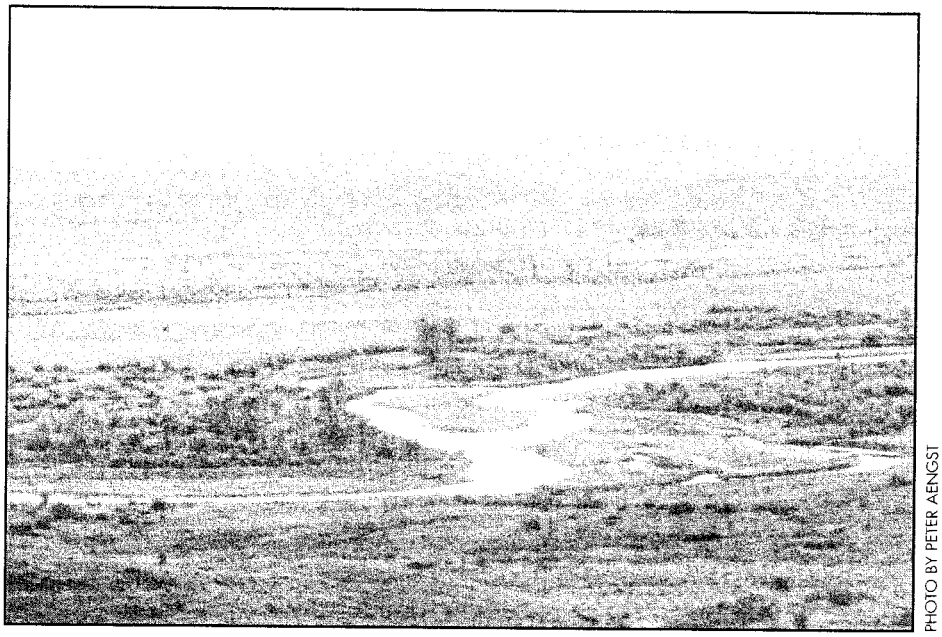


PHOTO BY PETER AENGST

This view of the Green River from Trapper's Point is seen by thousands of pronghorn and mule deer each year as they travel through a narrow migratory corridor at the northern end of the Upper Green River Valley.

- **Promote additional wildlife research by the BLM, the Wyoming Game and Fish Department, and other agencies and institutions.** The BLM should encourage the collection of up-to-date and accurate digital data on the distribution of wildlife habitats and work to more thoroughly understand the ecological impacts of all types of transportation routes on wildlife species in the Pinedale RMA. In particular, research is needed on species-specific impacts from different types, levels, and times (of day and season) of road use, as well as impacts from different activity levels and times of use on drill pads.

Conclusions

Sagebrush ecosystems found in the Upper Green River Valley of western Wyoming contain crucial habitat for some of the largest migratory populations of ungulates in North America and offer the best chance for survival of healthy populations of Sage-Grouse and other obligate sagebrush species. Yet fragmentation and declining quality of the valley's sagebrush and grassland ecosystems are the principal reasons populations and distributions of dependent

wildlife are declining (WGFD 2004). Given the rapid recent development of new roads and infrastructure for oil and gas development in this area, the BLM is now at a critical juncture in deciding the long-term fate of key habitat for the nationally significant wildlife populations found here.

The BLM is responsible for adopting a protective Resource Management Plan, including a travel management plan, that improves the Pinedale RMA's long-term ecological health and integrity while providing for balanced public access and use of the landscape and its resources. The scientific literature documents direct, indirect, and cumulative impacts of transportation features on ecological processes, wildlife, plants, and archaeological sites. In its upcoming RMP revision for the Pinedale RMA, the Pinedale BLM Field Office must make management decisions that recognize the best available science and proactively mitigate documented impacts to wildlife and other resources.

Good science, the law, and sound policy can guide the BLM as it develops a Resource Management Plan and a travel management plan to preserve large core areas of habitat for the four species studied in this report. Those areas will have value far beyond the targeted species. Maintenance of unroaded core areas or minimally roaded areas in key habitat units as recommended in this report will provide an opportunity to balance the needs of the area's important wildlife populations with the area's growing energy development.

This report offers the BLM science-based information and analysis for use in making critical management decisions. The Pinedale Resource Management Area, while heavily developed for oil and gas, hosts critical wildlife habitat for many species and has the potential to protect this habitat for generations to come. In its upcoming Pinedale RMP revision and in other analyses and plans, we encourage the BLM to reach sound, science-based management decisions that will close routes to restore and maintain critical habitat and habitat linkages.

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Appendix A: A Responsible Travel Management Plan

The analysis used to create this report and the results generated can and should be used by the BLM in revising the Pinedale RMP, in designating or limiting areas for further development, and in determining those areas where roads should be closed or subject to limited use. A spatial analysis of the impact of roads, routes, and other infrastructure on wildlife is also a key component of creating a comprehensive travel management plan for the Pinedale RMA, which should be created as part of the current planning process.

The BLM is legally required to designate areas and routes, avoid impairment of the public lands, and protect wildlife and other resources through its land-use planning process. In the Pinedale RMA, rapid expansion of roads to support gas exploration and development has been occurring and is projected to continue, heightening the adverse impacts on wildlife and the corresponding need to address these impacts through travel management planning.

Complete a Comprehensive Travel Management Plan as Part of the Resource Management Planning Process

At the outset, we urge the BLM to complete a travel plan for the Pinedale RMA as part of its RMP revision effort. In order to fulfill FLPMA's mandate to manage the public lands for multiple use and sustained yield, the BLM is required to, "with public involvement and consistent with the terms and conditions of [FLPMA], develop, maintain, and when appropriate, revise land use plans which provide by tracts or areas for the use of the public lands."[14] FLPMA mandates that the BLM "take any action necessary to prevent unnecessary or undue degradation of the lands"[15] and "minimize adverse impacts on the natural, environmental, scientific, cultural, and other resources and values (including fish and wildlife habitat) of the public lands involved."[16]

The BLM is also specifically obligated to address off-road vehicle (ORV) use as part of the land-use planning process. Executive Order No. 11644 (1972) (as amended by Executive Order No. 11989 (1977)) requires all federal agencies to make designations as to use of routes by ORVs. The BLM has promulgated regulations that require the agency to "designate all public lands as either open, limited or closed to off road vehicles."[17] The BLM is specifically obligated to make such designations during its RMP process, with public participation.[18] As explicitly stated by BLM regulations:

> The designation and redesignation of trails is accomplished through the resource management planning process described in Part 1600 of this Title. Current and potential impacts of specific vehicle types on all resources and uses in the planning area shall be considered in the process of preparing resource management plans, plan revisions, or plan amendments.[19]

The BLM's responsibility to complete travel planning is confirmed by the agency's internal guidance (Instruction Memorandum No. 2004-005), which states:

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[14] 43 U.S.C. § 1712(a).

[15] 43 U.S.C. § 1732(b).

[16] 43 U.S.C. § 1732(d)(2)(a).

[17] 43 C.F.R. § 8342.1.

[18] 43 C.F.R. § 8342.2.

[19] 43 C.F.R. § 8342.2(a).

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- "At a minimum, each RMP will divide planning areas into OHV [off-highway vehicle] area designations that are open, limited or closed."
- "Selection of a network of roads and trails should be performed for all limited areas in each RMP. This requires establishment of a process that includes selecting specific roads and trails within the limited area or sub-area and specifying limitation(s) placed on use."[20]

In making designations, the BLM is obligated by both the executive orders and its own regulations[21] to ensure that areas and trails are located:

- To minimize damage to soil, watersheds, vegetation, air, or other resources of the public lands, and to prevent impairment of wilderness suitability;
- To minimize harassment of wildlife or significant disruption of wildlife habitats, and especially for protection of endangered or threatened species and their habitats;
- To minimize conflicts between ORV use and other existing or proposed recreational uses of the same or neighboring public lands; and
- Outside officially designated Wilderness Areas or primitive areas and natural areas unless the agency determines that ORV use will not adversely affect the natural, aesthetic, scenic, or other values for which such areas are established.

The BLM can also close an area immediately until adverse effects are eliminated if there are "considerable adverse effects" on soil, plants, wildlife, habitat, or cultural/historic resources.[22]

As noted in the executive orders and BLM regulations, the use of ORVs has the potential to damage many public resources, such as vegetation, wildlife habitat, soil, watersheds, and air. The existence of roads and other routes for motorized travel may increase cross-country ORV use by providing greater access. As detailed above, similar adverse effects may result from cross-country ORV use as from the use of roads and routes in general — that is, fragmentation and destruction of critical wildlife habitat. In addition, water quality can be degraded by erosion and runoff caused by motorized vehicles.[23] Further, emissions and disturbance from vehicles can impair air quality.[24]

Consequently, the designation of roads and routes, including closures and limitations on use, will have a critical effect on the resources in the planning area. As acknowledged in BLM's official guidance on travel planning (IM No. 2004-005):

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[20] While this memorandum also permits some delay if designation of all routes is truly not feasible, the conditions detailed in the memorandum do not apply to the Pinedale RMA. In addition, failure to complete route designation would not obviate the requirement for completion of as many areas as possible and short-term maintenance to protect sensitive resources.

[21] 43 C.F.R. § 8342.1.

[22] 43 C.F.R. § 8341.2.

[23] The Clean Water Act, 33 U.S.C. § 1251 et seq., specifically includes sediment in the identified causes of water quality impairment.

[24] The Clean Air Act, 42 U.S.C. § 7401 et seq., identifies smog, carbon monoxide, and particulates (soot, dust, smoke) as prioritized criteria air pollutants (pursuant to 42 U.S.C. § 7408) and further highlights engine combustion products and gasoline vapors as hazardous air pollutants/toxics. 42 U.S.C. § 7412(b).

> A well-designed travel system can direct travel away from sensitive areas, yet provide quality recreational activities and access for commercial and recreational needs.

Following its own guidance, the BLM should: "Choose individual roads and trails, rather than using inherited roads and trails. Most existing roads and trails on public lands were created by use over time, rather than planned and constructed for specific activities or needs" (IM No. 2004-005).

In light of the BLM's obligation to designate areas and routes, avoid impairment of the public lands, and protect wildlife and other resources through land-use planning, the agency cannot and should not delay preparation of a travel plan for the Pinedale RMA, and should designate routes and specify closures as part of its ongoing preparation of an RMP for the area. Further, the BLM is well aware of the expanded road network that has already been generated by gas exploration and development in the area. Delay in the designation of routes and in the closure of roads and routes would allow the increased adverse effects from these roads, as well as the cross-country travel they facilitate, to continue, and would violate FLPMA's mandate that the BLM minimize adverse effects and prevent unnecessary or undue degradation of the environment.

Developing a Travel Management Plan

To make the best use of the data, analysis, and specific recommendations presented in this report, we urge the BLM to incorporate the following guidance as it develops a transportation plan.

Obligations

The BLM has substantial obligations under FLPMA and NEPA to collect and assess data in the decision-making and planning processes that lead to a transportation plan.

NEPA requires that the BLM take a "hard look" at the environmental consequences of a proposed action. FLPMA mandates that the BLM prevent unnecessary or undue degradation of the public lands and minimize adverse impacts on natural, environmental, and other resources and values, such as fish and wildlife habitat. When conducting land-use planning, the BLM must give priority to the designation and protection of ACECs and consider physical, biological, economic, and other sciences.[25]

The BLM cannot evaluate consequences to the environment, determine avoidable or excessive degradation, or assess how best to designate and protect ACECs without adequate data and analysis. NEPA's hard look at environmental consequences must be based on "accurate scientific information" of "high quality."[26] Essentially, NEPA "ensures that the agency, in reaching its decision, will have available and will carefully consider detailed information concerning significant environmental impacts."[27] The Data Quality Act and the BLM's interpreting guidance expand on this obligation, requiring that the agency use "best available science and supporting studies conducted in accordance with sound and objective scientific practices."[28]

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[25] 43 U.S.C. § 1712(c).

[26] 40 C.F.R. § 1500.1(b).

[27] *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 349 (1989).

[28] Treasury and General Government Appropriations Act for Fiscal Year 2001, Pub.L.No. 106-554 § 515. See also Bureau of Land Management "Information Quality Guidelines," available at http://www.blm.gov/nhp/efoia/data_quality/guidelines.pdf.

The BLM's internal guidance also recognizes the importance of the accumulation and proper analysis of data. Appendix H of the agency's Land Use Planning Handbook concludes, "Data without applicable models is no more useful than models without applicable data." In other words, appropriate analysis of data is as important as the accumulation of sufficient data.[29]

The BLM has significant obligations to fully assess the potential environmental consequences of actions. The agency must take into account the direct, indirect, and cumulative impacts of proposed actions and three related classes of actions: (1) connected actions, (2) cumulative actions, and (3) similar actions.[30] Also as part of the land-use planning process, the BLM must develop and assess a reasonable range of alternatives, including analysis of the direct, indirect, and cumulative environmental impacts of the alternatives and a clear definition of mitigation measures to reduce environmental impacts.[31]

Once an alternative is selected and a management plan is in place, the BLM is required to continue to monitor the plan, evaluate whether its implementation is meeting the established objectives, and, as necessary, make appropriate revisions.[32] The sufficiency of these analyses, in relation to meeting the legal standards and protection of wildlife, depends on data of sufficient quantity and quality.

Steps for Developing a Travel Management Plan

To meet its data collection and analysis obligations, the BLM should use the following procedures to develop a transportation network for the Pinedale Resource Management Area through the land-use planning process, taking into account the need to protect wildlife from the effects of transportation features.

1. **Generate transportation network scenarios** based on the multiple resources the BLM is required to manage for, using reliable data and high-quality analysis.
   a) Generate GIS data layers for all roads and other types of transportation routes in each proposed transportation network alternative in a Draft Environmental Impact Statement.
   b) Limit the potential transportation network scenarios to those that will provide for long-term protection of multiple use of the region's many resources.
   c) Limit routes:
      i) By eliminating user-created "wildcat" routes in the transportation system.
      ii) By ensuring that each road is justified and managed through an analysis of its impacts on resources at the level required by NEPA, taking into account spatial patterns of roads in addition to road length.

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[29] The BLM is considering a revision of its Handbook and has proposed a new Appendix H, titled "Data and Information," to address this crucial aspect of planning. The agency's statements in the current Handbook are notable. Section I ("Managing and Identifying Data") states, "Standardized, accurate, and reliable data and information are critical to the development of plan assessments, alternatives, impact analyses, and planning decisions." Section I.B ("Identifying Data Needs for a Land Use Plan") directs:

> The BLM planning project manager must identify existing data and information sources, and determine what additional data must be collected. A table of information should be prepared by the planning project manager and planning team which describes the specific data required to answer planning questions associated with the plan, along with the availability and status of the data. The table will reveal data deficiencies and identify strategies to obtain missing or incomplete data or information.

[30] See 40 C.F.R. § 1508.25.

[31] See 40 C.F.R. Part 1502.

[32] See 43 U.S.C. § 1712 (a); 43 C.F.R. §1610.4-9.

BUREAU OF LAND MANAGEMENT

iii) By ensuring that each road is deemed necessary for specified and defined uses of the area.

2. Assemble wildlife habitat use information to comply with agency obligations to use "accurate scientific information" of "high quality" to perform the requisite thorough analysis.

a) Collect information from the published literature on the impacts of roads on threatened and endangered species and other key plant and animal species in the area. The information should include, but not be limited to, the impacts of road density on local species, the distance of road effects to determine the width of effect zones for infrastructure features, and species dispersal distances to evaluate the size of core areas.

3. Generate landscape fragmentation metrics to represent the best available science and supporting studies conducted in accordance with sound and objective scientific practices.

a) Calculate landscape fragmentation metrics for all road network alternatives. Include, at a minimum, road density, distance-to-road (or road effect zone), and core area analyses. Metric parameters and the evaluation of results should be relevant to ecological conditions, species that are present, and human uses of the landscape.

4. Integrate the results into management plan alternatives and use them as the basis for selecting the preferred alternative. Through the application of landscape fragmentation metrics to relevant ecological conditions or other resources, the BLM can evaluate the direct, indirect, and cumulative impacts of the various alternatives.[33] To the extent that the BLM intends to rely on mitigation of potential impacts, sufficient support for the success of mitigation can be developed. Adaptive management can help to fulfill the obligations to monitor, evaluate, and revise plans.

a) Evaluate landscape fragmentation metrics to determine the impacts of development on specific local species and the necessary actions to protect habitat. The preferred alternative should be chosen to reduce impacts on wildlife based on the fragmentation metrics. Include these wildlife impacts with other ecological impact data in the planning documents throughout the land-use planning process and subsequent management or land-use decisions.

b) Include a road closure plan and define necessary mitigation to protect and improve habitat, core areas, and ACECs.

   i) Procedures, protocols, and priorities should be defined and implemented to close and reclaim roads and other routes that are unnecessary, do not meet the legal definition of a road, or are no longer actively used for a specified purpose.

   ii) An adaptive management plan should be established to ensure that the effects of the existing plan are monitored and that additional road closures and other mitigation measures are completed if monitoring and additional data collection indicate that wildlife populations are negatively affected.

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[33] Cumulative impacts are the impacts on the environment that result from the incremental impact of an 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 minor but collectively significant actions over a period of time. 40 C.F.R. § 1508.7.

Appendix B: Guidelines for Road Construction and Use

Where roads are to be constructed, they should follow standards published by the Wyoming Game and Fish Department (2004). The agency document entitled *Minimum Recommendations for Development of Oil and Gas Resources Within Crucial and Important Wildlife Habitats on BLM Lands* lays out extensive guidelines for infrastructure associated with energy development. A sampling of the agency's guidelines related to road construction and use are reproduced below:

- Use existing roads and two-tracks if they are sufficient and not within environmentally sensitive areas.
- Construct the minimum number and length of roads necessary.
- Use common roads to the extent practical.
- Coordinate road construction and use among companies operating in the same oil and gas field.
- Design roads to the appropriate standard no higher than necessary to accommodate their intended functions.
- Design roads with adequate structures or features to prohibit or discourage vehicles from leaving the roads.
- Locate all roads below ridgelines or behind topographic features (knolls, rises) to minimize the zone of visual and auditory effect.
- Locate roads away from bottoms of drainages, which often provide the most important sources of cover and forage for wildlife.
- Develop a travel plan that minimizes the amount of vehicular traffic needed to monitor and maintain wells and other facilities.
- Prohibit or substantially limit traffic during high wildlife use hours (within 3 hours of sunrise and sunset).
- Use pipelines to transport condensates off site.
- Transmit instrumentation readings from remote monitoring stations to reduce maintenance traffic.
- Post speed limits on all access and maintenance roads to reduce wildlife collisions and limit dust. Thirty to 40 miles per hour is adequate in most cases.

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Exhibit 11

A SPATIAL ANALYSIS OF A WYOMING GAS FIELD

Fragmenting Our Lands:

The Ecological Footprint from Oil and Gas Development

Ecological Analysis

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Fragmenting Our Lands:

The Ecological Footprint from Oil and Gas Development

A SPATIAL ANALYSIS OF A WYOMING GAS FIELD

By
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The Wilderness Society

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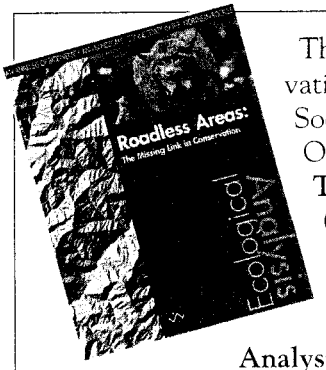
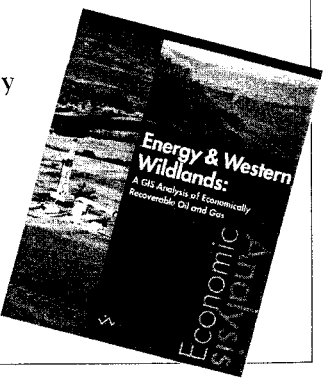


This science report is one of a series that stems from conservation research studies conducted by The Wilderness Society's Ecology and Economics Research Department. Other recent reports in the series include **"Roadless Areas: The Missing Link in Conservation (An Analysis of Biodiversity and Landscape Connectivity in the Northern Rockies)"** and **"Energy and Western Wildlands: A GIS Analysis of Economically Recoverable Oil and Gas."** These reports are available on The Wilderness Society's website (www.wilderness.org) or from The Wilderness Society, Communications Department, 1615 M Street, NW, Washington, DC 20036 (202-833-2300 or 1-800-THE-WILD).



Published by The Wilderness Society, September 2002

Preface

The magnificent public lands of the western United States sustain healthy ecosystems that provide clean drinking water, recreation, and solitude for millions of Americans, as well as critical habitat for numerous plants and animals. Most Americans recognize that these and other ecological benefits are vital to our quality of life, but often these values are not taken into consideration when logging, mining, and oil and gas exploration decisions are being made.

Through a pilot study of the existing Big Piney-LaBarge oil and gas field in the Upper Green River Basin of Wyoming, "Fragmenting Our Lands: The Ecological Footprint from Oil and Gas Development (A Spatial Analysis of a Wyoming Gas Field)" focuses on the habitat fragmentation that can result from the resource extraction activity. Using The Wilderness Society's state-of-the-art landscape analysis techniques, the report examines the effects of drilling pads, roads, pipelines, water disposal areas, and other infrastructure components and demonstrates the far-reaching impact they have on wildlife species and the surrounding land.

GIS Technician Chris Weller and Landscape Scientist Janice Thomson from the TWS Center for Landscape Analysis in Seattle and Resource Economist Pete Morton and Forest Ecologist Greg Aplet from our Four Corners Regional office in Denver provided analysis and interpretation of the data. Their specific findings offer an important illustration of the ecological consequences of resource extraction, while their particular methods demonstrate the significant benefits of incorporating landscape analyses in future public land resource assessments and planning documents.

William H. Meadows
President
The Wilderness Society

G. Thomas Bancroft, Ph.D.
Vice President
Ecology and Economics
Research Department

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Report Highlights

Fragmentation of habitat is widely acknowledged as detrimental to wildlife and plant species. Landscape analysis is a proven method to identify fragmentation and other agents of change in a given area. Yet landscape analysis is seldom completed prior to initiation of oil and gas projects, despite considerable evidence that oil and gas extraction and transmittal are likely to cause wide-ranging disturbances in the landscape.

We conducted a pilot analysis of the landscape of the existing Big Piney-LaBarge oil and gas field in the Upper Green River Basin of Wyoming, a region where more than 3,000 oil and gas wells have been drilled. We measured the degree of habitat fragmentation of the field using three metrics: linear feature density (primarily roads and pipelines), habitat in the infrastructure effect zone, and the amount of habitat in core areas (interior habitat that is remote from infrastructure).

Our results indicate an overall density of 8.43 miles of roads and pipelines per square mile. This is at least three times greater than road densities on national forests in Wyoming, South Dakota, and Colorado and is "extremely high" based on ratings in the Interior Columbia Basin Ecosystem Management Project.

The overall area of oil and gas infrastructure (roads, pipelines, pads, waste pits, etc.) at Big Piney-LaBarge covers 7 square miles of habitat, or 4% of the study area. But the effect of that infrastructure is much greater. The entire 166-square-mile landscape of the field is within one-half mile of a road, pipeline corridor, well head, retention pond, building, parking lot, or other component of the infrastructure. One hundred and sixty square miles—97% of the landscape—fall within one-quarter mile of the infrastructure. With respect to core area, only 27% of the study area is more than 500 feet from infrastructure, and only 3% is more than one-quarter mile away.

Our results, combined with a review of the scientific literature, suggest that there is no place in the Big Piney-LaBarge field where the greater sage-grouse—a potential candidate for the endangered and threatened species list—would not suffer from the effects of oil and gas extraction. And the vast majority of the study area has road densities greater than two miles per square mile, a level estimated to have adverse impacts on elk populations.

Because our results clearly show that oil and gas drilling and extraction cause significant fragmentation of habitat, we recommend that similar spatial analyses be incorporated into the evaluation and monitoring of the ecological impacts of proposed oil and gas projects.

We also recommend the following standards for incorporation into assessments of all future oil and gas production sites on public lands.

- Generate infrastructure scenarios prior to field development.
- Assemble regional habitat-use data.
- Generate landscape metrics for all infrastructure.
- Integrate results into management plans.

1. Introduction

The current administration's National Energy Plan calls for expansion of the amount of public land that is open for oil and gas drilling and includes steps to increase access to federal land. Up to this point, little of the debate over this policy has centered on ecological impacts—the "ecological footprint"—associated with the extraction of oil and gas.

Loss and fragmentation of habitat are among the significant ecological impacts from access roads, drill pads, pipelines, waste pits, and other components of the oil and gas project infrastructure. These impacts extend beyond the physical structures. Studies indicate that the actual ecological footprint of oil and gas extraction stretches across rangelands and forested lands for a considerable distance.[1]

Fragmentation of habitat can be defined as the decrease in the size of habitat patches and interior habitat and the increase in distance between patches (Noss and Csuti 1994). Fragmentation caused by roads, clearcuts, and conversion of wildlands to residential and commercial uses is a growing concern among ecologists, wildlife biologists, and land-use planners (Harris 1984, Wilcove 1987, Knight et al. 2000). The nation's sprawling road network that gives access to communities and resources also fragments wildlife habitat, promotes the spread of invasive non-native species and diseases, and is a major source of sediment in streams. Decisions to build access roads for oil and gas projects, therefore, hold the potential of detrimental and long-lasting ecological impacts on the landscape.

There has been much discussion about the exact size and extent of the ecological footprint, but there has been little, if any, quantitative analysis. Spatial analysis can help fill this information gap. Because fragmentation of habitat occurs across a wide area, the cumulative impacts cannot be adequately addressed at the site level. Rather, analyzing the overall ecological footprint requires spatial analysis of the landscape.

The Bureau of Land Management (BLM) and U.S. Forest Service are the two land management agencies responsible for much of the public land targeted in the administration's energy policy. The two agencies have rarely, if ever, required or completed landscape-level analysis of habitat fragmentation caused by oil and gas projects as part of the evaluation process required by the National Environmental Policy Act.

To address this shortcoming, we completed a pilot spatial analysis of the fragmented landscape of a gas field in the Upper Green River Basin of Wyoming. The objectives of our study are to: 1) estimate the degree of fragmentation associated with oil and gas drilling, 2) inform the public and decision-makers about the impacts to the landscape from oil and gas drilling, and 3) over the long term, improve the quality of BLM and Forest Service environmental analyses of proposed oil and gas projects as part of the National Environmental Policy Act process.

[1] The ecological footprint also penetrates to shallow aquifers and aquifers thousands of feet below the earth's surface.

2. Study Area

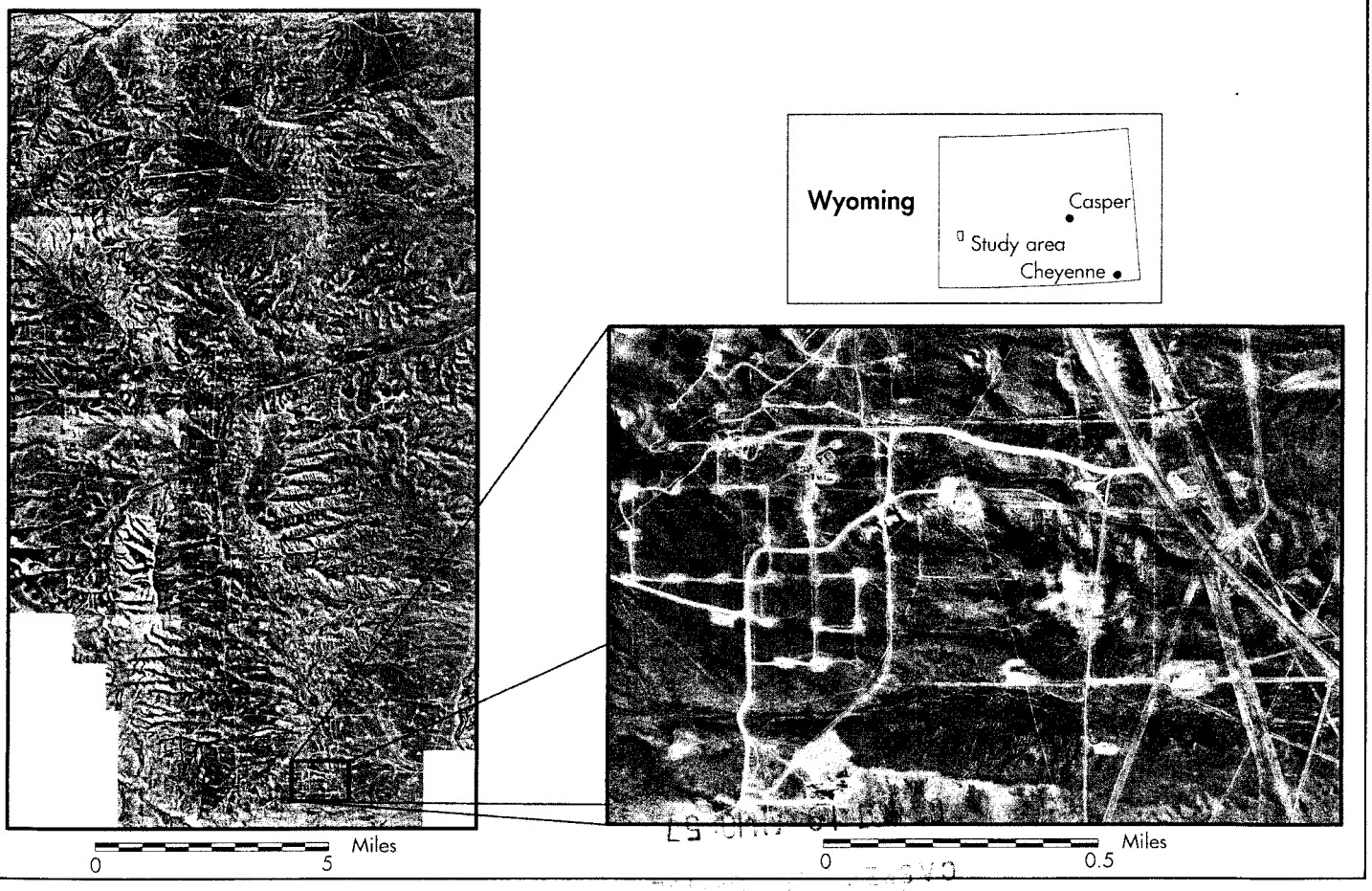
Our analysis focused on the Upper Green River Basin of southwestern Wyoming. This region contains high desert sagebrush framed by the Wind River and Wyoming mountain ranges. The basin, managed primarily by BLM, is a world-class wildlife area. It provides important habitat for 100,000 pronghorn antelope, mule deer, elk, and moose that inhabit the southern Greater Yellowstone Ecosystem and serves as a corridor for the longest big game migration in the continental United States. The basin also provides one of the last strongholds for greater sage-grouse. Wyoming populations of this species declined during the past 20 years, mostly because of loss, degradation, and fragmentation of habitat in shrub-steppe ecosystems (Holloran and Anderson 1999).

The region's rich and varied wildlife populations are popular with local hunters and recreationists. These animals also attract visitors to the region. Natural resource use has played a major role in the history of the Upper Green River Basin. Both ranching and oil and gas production have figured prominently over the last century. More than 3,000 oil and gas wells have been drilled in the

FIGURE 1.

Big Piney-LaBarge oil and gas field

The left image shows U.S. Geological Survey digital orthopotos of the study area. A portion of that image in more detail (right) illustrates infrastructure features of interest.



Upper Green River Basin, and BLM has authorized some 4,500 permits for additional wells (Bureau of Land Management 1999).

Within the Upper Green River Basin, the study area for our pilot project was the Big Piney-LaBarge oil and gas field located between and immediately west of the towns of Big Piney and La Barge in the midst of rangelands managed by BLM. Oil and gas were initially discovered in the area in 1924. The Big Piney-LaBarge gas field is one of the top ten fields in the country with respect to proven gas reserves (Energy Information Administration 1998). As of 1990, the field had a total of 1,864 drilled wells, of which 1,080 were still active (Bureau of Land Management 1990).

The field has produced oil and gas historically, but the current boom in production is largely natural gas. Seventy-two percent of the known gas reserves are predicted to be "tight sands" gas (also called continuous-type gas) (Energy Information Administration 2001), which is classified by U.S. Geological Survey as an unconventional fuel. Exploitation of tight sands gas requires drilling a significant number of wells because the distribution of this gas type is not well understood (U.S. Geological Survey 1996a).

The study area contains a web of infrastructure related to oil and gas drilling, including roads, pipeline corridors, drill pads, retention ponds, compressor stations, buildings, and parking complexes. The original extent of the study area followed the boundaries of 12 U.S. Geological Survey quarter quads (Figure 1). We excluded areas in the southeastern and southwestern corners because they contained infrastructure from activities other than oil and gas projects. Our study area covers 166 square miles.

We selected Big Piney-LaBarge oil and gas field for several reasons. First, the BLM is in the process of examining access to oil and gas in five basins of the Rocky Mountains, and the Greater Green River (containing the Big Piney-LaBarge field) was the first basin examined (U.S. Department of Energy 2001). The area has been targeted "because it contains the largest amount of estimated technically recoverable natural gas resource in the region" (U.S. Department of Energy 2001). The land-use plan for the Upper Green River Basin is one of the 22 "time-sensitive plans" that the administration has placed on a fast track, and revision of the Pinedale Resource Management Plan—the BLM document that will guide management of more than 930,000 acres in the region—is underway. Impacts on wildlife from oil and gas projects are among the most prominent issues related to that plan.

Second, within the Upper Green River Basin the Big Piney-LaBarge field is a developed oil and gas field for which digital aerial photos (dated after substantial oil and gas extraction) were available to conduct a spatial assessment of the landscape.

Third, the area has outstanding wildlife values. It provides important pronghorn antelope, mule deer, and elk winter range. It also contains habitat for the greater sage-grouse, which is under consideration for listing as a threatened or endangered species.

3. Methods

Data Generation

We obtained digital data of the infrastructure of oil and gas activities, including the location of roads, pipeline corridors, and wells within Big Piney-LaBarge gas field, from BLM's Pinedale (Wyoming) field office. However, a comparison of these data to aerial photographs indicated that substantially more roads and other infrastructure exist across the landscape.

We "captured" infrastructure features using 12 digital orthophoto quarter quads that we obtained from the Wyoming Geographic Information Science Center (www.sdvc.uwyo.edu/doqq). These quarter quads were generated with a pixel size of approximately one square meter from 1994 aerial photography.

The number and distribution of quarter quads we selected were based on the need to assess the wide variety of types and densities of infrastructure features that are associated with field development of gas, while minimizing the cost of manual digitizing. The 12 quarter quads we chose capture the bulk of existing (pre-1994) infrastructure at Big Piney-La Barge. However, development does extend beyond our study area boundaries, particularly to the north. Our study area was selected to demonstrate landscape analysis techniques, but was not intended to provide a comprehensive assessment of the field.

We generated our infrastructure data through on-screen digitizing of the features, using a geographic information system (GIS). A GIS analyst identified the features by visual inspection of the quarter quads on the computer screen and then traced them with the cursor to generate new GIS data files. This work was performed with ESRI's ArcView 3.2 GIS software.

We displayed the quarter quads at a scale of 1:10,000 to generate the data. We determined this scale as an acceptable balance, given our goal to capture a majority of the infrastructure features within the study area, while keeping the time and costs of digitizing within reason. Our data sets do not capture a limited number of small features that are difficult to discriminate, including unused roads that may be revegetating. Therefore, our assessment of the overall ecological footprint is likely conservative.

We stored the data in two separate GIS data files, one for linear features such as roads and pipelines and one for polygon features such as drill pads, pumping stations, utility buildings, and retention ponds. We visually reviewed the data to eliminate areas and features that are unrelated to gas development.

Together, the two files show the immediate physical footprint that gas extraction left on Big Piney-LaBarge oil and gas field. This does not take into account the impacts across the larger landscape.

In the spatial analysis of metrics discussed immediately below, we used ESRI's Arc/Info and RoadNET (Road Network Evaluation Tool). RoadNET, a spatially based computer software application that allows quantitative assessments of the fragmentation of landscapes, is a proprietary GIS-based software program developed by Dawn Hartley of The Wilderness Society. RoadNET incorporates Visual Basic and MapObjects technology and runs on Windows 95/98/2000/NT platforms.

Metrics for Measuring Habitat Fragmentation

Roads, pipeline corridors, and other linear features associated with oil and gas projects fragment the landscape by separating patches or core areas of interior habitat with abrupt edges. This creates edge habitat that may give rise to invasion by edge-loving species to the

▼
The ecological effects of infrastructure features extend across the landscape beyond physical structures of the oil or gas field.
▲

possible detriment of interior species, and it reduces the total area of habitat available. The degree of fragmentation caused by these linear features, as well as the effects of such fragmentation on the ecological composition, structure, and function of a landscape, are difficult to measure and far from fully understood. However, a variety of landscape metrics have been developed to measure the condition of a landscape and its level of fragmentation. For our study, we selected three relatively simple landscape metrics: the density of roads and linear features, the acreage of habitat in the infrastructure effect zone, and the acreage of habitat in core areas.

A comprehensive analysis of fragmentation would incorporate a measure of landscape metrics generated by natural vegetation patterns and geographic features across a landscape prior to oil or gas field development. The infrastructure would then be superimposed and the metrics regenerated for comparison. Because detailed vegetative cover was not available, our study focuses only on fragmentation caused by infrastructure at Big Piney-LaBarge.

Density analysis of linear features. Although not an exact measurement of fragmentation, road density is often used as a surrogate for fragmentation. Road density measures the number of road miles per unit area and is a common metric in quantitative assessments of ecological impacts from a landscape perspective. Road density is also an indication of the level of human activity. Road densities increase as more people move onto a landscape.

Roads are only one of the linear features that fragment habitat in an oil and gas field. In this study, the density analyses include all linear infrastructure features, most notably roads and pipelines. At a scale of 1:10,000, we were not always able to distinguish with a high level of certainty the roads from the pipelines at Big Piney-LaBarge, and there are undoubtedly differences in the impacts of roads and pipelines. Nevertheless, all linear features used in the analysis create significant breaks in the vegetative cover, and thus our linear feature density analysis is more comprehensive than a road density analysis alone.

Linear feature density was calculated both as an average for the entire study area and as a series of one-square-mile and four-square-mile sampling windows across the landscape. Measuring density in sampling windows of different sizes provides an understanding of the variability of density across scales, which is important to gauge the effects on different species (Urban

PHOTO COURTESY LINDA BAKER

Physical infrastructure of gas fields, Riley Ridge Natural Gas Project, Upper Green River Basin, Wyo. The ecological effects of roads, pipelines, drill pads, and other components of the infrastructure extend far beyond the infrastructure itself.

et al. 1987, Wiens and Milne 1989, Turner et al. 1994). For example, differences in dispersal distances among species cause them to respond to habitat features at different scales.

Analysis of the infrastructure effect zone. The ecological effects of infrastructure features extend across the landscape beyond physical structures of the oil or gas field. Forman (1999) calls the influence on edge environments parallel to roads the "road effect zone." We extended this zone of influence to all forms of infrastructure. To measure this metric, we constructed a spatial effect zone around the entire infrastructure associated with gas drilling at Big Piney-LaBarge oil and gas field. Infrastructure effect zone analysis measures both known effects on plant and animal species and changes in the landscape (Baker and Knight 2000).

The width of the effect zone simulates the area affected by gas field development. The effects vary with distance and affect numerous species and human uses. By altering the width of the effect zone, we can simulate various impacts from dust and noise to the pressures of hunting and poaching.

Roads, in particular, have a wide range of effects on the landscape that occur at varying distances from the road. For example, immediately on or adjacent to roads, the obvious impacts are road kill, soil compaction, and altered surface water runoff patterns, among others. For some impacts, the effect zone might be simply the width of the road or a few feet on either side. Farther from the road, say 50 to 100 feet on either side, the impacts may include barriers to wildlife movement, noise, increased dust, and the spread of invasive non-native species. Farther still might be the increased presence of people. In fact, access for people to previously remote areas is perhaps the most significant impact of roads. Such access results in increased legal hunting and illegal poaching pressures on wildlife. It should

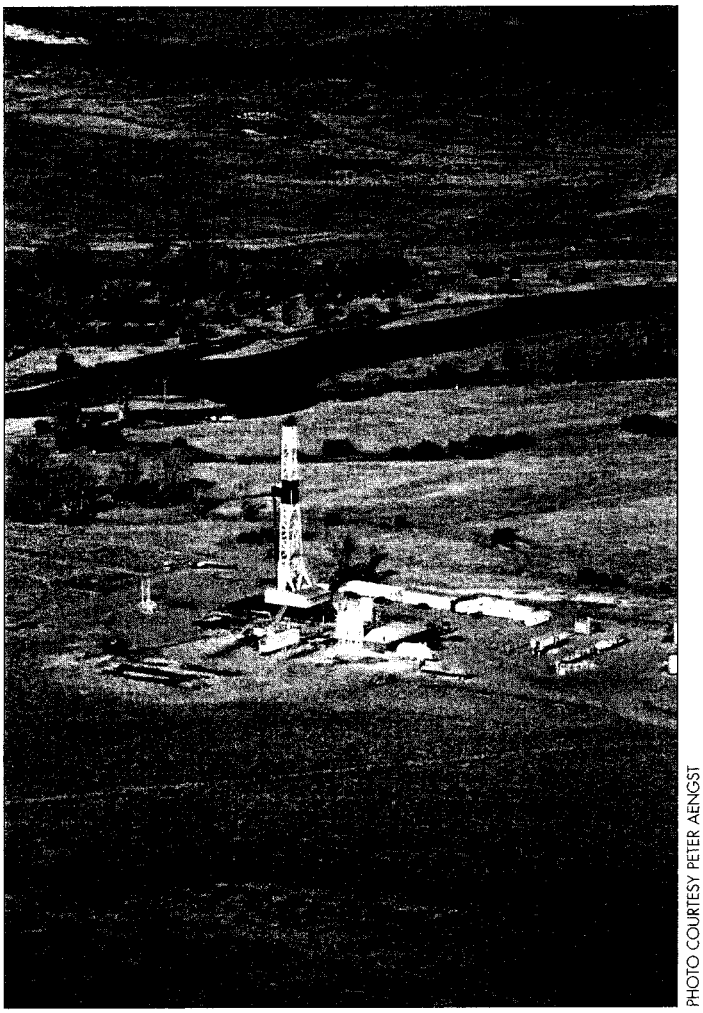


PHOTO COURTESY PETER AENGST

Drill rig in the Upper Green River Basin. The total regional impact of the infrastructure at any one site is magnified by the 3000+ gas and oil wells that have been drilled in the Upper Green River Basin, WY.

be also noted that roads built to service oil and gas projects are often permanent changes to the landscape and therefore represent permanent loss of habitat (Noon 2002).

Our analysis begins to assess the effects of roads and other infrastructure across the landscape of Big Piney-LaBarge oil and gas field. First, we gave the roads and other linear features an initial dimension of 3.5 meters, the average width of single lane roads defined by Trombulak and Frissell (2000). This is a conservative width since some of the roads will be wider. We performed effect zone analyses using widths of one mile, one-half mile, one-quarter mile, 500 feet, 250 feet, and 100 feet. We created these effect zones on the linear and polygonal feature coverages independently and then combined them to create a separate infrastructure effect zone coverage for each width. Finally, we clipped each coverage with the boundary of the study area to remove any portion of the effect zone that fell outside the study area.

Core area analysis. Another commonly used measure for landscape fragmentation is core area, sometimes referred to as interior habitat. Core areas exist in natural landscapes as contiguous blocks of uniform habitat types away from natural breaks or habitat edges. For our analysis, core areas are defined as portions of the landscape that are sufficiently far from human infrastructures or other human modifications to be relatively unaffected by them. Communities of native species and ecological functions persist uninterrupted in these areas.[2]

We looked at habitat patches on the landscape outside of the infrastructure effect zones. For each of the final effect zone coverages described above, we created a corresponding core area coverage. We combined each of the final effect zone coverages with the outer border of the study area to create boundaries for the core areas that lie at the edge of the study area outside the effect zones. This step assumes that core areas adjacent to the study area boundary are indeed core areas.

It is possible for additional infrastructure features to be located immediately outside the study area—features that, if included in the analysis, would increase the acreage that falls within the effect zones and decrease the acreage of core area. Because we considered only those infrastructure features within the study area, we may have overestimated the number and size of core areas.

In the final step, we removed the effect zone polygons, leaving only core area polygons, and calculated the number, size, and overall area of the remaining core areas as well as the percentage of the study area covered by all core areas.

[2] Fragmentation studies demonstrate that the size and pattern of core areas are important factors in forest landscapes (Baker 1992, McGarigal and Marks 1994, Tinker et al. 1998). Fewer studies have been completed for rangeland landscapes.

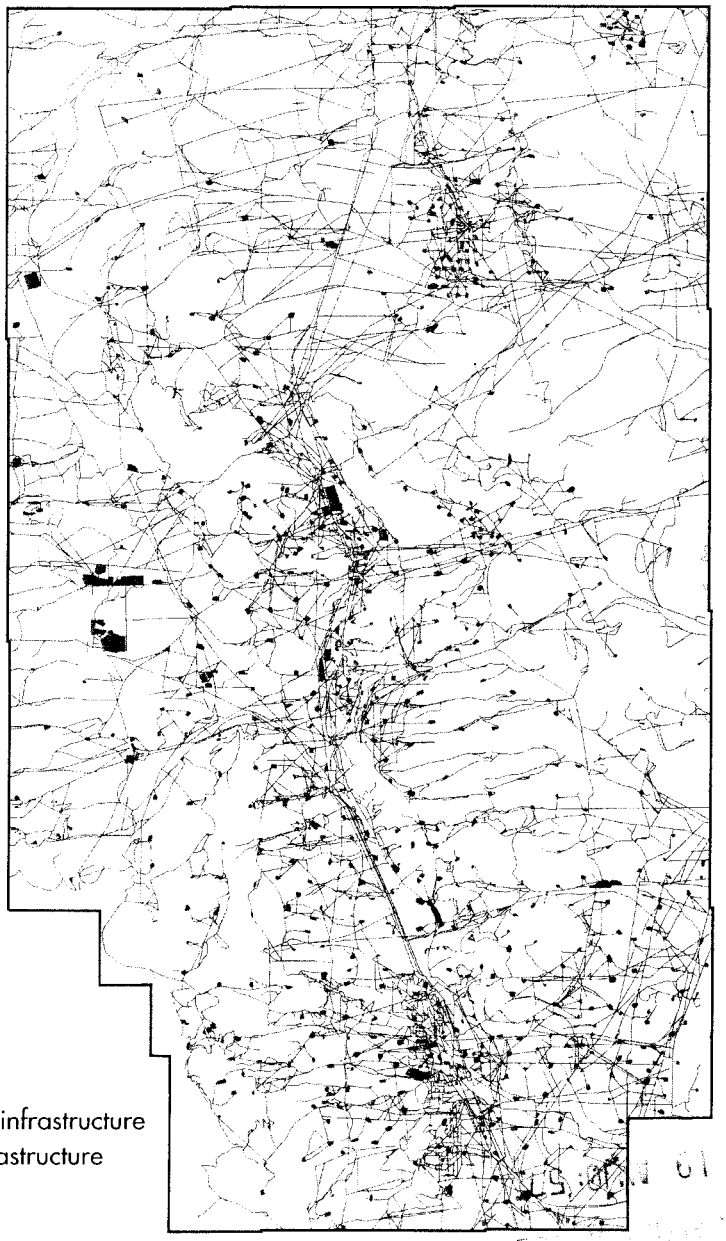
4. Results

All results are based on the digitized linear and polygon infrastructure data described in the methods section and displayed in Figure 2. The data set covers 166 square miles, the bulk of the area for Big Piney-LaBarge oil and gas field, and captures 1,400 miles of linear features and 3.8 square miles of polygon features. The amount of area covered by infrastructure (the physical footprint), and thus the amount of habitat lost, is

FIGURE 2.

The physical footprint of oil and gas development in the Big Piney-LaBarge field

The digitized physical footprint from oil and gas development in the Big Piney-LaBarge field includes both linear infrastructure features such as roads and pipelines and polygonal infrastructure features such as drill pads, pumping stations, utility buildings, and retention ponds.



7 square miles, or 4% of the study area. The ecological footprint is described in the results below.

Density Analysis of Linear Features

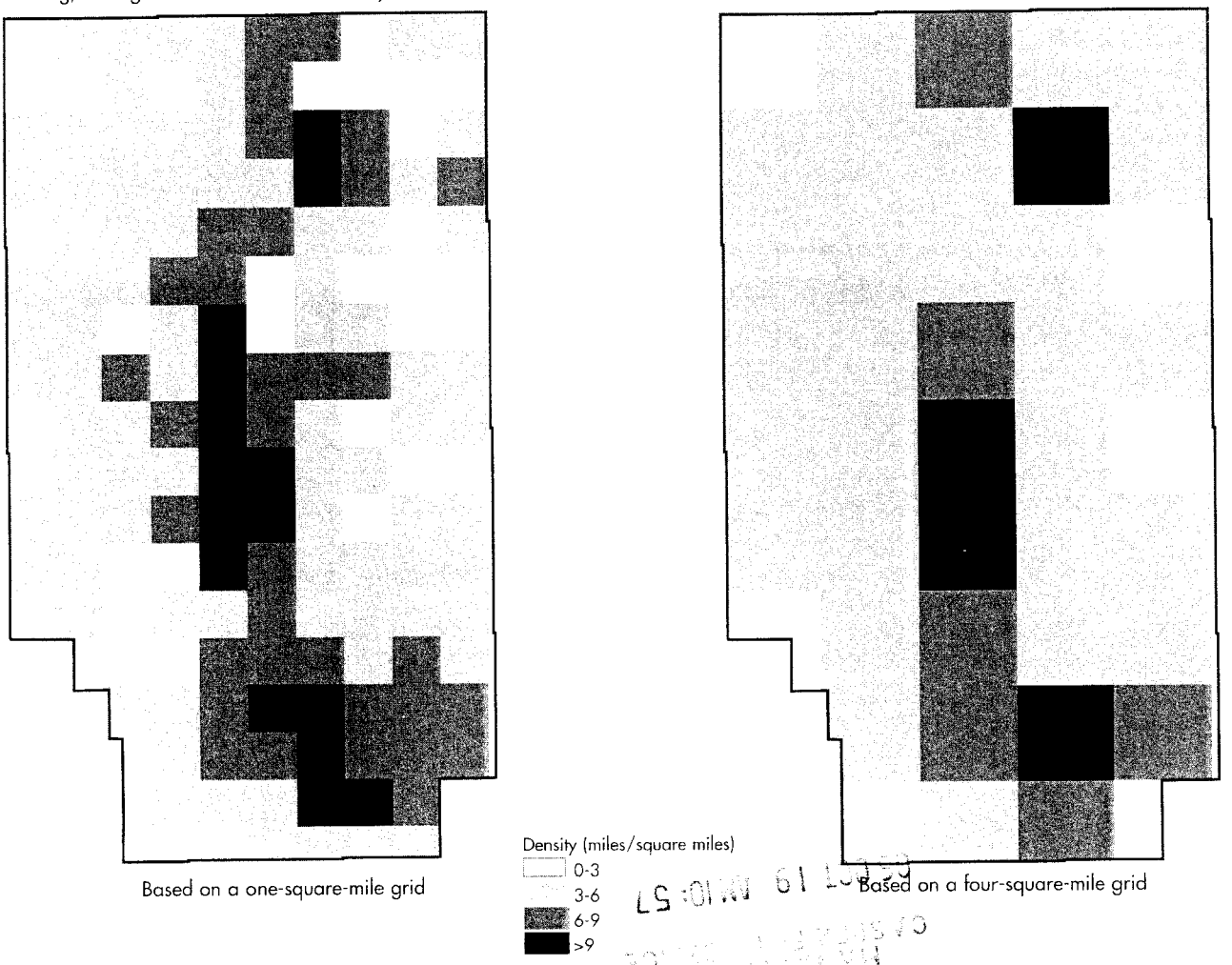
The average density of roads and other linear infrastructure features across Big Piney-LaBarge oil and gas field is 8.43 miles per square mile. However, linear feature density estimates are scale dependent and vary across the study area. To examine local variation in the density of roads and other linear features, we measured densities across both one- and four-square-mile blocks over the landscape (Fig. 3). The results show that densities in the one-square-mile cells range from a high of 17.1 miles per square mile to a low of 0.9 miles per square mile. Densities across the four-square-mile cells range from a high of 11.9 miles per square mile to a low of 2.3 miles per square mile.

Figure 3 illustrates the spatial distribution of linear feature density across

FIGURE 3.

Density of linear features, Big Piney-LaBarge field

The density of linear infrastructure features was calculated using both a one-square-mile grid and a four-square-mile grid. The darker the shading, the higher the linear feature density.



the study area. Table 1 shows the percentage of the landscape with different density ranges. The highest percentage of the landscape has a density of between three and six miles per square mile. This is true for both the one-square mile grid, where 49% of the study area falls into this category, and the four-square mile grid, where 64% of the study area falls. It is also important to note that 29% of the landscape in the one-square-mile scenario, and 24% of the landscape in the four-square-mile scenario have linear densities of more than six miles per square mile.

TABLE 1.

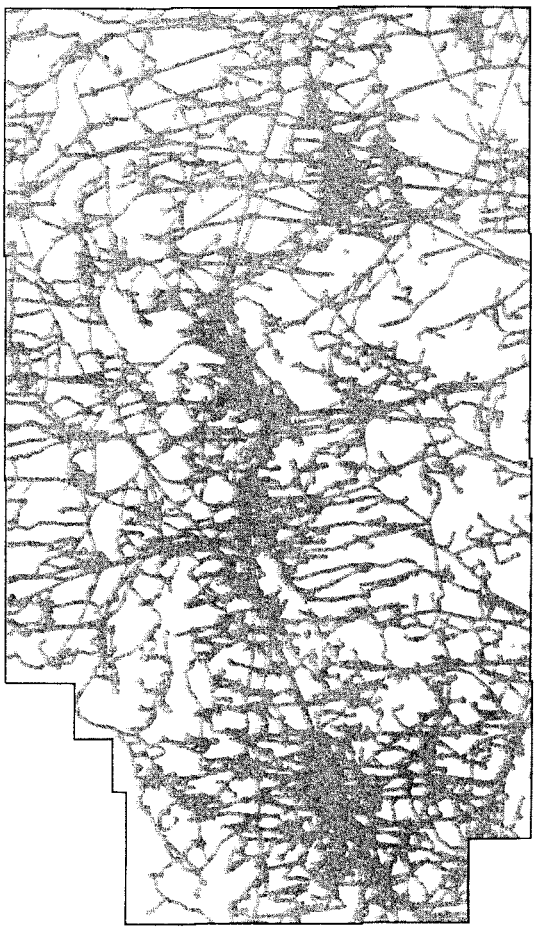
Percentage of the study area that falls within different linear feature density ranges

Linear feature density (miles/square mile)	Based on a one-square-mile grid	Based on a four-square-mile grid
0 - 3	22%	12%
3 - 6	49%	64%
6 - 9	20%	14%
> 9	9%	10%

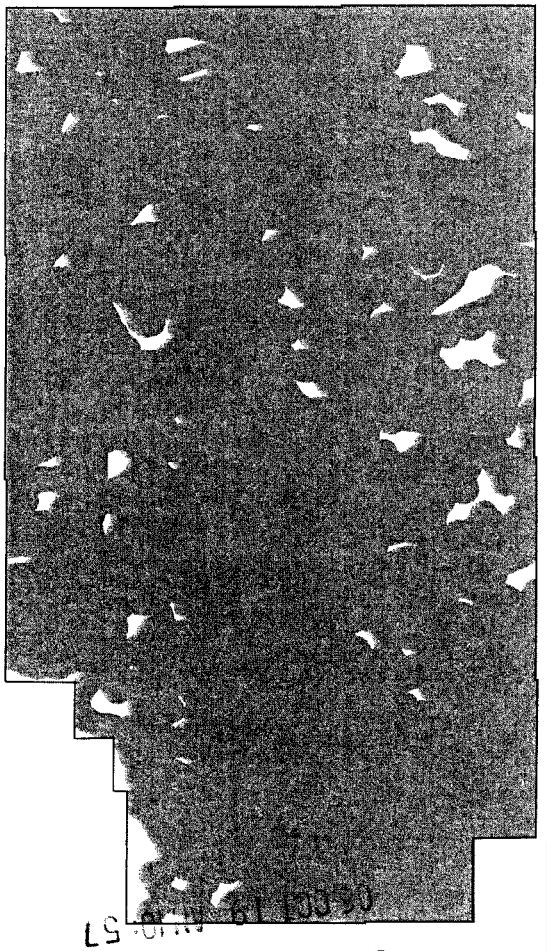
FIGURE 4.

Infrastructure effect zones from oil and gas development

Two examples of infrastructure effect zones based on zone widths of 250 feet and one-quarter mile. Shading indicates the extent of the landscape in the study area that is affected by oil and gas infrastructure.



250-foot effect zone



One-quarter-mile effect zone

Analysis of Infrastructure Effect Zone

Results of the one-mile and one-half-mile effect zone analyses show that the entire 166-square-mile study area is within one-half mile of a road, pipeline corridor, well head, retention pond, building, parking lot, or other component of the infrastructure involved in the oil and gas drilling process. Ninety-seven percent, or 160 square miles, falls within one-quarter mile of infrastructure. When effect zones of 500 feet and 250 feet in width are applied, 73% (122 square miles) and 52% (86 square miles) of the study area fall within the effect zone area. And 28%, or 47 square miles, of the study area is within the 100-foot effect zone. As sample illustrations, Figure 4 shows the scenarios for the 250-foot and one-quarter-mile effect zones.

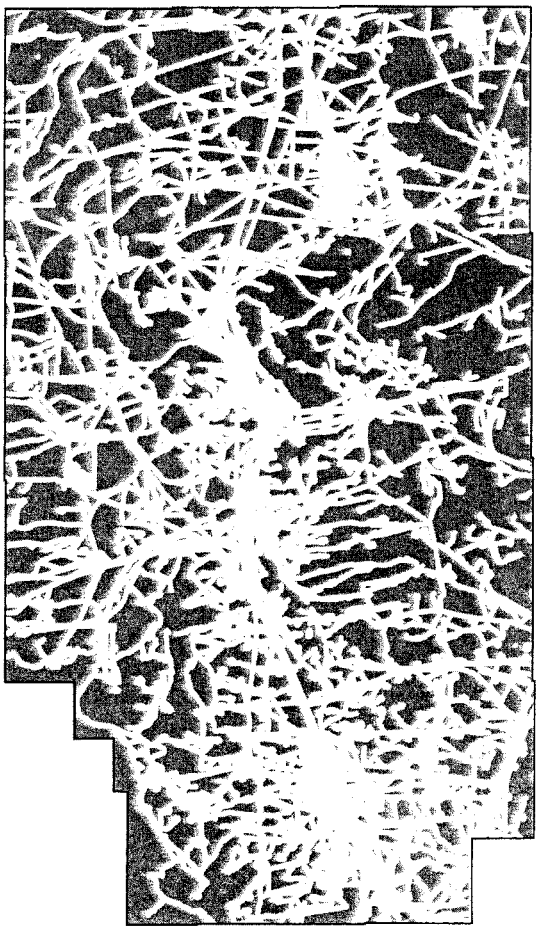
Core Area Analysis

Because our results show that the entire study area is within the infrastructure effect zone when zone widths of one mile and one-half mile are applied, there

FIGURE 5.

Core area beyond infrastructure effect zone

Two examples of core area maps based on 250-foot and one-quarter-mile infrastructure effect zones. Shading represents the areas beyond relatively narrow and wide infrastructure effect zones.



Core areas beyond 250-foot effect zone

Core areas beyond one-quarter-mile effect zone

are no core areas in those two scenarios. Remaining core areas are present when effect zone widths of one-quarter mile, 500 feet, 250 feet, and 100 feet are used (Table 2).

Results show that as the width of the effect zones increases, the total number of core areas decreases as does the maximum core area acreage, the total acreage of core areas, and the percent of the study area remaining in core areas. These results are consistent with an increase in the area of effect.

The results for the minimum core area size are so small in the most heavily developed areas of the study area as to be indistinguishable among the different scenarios. The results for mean core area size actually increase as the width of the effect zone moves from 100 feet to 250 feet and 500 feet because the smaller patches are progressively eliminated, shifting the mean to larger acreages. This effect drops off between 500 feet and one-quarter mile, and the mean core area drops, much as one might expect.

As an example, core areas in the 250-foot and one-quarter-mile effect zones are shown in Figure 5.

TABLE 2.

Summary of results from core area analyses under four different infrastructure effect zone scenarios

	100-foot effect zone	250-foot effect zone	500-foot effect zone	1/4-mile effect zone
Number of core areas	2,871	1,232	499	75
Maximum size (acres)	3,102	2,686	2,042	423
Minimum size (acres)	< 1	< 1	< 1	< 1
Mean size (acres)	27	42	57	46
Total area (acres)	76,214	51,385	28,420	3,457
Percent of study area	72	48	27	3

5. Discussion

Impacts

It is clear from the linear feature density, infrastructure effect zone, and core area analyses that the infrastructure at Big Piney-LaBarge oil and gas field fragments the landscape. We preface the discussion in this section of our report with a list of direct impacts from gas field development. The list is found in the draft environmental impact statement prepared by the Bureau of Land Management (1999) for Pinedale Anticline gas field northeast of our study area.

- Wildlife mortality from wildlife-vehicle collisions on or off project sites.
- Wildlife mortality during road, pipeline, and well-pad construction and other surface-disturbing actions.
- Wildlife mortality caused by consumption of or exposure to toxic compounds.
- Fragmentation of connected habitats.
- Removal of vegetation and other features such as rock outcrops that provide habitat.
- Degradation of aquatic habitats caused by alteration of stream banks and by siltation, and decreased water quality.
- Loss of forage for herbivores.
- Diminished animal use of habitats because of the effects of noise, dust emissions, and the presence of humans.
- Interruption or interference with wildlife life-history functions, including courtship, nesting and parturition, migration, and winter survival.

Many of these impacts persist over time, and additional impacts can be expected after full development of an oil or gas field. Comer (1982) lists several.

- Increased recreation, particularly by off-road vehicles.
- Increased conversion of habitat, especially for urban or suburban sprawl.
- Habitat degradation through encroachment by people.
- Increased noise, air, and water pollution.
- Increased poaching of game species.
- More numerous wildlife deaths on roads.
- Increased harassment of wildlife by uncontrolled pets, especially dogs.
- More invasions of non-native species.

Most of the impacts on these lists apply to the physical footprint—1,400 miles of linear features and 3.8 square miles of polygon features—left on Big Piney-LaBarge gas field. Many also extend beyond the physical footprint and require landscape analyses such as those we conducted to describe the extent of the area affected by these impacts.

Landscape Metrics

As described earlier, our density figures include other linear features in addition to roads (primarily pipelines). The majority of the features are roads, and all produce a significant break in natural vegetative cover. It is therefore useful to compare our linear feature density estimates to road density estimates elsewhere on public lands.

Road densities on national forests in Wyoming, South Dakota, and Colorado, for example, range from 0.42 miles per square mile to 2.37 miles per square mile (Baker and Knight 2000), nearly three times less than the density we document at Big Piney-LaBarge. The Interior Columbia Basin Ecosystem Management Project (U.S. Forest Service 1996) classified road densities as extremely high when they reach 4.7 miles per square mile. Based on this criterion, the overall density of 8.34 miles per square mile at

Big Piney-LaBarge suggests that tight gas drilling results in a highly fragmented landscape.

In more open landscapes such as the desert sagebrush environment of our study area, wildlife species are particularly vulnerable to the effects of disturbances and will be impacted by even lower road densities than those listed for forested landscapes in the preceding paragraph (see wildlife section below).

It is notable that local road densities exceed three miles of road per square mile over most of the study area. At all oil and gas production areas, a comparison is needed between the average and localized road density figures and the road density figures in the ecological literature to determine the impacts on specific terrestrial and aquatic species.

While the physical footprint, or the actual oil and gas infrastructure, comprises only 4% (seven square miles) of the study area, the infrastructure effect zone analyses show that the ecological footprint is much larger. The ecological footprint varies depending upon which disturbance is measured. A disturbance that reaches a quarter of a mile beyond the infrastructure creates a footprint of 160 square miles, affecting 97% of the study area. Even a more localized disturbance that only reaches 100 feet beyond the infrastructure affects 28% of the study area (47 square miles).

When choosing the appropriate effect zone widths for analysis, it is important to consider the particular disturbances that impact the area in question and which specific physical, biological, or human effects the disturbances have on the landscape. For example, the size of the effect zones should be constructed with widths that reflect documented effects on specific species in the study area.

Likewise, core area results should be compared to the size and shape of areas needed by local species for dispersal, breeding, and other life-history functions. As more scientific information becomes available regarding the specific habitat requirements of pronghorn antelope, mule deer, and sage-grouse, it can be used to formulate landscape analyses to assess the impacts of future development in the area.

In addition to considering the size and shape of remaining core areas, the connectivity of those core areas is critical to wildlife. If certain species must migrate between core areas and are unable to do so, the fact that there may be a large number of core areas with significant acreage will mean little to their survival.

While this study looks at core areas only as a function of infrastructure, assessments of core areas should also take into account the natural variation in vegetation cover patterns. And naturally occurring core areas should be compared to core areas that are caused when natural patterns are fragmented by oil and gas development infrastructure.

Future work should discriminate between types of linear and polygon features and their different effects on the landscape, if the data are available. For example, a frequently used road should be treated differently than a remote pipeline, as should an automated drill pad and a frequently used utility site. Such distinctions would allow researchers to calculate linear feature densities independently for features with differing impacts and to measure the edge effect zone at different widths for features with differing degrees of disturbance. This in turn would change the size of the core areas and potentially produce more accurate and useful landscape metrics.

Wildlife

The Upper Green River Basin is home to at least 25 species that the U.S. Fish and Wildlife Services lists as threatened or endangered, including the black-footed ferret, whooping crane, bald eagle,

▼ The overall linear density of 8.34 miles per square mile at Big Piney-LaBarge suggests that tight gas drilling results in a highly fragmented landscape. ▲

mountain plover, northern goshawk, peregrine falcon, and spotted frog (Bureau of Land Management 2001). As noted earlier, the study area is also wintering ground for elk, pronghorn antelope, and mule deer.

The large number of oil and gas fields in this basin block natural migration routes and encroach on crucial wildlife wintering grounds. Numerous studies document that elk avoid roads and, according to Lyon (1983), do not use habitat adjacent to roads to its full potential. Lyon found that when road densities are as low as one mile per square mile, elk habitat effectiveness is reduced by 25%. When road densities are two miles per square mile, elk are displaced from up to 50% of their habitat. When road densities exceed five to six miles per square mile, elk are unable to use more than 75% of the habitat and may not use any of the potentially available habitat. Roughly a quarter of our study area falls within the latter category.

As noted above, road avoidance by wildlife is particularly evident in open landscapes with little surrounding vegetation (Perry and Overly 1976, Morgantini and Hudson 1979, Rost and Bailey 1979). In areas with little cover, habitat is completely lost at a road density of only 0.8 miles of road per square mile (Lyon 1979).

A study on elk habitat effectiveness, in north-central Wyoming found that few elk used areas with road densities higher than 0.5 miles per square mile (Sawyer et al. 1997). Again, our results indicate that most of our study area has linear feature densities much higher than 0.5 or 0.8 miles per square mile.

Another study in western Wyoming indicates that elk are avoiding a relatively high-density oil and gas field in open habitat (Bock and Lindzey 1999). The lack of physical barriers to screen drilling activities has displaced elk up to three miles.

Perry and Overly (1976) concluded that more than 640 acres of elk habitat can be affected by one mile of road, while a radiotelemetry study by Edge and Marcum (1991) measured a 5% probability of elk using lands within one kilometer of a road during calving season.

Wyoming has by far the greatest concentration of pronghorn antelope in any state or provincial authority in North America, and the Green River Basin holds the highest concentration of this animal in Wyoming (Bureau of Land Management 2000). In addition, western Wyoming boasts the longest pronghorn migration in North America—up to 190 miles, depending on the route chosen, from Grand Teton National Park to winter range near the Jonah Field in the Upper Green River Basin. Archaeological digs indicate that this migration has continued uninterrupted for more than 6,000 years (Sawyer and Lindzey 2000).

The antelope are known to have crucial and non-crucial winter ranges, as well as spring, summer, and fall ranges, in Big Piney-LaBarge gas field (Bureau of Land Management 1999). BLM documents indicate that antelope in the nearby Whitney Canyon-Carter Lease fields felt the impacts of oil and gas projects with "nearly one mile of road per every square mile of occupied habitat" (Bureau of Land Management 1999). Our study area has average linear feature densities more than eight times greater than one mile per square mile.

The bulk of the study area is designated as mule deer winter habitat (Bureau of Land Management 1990). Mule deer have also been shown to avoid oil and gas development in their habitat. A study conducted in North Dakota found that mule deer avoided areas within 300 feet of well sites for feeding and bedding, resulting in a 28% reduction in secure bedding areas. Their avoidance of roads and facilities continued for more than

seven years, indicating a long-term and chronic loss of habitat (Jensen 1991).

Wildlife species other than big game animals also face the impacts of infrastructure. Southwestern Wyoming is considered the location of the largest and most robust North American population of the greater sage-grouse. Wyoming has more than 150 identified leks (breeding grounds)—key to greater sage-grouse survival—about two-thirds of which are located in Upper Green River Basin (Bureau of Land Management 1999). The population and distribution of greater sage-grouse across the West has decreased in the past 50 years as a result of habitat loss, and the decline has been dramatic in the past 20 years (Christiansen 2000). For this reason, the greater sage-grouse is being considered for listing under the Endangered Species Act.

Greater sage-grouse are affected by oil and gas development for miles beyond the infrastructure itself. A recent study (Lyon 2000) in Wyoming compared the behavior of females captured on leks within two miles of natural gas development to those captured on undisturbed leks (farther than two miles from any gas development). The study found that the hens captured on disturbed leks had lower nest-initiation rates and moved longer distances to nest sites than hens captured on undisturbed leks.[3] Given our results, then, there is no place in Big Piney-LaBarge gas field where the greater sage-grouse would be unaffected by natural gas development.

PHOTO COURTESY GARY KRAMER, U. S. FISH AND WILDLIFE SERVICE

Greater sage-grouse, a species that is being considered as a candidate for listing under the Endangered Species Act. The results of our study show that there is no place in Big Piney-LaBarge gas field where this species will not be affected by the gas extraction project.

Other bird species have been shown to decline in oil and gas fields of the Upper Green River Basin. Ingelfinger (2001) measured the distribution of birds along dirt roads in the Jonah Field II and the Pinedale Anticline Project Area. Results showed a 50% decrease in Brewer's and sage sparrows and the guild of sagebrush obligates within 100 meters of a road. Ingelfinger pointed to traffic and changes in habitat use as causes. A distance of 100 meters falls in between our impact zones of 250 feet and 500 feet, and thus our results suggest that the presence of Brewer's and sage sparrow and the guild of sagebrush obligates may also be reduced by half across 52% to 73% of Big Piney-LaBarge gas field.

[3] According to a recent report in *Wyoming Wildlife News* (Christiansen 2000), "Only 67 percent of the hens captured on strutting grounds near disturbance (well pads or roads) attempted to nest. This compares to 89 percent of the hens captured on a relatively undeveloped location. In addition, only 47 percent of the disturbance site birds remained within two miles of the disturbance during nesting while 89 percent of the undisturbed birds remained within two miles of where they were captured. Both groups had 50 percent of their nests hatch. This means that if 100 hens were associated with the disturbed and undisturbed sites and both groups had six chicks hatch from each successful nest, then the area within two miles of an undisturbed strutting ground would have hatched 238 chicks while only 94 chicks would have hatched within two miles of a disturbance."

Additional Concerns[4]

Our analysis is limited to a single spatial scale—that of the Big Piney-La Barge field. But oil and gas development may affect ecological phenomena at other scales as well. For example, we mentioned but did not analyze the potential effects of oil and gas development on animal migration. A comprehensive spatial analysis should examine impacts at multiple scales to understand this phenomenon.

A complete spatial analysis should also examine the effects below and above the land surface. Hydrocarbon extraction and fluid injection can have substantial impacts, including drawdown and contamination, on both shallow and deep aquifers. It is important to gather baseline data and predict the subsequent effects on natural systems and local agricultural and residential water users.

The oil and gas production process also emits pollutants into the atmosphere, including greenhouse gases. The Big Piney-LaBarge processing plant vents six million tons of carbon dioxide into the atmosphere every year (Allis et al. 2001). To compare, the theoretical carbon dioxide emissions from a 1000-megawatt coal-fired plant are assumed to be nine million tons per year (U.S. Department of Energy 1999).

[4] The condition of local wildlands affects a region's recreation opportunities and its ability to attract and maintain a quality work force. Aplet et al. (2000) documented six features that contribute to the wildness of a landscape: opportunities for solitude, remoteness from mechanical devices, natural ecological processes at work, natural vegetative and wildlife species composition, no alterations by human structures, and low levels of pollution. Our analysis of infrastructure documents a decrease in the level of solitude, remoteness, and natural species composition and an increase in human structures in the study area. These factors should be considered in assessments of the impacts from oil and gas projects—for local communities and for people who visit from more distant locations.

6. Conclusions and Recommendations

Despite the documented impacts that habitat fragmentation has on wildlife, proposed oil and gas projects are moving forward without adequate evaluation of those impacts. Land managers sometimes excuse their lack of evaluations by stating that data are insufficient to conduct impact assessments.

For example, the draft environmental impact statement that evaluates the effects of coal bed methane development in the Powder River Basin of Wyoming asserts in its wildlife section that it is difficult to assess the effects of roads and habitat fragmentation "because these determinant factors are largely unknown at this time" (Bureau of Land Management 2002). At the same time, the document concludes that there is enough habitat elsewhere to mitigate any habitat loss caused by fragmentation.

Comments on that document penned by a wildlife ecologist state:

> The relevance of the fragmentation process affecting wildlife populations rests on the understanding that information on habitat amount alone may be insufficient to predict the status of a species. When habitat is potentially limiting, then information on the spatial pattern of the habitat may be equally or more relevant than information on habitat amount. The importance of incorporating spatial data into effects analysis cannot be overemphasized. Knowledge of where on the landscape habitat loss will occur and in what spatial pattern is essential before one can conclude no significant adverse effects (Noon 2002).

This study has demonstrated three landscape metrics—linear feature density, infrastructure effect zone, and core area—for use in assessments of fragmentation across a landscape. These metrics, along with the ecological literature, illustrate that the ecological footprint from oil and gas development is much larger than the physical infrastructure footprint. Such spatial analysis can and should be incorporated into the evaluation and monitoring of the ecological impacts of existing and proposed oil and gas projects. When land management agencies consider plans to develop an area for its oil and gas resources, the required environmental impact statement should include similar analysis at the landscape level. The significant increase in availability and access of GIS data and software technology in recent years should make this possible.

We performed our analysis on data derived from an existing oil and gas field. The same kind of analysis should be performed prior to development of a new oil and gas field or when planning additional development in an existing field. The following recommendations for landscape assessments act as a guide for completing environmental evaluations to assess the true ecological footprint of potential oil and gas extraction prior to field development.

Generate infrastructure scenarios. Infrastructure data for all linear and polygonal features should be generated to construct scenarios for the proposed oil or gas field. Multiple road scenarios should be provided for the range of potential infrastructure, depending upon the type of resource extracted and the required support facilities. The scenarios should include generous and conservative estimates of infrastructure construction, based on probabilities for hydrocarbon resources in the field. Particular care should be taken if unconventional or continuous type deposits are involved, because "[l]and-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" (U.S. Geological Survey 1996b).

Assemble habitat use information from published literature where available for threatened and endangered species and other key plant and animal species in the proposed development area. The goal is to provide data needed to devise the parameters of metrics and for interpretation. The information should include, but not be limited to, impacts of road density on local species, distance of road effects to determine the width of effect zones for infrastructure features, and species dispersal distances to evaluate the size of core areas.

Generate landscape metrics. Calculate landscape fragmentation metrics on all infrastructure. Include at a minimum infrastructure density, infrastructure effect zones, and core areas. Metric parameters and the evaluation of results should be relevant to ecological conditions, species that are present, and human uses of the landscape in question.

Integrate results into management plans. Evaluate landscape fragmentation metrics of effects to determine the impacts on specific local species. Include these ecological footprint impacts along with other ecological impact data in federal planning documents throughout the planning process for potential development of oil and gas fields.

This landscape assessment comparing the impacts of extracting oil and gas resources with the maintenance of wildlife, habitat, and recreational resources fits well with existing federal environmental regulations. Such analyses should become a standard part of the environmental assessments, environmental impact statements, resource management plans, and coordinated activity plans conducted by the U.S. Forest Service and Bureau of Land Management. The Federal Land Policy and Management Act of 1976, which guides BLM management of public lands, specifically requires the "harmonious and coordinated management of the various resources without permanent impairment of the productivity of the land and the quality of the environment with consideration being given to the relative values of the resources and not necessarily to the combination of uses that will give the greatest economic return or the greatest unit output."

Comprehensive assessments of the ecological footprint should incorporate spatial analyses that extend beyond the scope of this study to include an assessment of landscape context and impacts on the subsurface and atmosphere. It is essential to evaluate the ecological role of the proposed field of development in the broader landscape. Consider both the content and function of the area. For example, does this landscape provide a food source, breeding ground, or seasonal range for threatened or endangered species that is not available in the surrounding landscape?

It is important to include analyses of hydrologic impacts such as drawdown or contamination for shallow and deep aquifers. These impacts should be evaluated for their short- and long-term ramifications related to ecosystem and societal needs for the water resources. Likewise the atmospheric emissions from extraction and processing need to be measured for their content, volume, and distribution.

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Exhibit 12

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.

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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.

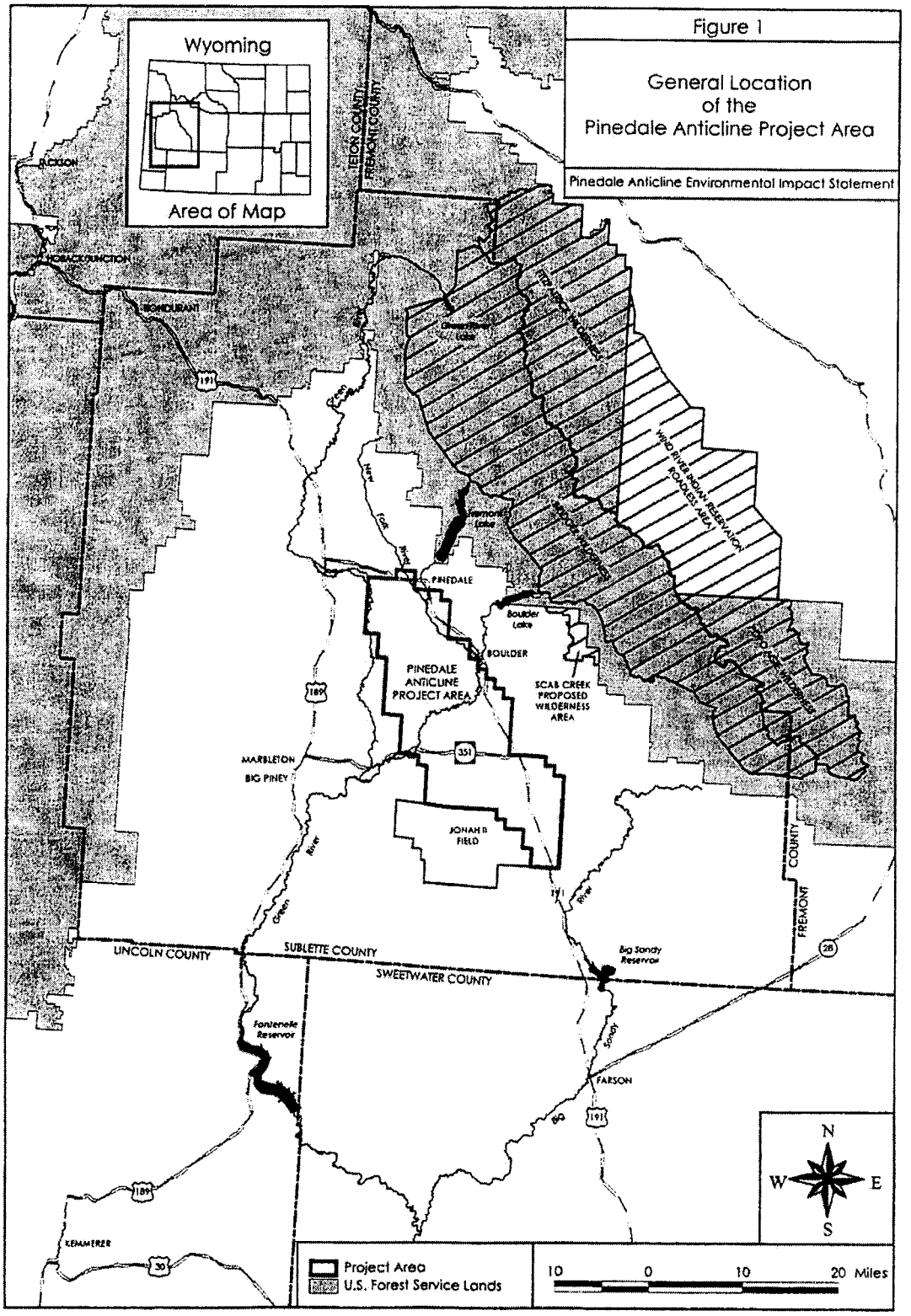

Figure 1.1 Location of Pinedale Anticline Project Area in western Wyoming (from BLM 2000).

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.

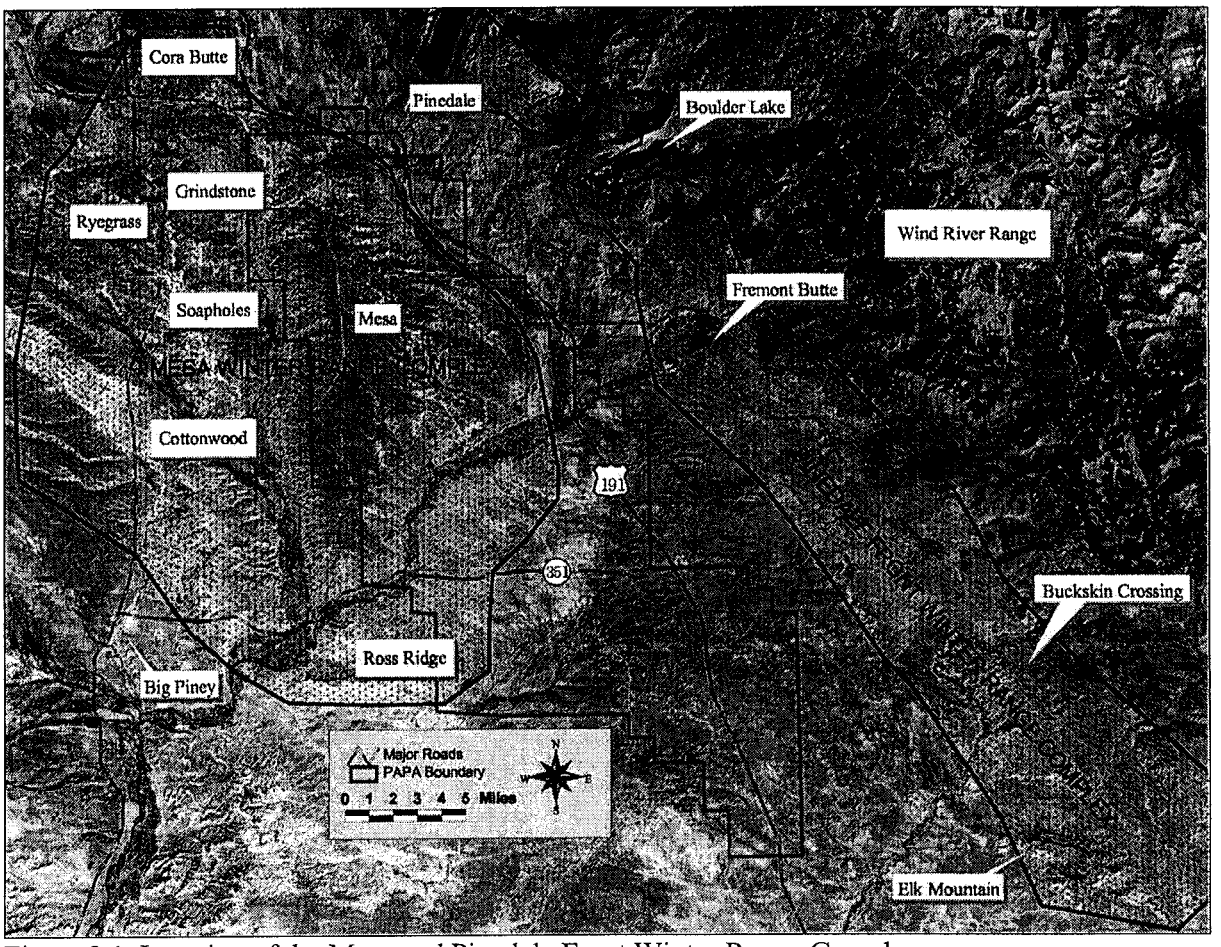

Figure 2.1 Location of the Mesa and Pinedale Front Winter Range Complexes.

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.

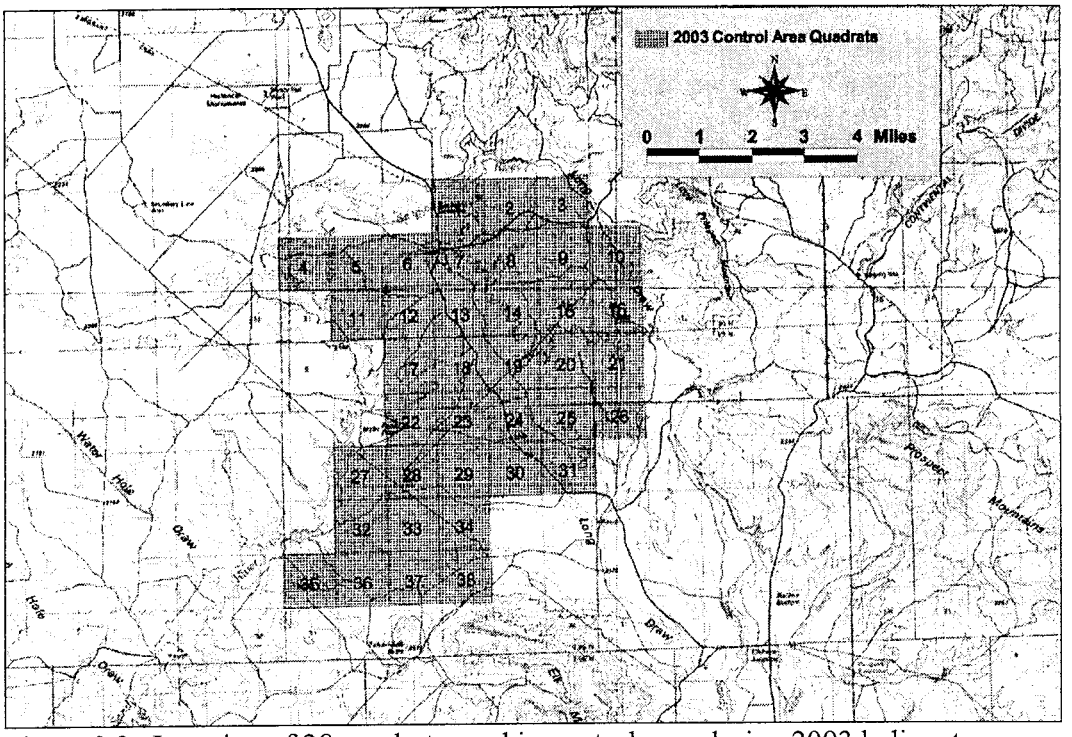

Figure 2.2 Location of 38 quadrats used in control area during 2003 helicopter surveys.

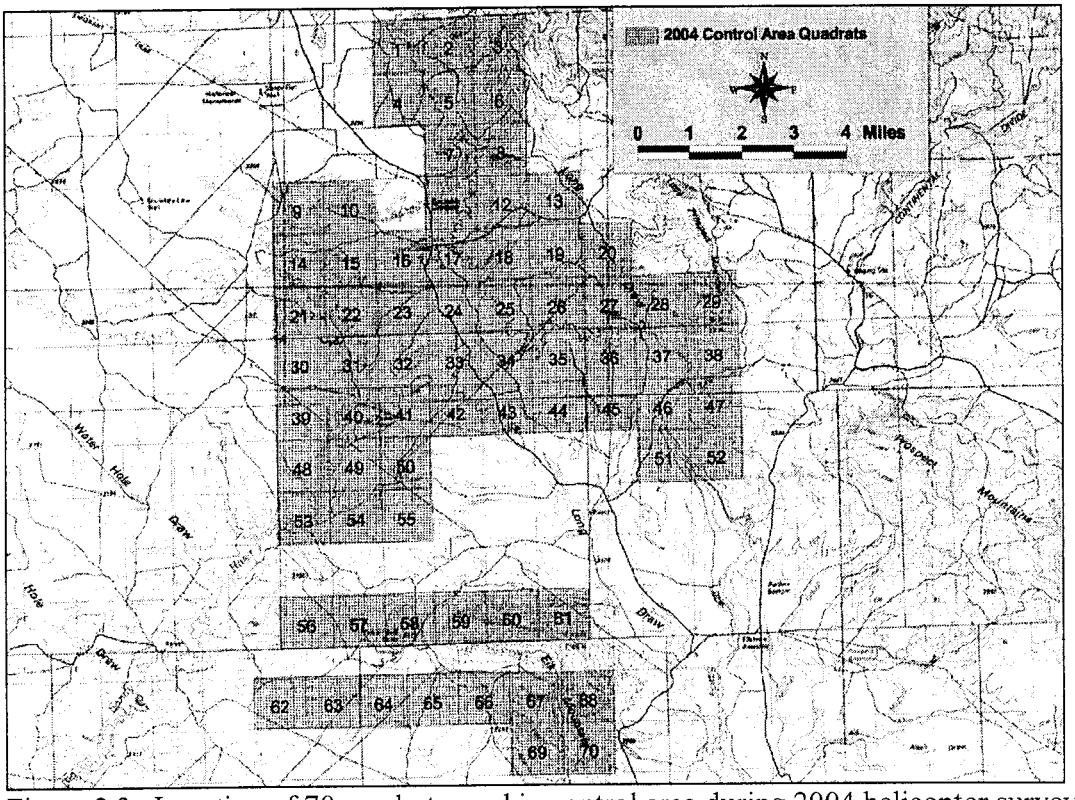

Figure 2.3 Location of 70 quadrats used in control area during 2004 helicopter surveys.

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.

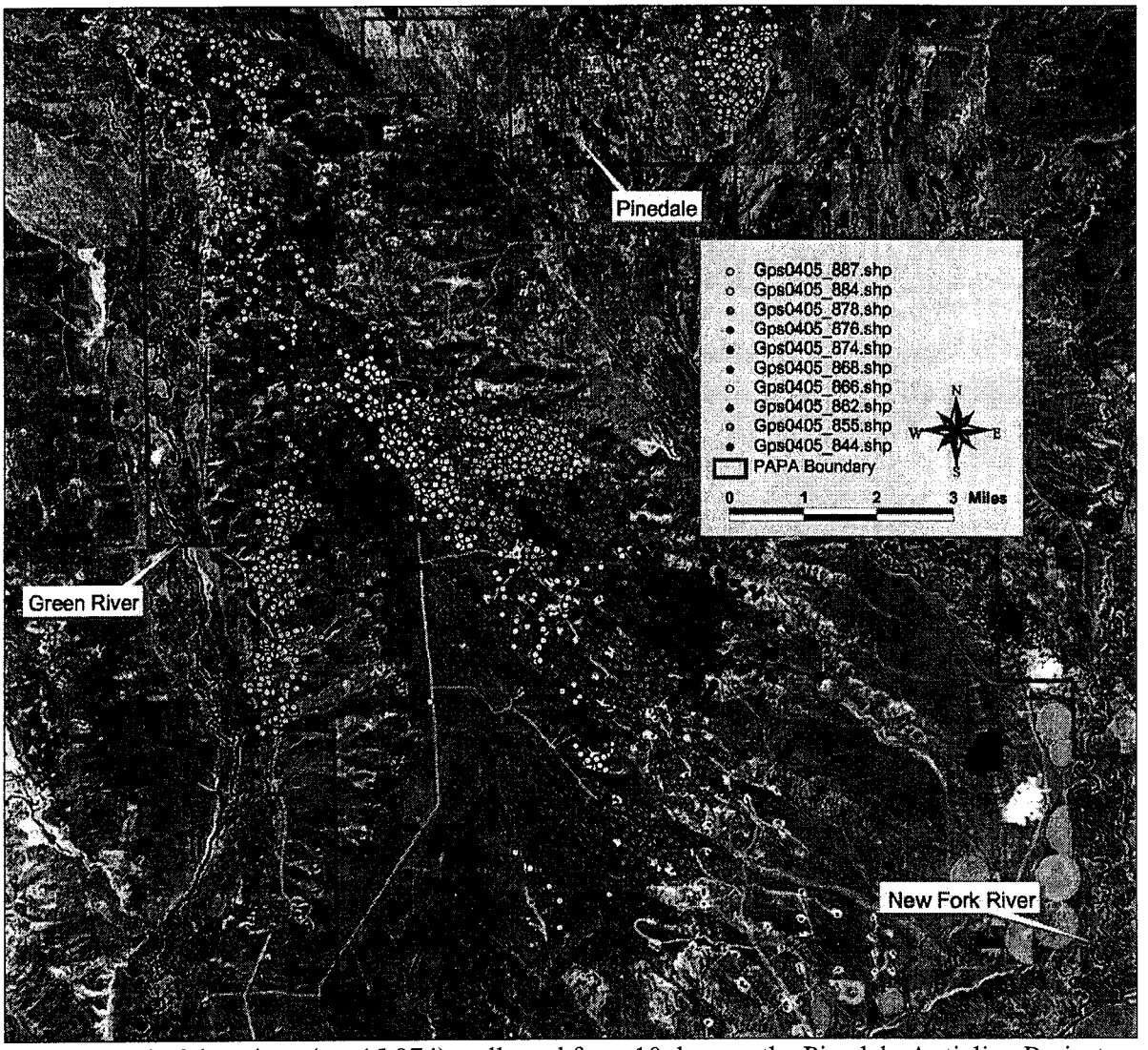

Figure 2.4. GPS locations (r = 15,974) collected from 10 deer on the Pinedale Anticline Project Area (PAPA), November 1, 2004 – April 15, 2005, overlaid on satellite image taken August 28, 2004.

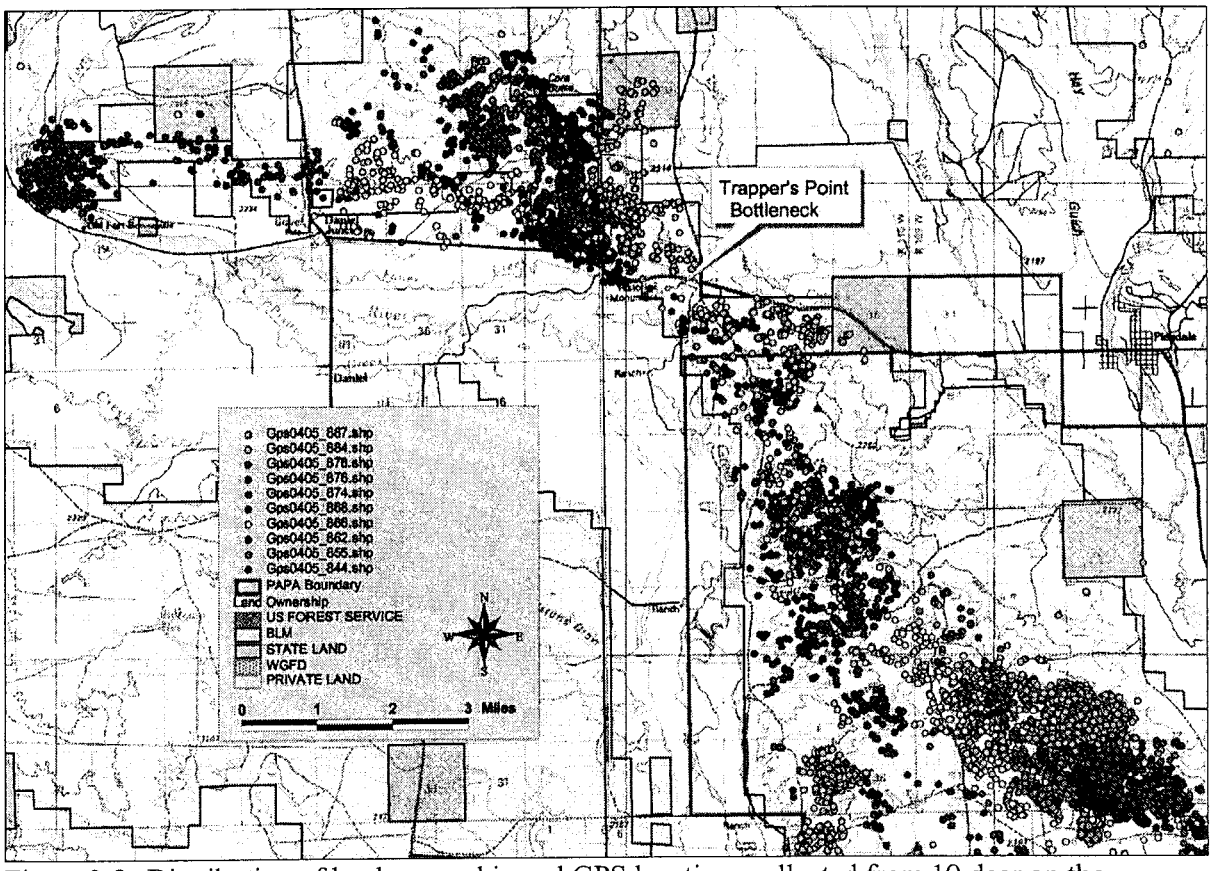

Figure 2.5. Distribution of land ownership and GPS locations collected from 10 deer on the Pinedale Anticline Project Area (PAPA), November 1, 2004 – April 15, 2005.

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.

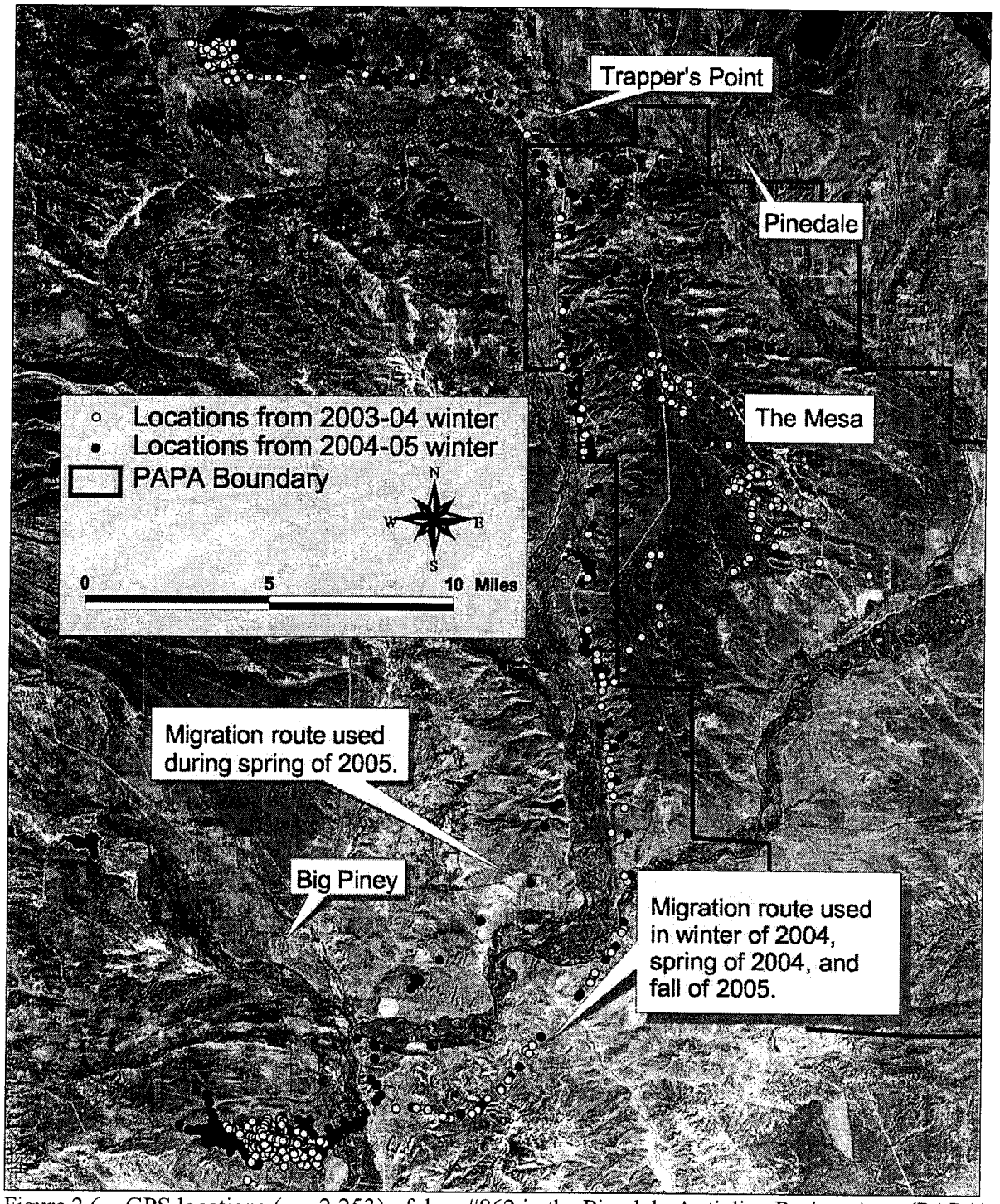

Figure 2.6 GPS locations (r = 2,253) of deer #862 in the Pinedale Anticline Project Area (PAPA), December 18, 2003 – April 15, 2004 (yellow) and November 1, 2004 – April 15, 2005 (blue).

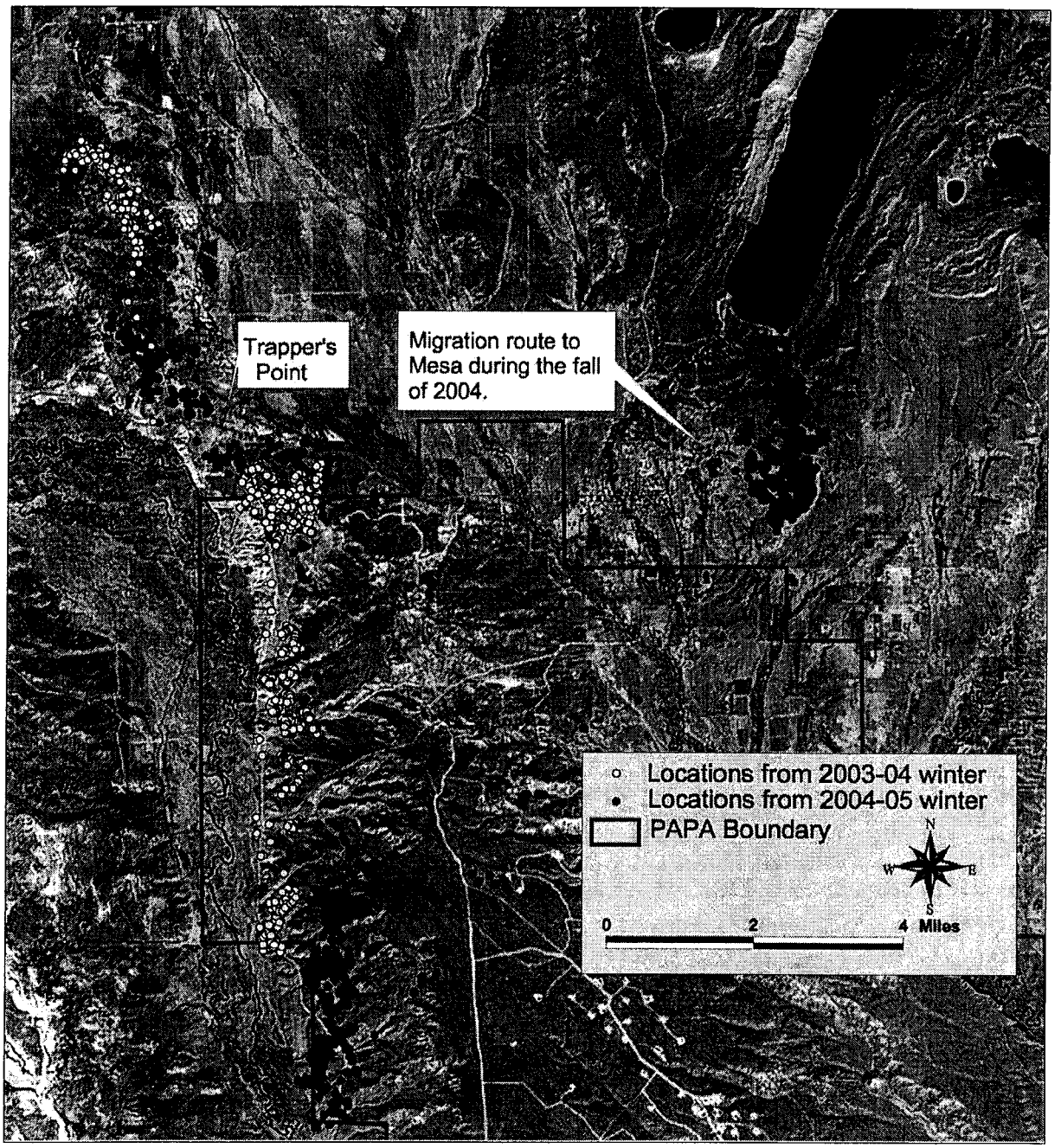

Figure 2.7 GPS locations (r = 2,368) of deer #887 in the Pinedale Anticline Project Area (PAPA), December 21, 2003 – April 15, 2004 (yellow) and November 1, 2004 – April 15, 2005 (blue).

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).

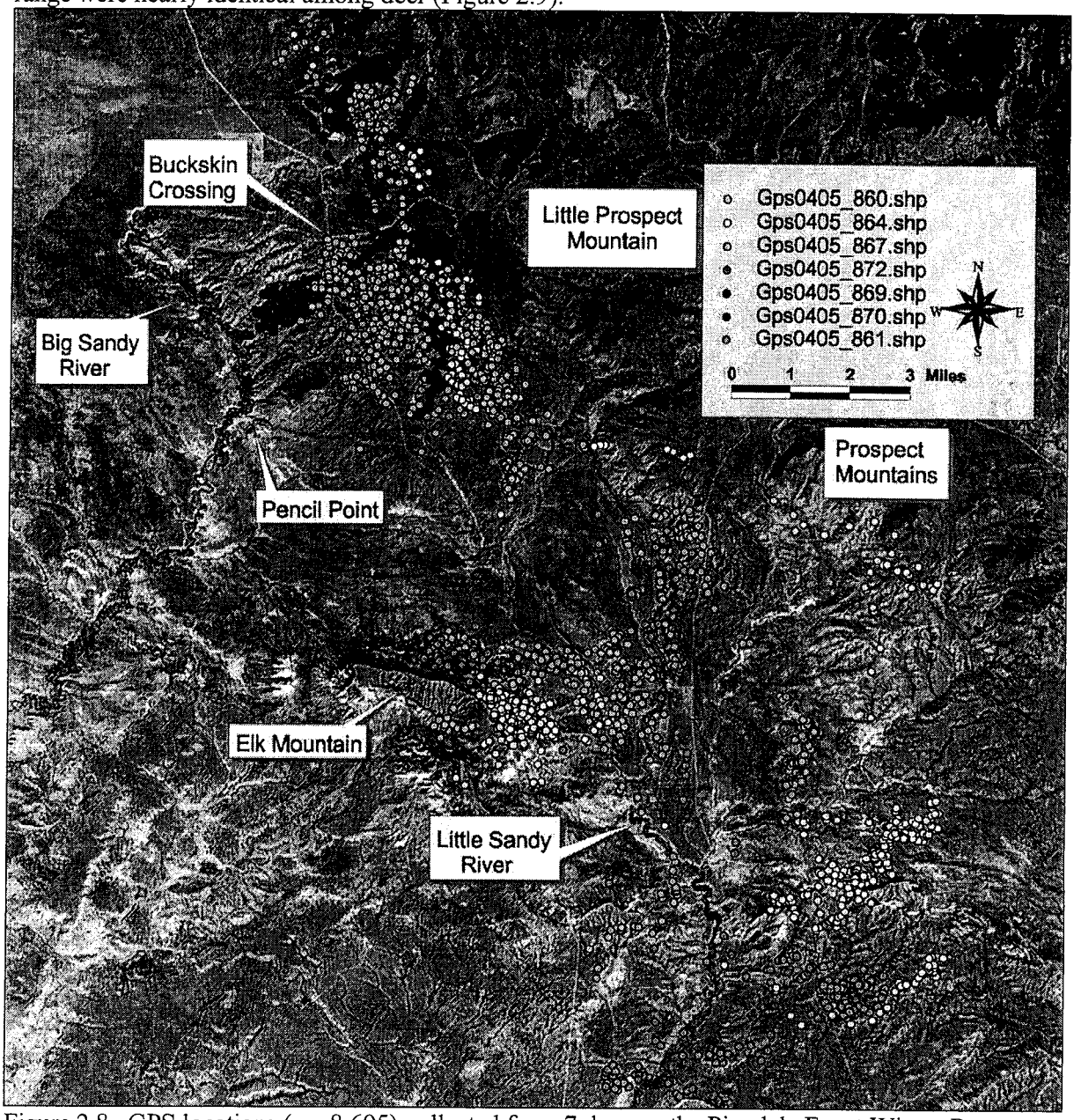

Figure 2.8. GPS locations (r = 8,695) collected from 7 deer on the Pinedale Front Winter Range Complex (PFWRC), November 1, 2004 – April 15, 2005.

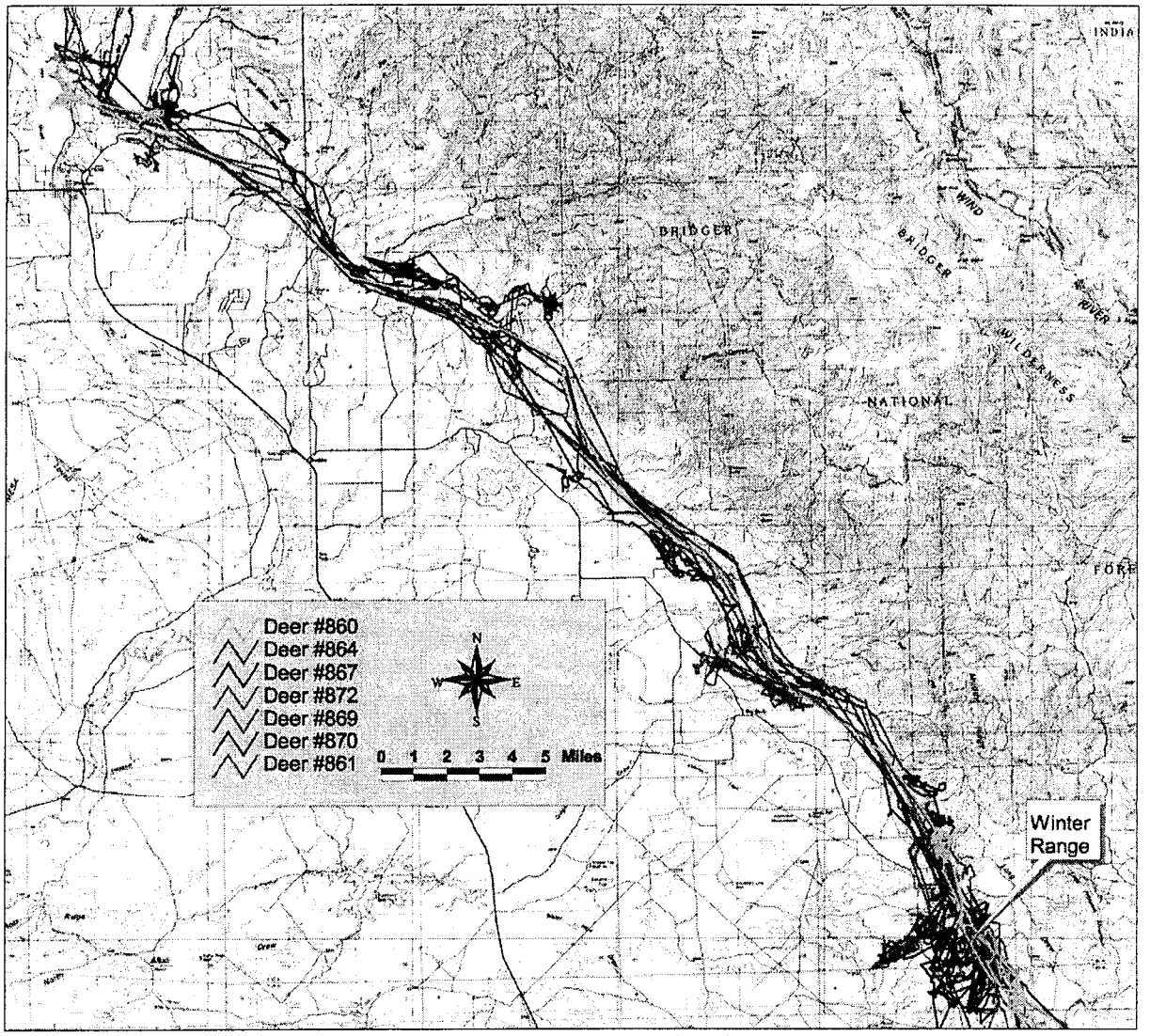

Figure 2.9. Migration routes from 7 GPS-collared deer on the Pinedale Front Winter Range Complex (PFWRC), November 1, 2004 – April 15, 2005.

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)

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%

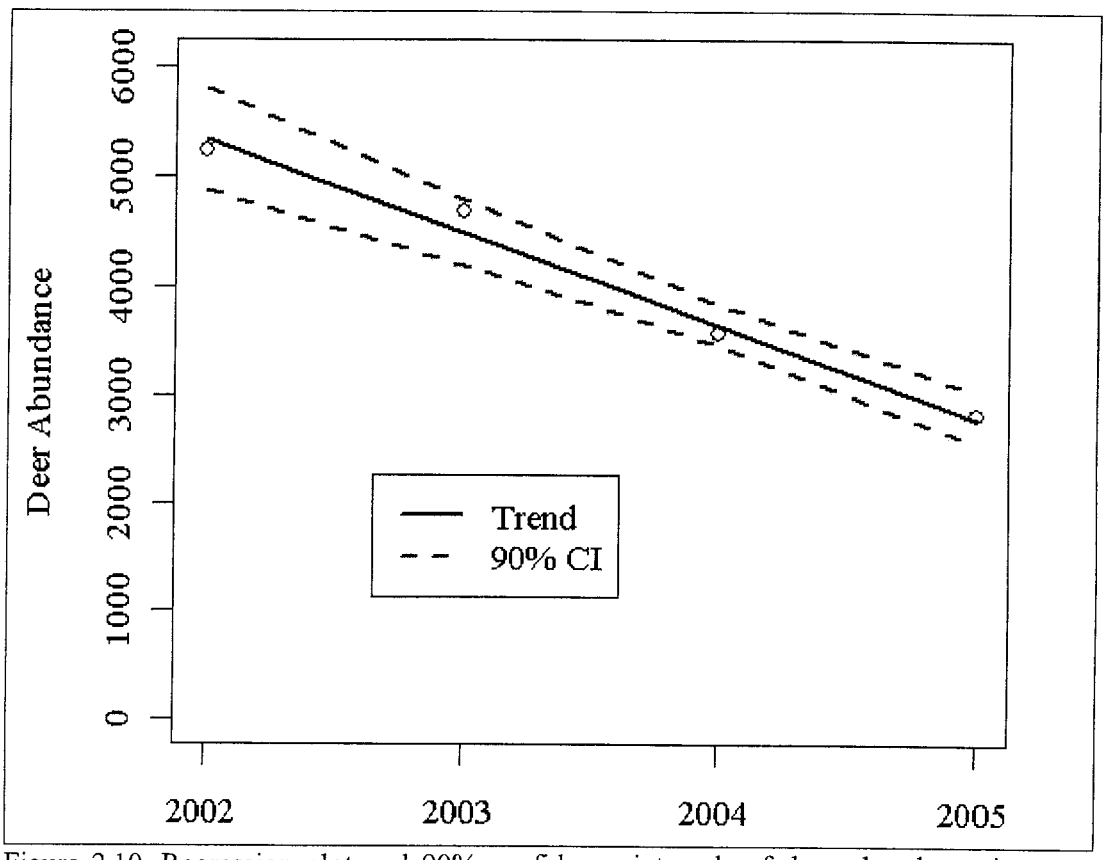

Figure 2.10. Regression plot and 90% confidence intervals of deer abundance in treatment area (Mesa), February 2002 – 2005.

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 ($V\hat{a}r(\hat{D})$)	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 ($V\hat{a}r(\hat{N})$)	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.

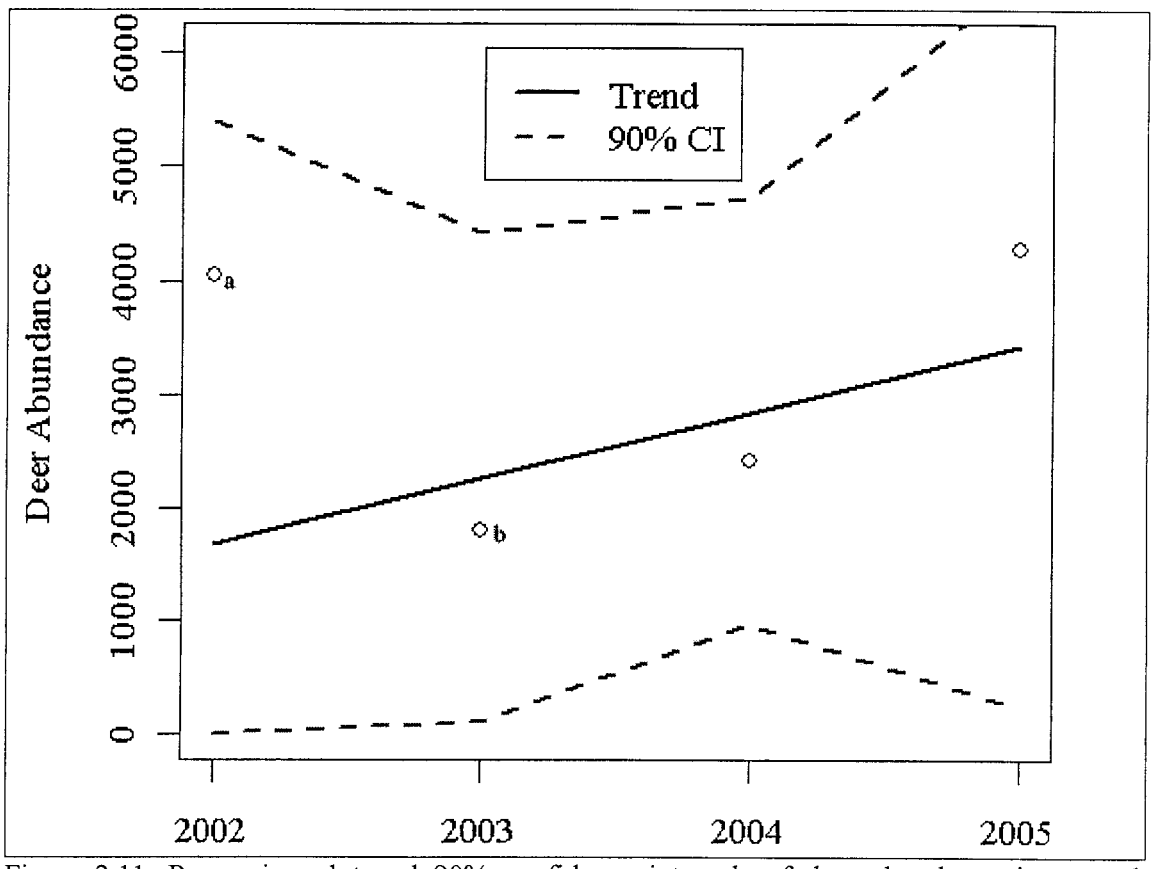

Figure 2.11. Regression plot and 90% confidence intervals of deer abundance in control area (Pinedale Front), February 2002 – 2005.

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.

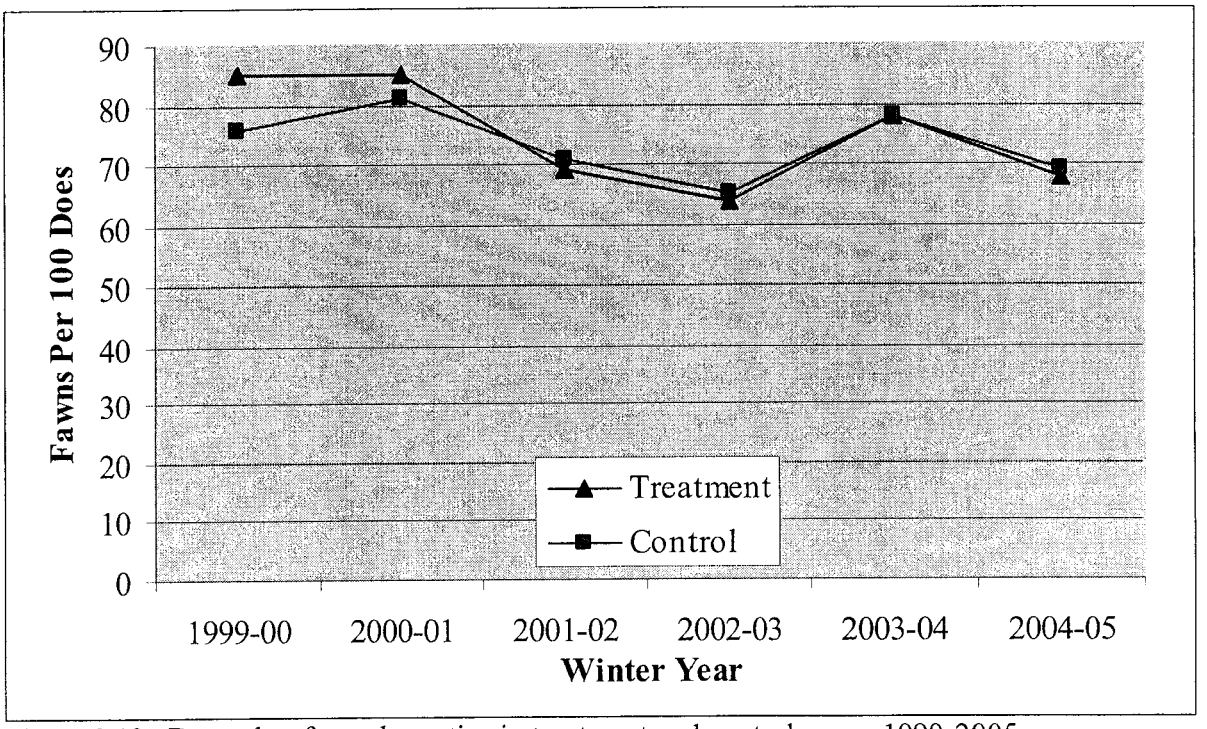

Figure 2.12 December fawn:doe ratios in treatment and control areas, 1999-2005.

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

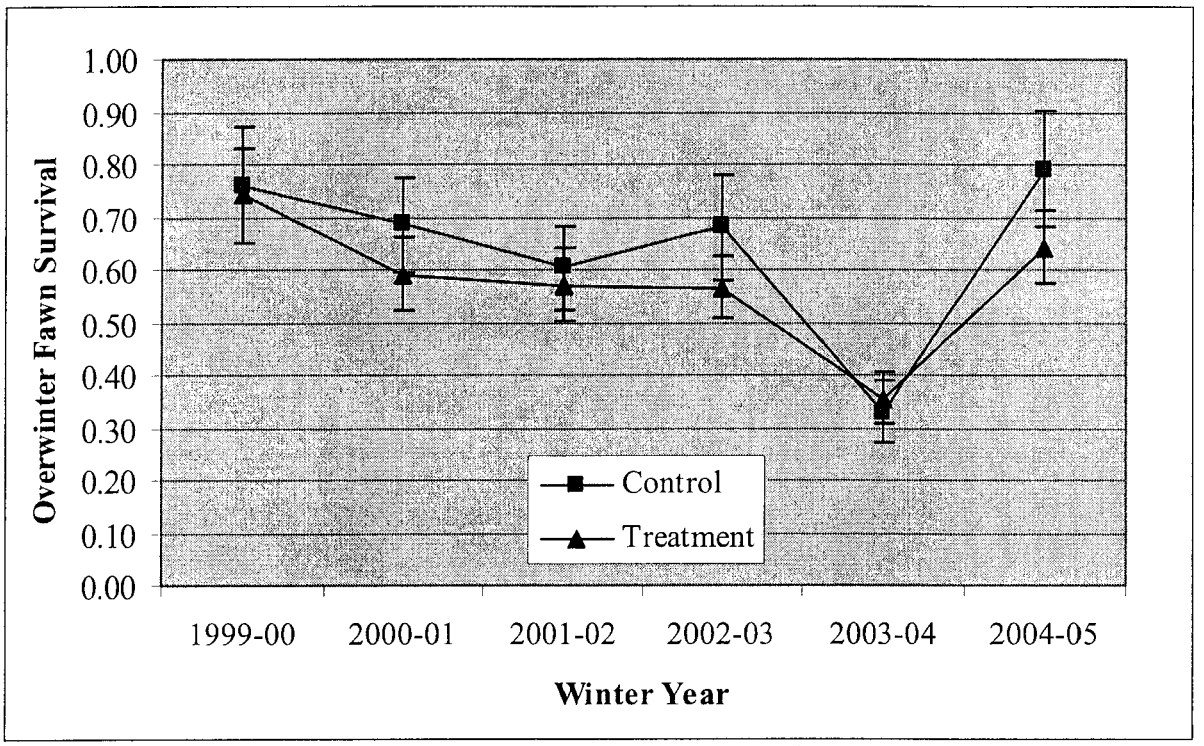

Figure 2.13 Estimated over-winter fawn survival and associated 90% confidence bands for treatment and control areas, 1999-2005.

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

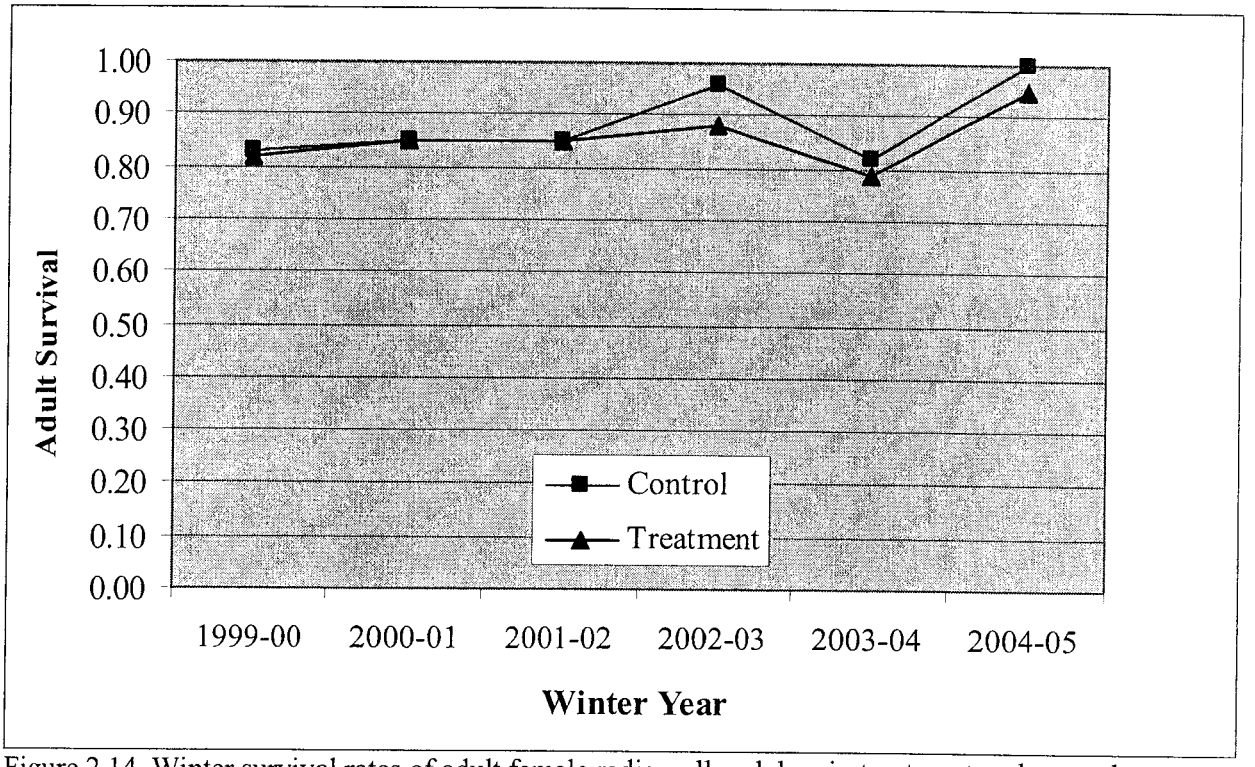

Figure 2.14 Winter survival rates of adult female radio-collared deer in treatment and control areas, 1999-2005.

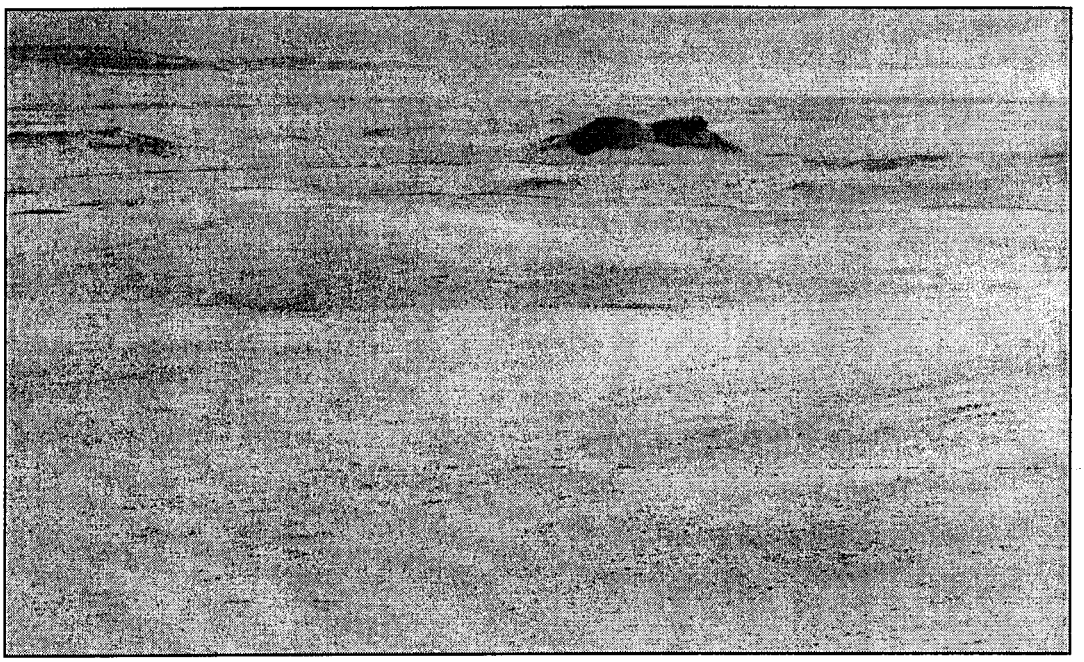

Photo 2.1 Snow conditions on Mesa during February 2004 (view south towards Two Buttes).

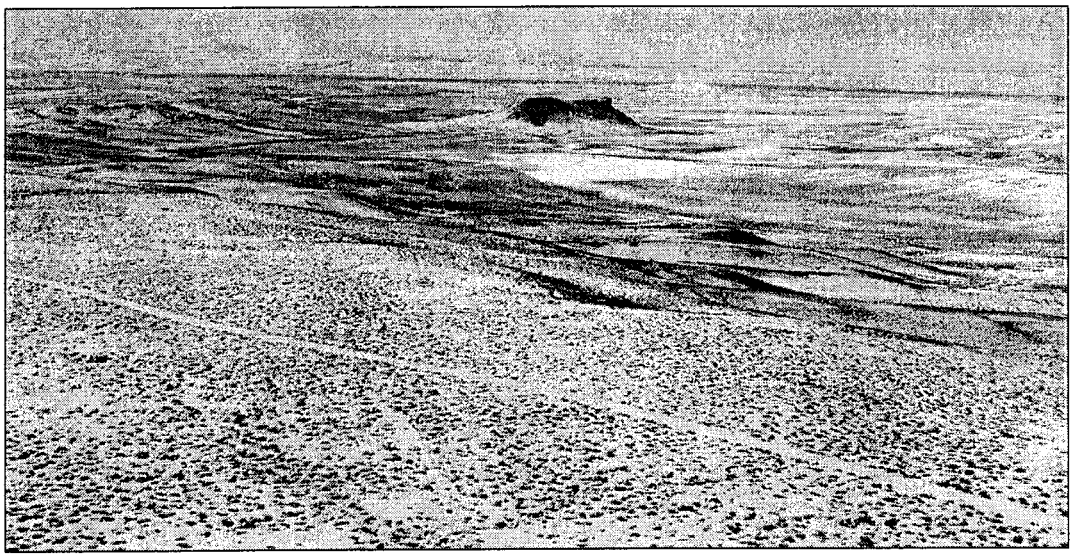

Photo 2.2. Snow conditions on Mesa during February 2005 (view south towards Two Buttes).

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).

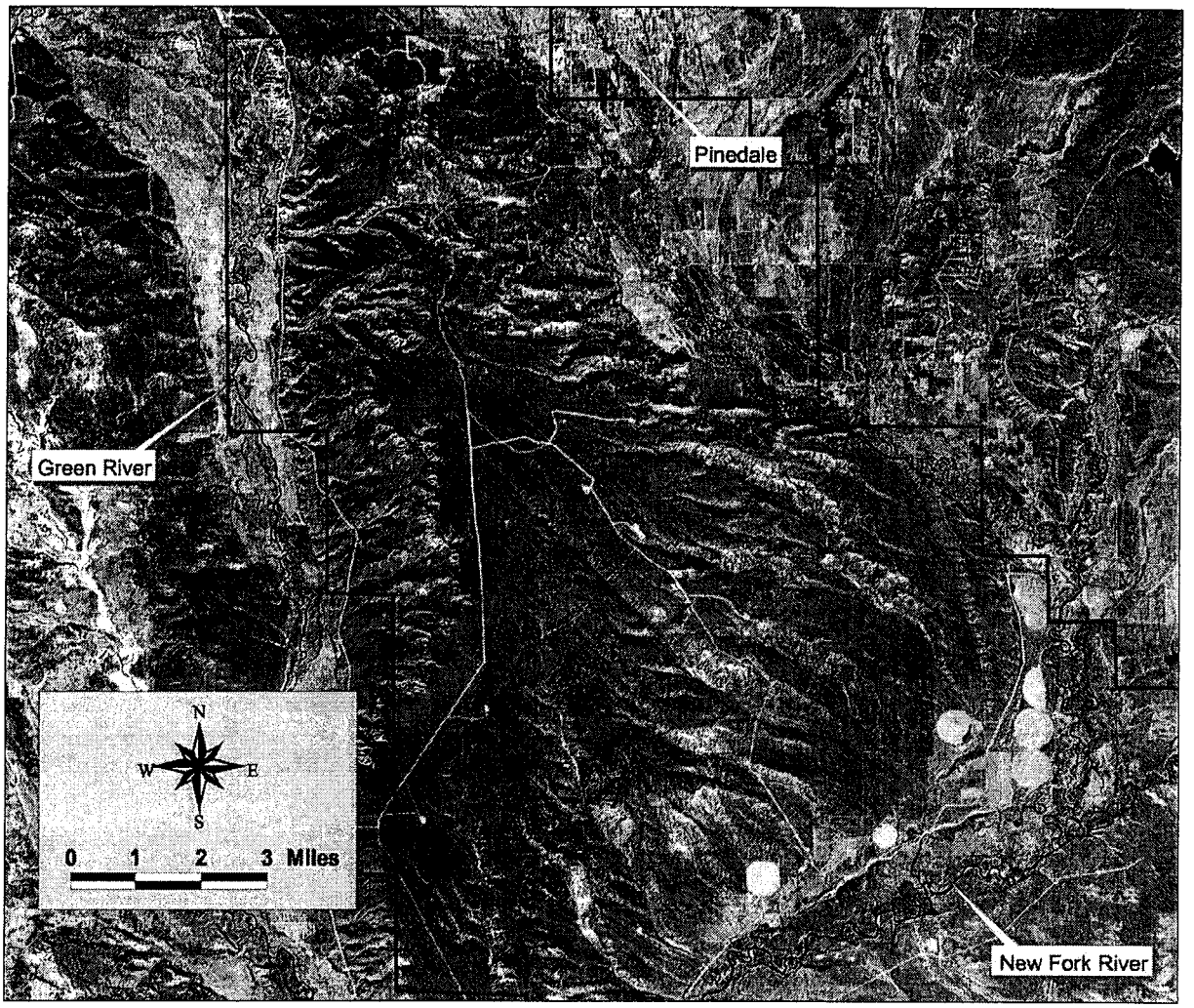

Figure 2.15 Satellite image of the Mesa on October 1999, prior to development of the Pinedale Anticline Project Area (PAPA).

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).

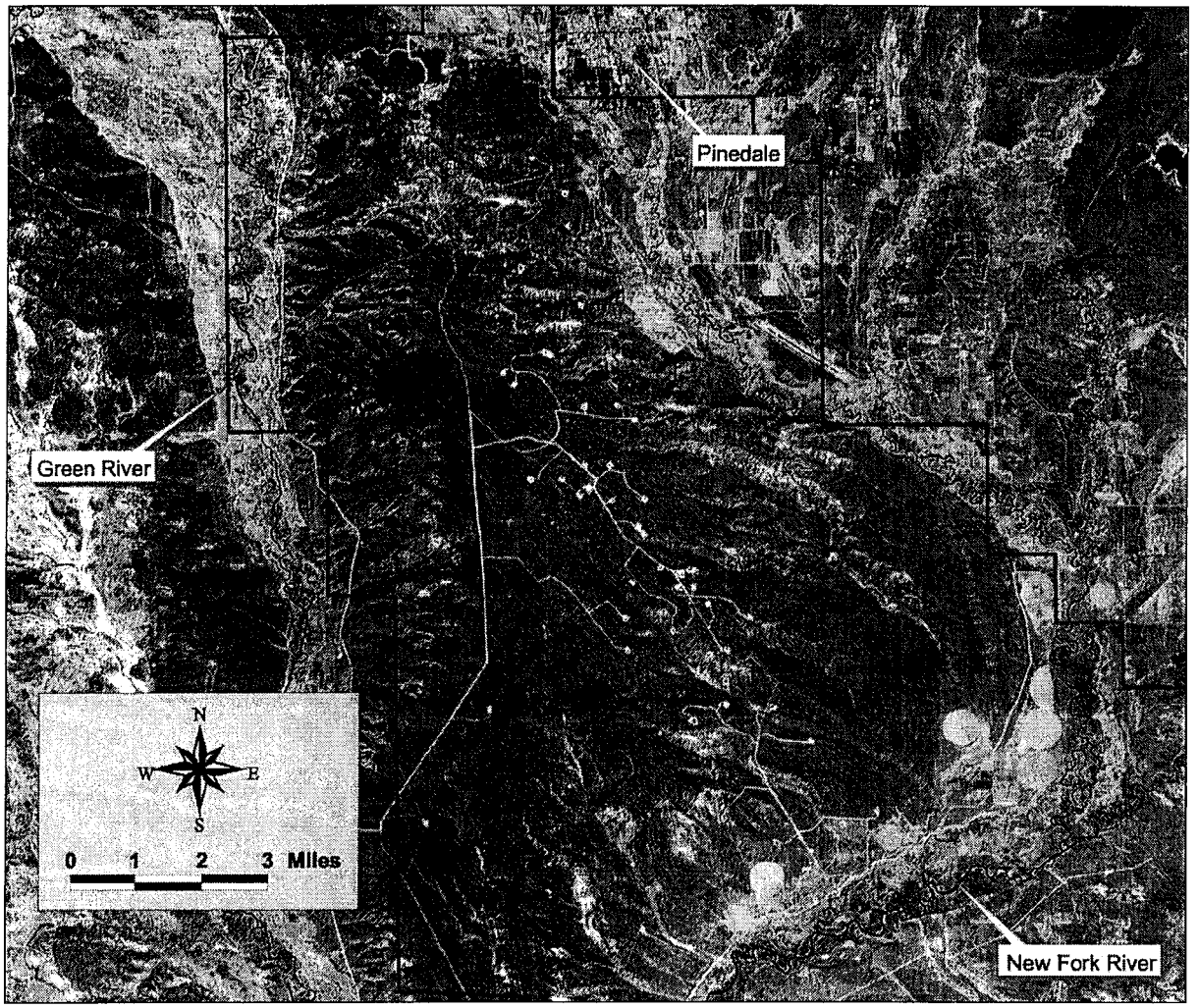

Figure 2.16 Satellite image taken in August 2001 during Year 2 of gas development in the Pinedale Anticline Project Area (PAPA).

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).

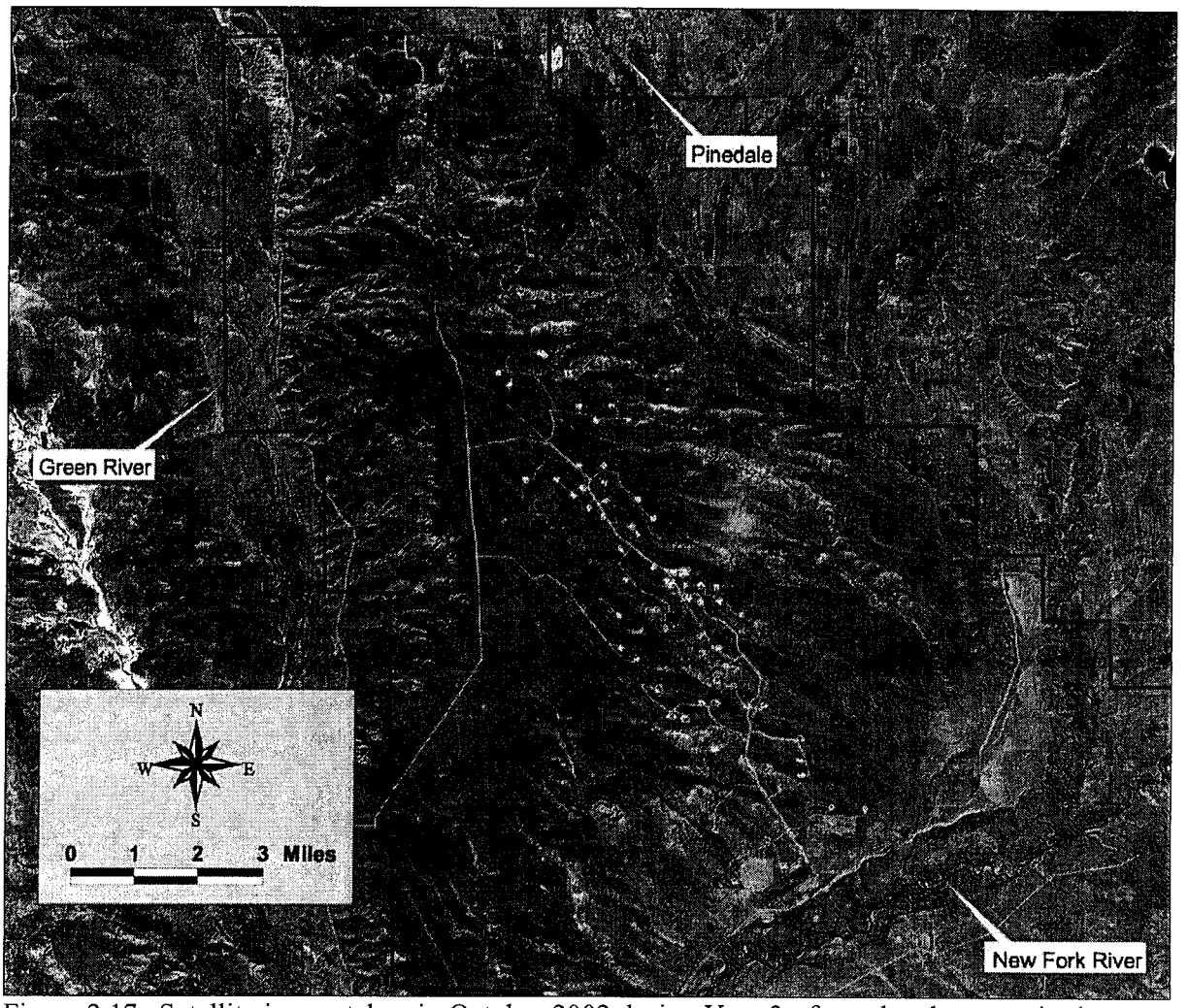

Figure 2.17 Satellite image taken in October 2002 during Year 3 of gas development in the Pinedale Anticline Project Area (PAPA).

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).

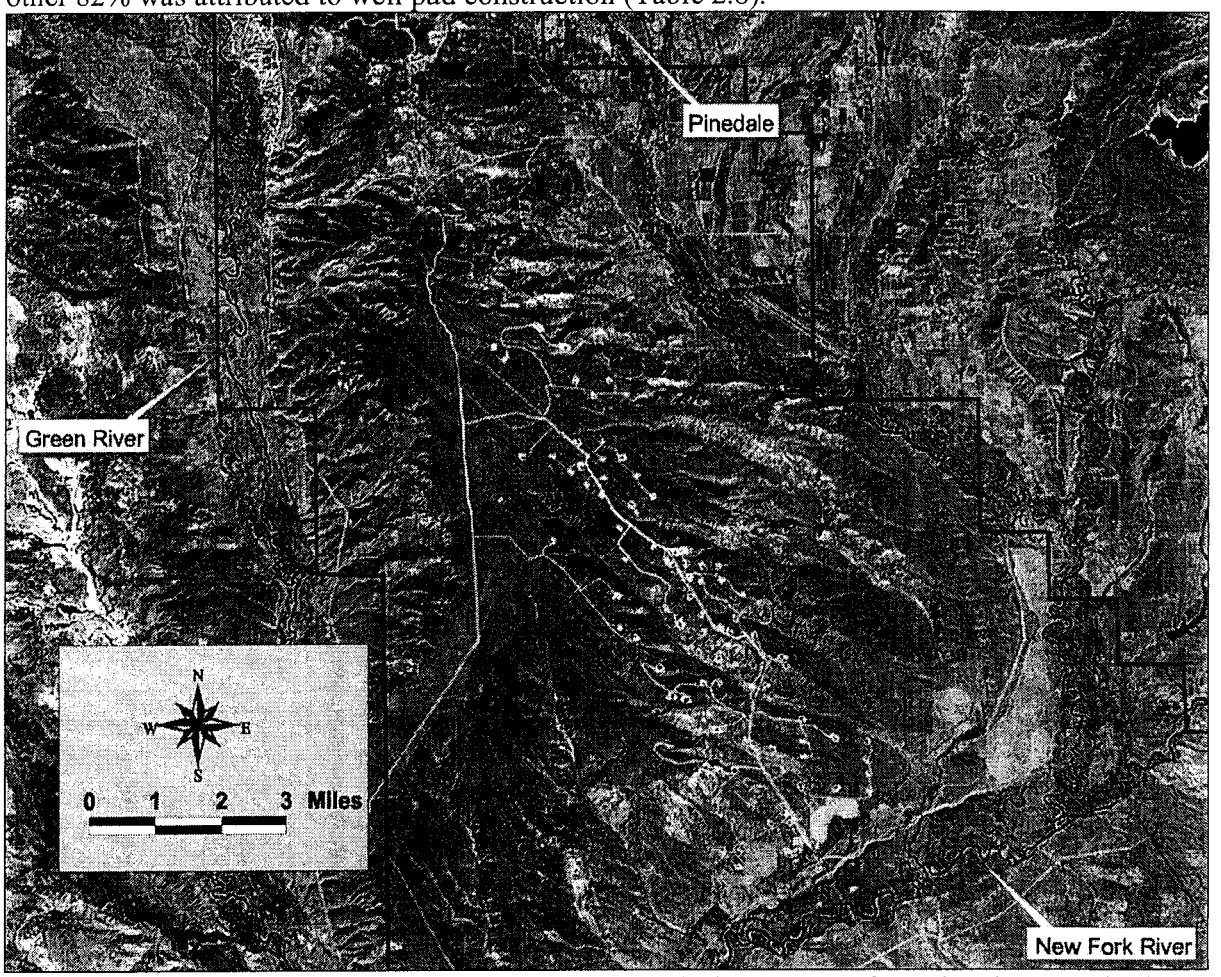

Figure 2.18 Satellite image taken in September 2003 during Year 4 of gas development in the Pinedale Anticline Project Area (PAPA).

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).

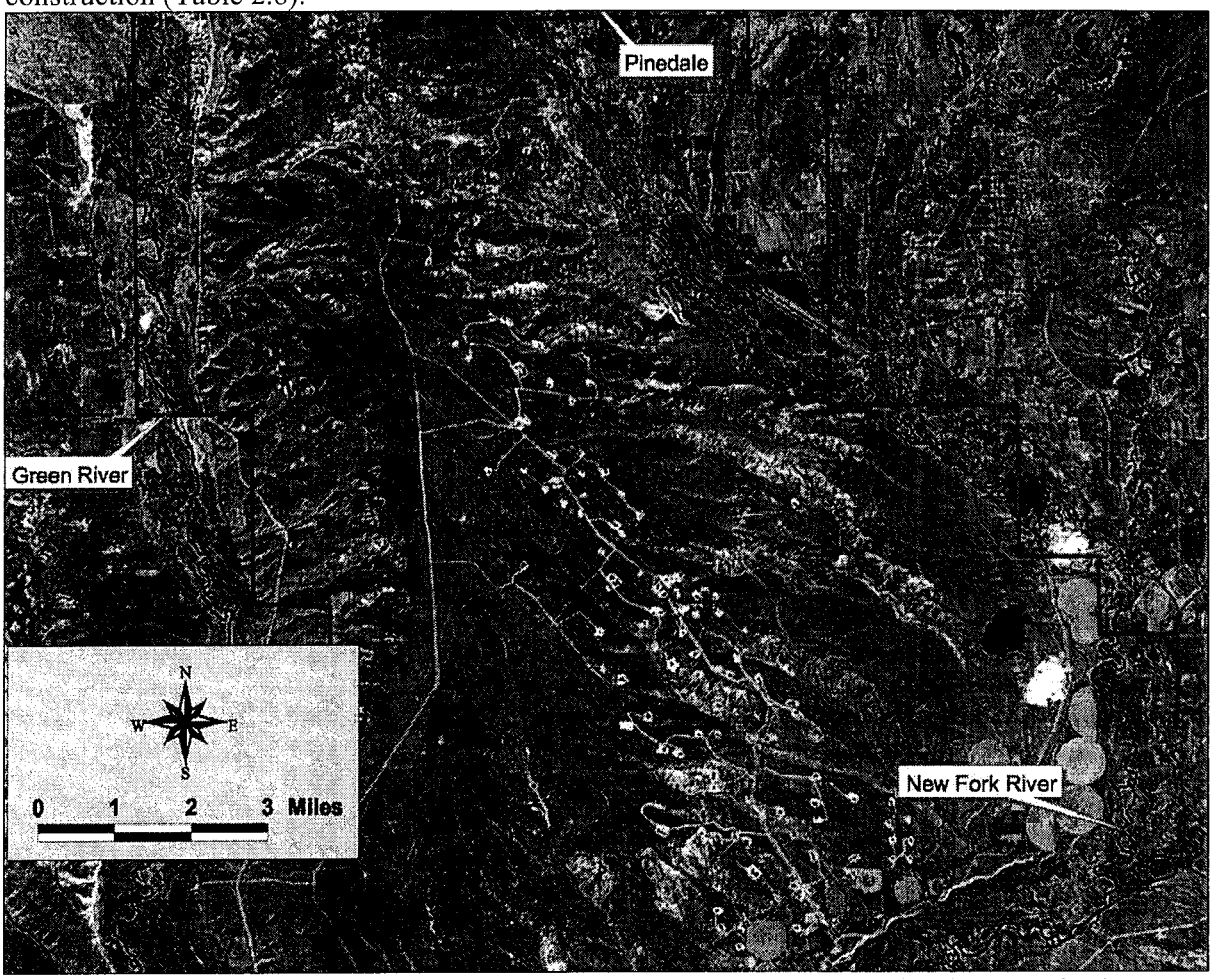

Figure 2.19 Satellite image taken in August 2004 during Year 5 of gas development in the Pinedale Anticline Project Area (PAPA).

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 2,275 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.

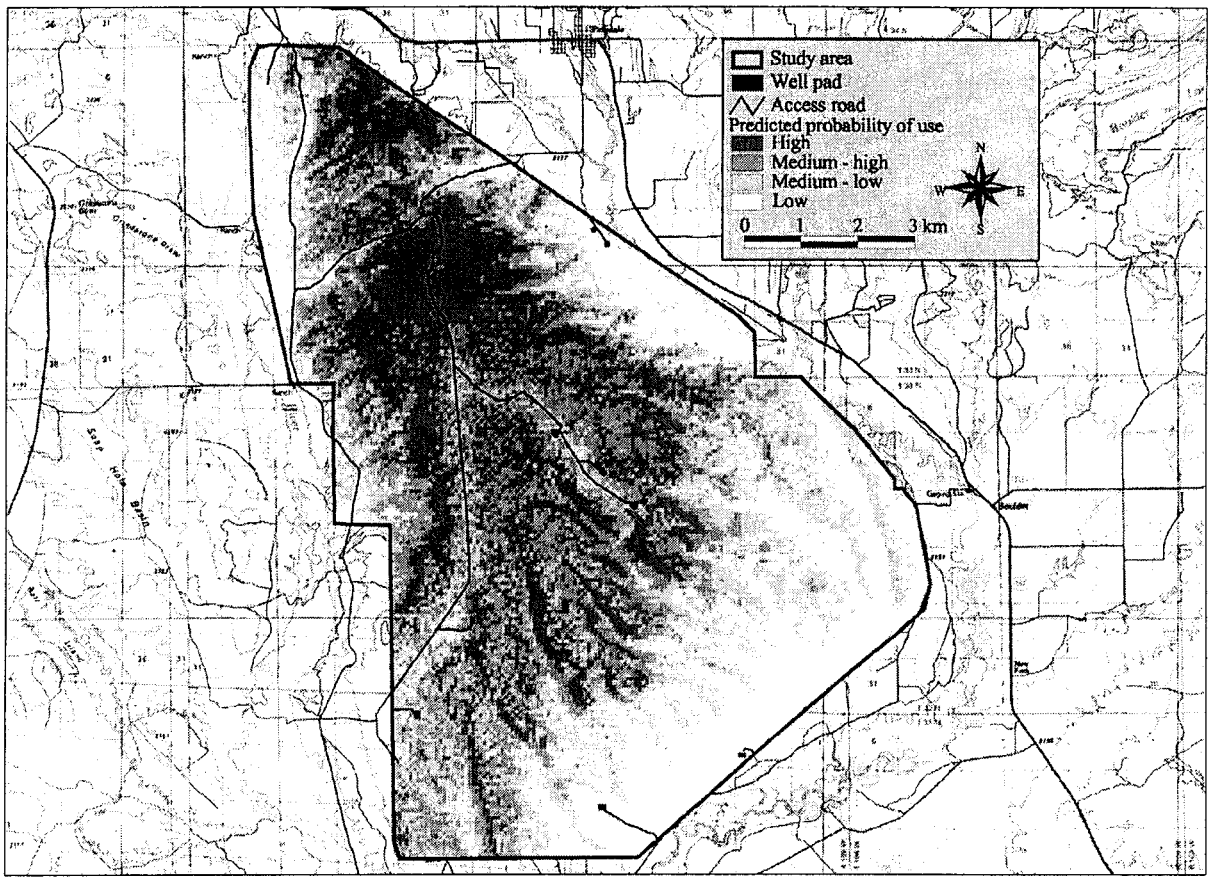

Figure 2.20. Predicted probabilities and associated categories of mule deer habitat use during 1998-99 and 1999-2000 winters, prior to natural gas field development in western Wyoming.

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[a]			Year 1			Year 2			Year 3			Year 4		
	β	SE	P	β	SE	P[b]	β	SE	P[c]	β	SE	P[d]	β	SE	P[d]
Intercept	-29.649	6.637	<0.001	-84.56	21.124	0.003	-75.712	12.93	<0.001	-104.295	11.316	<0.001	-60.949	13.117	<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	0.022	0.006	0.003
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	0.472	0.078	<0.001
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	-0.025	0.005	<0.001
Well distance	na			3.129	1.899	0.134	3.375	1.264	0.018	6.712	2.394	0.031	na		
Well distance^2	na			-0.465	0.229	0.073	-0.416	0.156	0.019	-0.719	0.289	0.047	na		
Road density	-0.249	0.027	<0.001	-0.827	0.387	0.061	ns			ns[e]			0.675	0.615	0.299
Road density^2	ns			ns			ns			ns			-0.624	0.128	<0.001
Aspect = NE	0.012	0.051	0.818	ns			ns			ns			na		
Aspect = NW	0.399	0.025	<0.001	ns			ns			ns			na		
Aspect = SE	-0.301	0.222	<0.001	ns			ns			ns			na		
Aspect = SW	0.194	0.028	<0.001	ns			ns			ns			na		

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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.

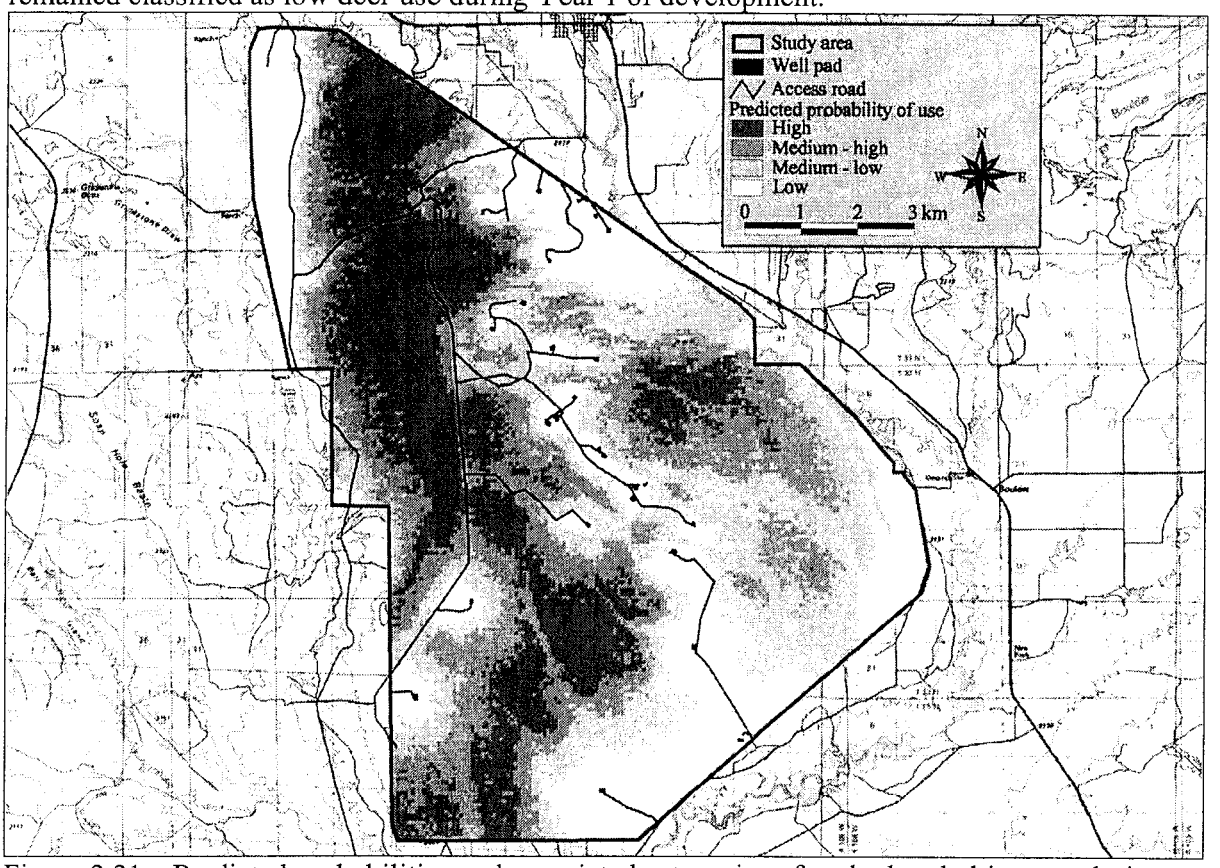

Figure 2.21. Predicted probabilities and associated categories of mule deer habitat use during Year 1 (winter of 2000-01) of natural gas development in western Wyoming.

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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.

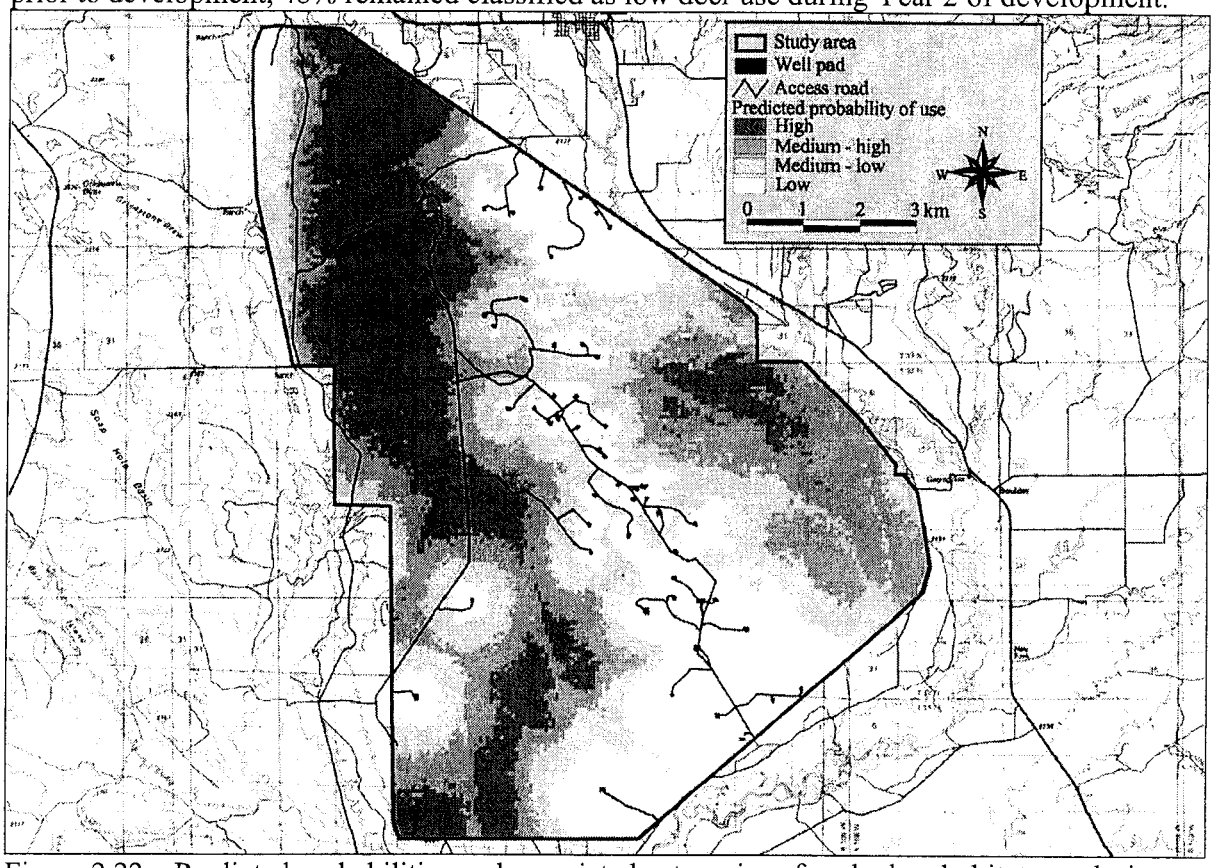

Figure 2.22. Predicted probabilities and associated categories of mule deer habitat use during Year 2 (winter of 2001-02) of natural gas development in western Wyoming.

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.

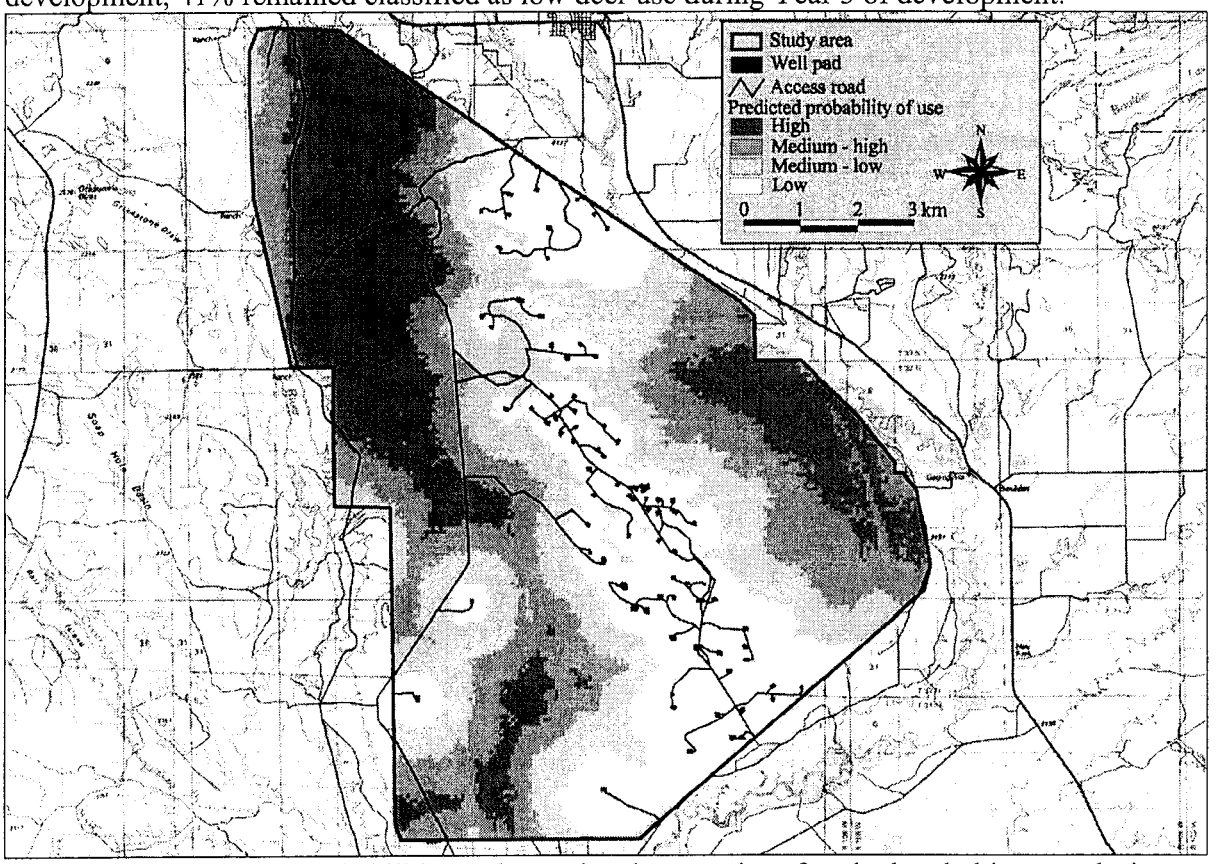

Figure 2.23. Predicted probabilities and associated categories of mule deer habitat use during Year 3 (winter of 2002-03) of natural gas development in western Wyoming.

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.

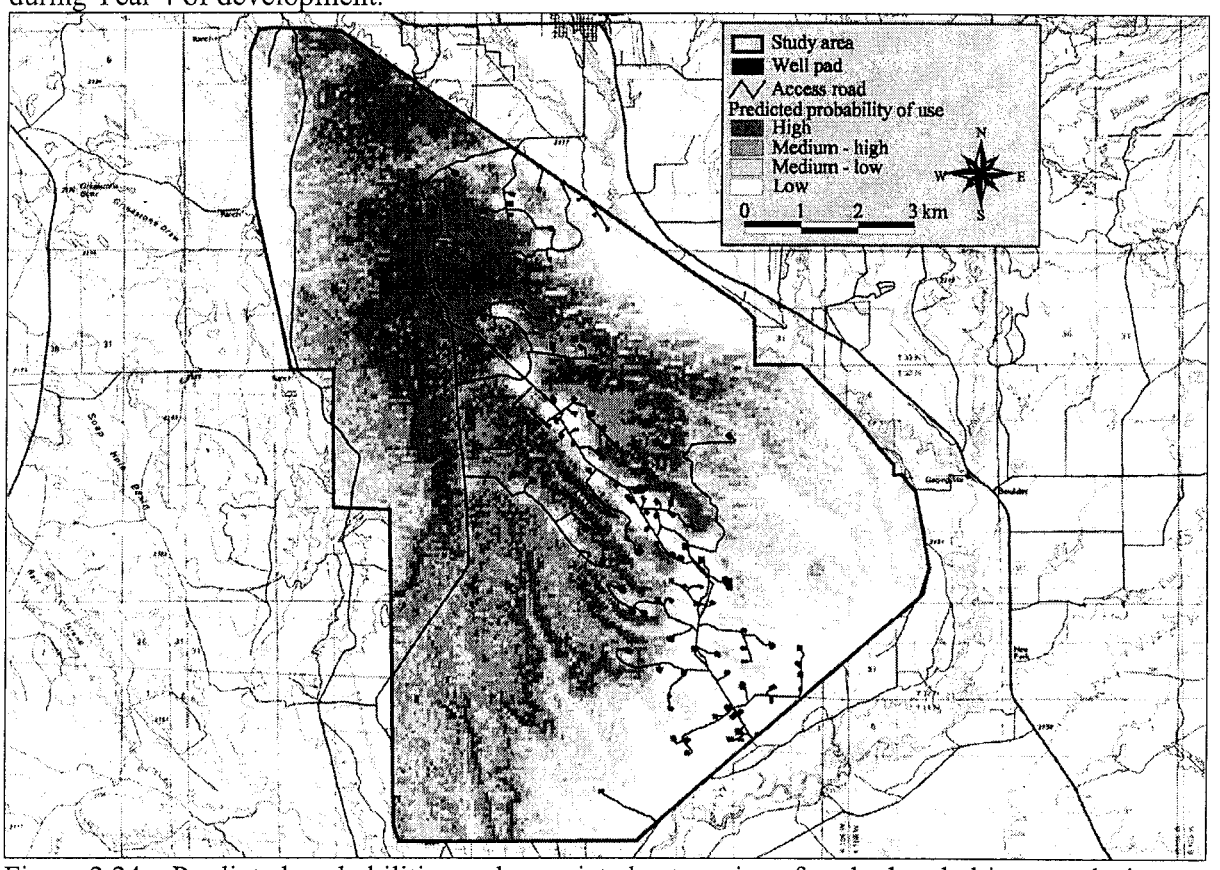

Figure 2.24. Predicted probabilities and associated categories of mule deer habitat use during Year 4 (winter of 2003-04) of natural gas development in western Wyoming.

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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

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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.

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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Exhibit 13

WYOMING OUTDOOR COUNCIL

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January 31, 2006

United States Bureau of Land Management
Split Estates Review Team
Washington, D.C.

Dear Split Estates Review Team:

The Wyoming Outdoor Council (WOC) is pleased to submit the following comments to the Bureau of Land Management (BLM) regarding its review of current split estate policies and practices. We encourage the BLM to include our recommendations in its report to Congress.

The Mineral Leasing Act

The WOC asks that BLM recommend that the Mineral Leasing Act (MLA) be amended to require the Secretary of Interior to secure the consent of the surface owner prior to issuing a federal oil and gas lease. This amendment parallels a provision in the Surface Mining Control and Reclamation Act that provides for surface owner consent prior to federal coal leasing. This requirement has not hampered coal development, and it would be unlikely to hamper oil and gas development.

Oil and gas development can severely harm the private surface on which split estate landowners ranch, farm, and live, especially when dozens if not hundreds of wells may be constructed on the private surface land. BLM's statement that "modern technologies and best management practices have reduced the area of near-term surface disturbance associated with an oil or natural gas lease to an average of 5 to 10 percent of the total area in development" provides little comfort that severe impacts are not occurring to private surface and certainly provides no proof of a lack of significant impact.

Among other things, considering only the amount of surface area directly disturbed ignores the harm that the infrastructure that attends oil and gas development causes beyond its immediate footprint. For example, coalbed methane (CBM) wastewater discharges can and do impact downstream landowners, causing widespread damage to soils and vegetation that extend far beyond the immediate "footprint" of the development.

Furthermore, focusing on the amount of disturbance misses the point; the point is that the surface owner should be given control over what goes on his land, and that is currently missing, meaning the MLA, and if needed the Stockraising Homestead Act (see below), should be amended to correct this problem.

Surface Owner Interests Must Be Protected And Surface Owners Must Be Provided Individual Notice

In addition to seeking amendment of the MLA, WOC recommends that BLM promulgate and enforce regulations and guidelines for leasing split estate minerals that recognize and implement the principle that both the mineral estate and surface estate "must exercise their rights in a manner consistent with the other." *Gerrity Oil & Gas v. Magness*, 946 P.2d 913 (Colo. 1997). The BLM should ensure, in leasing split estate minerals, that mineral owners and operators accommodate existing uses of the surface estate by minimizing damage to surface estate and utilizing alternative means of production if necessary to minimize such damage.

At present, surface owners receive little support from BLM in trying to modify development proposals to minimize impacts to their property and businesses. This should change.

The BLM has ample authority to implement such requirements to better balance the needs and rights of mineral and surface estates. The standard BLM lease requires that lessees conduct operations in a manner that minimizes adverse impacts to other land uses and users, and the agency's regulations at 43 C.F.R. § 3162.5 provide that mineral operators must conduct operations in a manner that does not unduly damage surface resources. The mineral owner and operator should thus be required to conduct operations in a manner that prevents as much harm to the surface owner as possible while still allowing the mineral owner to achieve a reasonable return on his or her investment.

BLM regulations at 43 C.F.R. § 2920.7, which govern terms and conditions for use authorizations, also provide BLM with authority to limit the activities of the mineral right owner if needed to protect the surface owner. Among other relevant provisions, this regulation provides that each land use authorization "shall contain terms and conditions which shall . . . protect lives and property." Id. § 2920.7(c)(3). The regulation goes on to provide that holders of the use authorization shall pay third parties the full value of all injuries or damage, and allows for bonds to be required. Id. §§ 2920.7(f)(2), (g).

In the case of CBM development, the BLM should implement policies and procedures requiring that CBM owners and operators dispose of produced water in the manner that is least harmful to the surface estate.

Many surface owners are unaware that Federal oil and gas resources under their land have been nominated for leasing or that they have been leased. As a result, they have no knowledge of or input into lease requirements, lease modifications and drilling permits. Proper and timely notification of surface owners is a minimal requirement that would significantly improve the ability of landowners to participate in major decisions that will impact their private property. Their participation would serve a valuable purpose in that the landowners, who know the better

than anyone, would be able to provide input regarding the location of particular resources and features on the lease so as to enable the BLM (and the lessee) to better account for and protect them.

Landowner participation would also reduce conflict. As noted by the U.S. Institute for Environmental Conflict Resolution in its report on split estate issues in the Powder River Basin, "many of those interviewed, especially state and local government officials, acknowledged that additional notice, public outreach and education to landowners would serve a valuable purpose and could reduce conflict." (pg. 53-54)

Currently, the BLM does not notify landowners individually of decisions concerning minerals underlying their property. Instead, the agency only posts lease sale information at its Field Offices and online. Notice of applications for permit to drill (APD) and notices of staking (NOS) are similarly only available if the surface owner regularly physically drops by the BLM office where they are posted in a notebook to inspect the filings, an impossible burden for all but a few. This should be corrected and individual notice to the surface owner should be provided of leasing that is planned on split estate lands, and of filings to initiate well drilling.

The MLA states that its posting requirements are "in addition to public notice required by other law." This other law certainly includes public notice provisions in the National Environmental Policy Act (NEPA), which requires public notification via "direct mailing to owners and occupants of nearby or affected property." This direct notification requirement should apply to oil and gas lease offerings, and APDs and NOSs, but this is not BLM's current practice.

The WOC recommends that the BLM notify surface owners in writing:

- that mineral resources underlying their property have been nominated for leasing upon nomination, or, at the very least, 45 days in advance of lease sales;
- whether mineral resources underlying their property have been leased, and if so, by whom;
- of any proposals from the operator or lessee regarding the lease (such as modifying or waiving stipulations, approving rights of way, protest resolutions, etc.);
- of the submission of an APDs or NOSs, with a copy of the APD or NOS attached, as soon as practicable after the APD or NOS is received by the BLM, and in no instance should the APD or NOS be approved without at least 15 days notice to the surface estate owner; and
- of the issuance by the BLM of an APD or NOS at the same time and in the same manner that BLM provides notice to the lease holder.

In all cases where BLM provides notice it should also provide information regarding any protest, appeal, or other legal rights that are available to the surface estate owner. The WOC notes that

BLM's just-published proposal for revising the Department of Interior NEPA manual proposes strong requirements for public participation in the NEPA process.

Surface Use and Damage Agreements

The WOC recommends that surface use and damage agreements be required between surface owners and lessees or operators and that such agreements be required to protect surface resources and interests. Many current agreements do not adequately address all impacts and adequately compensate landowners for damages, often because the "bond on" option available to the lease holder puts landowners in a limited negotiating position since a company can essentially say "take it or leave it."

Requiring surface use and damage agreements would put surface owners in a position to ensure that impacts from oil and gas development are minimized and that all damages are fairly compensated

The WOC recommends that written surface use and damage agreements be required to meet a set of minimum standards, recognizing that every agreement will vary depending on site specific circumstances. Such standards should:

1. provide for surface owner concurrence to the maximum extent possible as to the placement of roads, wells, drill pads, pipelines, power lines, compressor stations, and all other oil and gas operations improvements;

2. compensate the surface owner fully and fairly for damages to property that are caused by the operator's proposed operations;

3. include and be based on a separate but attached comprehensive water management plan that includes provisions for the documentation and monitoring of water sources and for the proper handling of any discharged water (including wastewater from CBM development);

4. require the operator to replace the water supply of a surface owner who obtains all or part of her/his supply of water for domestic, agricultural, or other legitimate uses from an underground or surface source that has been affected by oil and gas operations;

5. identify areas to be reclaimed after the completion of drilling operations, in full compliance with local, state and federal laws and regulations; and

6. require consultation with the surface owner before there is any release as to reclamation obligations; and

The BLM requires the lessee or its operator to enter into "good-faith" negotiations with a private surface owner, but does not specify what a "good-faith" effort must entail. In our view, "good faith" negotiation means, at a minimum, that a lessee or its operator negotiates with an open mind and genuine desire to reach agreement and, where appropriate, be prepared to compromise.

This does not mean that the parties must reach agreement. However, negotiation in good faith involves the lessee or its operator acting honestly and reasonably in all circumstances. If the lessee or its operator receives a proposal from the surface owner they must give genuine consideration to it. In addition, the lessee or its operator must:

- Maintain a level of active communication with the surface owner,
- Respond promptly to phone calls, letters and other forms of communication,
- Provide relevant and accurate information to the surface owner about the proposed activities and plan of operations (including likely future activities and plans of operatioins) and disclose all significant facts (such as the surface owner's right to protest and/or appeal a bond),
- Attend and constructively participate in meetings when they are arranged,
- Ensure that people with real decision-making authority are involved in the negotiations,
- Put forward genuine offers and counter proposals, and be willing to put a verbal agreement into writing,
- Be prepared to move from their original position, and not change their position just as an agreement is in sight,
- Not make an issue of trivial items of disagreement, and
- Conduct themselves appropriately outside the negotiations, for example, making comments to the media.

The WOC recommends that the BLM adopt and implement these criteria for good faith negotiations.

Bonding

The WOC recommends that the BLM broaden its regulatory definition of the language in the Stock Raising Homestead Act that a bond must compensate the surface owner for damages to her/his "crops or tangible improvements." The agency specifies that "crops include those for feeding domestic animals, such as grasses, hay and corn, but not plants unrelated to stock raising." This leaves out many other crops and also ignores impacts to stock raising and herd management caused by more roads, produced water containment ponds, ephemeral draws flooded with wastewater, etc.

The agency also states that "tangible improvements" do not include those "associated with nonagricultural development." This definition leaves surface owners who are not involved in agricultural development (an increasingly common situation) without apparent recourse for damages.

Finally, the bond does not cover a host of other damages caused by roads, well pads, wastewater discharges, containment ponds, etc. All of these activities disrupt ranching, agricultural production and daily living activities during the life of an oil and gas drilling operation and should be compensated during the interim period of loss.

An alternative approach to broadening the regulatory definition of "crops or tangible improvements" in the Stock Raising Homestead Act would be to amend the Act

Once the BLM has expanded its regulatory definition of "crops or tangible improvements," or a new definition has been added to the Stock Raising Homestead Act, BLM should ensure that the surface damages bond is sufficient to meet the full cost of damages incurred under the new or expanded definition, based on site-specific analysis.

The surface owner has a right to protest and/or appeal the amount of the surface damages bond that is required under the Stock Raising Homestead Act. The BLM should independently notify the surface owner, in writing, of her/his rights regarding protests and appeals to the sufficiency of the surface damages bond. The problem from our point of view, however, is that the BLM often notifies the surface owner about her/his rights after an agreement has failed and a bond has been served on the surface owner by the lessee or its operator.

Equally important is that even if an agreement has been reached, the operator should certify that the surface owner's rights to protest and/or appeal the bond were disclosed *at the beginning of negotiations*. Full knowledge by the surface owner of his legal rights is a prerequisite to fair negotiation. BLM should be proactive and require the lessee or its operator to notify the surface owner of her/his rights to protest and/or appeal the bond at the beginning of negotiations, rather than notify them after the fact, as is current practice.

The BLM schedules an on-site pre-drill inspection with the lessee for the purposes of planning the development of the oil and gas resources and invites the surface owner to participate, but this onsite inspection can occur as late as 15 days after the APD is deemed to be complete. Given the fact that there is a 30-day comment/protest period for drilling permits, this inspection is much too late in the process.

Reclamation

Reclamation planning and financial assurance for oil and gas sites falls far short of actual clean-up needs. The Western Organization of Resource Councils has prepared a report that addresses this issue, and we ask BLM to consider it fully. See http://www.worc.org/energy/bonding/report.html

The WOC recommends that the following six steps be instituted to improve the BLM's reclamation and financial assurance programs, either by strengthening the existing regulations and/or amending the Federal Onshore Oil and Gas Leasing Reform Act:

1. Require site-specific reclamation plans for each oil and gas operation that identify all impacts to surface lands and other resources.

2. Adopt clear, specific reclamation requirements and performance standards for oil and gas operations consistent with those required for other extractive industries, such as those applicable to coal mining.

3. Require financial assurance estimated by a professional ecologist or other competent biologist or similarly trained and qualified person that covers the full cost of performing all reclamation tasks based on site-specific project analyses, prior to issuance of drilling permits.

4. Review and update reclamation plans and financial assurances regularly.

5. Require an additional bond of $2/foot for inactive wells (not in operation for 12 months).

6. Require that the "operating rights owner(s)" and the "record title lessees" be held jointly responsible and liable for reclamation.

Orphaned and Abandoned Wells

Section 349 of the Energy Policy Act of 2005 directs the Secretary of Interior to establish a program to provide technical and financial assistance to oil and gas producing States to help clean-up orphaned or abandoned oil and gas wells on State and private land. The WOC believes that BLM should fully implement this provision in its Fiscal Year 2007-2010 budgeting process as part of its commitment to minimizing impacts on privately owned surface.

The Gold Book

The Gold Book specifies surface operating standards and guidelines for oil and gas development on Federal lands. It does not have legal standing by itself unless adopted by a Field Office Manager in whole or in part into the permit. The WOC believes that BLM should require that the relevant BLM Field Office Managers either adopt the Gold Book in its entirety or incorporate specific Gold Book standards in drilling permits, especially those Best Management Practices designed to reduce the environmental effects of energy exploration and production.

The Stock Raising Homestead Act

Many of the private lands in the Wyoming were acquired under the Stock Raising Homestead Act (SRHA) of 1916. The people who homesteaded this land received ownership of the surface, while the federal government retained ownership of the minerals. Once the minerals are leased, the SRHA provides a right of entry for the mineral owner (see subsection (a) of the SRHA).

Subsections (b) through (o) of the SRHA place additional requirements on mineral developers for bonding, filing a plan of operation, assuring contemporaneous reclamation, and allowing surface owners to request an inspection. Unfortunately, minerals subject to disposition under the

Mineral Leasing Act (in other words, oil and gas) are not covered under subsections (b) through (o). Congress should rectify this omission by amending the Stock Raising Homestead Act to include oil and gas under subsections (b) through (o), and BLM should recommend that Congress do so.

Inspection and Enforcement

Inspection and enforcement is a critical component of the federal oil and gas program. In fact, the BLM recognizes that "inspection and enforcement is the single most critical activity that ultimately ensures protection of the natural environment and proper management of ecosystems with regard to the impacts of oil and gas activities." Yet, in the past, the BLM has suffered from a lack of resources for this activity.

The BLM has not balanced its efforts to speed oil and gas drilling with equally strong efforts to protect split estate landowners from the harmful impacts of this drilling through an active enforcement program. The Government Accounting Office issued a report in July 2005 that concluded, among other things, that the BLM is so focused on issuing permits for oil and gas drilling that it is neglecting its responsibility to protect the land and other resources. This needs to be corrected. The GAO report is available at http://www.gao.gov/new.items/ d05148.pdf

Section 362 (c) of the Energy Policy Act of 2005 directs the Secretary of Interior and Secretary of Agriculture to "improve inspection and enforcement of oil and gas activities, including enforcement of terms and conditions in permits to drill," and authorizes $20 million for each of fiscal years 2006 – 2010 for this program. BLM should fully implement and give priority to this provision, including in its budget requests.

Wyoming's Surface Owner Accommodation Act

In a letter to Wyoming's Oil and Gas Supervisor dated June 13, 2005, BLM Director Kathleen Clarke expressed the belief that Wyoming's newly passed Surface Owner Accommodation Act did not apply to federal minerals. The WOC strongly objects to any such position on the part of BLM. The WOC believes that BLM should support and assist in implementing this State law on estates where the minerals are federally owned. This law includes many of the measures described above that we believe are necessary in BLM's split estate policies, and thus we believe it should be looked to and implemented by BLM and not repudiated. President's Bush's Executive Order requiring federal agencies to engage in cooperative conservation with the State's fully supports our view that BLM must help implement Wyoming's Surface Owner Accommodation Act, and seeking to make this law ineffective on federal lands is contrary to the Executive Order.

Thank you for considering these comments, and we look forward to continued participation in this process.

Sincerely,

s/ Bruce Pendery

Bruce Pendery
Program Staff Director

Exhibit 14

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

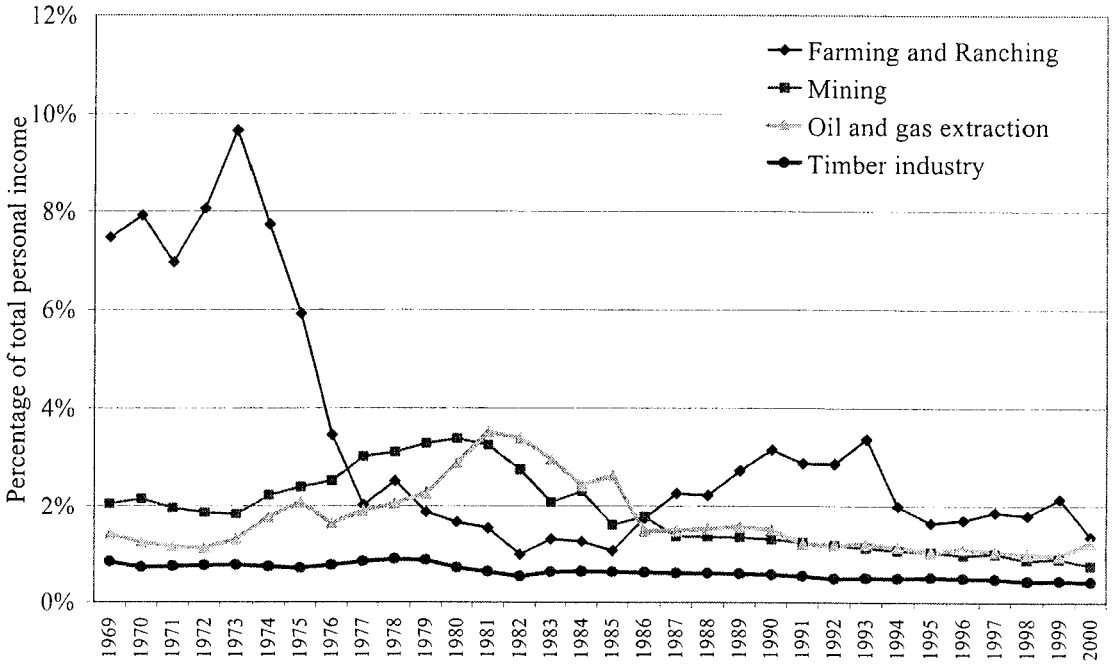
[1] We provide examples of the statistics and data available to analyze each of the key indicators. These examples focus on the five Rocky Mountain states, but the methods and analyses presented apply to other states throughout the region. The states we focus on in this brief are: Colorado, Montana, 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.

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.

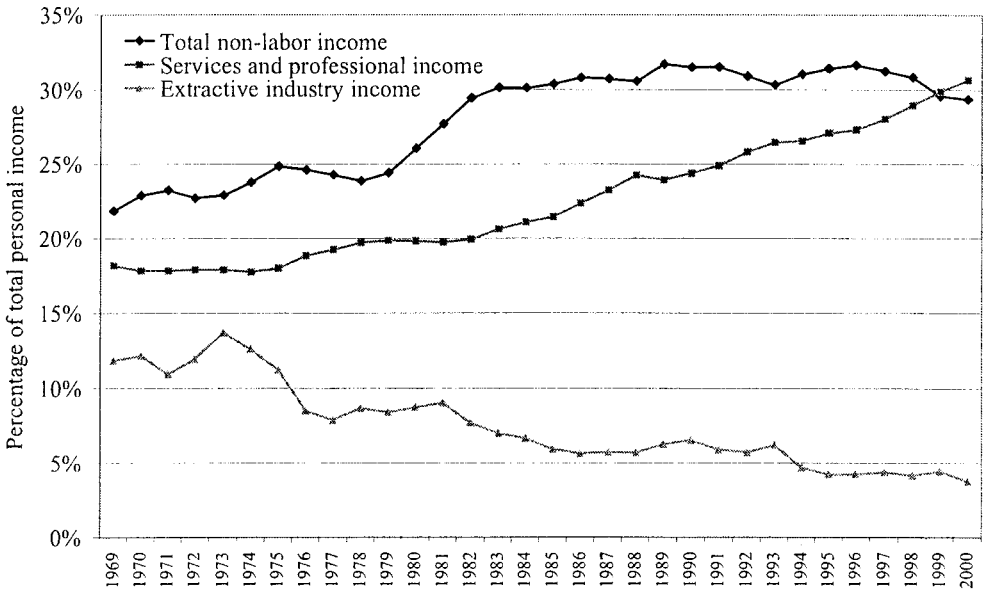
A. Non-labor income

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

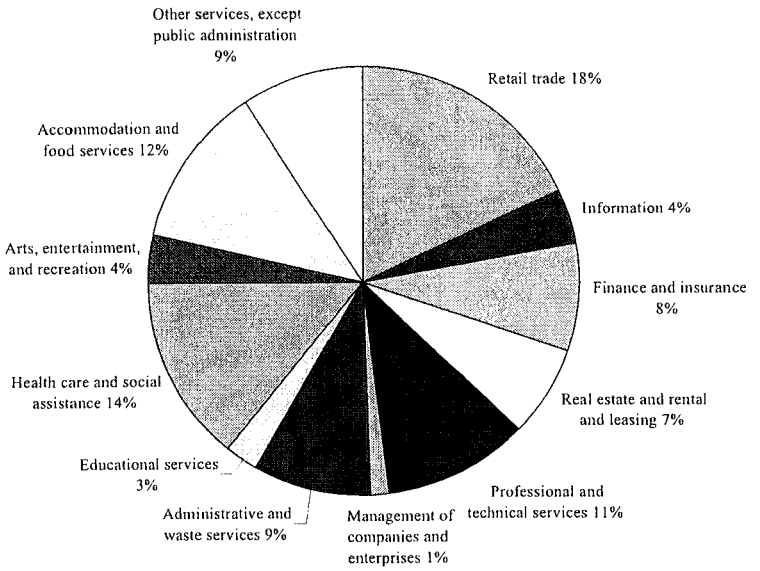
It should be noted that non-labor income also includes income support payments such as Medicaid, welfare and unemployment. However this category is consistently a small portion of total non-labor income and therefore a small portion of total personal income. Income support is less than 4 percent of total 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.

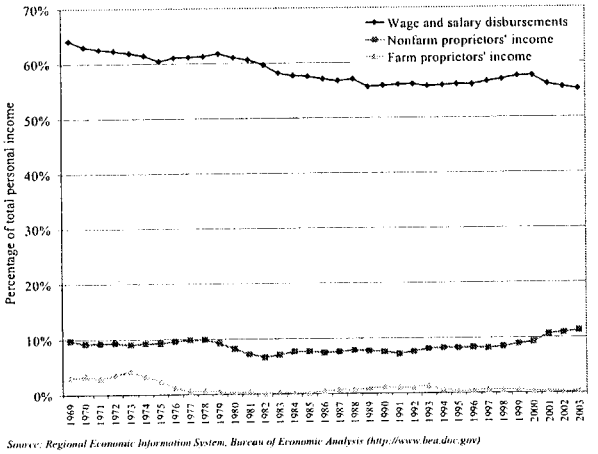


Figure 4. Rocky Mountain Personal Income by Type

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.

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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