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January 22, 2003

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Dear Peter, Kelly, and Scot:

As requested by The Wilderness Society, The Wyoming Outdoor Council, and the Greater Yellowstone Coalition, we have provided a scientific review of the big game portions of the existing Pinedale BLM Resource Management Plan, the Pinedale Anticline EIS and associated documents. We have also compiled and analyzed various peer reviewed and unpublished articles that address ungulate demographic and habitat issues pertinent to land use management in the Upper Green River Basin. This review and analysis was prepared to provide you with an objective document for use during the upcoming scoping process for the revision of the Pinedale Resource Management Plan.

The enclosed report describes the existing ecology and population status of mule deer, pronghorn and elk populations and provides a description of existing habitat conditions within the BLM's Pinedale Resource Area. The report provides a review of the current Pinedale RMP and the Anticline EIS based on existing scientific literature. The report also provides recommendations on how the Pinedale RMP may be revised to best manage ungulate populations within the BLM Pinedale Resource Area.

The enclosed report was prepared by Dr. Bryan Manley and me, with significant assistance from the staff of **W**estern **E**co**S**ystems **T**echnology, Inc, particularly Mr. Rhett Good. Dr. Manly is recognized internationally for his work in theory and applications of statistics in the biological sciences. He is the author of current texts: *The Statistics of Natural Selection on Animal Population, Multivariate Statistical Methods: A Primer, Stage-Structured Populations: Sampling, Analysis and Simulation,* and *Randomization and Monte Carlo Methods in Biology* and *The Design and Analysis of Research Studies*. In addition, he is lead author of *Estimation and Analysis of Insect Populations,* and *Resource Selection by Animals: Statistical Design and Analysis*. Professor Manly has extensive consulting experience and was the Director of the Center for Applications of Statistics and Mathematics at the University of Otago. He has taught at two universities in the United States, written commercial statistical computing software, and has conducted WEST, Inc. Statistics Workshops for biologists.

I am currently Vice-President and Senior Ecologist with Western EcoSystems Technology, Inc. (WEST) in Cheyenne, Wyoming. I received a B.S. in Zoology (1969) and an M.S. in Wildlife Management (1972) from the University of Tennessee and a Ph.D in Zoology from the University of Wyoming (1975). Prior to my employment with WEST I served as a scientist and administrator with the Wyoming Game and Fish Department for 15 years and as a research associate on the faculty of the Department of Statistics at the University of Wyoming. I also taught courses in wildlife management and statistics as a visiting instructor at the University of Wyoming.

I have over thirty years of experience in ecological research and wildlife management. My specialties include the design, conduct, and analysis of field studies of terrestrial and avian wildlife, ungulate ecology, threatened and endangered species, and impact, risk, and injury assessment studies. I am author of more than 75 papers and technical reports in the scientific and popular literature on wildlife research and natural resource conservation and management. I am the lead author of a chapter on harvest management in the 5th edition of the *Wildlife Techniques Manual* and co-author of the text *Wildlife Study Design* published in 2001. I also contributed to guidance documents for the National Oceanic and Atmospheric Administration for the quantification of injury due to oil spills in Type B Natural Resource Damage Assessments and authored a chapter in a guidance document on the conduct of research on avian wind power interactions for the National Wind Coordinating Committee. I am a member of the American Statistical Association, The Ecological Society of America, Certified Senior Ecologist, The Wildlife Society, Certified Wildlife Biologist, and Wyoming Chapter, The Wildlife Society, Past President.

My Ph.D. research was on the ecology of mule deer in Medicine Bow Mountains in Southeastern Wyoming. During my tenure with the Wyoming Game and Fish Department I provided guidance and technical support to the Wildlife Division for management of all game species, including mule deer. As a scientist with WEST I have conducted additional mule deer research in Wyoming, South Dakota, and Nebraska.
If you would like further information about the report or the qualifications of individuals involved in its development please feel free to contact me.

Sincerely,

M. Dale Strickland, Vice President

WEST, Inc.

An evaluation of the 1988 BLM Pinedale Resource Management Plan, 2000 BLM Pinedale Anticline Final EIS and Recommendations for the current revision of the Pinedale Resource Management Plan

January 22, 2003

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Introduction

The Upper Green River Basin (UGRB) generally refers to the area north of Interstate 80, west of the Wind River Range, east of the Wyoming Range, and south of the Gros Ventre Range. The UGRB encompasses approximately 8,000 mi^2; nearly 8% of the surface area in Wyoming. Historically, this sagebrush-dominated basin was occupied by a variety of ungulate species, including mule deer, elk, moose, bighorn sheep, pronghorn, and bison. Aside from providing large amounts of year-around habitat for wildlife, the mid-elevation (<7,600 ft.) basin serves as a natural corridor and winter range for migratory animals that occupy the surrounding mountain ranges.

Today the UGRB continues to support the largest, most diverse ungulate populations in the Rocky Mountain region. The Sublette mule deer and pronghorn populations (herd units), managed by the Wyoming Game and Fish Department (WGFD), cover the core of the UGRB. The WGFD manages these two herd units to meet numerical objectives of 32,000 and 48,000, respectively. While the areas occupied by these two herd units are fairly large in size, wintering areas available to mule deer and pronghorn in this region are often restricted and relatively small in size. Nonetheless, UGRB winter ranges support more than 10% of total mule deer and pronghorn in Wyoming. The Sublette herd unit alone supports more pronghorn than any western state, except Colorado (~70,000) and Montana (~55,000). Additionally, mule deer and pronghorn migrations within the UGRB are among the longest in North America, often reaching or exceeding distances of 100 miles.

Ungulate populations of the UGRB are valuable resources, both biologically and socially. While these populations summer over vast portions of western Wyoming, they rely on limited amounts of winter and transition range in the UGRB. Most of the winter and transition ranges occur on federal lands administered by the BLM, and must be balanced with other land uses, such as livestock grazing, recreation, and energy development. Negative impacts resulting from disturbances or habitat loss in winter or transition areas in the UGRB will not likely be localized; rather they will be evident across western Wyoming in the summer ranges these ungulate populations occupy. Of particular concern are the potential impacts to these populations from increased natural gas production and development in the UGRB.

The Pinedale Field Office of the Bureau of Land Management (BLM) announced on February 25, 2002 its intention to revise the Pinedale Resource Management Plan. The Pinedale Resource Area contains significant reserves of natural gas currently targeted for development. The Pinedale Resource Area also contains winter ranges that support an estimated 32,000 mule deer from five different mountain ranges and thousands of pronghorn, including some from as far away as Grand Teton National Park (Sawyer and Lindzey 2000, 2001). To provide informed comments during the revision of the Pinedale Resource Management Plan, The Wilderness Society, Wyoming Outdoor Council, and Greater Yellowstone Coalition contracted with **W**estern **E**co**S**ystems **T**echnology, Inc. to analyze the existing Pinedale RMP and the Pinedale Anticline EIS, identify potential oil and gas impacts on ungulates, and provide recommendations for mitigation and monitoring by focusing on the following main sources of information:

- **Literature Review –** We reviewed published and peer reviewed articles, theses, and gray literature on antelope, mule deer, and elk that address the issue of impacts of habitat fragmentation and winter range disturbances from road building and/or oil and gas development activities. Our reviews included biological/ecological and design and statistical aspects of the literature, where appropriate.

- **Review of the Pinedale Resource Management Plan and the Pinedale Anticline Project EIS** – We reviewed relevant chapters of the existing Pinedale Resource Management Plan (RMP), Pinedale Anticline EIS, and pertinent technical appendices and monitoring reports.

- **Upper Green River Basin Reports and Discussions with Local Biologists and Researchers –** We reviewed relevant WGFD monitoring reports, annual surveys, and special reports that pertained to ungulate populations and habitat in the Upper Green River basin, including Wyoming Cooperative Fish and Wildlife Research Unit reports; and, we conducted discussions with agency managers/biologists and academic researchers involved in the study of ungulate numbers, movements and habitat issues in the Upper Green River basin.

Literature Review

This section provides a review of literature describing the effects of habitat fragmentation and disturbances to wintering big game from road building and oil and gas development. The literature review provides the basis for reviewing big game sections of the Pinedale Anticline EIS and Pinedale Resource Management Plan. Our conclusions regarding this review are weighted toward peer-reviewed literature, which typically has undergone rigorous scientific review. We also provide more critical reviews of unpublished studies conducted within the Upper Green River Basin.

Winter is a crucial period of time for the survival of many big game species in Wyoming. Deer, for example, do not maintain body condition during the winter because of reduced forage availability and the increased energy costs of thermogenesis (Reeve and Lindzey 1991). As deer expend more energy than they take in, body condition gradually declines over winter (Short 1981). Increased energy expenditures will increase the rate at which body condition declines, and the energy balance determining whether a deer will survive the winter is thought to be relatively narrow, especially for fawns (Wood 1998). Overwinter fawn survival may decrease in response to human activity or other disturbances causing increased energy expenditures (Stephenson et al. 1996).

Habitat fragmentation occurs when relatively large blocks of habitat are separated in smaller and relatively less accessible habitats. Fragmentation of habitat may limit the ability of big game populations to move throughout the winter range as conditions change, causing big game to utilize less suitable habitat (Brown 1992).

What are the documented effects of roads on wintering big game?

Research has consistently documented avoidance by elk of roads open to vehicular traffic during the spring, summer and fall months (Irwin and Peek 1979, Thomas et al. 1979, Witmer and deCalesta 1985, Edge et al. 1987, Lyon and Canfield 1991, Rowland et al. 2000). Although habitat near roads is available to elk, it is not used to its potential (Lyon 1983). Because information concerning the effects of elk use and traffic volume is limited (Wisdom et al. 1986), it is generally assumed that road closures to elk are only successful if vehicular use is completely restricted. The effects of open roads on other ungulate species, such as mule deer and pronghorn, are much less understood. While roads are generally not considered a movement barrier to ungulates, certain types of right-of-way fencing adjacent to roads can make ungulate movements difficult, and in some cases, impossible. Additionally, vehicle-animal collisions can be a major source of mortality.

Aside from open roads, elk displacement has also been described for activities associated with logging (Edge et al. 1985), mining (Kuck et al. 1985), recreation (Cassirer et al. 1992), and ski area expansion (Morrison et al. 1995). While methodologies for documenting animal displacement or changes in distribution are fairly straight forward, those for documenting population-level impacts (i.e., survival, reproduction) are extremely complex. Thus, little information is available concerning how human-related disturbances impact reproduction and survival of ungulates. However, Phillips and Alldredge (2000) found that high levels of human disturbance during parturition likely resulted in reduced reproductive success of elk populations in Colorado.

While numerous authors have documented the effects of roads on elk on summer ranges (Lyon 1979, Czech 1991, Cole et al. 1997, Rowland et al. 2000), few authors have documented the effects of roads on wintering big game. We found only two publications and one unpublished report that specifically examined the effects of roads and associated disturbance on wintering big game.

Rost and Bailey (1979) examined mule deer and elk use in hunted populations during the winter east and west of the Continental Divide in Colorado. The authors used pellet abundance as an index of use. The authors found that deer and elk avoided areas within 200 m of roads on the east side of the Continental Divide. Road avoidance was greater where roads were more traveled. Only mule deer showed a clear avoidance of roads west of the Continental Divide. Mule deer also showed greater avoidance of roads in shrub habitats versus more forested areas. The authors concluded that mule deer and elk were able to select habitats away from roads east of the Divide, where greater amounts of winter habitat are present, while, suitable winter habitat was more limited west of the Divide and elk were less able to find suitable habitat away from roads.

Schultz and Bailey (1978) found very different results in a brief study of an unhunted population of elk in Rocky Mountain National Park in the winter. The authors conducted counts of elk during mornings and evenings in two areas during one 4-week period. Elk were first counted and then intentionally harassed on alternate weeks within 200 m of roads. The authors found no statistical difference between elk sightability and distribution between the two periods. The authors concluded that elk had become habituated to human activity in Rocky Mountain National Park.

We found no published studies that examined the response of wintering pronghorn to roads. Researchers have documented the potential for Interstate 80 in Wyoming and associated woven wire fences to fragment pronghorn habitat. Deblinger (1988) followed yearlong pronghorn movements within the Red Desert. Deblinger found only 1% of marked antelope south of Interstate 80 during four years of study, and concluded that Interstate 80 effectively blocks north and south movements of pronghorn in the Red Desert.

Historically, pronghorns have moved to winter ranges as a response to winter severity. Often, pronghorns from northern portions of the desert moved to winter ranges south of the existing interstate. During the severe winter of 1983-1984, pronghorn migrated as far south as I-80, but were forced to move east and west along the woven wire fence line in order to find suitable winter habitat. Deblinger found pronghorn had difficulty crossing fences of all types during the severe winter, and he documented 157 dead pronghorn within 10 m of fences after searching 480 km of fence line. Bruns (1977) also found pronghorn movements during the winter in south-central Montana were limited by fences.

Reeve (1996) attempted to determine if well recompletions and road traffic associated with normal maintenance activities at well sites affected winter mule deer distribution within a 12 mi^2 area in the Big Piney – Labarge wintering complex in Wyoming. A total of 15 surveys were conducted from December 28, 1990 – March 29, 1991 within an area scheduled for well recompletions. Reeve assumed that human activities associated with well recompletions are similar to activities associated with the initial drilling of a well. Surveys for mule deer were conducted from four-wheel ATV's along existing roads. Four wells were recompleted during the study. Reeve (1996) found no difference in the distance of mule deer observations and random points from roads and producing wells, and he concluded that mule deer were able to tolerate roads and wells associated with "normal well-field activities." We feel the methods used to collect mule deer distribution data were biased, and the data presented within the report do not support the statement that mule deer tolerated traffic associated with normal maintenance activities. The roadside surveys for mule deer were conducted from existing roads, mule deer located away from roads and wells had a lower probability of being observed than mule deer located near roads. There is also a likelihood that deer that remain close to roads are habituated to traffic and there is no estimate of the number of animals that abandon new roadsides rather than remain and become habituated. Inference is restricted to existing roads and not all areas occupied by mule deer.

The author examined the effects of well recompletions on mule deer distribution by comparing mule deer densities within 0.5 miles of the wells before, during and after recompletion activites. Mule deer densities were significantly lower during recompletion activities than before or after activities were conducted. Mule deer returned to the disturbed areas 10 days after activities were completed. The author concluded that recompletion activities resulted in abandonment of areas by wintering deer during recompletions, however, deer returned shortly after activities were finished and the overall effects were thought to be short term. While the data presented may show mule deer avoided areas during recompletion activities, problems existed with data collection that limit the inferences which can be made. The number of surveys conducted before, during and after activities varied at each well, thus sampling effort was not consistent among the areas studied. Additionally, two recompleted wells were located at the edge of the study area and the entire 0.5 mile buffer around these wells was not surveyed. Finally, as with roads it is inappropriate to make inference to the effect of new wells on deer because only existing wells were studied.

The author also compared mule deer densities at recompleted wells with two control wells where no recompletions were conducted. However, the two control wells were located in areas with different habitat characteristics and at a higher elevation, limiting the ability to compare control and treatment areas.

Oil and gas activities on winter ranges

We found only one published article that examined the effects of oil and gas drilling on wintering big game populations. Van Dyke and Klein (1996) documented elk movements through the use of radio telemetry before, during and after the installation of a single oil well within an area used year round by elk. Drilling activities during their study ceased by November 15, however, maintenance activities continued throughout the year. Elk showed no shifts in home range between the pre and post drilling periods, however, elk shifted core use areas out of view from the drill pad during the drilling and post drilling periods. Elk also increased the intensity of use in core areas after drilling and slightly reduced the total amount of range used. It was not clear if the avoidance of the well site during the post drilling period was related to maintenance activities or the use of a new road by hunters and recreationists. The authors concluded that if drilling activities occupy a relatively small amount of elk home ranges, that elk are able to compensate by shifting areas of use within home ranges.

We found five non-peer reviewed reports examining the effects of oil and gas activity on wintering big game in Wyoming. Johnson and Wolrab (1987) conducted aerial surveys for elk on two winter ranges from 1979 – 1987. One well was drilled during the winter of 1984 – 1985 adjacent to Graphite Hollow winter range. One well was drilled during 1980 and three wells were drilled in 1981 at the Riley Ridge winter range. The authors present count data that indicate a decrease in use of areas during drilling activity. However, the authors present only raw numbers and percentages, and did not conduct statistical analyses to reveal if differences in numbers observed were statistically significant. Additionally, count numbers were not standardized by effort, making it difficult to draw conclusions from the data presented. Finally, other variables potentially influencing use near the wells were not considered (e.g., the number of elk available to use the area).

Hayden-Wing Associates (1991) analyzed WGFD aerial count and Wildlife Observation System (WOS) data from 1979 – 1990 from Riley Ridge and the Graphite Hollow winter range. Contrary to Johnson and Wolrab (1987) the authors found that elk numbers were not significantly different between the pre-construction, construction, and post-construction periods. Rather, elk numbers were correlated with mean snow depth. The authors also examined elk distribution using count data and data from the Wyoming Game and Fish Department's WOS using Chi-square tests to examine changes in elk distribution within legal sections in the respective winter ranges. The authors concluded that while elk numbers remained the same, elk distribution changed between pre-construction, construction and post-construction periods. The authors also documented the proportion of elk observed within 1.75 miles of one well site increased during and after construction, however, the distribution of elk within 1.75 miles changed (elk moved out of site of the well). The proportion of elk wintering adjacent to one well decreased during construction and post-construction, and elk expanded use of winter range in to areas not used prior to well installation. While the results and conclusions of Hayden-Wing Associates are similar to those found by Van Dyke and Klein (1996) several problems may exist with methods used to collect and analyze data. We highlight a few here:

1) Raw count data were used in analyses. Two main habitat types occur in the study area, forest and shrub habitats. Sightability of elk likely differs between habitat types, and habitat types are not distributed uniformly across the study area. Thus elk located within forested environments are likely under-represented within the sample. Because elk counts were not standardized (e.g., by using line transect density estimates) results are likely biased toward elk locations and numbers in shrub habitats, and may not be representative of elk numbers and locations across the study area.
2) Methods section of the report does not provide a complete description of data collection methods. It is not clear if the same routes were flown in different years, if similar amounts of time and distances were spent searching for elk. Johnson and Wolrab (1987) state that survey efforts were intensified during and after well construction.
3) WOS data were used in calculations of elk distribution. WOS data are primarily opportunistic observations made by WGFD and other personnel, and are not collected by standardized survey methods. Thus, observations from the WOS database do not have an equal chance of occurring throughout the study area, and are usually made from roads and in open environments. WOS observations may therefore bias the data so more elk appear to use habitats within view of roads and well locations greater than expected by random chance.

Hiatt and Baker (1981) examined the effects of a single well installation on winter distributions of elk and mule deer in relation to the well location and access road in a relatively forested environment in central Wyoming. Both the well and road were located within mule deer and elk winter ranges, and construction took place during winter months. Distributions were monitored using nine track count transects located around the well site and the access road and were 0 – 3.2 + km from the road and well site. One count was conducted 3 – 7 days prior to construction activities, and three additional counts were conducted during the opening of the access road and during drilling activities. Distributions were also monitored using ground surveys from the access road, aerial surveys of the entire survey area and two time laps cameras near the well site. The distribution of tracks along transects showed both mule deer and elk avoiding the well site during drilling, but neither species showed avoidance of the access road. However, visual observations of mule deer and elk near roads indicated that traffic caused some disruption to the species behavior. The authors also examined habitat types present at track location and concluded that shifts in types of habitat used did not explain shifts in use away from the well site.

As described by the authors, conclusions based on data collected by Hiat and Baker are severely limited by the lack of pre-construction data, the fact that the study was conducted during a relatively mild winter, and inadequate measurements of habitat use and climatic factors. We would add that the study lacked spatial and temporal replication and control data. While the data collected by Hiat and Baker may indicate avoidance of the well site and tolerance of the access road, more baseline (pre-treatment) data, more accurate measurement of habitat and climate, control or reference data, and spatial and temporal replication are needed before conclusions can be made with any degree of confidence.

Easterly et al. (1991) examined the distribution and habitat use of pronghorn and mule deer within and outside but adjacent to the Rattlesnake Hills petroleum production complex in central Wyoming during the winters of 1989 - 1991. Distribution was examined through aerial surveys and radio telemetry. The authors placed radio transmitters on 22 pronghorn and 24 mule deer. An additional 204 pronghorn and 8 mule deer were marked with neck bands or ear tags. Pronghorn used four of six oil fields in proportion to their availability. The two most active oil fields were used less than expected by pronghorn given their availability. Five out of six oil fields were used in proportion with their availability by mule deer. No mule deer were observed within one of the most active oil fields. The authors found that pronghorn and mule deer used sites closer to roads than random sites, however, most of the used sites were visual observations recorded from roads. While the results of Easterly et al. may suggest that pronghorn and mule deer will continue to use winter ranges after construction of oil and gas fields are complete, because of the lack of pre-construction data, the authors could not determine if use of the oil and gas fields has decreased from pre-construction levels. Additionally, the roadside surveys were ad hoc and contained the same biases as reported in reviews of earlier studies using similar methods.

Summary

Several authors have described the potential effects of wintering big game to human-related disturbances. Anderson (1999) suggests impacts to wildlife species be defined as the change in a population's reproduction and/or survival caused by some disturbance. However, detecting changes in reproduction and survival, and then attributing that change to a specific disturbance is extremely difficult requiring relatively long-term and appropriately designed studies. Unfortunately, studies of this type have not been conducted and the available knowledge of impacts to wildlife is extremely limited.

While the ultimate measure of the effects of oil and gas development of wintering big game is reproduction and survival, no author has measured these variables in relation to oil and gas activity. Authors have measured effects of roads and oil and gas activity on the distribution of wintering big game, and some have shown shifts in distribution in mule deer and elk (Rost and Bailey 1979, Van Dyke and Klein 1996), which arguably could have caused big game to use more energy avoiding disturbance and may have concentrated use in other areas. Additionally, several authors have shown that elk actively avoid roads during the summer months in forested environments (Lyon 1979, Czech 1991, Cole et al. 1997, Rowland et al. 2000). Other authors of unpublished studies have attempted to examine effects of energy development on distribution of wintering big game in Wyoming; however, most of the studies lack adequate sample size, replication and study designs to draw conclusions. So, although evidence suggests energy development activity may negatively affect big game populations, no research has demonstrated direct reductions in reproduction or survival from energy development. Additionally, no authors have examined the potential impacts of habitat fragmentation on wintering big game.

Sawyer and Lindzey (2000, 2001) documented several natural and man-made bottlenecks that occur along 40 – 150 mile migration routes used by mule deer and pronghorn in northwestern Wyoming. Bottlenecks as referenced here are very narrow portions of well established migration routes, the loss of which would severely restrict seasonal movements necessary to maintain healthy populations. Some of the bottlenecks are only ½ mile in width. Changes in land use within these bottlenecks has the potential to disrupt mule deer and pronghorn migrations and prevent migrating animals from reaching winter ranges.

Currently, two studies related to energy development and big game populations are being conducted within the Pinedale Resource Area (Sawyer et al. 2002, Banulis and Lindzey unpublished data). Sawyer et al. 2002 is a continuation of the Sublette mule deer study (Sawyer and Lindzey 2001) and will measure mule deer population characteristics and habitat use in relation to energy development. This study is a cooperative effort funded primarily by industry. Banulis and Lindzey are using radio-collars with global positioning systems to compare elk utilization of native winter ranges in developed and non-developed areas. Preliminary data appear to indicate that elk were excluded from densely roaded areas with high human use. Also, elk within the developed area utilized more uneven terrain and cover while elk in the undeveloped area used most resources in accordance with their availability. The results from the study conducted by Banulis and Lindzey will be available by the spring of 2003.

Review of the Pinedale Resource Management Plan and the Pinedale Anticline EIS

This section contains a review of the information relating to big game within the referenced documents and associated technical reports and includes the following sections:

- What actions did the plan propose? Description of Alternatives and Management Actions as they relate to big game.
- Were Resources in the area accurately described?
- Were the impacts properly evaluated?
- Were mitigation and monitoring requirements adequate and appropriate?

What actions did the plan propose? Description of Alternatives and Management Actions as they relate to big game.

The Pinedale RMP analyzed the preferred and three additional alternatives to the current plan. The preferred alternative allows for resource extraction with increased protections of environmental resources over the current plan. The three additional alternatives allow for varying levels of resource extraction. We describe only the preferred alternative here.

The objective of the Pinedale RMP is to maintain big game populations at 1987 WGFD strategic plan levels. The following are the proposed actions to benefit or protect big game and their habitats, and a description of their implementation to date:

- ***Writing of habitat management plans for winter ranges.*** We were not able to obtain copies of any habitat management plans written for the Pinedale RMP. It is not clear if the plans were written.
- ***Seasonal restrictions on big game winter ranges.*** The BLM enforces seasonal restrictions on winter ranges, and requires written requests and justification for exceptions to winter stipulations. However, within the PAPA from November 15, 2001 – April 30, 2002 a total of 48 of 58 exceptions to winter range restriction were granted by the BLM Pinedale Field Office (Unpublished data, BLM, Pinedale). From November 15, 2002 – December 15, 2002 a total of 34 of 39 exceptions to winter range restrictions were granted by the BLM Pinedale Field Office (BLM Press Release, 12/13/02, available at: www.wy.blm.gov/newsreleases/2002/dec/12-13winterrange.htm). As of

December 26, 2002 the Pinedale Field Office granted 41 of 45 exception requests for various activities during the winter of 2002-2003 within the Pinedale District. Of the requests granted, one was for the entire season, two were for one month, and 38 were two weeks or less in duration (http://www.wy.blm.gov/pfo/wildlife/wild_winter_exc0203.htm).

- ***No treatments unless "beneficial to antelope and mule deer" are allowed on crucial winter ranges.*** The BLM has conducted some habitat improvements on ungulate winter ranges; however, it is not clear if these improvements were conducted on areas designated as crucial. Within the Draft EIS for the RMP, habitat treatments are described as brush control or vegetation manipulation, such as "controlled burning, mechanical treatment, artificial seeding, etc."
- ***Only 20 % of the areas covered by sagebrush may be treated at any one time on antelope, elk, moose and mule deer winter ranges.*** NEPA documents written in the Pinedale Field Office consider the amount of sagebrush affected by proposed projects
- ***Maximum of 40 % of the areas covered by sagebrush may be treated on elk crucial winter ranges and winter yearlong ranges.*** NEPA documents written in the Pinedale Field Office consider the amount of sagebrush affected by proposed projects
- ***No surface occupancy allowed on feed grounds and the Graphite elk crucial winter range.*** The BLM has not allowed surface occupancy on the described lands.
- ***Consideration of 16,000 acres for habitat improvement.*** The BLM has conducted various habitat treatments on approximately 10,900 acres within the Pinedale Resource Area in conjunction with the WGFD over the last 15 years (Dan Stroud, WGFD, pers. comm.).
- ***Monitoring of elk calving areas and other big game habitats, including crucial habitats.*** We are not aware of any well designed habitat monitoring conducted by the BLM on elk calving areas or other big game habitats. Within the RMP, the BLM states that monitoring of crucial habitats will be conducted in conjunction with livestock and watershed studies (See section: *Were mitigation and monitoring requirements adequate and appropriate?*).
- ***Monitoring of mule deer, elk and antelope use patterns.*** We are aware of only one research project within the Pinedale Resource Area. The study was initiated during 2000 as part of the Pinedale Anticline AEM (Sawyer et al. 2002).
- ***Management of grazing and habitat to provide adequate forage on elk winter ranges.*** Only one intact elk winter range is present within the Pinedale Field Office, the Labarge elk winter range. The BLM has written a grazing management plan for a portion of the Labarge elk winter range. However, the existing RMP does not provide for adequate monitoring of habitat conditions on ungulate winter ranges, making it difficult for the BLM to manage winter ranges for both elk and domestic cattle.
- ***Limiting logging to only 10 % of important elk winter ranges over 20 years***. The BLM has conducted very limited logging within important elk winter ranges in the Pinedale Resource Area.

We believe a description of the above measures should be included in the RMP revision process and these objectives and mitigation measures continued in the updated RMP.

Were Resources in the area accurately described?

The Affected Environment section of the Pinedale RMP describes the big game populations and habitat conditions present in the Pinedale Resource Area. Data regarding big game populations within the Pinedale Resource Area are presented from WGFD Herd Unit Reports, and were likely the most accurate data available at the time the plan was written. Population estimates and trends for big game populations have changed since 1988 (See **Historic and Current Population Levels of Big Game**).

The plan accurately describes BLM land within the Pinedale Resource Area as providing the majority of crucial winter ranges for big game within the Upper Green River Basin. However, recent studies have shown that range designations do not accurately reflect areas used by wintering mule deer and pronghorn within the Pinedale Resource Area (Sawyer and Lindzey 2000, 2001). We provide a detailed description of winter range mapping within later sections.

The plan also describes general habitat use patterns and limiting factors for pronghorn, mule deer and elk within the Pinedale Resource Area.

Pronghorn

The plan describes pronghorn populations as having periodically undergone drastic declines in the past as a result of severe winters. Periodic severe winters combined with poor range condition can significantly reduce pronghorn populations. However, on an annual basis, most adult pronghorn that die are killed through hunting, which is the primary management tool for regulating pronghorn populations. Predators may take a substantial portion (~50%) of fawns (Yoakum and O'Gara 2000), but authors have speculated that when predation limits population growth or stability it is generally associated with poor habitats or small pronghorn populations (Yoakum and O'Gara 2000).

The plan describes pronghorn winter habitat use as "dispersed and [utilizing] a much greater area" during open winters, but concentrated on lower, south-southwest facing slopes on crucial ranges during severe winters. While pronghorn use is likely more concentrated during severe winters, pronghorn have demonstrated a high degree of fidelity to winter ranges during even mild winters. During two consecutive mild winters (1998-1999, 1999-2000), Sawyer and Lindzey (2000) found that each radio-collared pronghorn in the Green River Basin occupied areas < 5 miles apart from one winter to the next. Although pronghorn may use traditional winter ranges, the size of their winter home ranges may vary greatly between years (Hoskinson and Tester 1980), likely due to environmental factors.

The plan also describes fences as a potential barrier to antelope movements; however, the plan states that, with the exception of highway fences, there are no known problems with fences within the planning area. Sawyer and Lindzey (2000) estimated pronghorn migrating from GTNP to winter ranges south of Pinedale had to cross at least 35 fences. De Groot (1992) completed a fence inventory project for western Wyoming and compared fence characteristics between the Rawlins, Lander, Rock Springs, Kemmerer, and Pinedale Field Offices (FO) of the BLM. The Pinedale FO had the 2nd highest miles of fence (805 mi) and the highest fence density (0.56 mi/mi^2). However, only ¼ of the fences in the Pinedale FO were considered restrictive to pronghorn movements, while about ½ of the fences in the Rawlins, Kemmerer and Rock Springs FO's were restrictive.

Fences can pose significant obstacles for pronghorn (Spillet et al. 1967, Yoakum and O'Gara 2000) and, in some cases, restrict movements completely (Ryder et al. 1984). Fences are often more of a barrier to pronghorn than other big game species, such as deer and elk, because pronghorn typically do not jump fences. Rather, pronghorn prefer to move underneath or through fences. Thus, woven wire fences and barbed-wire fences with low (< 16 in) bottom wires are considered restrictive to pronghorn movements (Yoakum and O'Gara 2000). Negotiating fences may become even more difficult for pronghorn when snow depths increase or drift, causing the space between the ground and bottom wire to be reduced. Deblinger (1988) found that pronghorn had trouble negotiating all types of fences during a severe winter in the Red Desert.

The plan does not describe migratory movements of pronghorn within the planning area, nor does it recognize the existence or proscribe special management for migratory bottlenecks that exist in the planning area. Sawyer and Lindzey (2000) found most pronghorn that summer in the Gros Ventre River Drainage and Grand Teton National Park wintered south of Pinedale and used well-defined migration routes, including migratory bottlenecks found within the Pinedale Resource Area.

Mule Deer

The plan describes mule deer winter range as the limiting factor for populations within the Pinedale planning area. However, some researchers have argued that all portions of mule deer range are equally important for herd survival (Clements and Young 1997). The Sublette mule deer herd is highly migratory, and mule deer spend 5-6 months per year on transition ranges, often give birth on transition ranges and move fawns to summer ranges at higher elevations once sufficient amounts of snow melts (Sawyer and Lindzey 2001). While winter ranges are important to the survival of the Sublette mule deer herd, the importance of transition ranges should not be overlooked.

Interestingly, the plan uses a different definition of crucial winter range for mule deer than pronghorn within the draft EIS. Additionally, the definition used by the BLM for crucial winter range within the draft EIS differs from the definition used by the Wyoming Chapter of the Wildlife Society (Wyoming TWS 1990). The Pinedale RMP defines mule deer crucial winter range as "… those areas where most members of a population are forced to subsist during maximum snow cover each year." In the past the WGFD has also typically delineated only severe winter relief ranges as crucial winter ranges. While these areas are important to big game populations, they are used only during infrequent years when winter conditions are especially severe. These conditions have only occurred during 2 – 3 winters over the last 20 years (Sawyer and Lindzey 2001). Since the publication of the Pinedale RMP, the Wyoming Chapter of the Wildlife Society (1990) defined crucial ranges as "any particular seasonal range or habitat component that has been documented as the determining factor in a population's ability to maintain itself at a certain level (i.e., WGFD population objective) over the long term. Example: The total 'crucial' winter range for an elk herd unit should be available, relatively intact, and allow a population at the objective level to survive the winter in adequate body condition and to maintain average reproductive rates 8 out of 10 years."

Elk

Elk habitat within the Pinedale Resource Area on BLM land is accurately described as winter range with some areas of calving grounds. The Resource Area also contains several elk feedgrounds. The RMP describes the area between LaBarge and Cottonwood Creek as having a high level of oil and gas development, and as approaching the threshold for acceptability by elk. The plan does not describe how the threshold was determined, or what the threshold is. If the BLM describes an area as reaching a disturbance threshold for elk, it is prudent for the BLM to define that threshold. Without a measurable threshold it is difficult for the BLM to assess if future actions will impact wintering elk.

Were the impacts properly evaluated?

The environmental consequences section of the Pinedale RMP is based on assumptions of the number of wells that may be drilled within 10 and 20-year periods. This is referred to as the "Reasonably Foreseeable Development Scenario" or RFD. The 1988 Pinedale RMP set the RFD at 900 wells; the RFD was later amended to 1,900 wells through the Pinedale Anticline EIS.

The RMP also assumes a total of 5.5 acres of long-term disturbance for each well location. Acres of disturbance within mule deer, pronghorn and elk winter ranges are presented. A total of 16 % of mule deer crucial winter range, 9 % of crucial elk winter range and 4 % of crucial pronghorn winter range would be affected.

There are several problems with basing impact evaluations on the above calculations. The following points should be considered by the BLM during the revision of the Pinedale RMP:

- There may be problems with acres of disturbance calculations. The calculations take into account local access roads, but no definition of a local access road is given. We assume the calculations do not include major roads, pipelines and other infrastructure built and maintained after the well has been plugged and abandoned.

- The calculations also assume that 11 acres per well site are reclaimed and used by big game. The RMP states that some rehabilitation efforts are unsuccessful, largely due to the poor soils, severe weather and low rainfall. The BLM does not provide data regarding the shrub establishment and percentages of successful reclamation efforts. Without data regarding shrub establishment on reclaimed well pads, we feel it is inappropriate to assume that 11 acres per well are reclaimed, especially considering the BLM observations that some efforts are unsuccessful.
- Secondary or indirect disturbance is not included in the analysis. While rough estimates of physical disturbance are calculated, no calculations of acres lost due to avoidance of well sites and roads are provided. The RMP states that behavioral avoidance zones should be considered, and cites a USFWS publication that indicates that twice as much habitat is lost through avoidance (Thomas 1983), but this relationship is apparently not used in estimating impacts of development.
- The analysis assumes impacts to ranges mapped as non-crucial winter ranges and unmapped transition ranges do not affect populations. While no studies have documented reductions in populations associated with winter range disturbance, available evidence suggests the potential exists for disturbance to wintering big game may negatively affect populations. The effect of development on transition ranges is unknown.
- The analysis does not address the impacts of creating new roads and associated disturbance to big game that continue to be used after wells have been plugged and reclaimed.
- The calculations assume that big game crucial winter ranges are mapped accurately (See later discussion). The RMP assumes that the carrying capacity for mule deer is lowered by 16 % within the area due to oil and gas activities. Because the amount of crucial winter ranges is likely underestimated based on Sawyer and Lindzey (2000, 2001), the estimate may change.

The Pinedale RMP lacks a cumulative impacts analysis section. Although required under NEPA, many NEPA documents written by the BLM and other federal agencies in the 1980’s lacked cumulative impacts sections. The plan attempts to address the concept of cumulative impacts in the section on impacts to elk, describing the historical and current level of development in one area of the district as approaching the tolerance threshold for elk (see previous section).

Were mitigation and monitoring requirements adequate and appropriate?

The RMP attempts to provide for mitigation of the described potential impacts through the implementation of seasonal restrictions on surface disturbing activities within big game winter ranges, no activity or surface disturbance in elk calving areas during calving season, and no surface occupancy within elk feed grounds. While these measures prevent drilling of wells during the winter, wells may be drilled during the summer months in these areas and maintained throughout the winter. Traffic associated with maintenance of wells and general road traffic within winter ranges may continue to disturb big game, potentially causing them to use valuable energy reserves during a time when they are in a negative energy balance. Additionally, the BLM regularly grants exceptions to winter stipulations two weeks or less in duration. Thus, the effectiveness of seasonal restrictions on surface disturbing activities is unknown.

The Pinedale RMP also states "Mule deer, elk, antelope and sage grouse use patterns will be monitored." The plan does not describe any objectives regarding the monitoring of use patterns nor how monitoring will lead to mitigation. We assume the intent of the BLM was to examine use patterns in relation to management activities and oil and gas development within the Pinedale Resource Area, with the overall goal of determining if BLM approved activities have positive or negative effects on big game and sage grouse distribution and populations, with subsequent management adjustments. While avoidance of oil and gas development by big game may provide an indication of negative effects of BLM approved activities, the ultimate measure of herd health is fawn and adult female survival.

Monitoring of big game use within the Pinedale Resource Area has included two studies. Both studies were initiated recently (1998) and focus on pronghorn and mule deer use of the Pinedale Anticline Project Area (PAPA) (Sawyer and Lindzey 2000, 2001). Both studies were funded primarily by industry (Ultra Petroleum) as required by the Pinedale Anticline ROD.

The plan also states that crucial habitats will be monitored in conjunction with livestock and watershed studies. As described within the Pinedale RMP, monitoring is limited to photo points. The plan does not describe the number of stations that will be placed within crucial habitats, thus it is impossible to determine of adequate sample sizes were obtained. Because plots were placed in conjunction with other livestock and water shed studies, the plots may not be representative of crucial habitats throughout the Resource Area. The use of photo points allows only a descriptive analysis of habitat change within the Resource Area, making it impossible to quantify changes in habitat quality (live shrub stem density etc) within the Resource Area. Overall, the BLM's plan for monitoring crucial habitats within the Pinedale Resource Area does not allow for a quantitative assessment of the relative health of crucial big game habitats, making it difficult to adequately address the potential cumulative effects of resource extraction on ungulate populations.

The RMP outlines guidelines for shrub treatments. The RMP states that treatments for brush control will not be allowed within crucial pronghorn and mule deer winter ranges unless beneficial to mule deer or pronghorn. We feel that the measure, if implemented as described, helps to minimize impacts to sagebrush winter habitats.

Pinedale Anticline EIS

What actions did the plan propose? Description of Alternatives and Management Actions as they relate to big game.

The Pinedale Anticline EIS was prepared with a high degree of uncertainty as to where potential development would occur, as well as the level of development. Therefore, the EIS analyzes alternatives under three levels and extents of development and three levels of resource protection.

The three extents of development include:

1) Project wide development and exploration,
2) Anticline crest development and exploration and,
3) No further development.

The three levels of development include:

1) Development of 500 producing and 150 non-producing pads,
2) Development of 700 producing and 200 non-producing pads and,
3) No development.

The three levels of resource protection include:

1) Standard stipulations. The standard stipulations scenario only requires restrictions on development as outlined in each oil and gas lease.
2) Resource protection on federal lands and leases. This alternative implements more protection measures, such as limiting the total number of pads in winter ranges, only on federal lands.
3) Resource protection on federal and non-federal land and leases. This alternative implements these protection measures to both federal and private lands.

The EIS also analyzes two options for reducing impacts to resources, including directional drilling using multiple wells from each pad location and centralized production facilities (CPF). The CPF option congregates production equipment that is commonly placed at each pad into to one location, reducing the number of maintenance trips required to each pad location.

The preferred alternative was the project wide development scenario with the resource protection alternative on federal lands. The implementation of the CPF and directional drilling options will be determined by the BLM and the Adaptive Environmental Management Committee (AEM). In addition, because the proposed number of wells exceeds those allowed within the Pinedale RMP, as discussed earlier, the EIS also revises the foreseeable development scenarios within the cumulative impacts section for the entire Pinedale Resource Area.

Were Resources in the area accurately described?

Overall, big game populations and habitat conditions are accurately described within the EIS. However, studies conducted after the completion of the EIS show the delineations of winter range and crucial winter range to underestimate the amount of area used by wintering pronghorn and mule deer (Sawyer and Lindzey 2000, 2001). BLM and WGFD define "winter" as November 15-April 30. Using this criteria, locations of radio-collared mule deer and pronghorn can be used to objectively delineate accurate winter or crucial winter ranges for the animals marked and their associates. Presumably the marked animals are representative of the entire population.

The same studies have also documented migratory paths and bottlenecks within the project area that are not described within the document. Mule deer migration bottlenecks or areas of concern that occur on or near BLM lands include: 1) Trapper's Point Bottleneck, 2) Fremont Lake Bottleneck, and 3) Green River Crossing. These areas appear to meet the BLM criteria for designation as Areas of Critical Environmental Concern (ACEC).

Were the impacts properly evaluated?

The Anticline EIS uses the 1998 WGFD mitigation policy as a guide for determining the significance of impacts to wildlife populations. The WGFD mitigation policy recommends no loss of habitat function for crucial ranges and no net loss of habitat function for winter and yearlong ranges. We feel the use of the WGFD mitigation policy for the determination of significant impacts is appropriate and allows for a standard that can be used with all BLM projects.

The EIS uses Bayesian probability models and GIS to predict acres of impact to pronghorn and mule deer winter ranges under different development scenarios. The results of this model are used to compare the effects of the differing development scenarios on winter habitat and are the basis for the decision to choose the preferred alternative. We believe modeling the potential impacts of oil and gas development on ungulate populations is an appropriate method for predicting future impacts. However, the Bayesian analysis used within the Pinedale EIS was an inappropriate choice of modeling procedures and was incorrectly applied. Below we provide a thorough critique of the Bayesian model used within the EIS.

Review of the Bayesian Habitat Model

There are several very serious deficiencies in the Bayesian analyses used to evaluate the possible impacts of the Pinedale Anticline Oil and Gas Exploration and Development Project on pronghorn and mule deer winter habitat and sage grouse nesting habitat within the Upper Green River Basin. To view the full analysis see *Appendix A*. In brief, these are that:

(a) the sample unit that probabilities refer to is not made clear, although the phrases 'parcel of land' and polygon are sometimes used without a proper definition;

(b) similarly, 'suitable' and 'marginal' habitat are defined so vaguely that it is hard to see how probabilities of these can be evaluated;

(c) prior probabilities are purely subjective, having no basis in real data, and in certain cases do not sum to one as they should;

(d) conditional probabilities are purely subjective (although in this case it should be possible to evaluate them using the GIS database) and sometimes have impossible values;

(e) the probabilities for eight habitat characteristics are multiplied together to get their joint probability, which wrongly assumes that these characteristics occur independently over the study region; and

(f) there are mistakes in the Appendix of the EIS on the application of Bayes' theorem.

We believe the Bayesian analysis by the Bureau of Land Management on the potential impacts of the Pinedale Anticline Oil and Gas Exploration and Development Project is inadequate. It is based on the incorrect application of a method of modeling wildlife habitat requirements that is very subjective and, thus open to considerable criticism, even if done correctly. Because of the serious problems with the model we do not consider this analysis adequate for simulating the effect of oil and gas development.

Were cumulative impacts properly evaluated?

The cumulative impact section of the EIS includes the entire Pinedale Resource Area and much of southwest Wyoming. The BLM presents the number of wells currently present and the number of wells currently permitted but not developed for herd units within the PAPA. The BLM also provides current road and well densities for each herd unit, and identifies units currently having the highest well and road densities. The BLM presents the results of regression analysis showing the relationship between pronghorn and mule deer fawn production and survival with winter precipitation and oil and gas development. The BLM indicates that some pronghorn and mule deer herd units show correlations between decreased fawn survival and increased development. However, the same units also show correlations with winter precipitation. The BLM describes the results of these correlations as inconclusive, and the BLM claims the declines cannot be directed at only oil and gas development. We provide a review of the analyses presented within the Technical Report.

Population Parameters Estimated

The production rate of adult females (juveniles per adult female) is estimated on the basis of several assumptions listed on page 58 of the report, and seems reasonable. The estimation of a survival rate for juveniles from ages 4-6 months to 16-18 months is more complicated, but also seems reasonable given the data available. Two methods are described to do this, with the details in Appendix B of the EIS.

Analysis of Population Parameter Estimates

Our main concern with the analysis provided in the technical report is that it is rather illogical, and does not make good use of what appears to be a reasonable data set for assessing the effects of oil and gas related activities.

For pronghorn a table (Table II.E-1) is presented showing mean values for fawn productivity and maximum fawn survival rates, for periods before and after major oil or gas projects started, for seven Antelope Herd Units. The mean values before and after the projects started are similar for the estimated maximum survival rates, but decreased production rates appear to be correlated with increased oil and gas related activity.

It is noted in the technical report that winter precipitation and other variables may influence production rates, and that therefore the results shown in Table II.E-1 do not conclusively identify oil and gas developments as adversely affecting this population parameter. This is correct, but the report goes on to make a number of inappropriate comparisons between various estimated maximum survival rates and production rates, before indicating that no conclusions about the effects of oil and gas developments are really possible.

It may well be that the data do not enable clear conclusions to be reached. However, these data are of the before-after-control-impact (BACI) type (Morrison *et al*., 2001), with the impact occurring at different times at different locations. A multiple regression model can therefore be set up in which the production rate at a site can be assumed to depend on (1) a site-specific mean level, (2) the precipitation in the year in question, (3) time trends that are either common to all sites or are site-specific, and (4) whether there is an impact of oil and gas developments. Presumably, the amount of gas and oil activity can also be measured. In that case the simple presence or absence variable (4) could be replaced by the measure of the level of activity. Non-linear effects (e.g. of precipitation) might need to be allowed for, but that is only a minor complication.

This type of regression approach may still leave some uncertainties about the effects of oil and gas developments. However, it is likely to give much clearer results than those in the technical report.

A similar type of regression approach could also be used with the mule deer population parameters. In this case the results of regressions of estimates of maximum fawn survival rates against precipitation are discussed. Here the statement is made that "... the rate of decrease (slope of the regression equation) for fawn survival with increasing precipitation was significantly greater with data collected between 1995 and 1998 than with data collected before 1995". It is not clear here what the word "significant" means. However, given the data plot (Figure II.E-1 within the Technical Report), it seems unlikely that there was a statistically significant change in the regression slope in 1995. We suspect that what is observed is most likely just due to random variation.

There are some minor aspects of the report that can be questioned, but nothing major is stated that is obviously wrong. Our main concern is that the data analysis is rather illogical, and makes no real attempt to use the available data efficiently to assess the effects of oil and gas developments, taking into account at least the apparent effects of precipitation. We strongly recommend that the data analysis be reconsidered for this part of the report, using either a multiple regression approach along the lines suggested above, or some other alternative that allows for the BACI type of study that is involved here.

The BLM correctly states that the functions of pronghorn and mule deer winter ranges have decreased from the early 1980's. Due to the inconclusive results of the analyses and overall lack of information regarding the effects of oil and gas development on ungulate populations, the BLM does not analyze the potential cumulative effects of oil and gas development.

While we agree that existing data are insufficient to accurately predict the cumulative effects over such a large area, the implementation of the AEM (See next section) was approved to monitor the effects of the proposed project on ungulates. It was not designed to monitor the cumulative effects of non-BLM activities in the Resource Area on ungulate populations, such as the development of subdivisions on private land.

Were mitigation and monitoring requirements adequate and appropriate?

The Pinedale Anticline ROD outlines several mitigation and monitoring requirements. We highlight and evaluate the major measures:

- *No pad or road development within the Mesa Breaks.* The area delineated as the Mesa Breaks serves as severe winter relief area for wintering mule deer and pronghorn within the project area. The required mitigation measure should be effective in preventing disturbance to big game wintering within the Mesa Breaks during severe winter conditions. However, the BLM has recently granted an exemption to allow drilling during this winter next to the Mesa Breaks.

- *Seasonal restrictions on activities or surface use on crucial winter ranges.* Minimizing human-related activities (i.e., traffic, construction, drilling, and recreation) during winter likely reduces disturbance to big game. It is not clear from the Record of Decision if regular maintenance activities are allowed on wells within crucial winter ranges. If maintenance activities are allowed, wells are likely checked at least once per week. The effectiveness of timing restrictions and the effects of regular maintenance activities are currently unevaluated.

Additionally, the BLM regularly grants exceptions to winter timing restrictions lasting two weeks or less.

- *Requiring operators to consider CPF's or directional drilling if more than 4 pads are required per section in crucial winter ranges.* Limiting the number of pads per section within crucial winter ranges would decrease the acres of important habitat lost and help reduce disturbance to wintering big game. The effectiveness of the CPF option is less certain. BP Amoco indicated that equipment such as heat liners and methanol storage would still be required at each well location. These items require more visits than anticipated by the BLM within the EIS, thus the CPF option may not significantly reduce the number maintenance trips required to wells within crucial winter ranges during the winter.

- *Adaptive Environmental Management (AEM) Planning Process.* If implemented correctly, the use of the adaptive management process has the potential to significantly reduce impacts associated with the Pinedale Anticline project. Implementation of AEM is critical to this project due to uncertainties regarding the location and extent of actual gas development. However, the AEM committee was only recently certified in the Federal Register on August 15, 2002, a full two years after the publishing of the Record of Decision on July 27, 2000. Adaptive management requires that management activities be thoroughly evaluated through monitoring and research and that future management be modified based on these evaluations. It is not clear that sufficient monitoring and research is planned to effectively implement the AEM. Additionally, the process will require long term, guaranteed funding in order to be successful.

Upper Green River Basin Reports and Discussions with Local Biologists and Researchers

Historic and Current Population Levels of Big Game

Several factors make assessing long-term (> 10 years) population trends for big game species in the Pinedale BLM Field Office (FO) extremely difficult. First, the WGFD estimates big game population numbers for large management areas referred to as herd units. Herd units consist of several smaller units known as hunt areas. Over the years, hunt area boundaries have changed and hunt areas have been added, removed, and/or combined with other hunt areas or herd units, so that the internal structure of herd units often change through time. Although less frequently, herd unit boundaries may also change. Significant effort is required to ensure these data are spatially correct and comparable through time (Ayers et al. 2000), and is beyond the scope of this summary. Additionally, WGFD monitoring efforts are influenced on an annual basis by available funding, personnel changes, weather conditions, and modeling techniques. Further, methods for estimating populations continue to improve and are likely better today than they were ten years ago. Finally, population trends correlate poorly with trends in habitat over relatively short periods. Response to habitat impacts tends to occur as pulse events, occurring primarily in those years when some resource (e.g., winter range) is limiting.

Although these population data assist the WGFD with determining annual hunting seasons, they are coarse and a poor measure of long-term (>10 years) population trends for large geographic areas (i.e., herd units) in response to some treatment of interest. Figure A illustrates the annual variation among big game population estimates for the Pinedale Resource Area from 1988-2001.

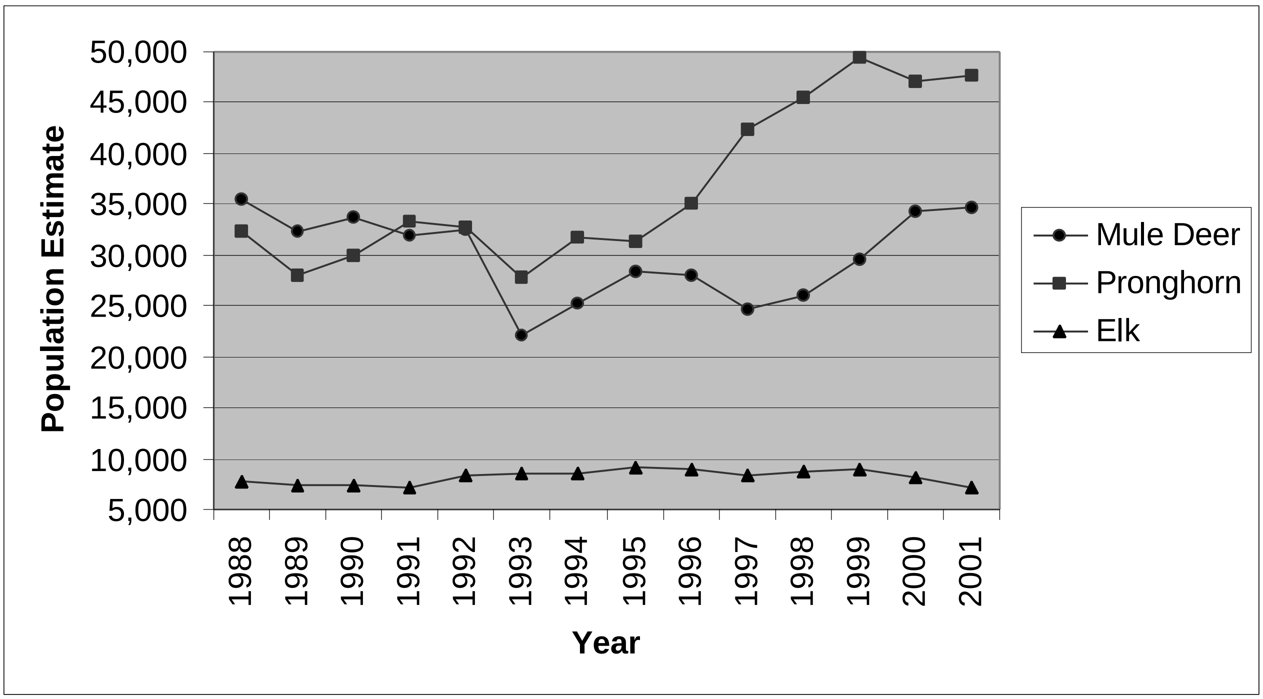

Figure A. Annual population estimates for mule deer, pronghorn, and elk in the Pinedale Resource Area, 1988-2001. Data were compiled from WGFD Job Completion Reports and include data from the Sublette Mule Deer Herd Unit (# 104), the Sublette Pronghorn Herd Unit (# 401), and the following elk herd units: Piney, Green River, and Pinedale (#'s 106 – 108, respectively).

While Figure A may be used to identify dramatic changes, such as large die-offs associated with the 1992-93 winter, these estimates are intended to detect trends rather than precisely quantifying animal numbers (e.g. estimates with +/- 10% error). For example, although most biologists would agree pronghorn populations reached a low following the 1992-93 winter and have steadily increased since, no biologists familiar with the area would confirm that there were 15,000 more pronghorn in 1999 than there were in 1988, as suggested by Figure A. We provide this example to illustrate the difficulty in comparing historic and current population estimates.

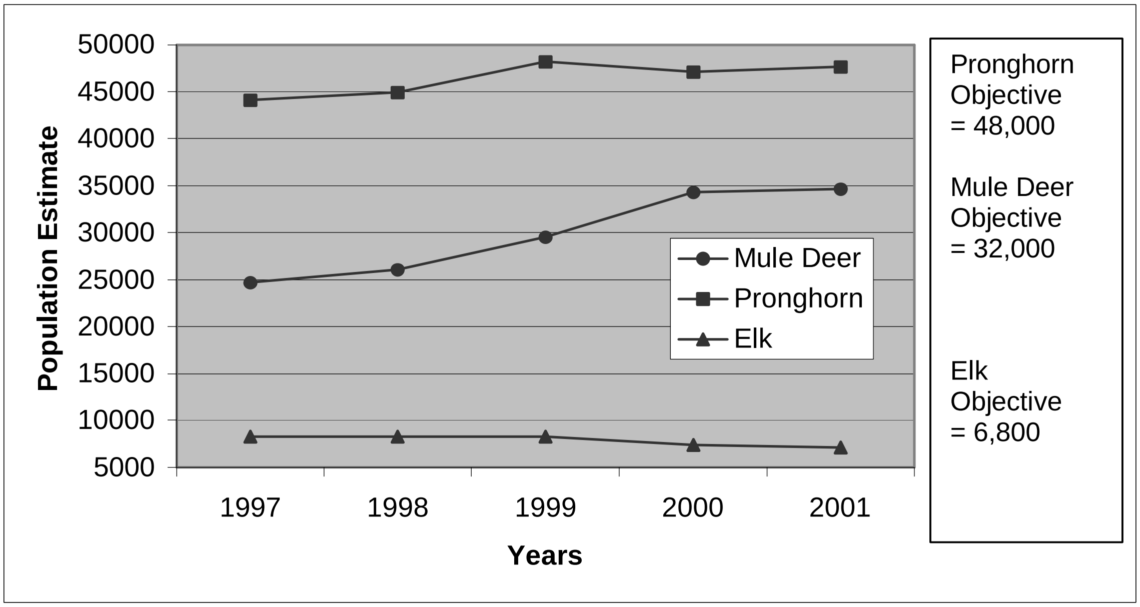

Figure B. Annual population estimates associated with POP II model output for mule deer, pronghorn, and elk in the Pinedale Resource Area, 2001. Data were compiled from WGFD Job Completion Reports and include data from the Sublette Mule Deer Herd Unit (# 104), the Sublette Pronghorn Herd Unit (# 401), and the following elk herd units: Piney, Green River, and Pinedale (#'s 106 – 108, respectively).

Most WGFD population estimates are products of computer models (POP II) with input variables that include annual measures of age/sex structure, winter severity, and survival. Because new data are added to the model annually, the model and subsequent output also change annually. Thus, a more appropriate method for assessing population trends is to examine the most recent population estimate (e.g., 2001) and model output (for previous years) associated with that estimate. The WGFD reports 5-year population averages with each year's population estimate. Figure B depicts population estimates from 2001 and associated model output for 2000, 1999, 1998, and 1997. These 5-year trends are most likely to reflect how big game populations are growing or declining in a particular region of Wyoming, and most likely to reflect actual population numbers. Figure B indicates that mule deer and pronghorn populations in western Wyoming have steadily increased since 1997 and have just recently approached or exceeded population objectives set by the WGFD. Elk populations on the other hand, have generally exceeded objective levels since the mid 1990's and liberal harvest programs are gradually reducing those populations to meet WGFD objectives.

Biologists in the region (Scott Smith, Gary Fralick) concur with the assessment that mule deer and pronghorn populations substantially declined following the 1992-93 winter. Since then, populations have gradually recovered, due largely to mild winters and conservative harvest programs. Because most elk are concentrated on feedgrounds during the winter, the biologists felt their counts and populations estimates are more precise than those of pronghorn and mule deer. Elk populations have generally met or slightly exceeded objective levels from 1997 through 2001.

Grand Teton National Park Pronghorn

Although they only represent approximately 1% of the Sublette pronghorn herd, the pronghorn of Grand Teton National Park (GTNP) and the Gros Ventre River Drainage (GVRD) have received much attention because of the extraordinary 100+ mile migration they complete every year (Sawyer and Lindzey 2000). Segerstrom (1997) compiled summer count data for the GTNP and GVRD pronghorn from 1970-1996. Count numbers range from 423 in 1990 to 162 in 1996. During the last 10 years, most count totals range from 150 to 300 animals. Count data represent a minimum number pronghorn present and most were collected through informal ground surveys conducted by the WGFD that vary in effort and intensity on a year-to-year basis. Allocating funds and personnel time to conduct annual aerial surveys for this pronghorn population is a low priority for the WGFD because of the small population size and the minimal hunter opportunities it provides (D. Brimeyer, WGFD, pers. comm.). Because aerial counts are rarely conducted for this population, and the informal nature of the ground surveys, these data should be used with caution when making any generalizations regarding the performance of this component of the pronghorn population.

Recruitment for the GTNP pronghorn has historically been much lower than the GVRD and other parts of the state, including the Green River Basin (Segerstrom 1997, D. Brimeyer, pers. comm.). Sawyer and Lindzey (2000) suggest low natural adult mortality combined with minimal hunting loss has allowed the population to maintain itself, despite low recruitment rates. Additionally, they suggest that pronghorn producing young in the Green River Basin that migrate to GTNP the following year, may supplement recruitment.

Ground surveys conducted for the GTNP and GVRD pronghorn lack the precision and accuracy needed to accurately assess population status. Much of the inaccuracy and lack of precision associated with these ground surveys is likely a result of differential survey effort and the biases inherent with ground survey techniques. Aside from the numerous environmental factors (e.g., precipitation, forage condition, winter severity, and predation) that influence reproduction and survival, the number of pronghorn counted in GTNP every summer may vary because of annual shifts in migration patterns. As Sawyer and Lindzey (2000) indicated, only 62% of radio-collared pronghorn captured in GTNP returned the following year. The size of the GTNP pronghorn population may also be affected when pronghorn attempt to over-winter in the GTNP area, rather than migrate to the Green River Basin. Over-winter attempts in the GTNP area by pronghorn are generally unsuccessful and result in significant levels of mortality (Segerstrom 1997).

Current Status of Habitat Conditions

Shrub communities in the Green River Basin are the single most important habitat type for supporting the tens of thousands of wintering mule deer and pronghorn. However, inventory data on BLM lands is limited and habitat management typically receives low priority by the BLM (D. Stroud, WGFD, pers. comm.). The only comprehensive vegetation inventory conducted in the Pinedale Resource Area was done on BLM lands located between North Piney Creek and Fontenelle Creek, during 1988 and 1989 (Cundy 1989). The purpose of the Cundy (1989)'s inventory was to evaluate shrub community conditions on mule deer winter ranges. Results indicated that >60% of 86,590 acres of shrub communities inventoried were in fair to poor condition and appeared incapable of perpetuating themselves. While big sagebrush (*Artemisia tridentata*) utilization of 30-35% is considered proper for sustained use by browsing animals, sagebrush in these shrub communities averaged 45% utilization. Other species such as mountain mahogany (*Cercocarpus montanus*), Gardner's saltbush (*Atriplex gardneri*), and winterfat (*Ceratoides lanata*) were utilized to a much greater degree. Cundy (1989) suggested the following factors contributed to deteriorated shrub conditions in the region:

- Fire suppression
- Over-utilization by wildlife and livestock
- Habitat loss associated with energy development
- Drought conditions

Cundy (1989) does not provide an explanation for how energy development affects habitat quality. We feel energy development may affect habitat in a couple of ways. First, shrub communities are converted to pads, roads and other infrastructure resulting in a direct loss of habitat. Secondly, the remaining shrub communities may be over-utilized due to the loss of habitat from energy development, potentially degrading the quality of the remaining habitat.

Consistent with Cundy (1989), Clause (1999) evaluated habitat conditions in the Bear River Watershed in southwest Wyoming and found plant communities exhibited signs of heavy use, low production, and lacked diversity among age-classes. Clause (1999) attributed the overall poor habitat conditions to lack of natural disturbance (i.e., fire) and heavy ungulate utilization. Habitat conditions documented by Cundy (1989) and Clause (1999) likely reflect current habitat conditions across the Pinedale Resource Area.

Most shrub communities in the Pinedale Resource Area are dominated by big sagebrush, although small areas of mixed shrubs, such as bitterbrush (*Purshia tridentata*) and mountain mahogany (*Cercocarpus spp*) can be found along the foothills of the Pinedale and Piney Front (D. Stroud, WGFD, pers. comm.). Historically, fire was a natural component of most sagebrush ecosystems, with fires typically occurring at 20-30 year intervals (Clause 1999). According to Cundy (1989) fire suppression and the reduction or elimination of fine fuel loads by livestock grazing has precluded natural fire. Further, the desirable shrub components of these ecosystems have also deteriorated with heavy use by domestic and wild ungulates. As a result, Cundy (1989) suggests the ability of these sagebrush communities to regenerate themselves and remain productive has greatly diminished. Thus, sagebrush stands are often monotypic, old-aged, varyingly decadent, and possess little or no seedling regeneration.

In addition to poor shrub conditions in the area, the WGFD has identified aspen regeneration as a major habitat concern (WGFD 2002). A substantial amount of aspen stands in the Pinedale Resource Area occur on lands administered by the BLM. Aspen is unique and especially important because it is the only upland deciduous tree species that occurs in Wyoming and it provides key habitat for wildlife (Finch and Ruggiero 1993). Loss of aspen in western Wyoming has largely been due to conifer encroachment and over-utilization domestic livestock and elk (Dieni and Anderson 1997, Clause 1999). Aspen is generally considered a seral species in the Rocky Mountain region, pioneering disturbed areas, but eventually being replaced by more shade-tolerant conifers. Most aspen stands require periodic disturbance to remove conifers and induce sufficient suckering for stand replacement. While, researchers have suggested fire suppression has led to aspen stand deterioration across the Intermountain West, heavy browsing by ungulates, particularly elk, may have severe effects on aspen growth and regeneration (Dieni and Anderson 1997).

Key Areas for Big Game Migrations

Elk

The Pinedale Resource Area features diverse and abundant big game populations that rely on migratory behavior to meet their seasonal forage requirements. Historically, elk may have migrated to the Upper Green River Basin from as far away as Yellowstone National Park during the onset of winter primarily travelling through the Hoback and Gros Ventre drainages (Sheldon 1927, Alred 1950, Murie, 1979). However, to avoid conflicts with agricultural interests, starting in the 1920s, elk in the region began to be fed during much of the winter. WGFD feedgrounds are strategically placed to intercept elk migrating back to lower-elevation winter ranges. Winter feeding of elk is expensive and brucellosis is common in feedground elk. Recently the WGFD has attempted to improve native winter ranges around feedgrounds to reduce the length of time elk must be fed. Of the 23 elk feedgrounds that operate in western Wyoming, 10 are located in the Green River Basin portion of the Pinedale FO: Bench Corral, North Piney, Finnegan, Jewett, Franze, Scab Creek, Muddy Creek, Fall Creek, Black Butte, and Soda Lake. Maintaining movements to and from these feedgrounds and pursuing habitat improvement projects on adjacent native ranges should be a top priority for managers.

While most elk in the region rely on WGFD feedgrounds, elk herds southwest of Big Piney continue to utilize native ranges during the winter. BLM lands (e.g., Miller Mountain, Muddy Creek) between LaBarge Creek and Fontenelle Creek support hundreds of wintering elk (this area is approximately 100 mi^2 in size). The Rock

Creek/Graphite Hollow area north of LaBarge Creek is also important native elk winter range (approximately 30 mi^2 in size). The Wyoming Cooperative Fish and Wildlife Research Unit is in the final stages of an elk study in this area that examines habitat use patterns in undeveloped area south of LaBarge Creek and developed areas north of LaBarge Creek. These data should provide important information on seasonal ranges and migration routes of elk in the southwest portion of the Pinedale Resource Area.

Mule Deer

While most elk migrations in the Pinedale Resource Area end at WGFD feedgrounds, deer and pronghorn populations are among the most migratory big game herds in the lower-48 states, and winter exclusively on native ranges. Prior to 1998, few details of the mule deer and pronghorn migrations were known. However, in 1998 the Wyoming Cooperative Fish and Wildlife Unit teamed with Ultra Petroleum, the WGFD, and the BLM and began a study to determine movements and seasonal distribution of mule deer and pronghorn in the Green River Basin (Sawyer and Lindzey 2000, 2001). Both studies resulted from concern with the proposed energy development in the Pinedale Anticline Project Area (PAPA).

The Sublette Mule Deer Study (Sawyer and Lindzey 2001):
The purpose of the mule deer study was to identify seasonal ranges, determine movement patterns, and estimate survival rates of deer in the Sublette herd unit. The Sublette mule deer herd unit covers most of the Pinedale FO area, includes 15 hunt areas (130, 138-142, 146, 150-156, 162), and has a post-season population object of 32,000. Deer were captured across winter ranges in February of 1998 and equipped with radio-collars. Of 161 radio-collared deer, 106 were captured on winter ranges west of US 191, including the Mesa (PAPA), Ryegrass, Grindstone, Ross Ridge, and Cora Butte areas. The remaining 55 deer were captured on winter ranges east of US 191, from Elk Mountain north to Fremont Lake. Between February 1998 and October 2000, a total of 11,826 locations were collected from 157 radio-collared deer. Approximately 96% (n=150) of the radio-collared deer were considered migratory. Most deer seasonally migrated 40-100 miles north/northwest to summer in portions of five different mountain ranges, including the Gros Ventre Range, the Wind River Range, the Snake River Range, the Wyoming Range, and the Salt Range.

Deer typically spent 4-5 months of the year on mid-elevation transition ranges during the study. The extended period of time deer occupied transition ranges demonstrated the importance of this habitat component to the Sublette deer herd. Other important areas identified included highway crossings, river crossings, and migration bottlenecks (Figure 1). Migration bottlenecks were defined as areas along migration routes where vegetation, topography, development, and/or other landscape features restricted animal movements to narrow or limited regions. Development within migratory bottlenecks which sever migration routes would likely result in impacts to deer migration resulting in disruption of normal habitat use, potentially affecting fawn survival and production. The two most important migration bottlenecks identified for mule deer were the Trapper's Point and Fremont Lake Bottlenecks (Figure 2).

The Trapper's Point Bottleneck is located approximately 7 miles west of Pinedale near the junction of US 191, WY 352, and CR 110 (Figure 3). This naturally-occurring bottleneck is a sagebrush ridge, 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 River riparian complex (Figure 3). Archaeological records indicate the area has been used for thousands of years (Miller et al. 1999). Although much of the lands are administered by the BLM, portions of the bottleneck have been subdivided and fenced into small-acreage lots. Subdivision development has narrowed the effective width of the bottleneck to < 0.5 mile. An estimated 2,000-3,000 mule deer migrate through this bottleneck twice a year.

The Fremont Lake Bottleneck is located between the town of Pinedale and Fremont Lake (Figure 4). Expanding housing development has narrowed the effective width of this bottleneck to approximately 1 mile. The area contains BLM, USFS, state, and private lands. A minimum of 3,500 mule deer migrate through the bottleneck twice a year.

The Cora Butte transition range is also an important area for migrating pronghorn and mule deer documented by Sawyer and Lindzey (2000, 2001). See *Areas that meet the criteria for consideration as ACEC designation (Area of Critical Environmental Concern)* for a full description.

Pronghorn

The Sublette pronghorn herd unit covers the entire Pinedale BLM FO. The herd unit encompasses 10,546-mi^2 and includes eleven WGFD hunt areas (85-93, 96, 107), covering most of the Green River basin north of Interstate 80 and portions of the Hoback and Gros Ventre drainages. The WGFD manages this herd unit for a post-season population objective of 48,000 antelope. An estimated population of 49,500 was present in 1999, with a 5-year (1994-1998) average of 43,260 (WGFD 1999).

Most knowledge of pronghorn migrations in the area came from neck-banding and radio-collaring work done by the WGFD in the late 1980's (Raper et al. 1989). The WGFD marked 877 pronghorn in the Sublette herd unit between 1986 and 1988. Most pronghorn were marked with colored neckbands so that distribution and movement data were only collected when an animal sighting was reported. Only 13 animals were equipped with radio-collars in 1986, 19 in 1987, and 16 in 1988. Nonetheless, this research effort provided agencies with information on general movement patterns and seasonal distribution of pronghorn in the Sublette herd unit. When neckbanded pronghorn were observed in GTNP, it confirmed some pronghorn were migrating 100-200 miles to summer ranges (Segerstrom 1997). However, the movement data collected by Raper et al. (1989) was not precise enough to define specific migration routes.

While the Sublette pronghorn herd unit supports close to 50,000 pronghorn, much interest has been directed to the small portion (~300 animals) that migrate to GTNP and the GVRD. The Jackson Hole Pronghorn Study focused on this population segment.

Jackson Hole Pronghorn Study (Sawyer and Lindzey 2000):
The purpose of the pronghorn study was to identify migration routes and seasonal ranges of pronghorn that summer in Grand Teton National Park (GTNP) and the Gros Ventre River Drainage (GVRD) (Sawyer and Lindzey 2000). Thirty-five pronghorn were captured and radio-collared during July of 1998. Subsequent monitoring revealed the longest pronghorn migration in North America, covering distances of > 100 miles between winter and summer ranges. Most of the migration route between GTNP and the upper Green River occurs on USFS lands, while the remainder of the migration, from the upper Green River south into the Green River Basin, occurs on BLM and private lands. Most pronghorn had to negotiate a minimum of 35 different fences along the 100+ mile migration route. Although most of the migration bottlenecks identified for pronghorn occurred on USFS lands, the Trapper's Point Bottleneck was the only one that involved BLM lands. Refer to the previous section for a description of the Trapper's Point Bottleneck. Three other bottlenecks identified on US Forest Service land include the Green River Crossing, Upper Green River Basin / Bridger-Teton National Forest Boundary and Gros Ventre / Bacon Creek.

Key Areas for Big Game Winter Range and Parturition Areas

The BLM and WGFD generally define winter as November 15-April 30. Using this definition, locations of radio-collared mule deer and pronghorn can provide valuable data for the delineation of winter or crucial winter ranges. However, it should be noted that seasonal range information obtained from the Sublette Mule Deer Study and Jackson Hole Pronghorn Study only represent a small portion of mule deer and pronghorn that occupy the Pinedale Resource Area.

<u>Mule Deer</u>

Sawyer and Lindzey (2001) identified two distinct wintering complexes in the Sublette herd unit: 1) the Mesa Winter Range Complex (MWRC) and 2) the Pinedale Front Winter Range Complex (PFWRC). Generally the MWRC included the PAPA and those areas west of US 191 and north of WY 351. The PFWRC included those areas east of US 191 to the base of the Wind River Range, from Elk Mountain north to Fremont Lake. Winter range boundaries were delineated for both the MWRC and PFWRC (Figure 5). The MWRC analysis used 1,435 locations from 107 radio-collared deer between November 15-April 30, 1998-2000, while the PFWRC analysis used 658 locations from 58 radio-collared deer between November 15-April 30, 1998-2000.

The discrepancy between existing winter range delineations and delineations using data from this study suggest that current WGFD and BLM seasonal range maps underestimate areas consistently used by deer during the winter. These data are currently being used by the WGFD and BLM to update and modify several winter range designations.

Sawyer and Lindzey (2001) also identified the Hoback Basin as an important parturition area for mule deer. The Hoback Basin was used by 70% (n=101) of all radio-collared deer monitored through at least one summer. Figure 6 shows a polygon delineating the area using 140 locations from 99 radio-collared deer between June 1-15, 1998-2000.

Pronghorn

Sawyer and Lindzey (2000) estimated 1,500-2,000 pronghorn, and 85% of radio-collared consistently occupied winter ranges in or adjacent to the Pinedale Anticline Project Area (PAPA), more commonly referred to as The Mesa. While pronghorn tended to concentrate along the southern end of the Mesa, near the New Fork River, and Sand Springs Draw areas from December-February, pronghorn consistently used large areas to the north during November, March, and April. Although Sawyer and Lindzey (2000) did not develop a polygon to delineate winter range boundaries as they did with mule deer (Sawyer and Lindzey 2001), a simple plot of winter locations on current seasonal ranges suggest the existing maps may be inaccurate. Figure 7 includes 351 winter locations from 32 radio-collared pronghorn between 1998 and 2000. These data could be used to improve winter range delineations. However, because herd segments other than those studied by Sawyer and Lindzey (2000) are present in the Pinedale Resource Area and PAPA, we do not feel it is appropriate to remove areas from winter range designation based on data collected by Sawyer and Lindzey (2000). We feel it is appropriate for the BLM and the WGFD to designate additional areas as winter range based on these data.

Sawyer and Lindzey (2000) did not provide any specific information on areas used by pronghorn for parturition. Because all pronghorn were migratory, most likely gave birth in the Upper Green River, GVRD, or GTNP.

Recommendations

Considering the lack of well-designed studies that examine the potential effects of oil and gas activity on ungulates, our recommendations for the revision of the Pinedale RMP are based primarily on theory and potential effects. We attempt to utilize the few studies available, and include citations where appropriate.

1. We recommend that data be collected sufficient to define ecological and landscape conditions necessary for maintaining high quality habitat, including minimum size requirements and basin-wide needs for maintaining ungulate numbers consistent with Wyoming Game and Fish Department management objectives.

The Pinedale Resource Area supports large, generally healthy herds of ungulates. Historic and current success of big game species in the region is likely a result of quality habitat, wildlife management, and large tracts of public land, where animals have the flexibility to migrate and shift within their seasonal ranges in response to changing environmental conditions. Available evidence suggests most deer, pronghorn, and elk in the region are migratory. Continued success of these populations will likely require the identification and subsequent conservation of seasonal ranges (i.e., winter, summer, transition) and migration routes that connect them. Sawyer and Lindzey (2000, 2001) provided important information regarding seasonal ranges and migration routes for mule deer and pronghorn populations in the region. We feel these studies reveal the need to consider the biological importance of all ranges to migratory populations. However, these studies only represent a portion of mule deer and pronghorn in the region. Similar studies and monitoring efforts should be pursued for other population segments in the Pinedale FO. As biologically important areas are identified through research, agency management plans should be updated to include the most recent information.

*2. **We recommend analysis of ungulate population trends and habitat quality trends, including recommendation on how the BLM should proceed considering current population trends and habitat conditions.***

Big game populations and habitat conditions are dynamic and annually fluctuate in response to a variety of environmental factors. Human-related activities such as hunting, recreation, livestock grazing, and development may also affect big game populations and habitat conditions. While hunting, recreation, and livestock grazing are variables that can be managed, development is difficult to control and the effects on wildlife populations are unclear. Whether in the form of housing subdivisions, new roads, fences, or gas fields, development has the potential to negatively impact big game populations and habitat conditions. Impacts may be direct and indirect. Direct impacts include loss of habitat to a development, such as a house, road, well pad, or pipeline. Indirect impacts may include changes in animal distribution, stress, or activities that result from increased human disturbances associated with development. Although direct impacts are easily quantified, indirect impacts are poorly understood and difficult to assess.

3. Measures should be put in place that require no surface occupancy in areas that provide severe winter relief range for mule deer and antelope.

Available evidence suggests big game populations in the region are currently at or near WGFD objectives. Severe winter conditions similar to those in the winter of 1992-1993 have the potential to cause significant amounts of mortality in ungulate populations, particularly the younger age classes. The frequency of severe winters in the future are difficult to predict, however, it is safe to assume that winter conditions similar to those in 1992-1993 will occur again. During severe winter conditions ungulate populations are often forced to move greater distances in order to find suitable habitat (severe winter relief range). If important habitat is lost and migration routes severed the next winter of similar severity will likely cause even higher mortalities. Mitigation measures within the Anticline EIS require no surface occupancy of the Mesa Breaks, an area thought to provide severe winter relief range for mule deer and pronghorn. Similar measures should be considered on severe winter relief range throughout the Pinedale Resource Area. However, of equal importance, efforts should be made to reduce movement barriers to allow for greater movement flexibility by ungulates (Sawyer and Lindzey in press). DeGroot (1992) found that the Pinedale FO contained one of the highest densities of fences within BLM Field Offices in Wyoming. The BLM should identify areas where fences can be removed or fence types altered to minimize barriers to pronghorn and mule deer movements during severe winters.

However, because severe winter conditions only occur once or twice every decade (Sawyer and Lindzey 2001), winter and transition ranges may be equally important to the long term health of ungulate populations.

4. The WGFD Strategic Habitat Plan should be closely followed and included within the Pinedale RMP revision.

The WGFD actively pursues habitat improvement projects and uses a combination of burning and mechanical (e.g., harrow, mowing, spike, chaining) treatments. These treatments are generally successful in terms of rejuvenating plant health and vigor. However, these treatment areas are relatively small and largely ineffective for improving region-wide habitat conditions. Large-scale vegetation treatments and subsequent improvement of habitat conditions in the Pinedale Resource Area will require long-term interagency (USFS, BLM, WGFD) coordination and commitment. The WGFD recently developed a Strategic Habitat Plan (SHP) (WGFD 2001) that outlines habitat management goals and strategies for each WGFD region. The Jackson/Pinedale region Strategic Habitat Plan (WGFD 2002) prioritizes vegetative communities in greatest need of attention, identifies wildlife species of concern, and describes specific opportunities for habitat enhancements.

The Strategic Habitat Plan should be used to guide habitat management in the Pinedale Resource Area (Appendix A). Both Cundy (1989) and Clause (1999) recommend long-term planning and large-scale treatments (e.g., fire, cutting, mowing) to improve habitat conditions. Areas of most concern to big game species include shrub and aspen communities that have deteriorated due to fire suppression and heavy browsing. Because most of the big game winter ranges and areas of concern occur on BLM lands, habitat management plans administered or recognized through the RMP appear to be the most likely means for identifying, funding, implementing, and monitoring habitat improvement projects.

Researchers have shown that high densities of wildlife may not be an indicator of habitat quality (Van Horne 1983). Thus, although ungulate populations in the Pinedale Resource Area are at population objectives, it may not be appropriate to assume current habitat conditions in the area are good. Vegetative inventories should be used to assess habitat conditions, rather than assuming the presence of large ungulate populations indicates healthy habitat conditions. Habitat improvement projects should not be deemed unwarranted or categorized as a low priority because current ungulate population objectives are being met.

When direct habitat losses associated with energy development occur, habitat improvement projects jointly developed with the WGFD should be considered for mitigation opportunities.

5. We recommend detailed guidelines be developed for how the cumulative long-term effects assessment should be undertaken in the Pinedale RMP revision.

Several tools are available to the BLM that allow for analysis of long term, cumulative impacts over large areas. The use of Geographic Information Systems (GIS) allows analysis of different development scenarios on ungulate ranges and migration corridors (Weller et al. 2002). In addition to analysis of the acres potentially disturbed by development, GIS also allows the analysis of variables potentially important to ungulates relating to habitat fragmentation. Preliminary data from the Wyoming Cooperative Fish and Wildlife Research Unit may indicate that impacts of oil, gas and road activity to elk within open sagebrush habitats in the Red Desert may be accurately modeled using viewshed analyses (J. Powell and F. Lindzey, pers. comm.). Viewshed analyses allow the portion of the study area visible from selected points along existing and proposed roads to be calculated based on topography, providing an estimate of security cover available to elk in open habitats. However, the use of GIS to model cumulative impacts requires that the location of future oil and gas facilities be known prior to the revision of the RMP.

Long term, cumulative impact analyses should account for all forms of development within the planning area. The Pinedale Anticline EIS cumulative impacts section only considered oil and gas development. A true cumulative analysis should consider such questions as what happens to ungulate migratory corridors if most of the private land surrounding Pinedale is developed as subdivisions.

The Pinedale Anticline EIS utilized Bayesian models within GIS to analyze impacts of the proposed project on ungulate habitat. Because of the described deficiencies in the model (See Review of the Bayesian Habitat Model), we judge the Bayesian approach to be inadequate for the evaluation of potential habitat impacts in this case. We believe a more effective study would be one that compares the availability of different 'parcels of land' with different habitat characteristics, with the use of those parcels by the animal being considered. By using the described approach a map of the project area can be created depicting the probability of use by ungulates prior to development. The impact of habitat changes could then be assessed in terms of the development of gas resources on parcels of land with a high likelihood of use to parcels with a lower likelihood of use (Manly *et al*., 2002, Chapter 13).

However, the calculation of likelihoods of use requires the use of resource selection functions based upon properly designed resource selection studies and requires that accurate maps of habitat are available (Manly *et al.* 2002). Given an understanding of how roads and wells impact the likelihood of use by big game of parcels of land it should be possible to predict the effect of potential road and well density on future use. To date no author has examined the effects of gas and road development on the probability of pronghorn and mule deer use of winter ranges. The results of an ongoing mule deer study (Sawyer at al. 2002) may be useful for future modeling efforts.

Until the results of Sawyer et al. (2002) and other studies are available, we suggest a simpler and more conservative approach for comparing impacts of differing development scenarios. Using existing data, crucial and winter/yearlong ranges should be delineated to accurately represent areas used by big game during these periods. Using these better defined ranges, acres of habitat potentially impacted can be calculated under different development scenarios using GIS. In addition to the physical acres impacted, zones of potential avoidance should be created surrounding potential well and road locations by buffering potential well and road locations by some distance. The distances used to buffer and wells should be based upon what little data is available. The results of Rost and Bailey (1979) indicate that wintering mule deer may avoid roads by approximately 200 m in shrub habitats in Colorado. Based on Rost and Bailey (1979), a minimum buffer of 200 m could be used for new road and pad locations to calculate zones of avoidance. No data are available for pronghorn, but we feel 200 m would also provide a conservative estimate for pronghorn avoidance. Because elk have been shown to move out of sight of disturbances (Van Dyke and Klein 1996), viewshed analyses may be utilized to determine zones of avoidance for wintering elk.

Most mule deer and pronghorn that winter within the PAPA are migratory. Because migratory mule deer (Nicholson et al. 1997) and pronghorn may be more sensitive to disturbance than resident mule deer and pronghorn, the 200 m zones of avoidance should be considered a minimum. The realized area of avoidance may be greater, however, and so a larger avoidance zone estimate should be considered.

6. We propose modification of ungulate mitigation and monitoring requirements for the RMP revision.

The past approach of the BLM has been to determine that development within important ungulate habitat has no significant impact based upon mitigation and monitoring requirements. Because the most important ungulate habitat on BLM land within the Pinedale Resource Area is winter range, the focus of most standard mitigation requirements are timing restrictions on well drilling. As described within previous sections of this report, the effectiveness of timing restrictions on winter range drilling is unknown because similar restrictions do not apply to the operations phase.

While it is unclear how indirect impacts associated with development will affect big game populations in the future, we believe that direct impacts will reduce the ability and capacity of the habitat to support current big game numbers, particularly when habitat losses occur in biologically important areas. Efforts should be made to identify key wildlife areas and minimize direct impacts (e.g., habitat loss) that occur in these areas.

Ideally, direct and indirect impacts to big game populations and/or habitats should be assessed prior to leasing. Once leases are issued, there appear to be fewer options available for protecting wildlife since the operators may have additional legal rights for development on those leases.

Within the following section we describe mitigation and monitoring requirements which we believe, if incorporated and properly implemented within the revised resource management plan, will help mitigate and/or minimize the potential effects of oil and gas development on ungulate populations within the Pinedale Resource Area. Our recommendations can be categorized as:

- Collection of Important Baseline Data
- Long Term Monitoring
- Mitigation Measures
- Overall Planning and Adaptive Management

Baseline Data. The basis of most mitigation measures within the Resource Management Plan is increased protections for important ungulate ranges and habitats. However, recent studies have shown the current ranges may not accurately represent areas used by ungulates for winter ranges and parturition areas for herd segments that winter in the Pinedale Anticline Area (Sawyer and Lindzey 2000, 2001). Other herd segments within the Pinedale Resource Area are relatively unstudied. If the current range designations for certain herd segments are not accurate, mitigation measures employed for the purposes of protecting parturition and winter ranges may be ineffective.

Long Term Monitoring. As described within this report, there is a paucity of well-designed studies that assess the impacts of oil and gas activity on ungulate populations. The Upper Green River Basin contains a variety of ungulate habitats and contains winter ranges for some of the longest migrating ungulate herds in the west. Thus the most effective means for assessing impacts from oil and gas projects on ungulate populations within the area is the implementation of well designed studies of the effects of oil and gas development on ungulate ecology and habitat. Long term monitoring should also be used to verify the efficacy of approved mitigation measures within important big game habitats. The revision of the Pinedale RMP should include requirements for monitoring of ungulate use and movements through radio telemetry to verify the accuracy of existing range designations. Ideally, these studies should be of sufficient duration (e.g., 5 – 10 years) in order to capture a fairly wide range of winter severity. The studies should be conducted so that inferences can be made to all herd segments within the Pinedale Resource Area potentially impacted by resource development. Additionally, habitat mapping is needed to help identify key areas for ungulates.

Mitigation Measures. Within the RMP and Anticline EIS the BLM identifies several mitigation measures for minimizing short-term impacts to ungulates and habitat. As discussed previously, the effectiveness of these measures, including timing restrictions on surface disturbing activities and the granting of exception requests to these restrictions, are largely unknown. However, these measures may help minimize the potential effect of oil and gas development if instituted in combination with long-term planning and adaptive management (see **Overall Planning and Adaptive Management**).

Perhaps the short term mitigation with the most potential to reduce impacts from gas development is directional drilling from a limited number of pads. By reducing the number of pads per section from 16 to 4, the acres of habitat lost are reduced and the amount of disturbance to ungulates from maintenance activities is lessened. However, it is important that a maximum limit be placed on the size of each pad in order to realize the benefits of the mitigation measure. Additionally, careful placement of pads in small depressions or valleys can reduce the amount of disturbance to ungulates from maintenance activities.

Findings of no significant impacts regarding habitat impacts within the RMP are based on the assumption that much of the area disturbed during drilling and resource extraction are reclaimed and used by big game. The BLM should institute quantitative and measurable recovery goals for reclamation sites to ensure that habitat reclamation efforts serve their intended purpose. For example, within shrub habitats, the BLM should require live stem densities and percent coverage of shrubs reach defined thresholds within a defined number of years, similar to the reclamation standard required by the State of Wyoming for mine reclamation. The BLM should also monitor all reclaimed areas to determine if thresholds have been met, and require additional mitigation or collection of bonds if reclamation goals are not met. The BLM should also incorporate results of monitoring of past reclamation efforts in to the revision of the RMP, including the consideration of the relative success of past reclamation efforts.

Long term the BLM should coordinate habitat management and restoration activities so that sufficient important seasonal ranges exist for the resident ungulates. This habitat plan should be coordinated with ungulate population needs and anticipated future developments.

Overall Planning and Adaptive Management. We believe the most effective means for minimizing the potential effects of oil and gas development on ungulates is to set overall planning goals for the Resource Area. Goals for the Resource Area should include:

- Setting limits on the density of wells and roads per section within important ungulate habitats as determined through monitoring and research projects
- Protecting from disturbance a minimum amount of important big game habitat
- Identifying areas where future sales of oil and gas leases should be prohibited
- Coordinated habitat management
- Management that adapts to new information about habitat impacts and animal requirements.

Due to the lack of data it is difficult to establish these limits. Rather, we recommend the BLM incorporate principles of adaptive management within the revision of the RMP. Outlined below are the potential steps to such an adaptive process:

1. Accurate delineation of important ungulate habitats, including winter ranges and parturition areas;
2. Development of a relatively low number of wells allowed initially, followed by an assessment of the effects of the low level development through monitoring and research; and,
3. Utilization of the results of the initial study of low level development to determine appropriate levels of development throughout the project area and the determination of effectiveness of mitigation measures.

Science based adaptive management operates on the premise that a) uncertainty exists in a managed system, and reduction of uncertainty should improve management; b) management decisions must be made periodically despite that uncertainty; c) monitoring and research programs are in place for evaluation of decisions; and d) learning about the effects of management contributes toward adjusting management objectives.

Thus, adaptive management is a series of scientifically driven actions that use the monitoring and research results to test predictions and assumptions in management activities, and use the resulting information to improve them. Adaptive management works iteratively with management beginning at a relatively small scale, followed by research and monitoring, followed by evaluation, followed by enlightened management.

A major implication of adaptive management is that acquisition of useful data becomes one of the primary goals of management. Thus, the need for useful data should be considered when making management decisions. Monitoring and research should be designed to reduce uncertainty. Typical sources of uncertainty include:

- Ecological (structural) uncertainty: population, community, or landscape dynamics are not completely known; important biological processes are at work; and, there are competing lines of thought as to how they work
- Environmental variation: uncontrollable changes that increase randomness in system dynamics
- Partial controllability: management decisions are applied to system indirectly, and
- Partial observability: uncertainty about resource status, inability to see the system.

An adaptive management program should document the assumptions and objectives of management and provide a framework for conflict management. Adaptive management should also account for the dynamic nature of resources and provide the opportunity for effective and efficient conservation of resources through time. Management becomes adaptive when uncertainty is recognized, is measured, and is reduced through informed decision-making.

7. Areas that meet criteria for consideration as for ACEC designation (Area of Critical Environmental Concern).

The most effective approach to minimizing impacts to ungulates from oil and gas development is to avoid important habitat areas that are likely to be negatively impacted. However, due to the lack of data regarding potential impacts of oil and gas development on ungulate populations, particularly the extent of indirect effects, it is difficult to recommend areas where no further leasing of oil and gas resources should be allowed. Even without substantive data on impacts, we believe four locations within the Pinedale Resource Area clearly merit designation as ACEC's, based upon their documented importance to ungulate ecology within the area.

Trapper's Point Mule Deer and Pronghorn Migratory Bottleneck. The Trapper's point bottleneck and surrounding BLM parcels should be considered for ACEC designation (Figures 2-3). An estimated 2,000 – 3,000 mule deer and thousands of pronghorn use the Trapper's point bottleneck to access winter ranges on the Mesa south of Pinedale (Sawyer and Lindzey 2000, 2001). The effective width of the bottleneck is currently ½ mile and is composed largely of BLM land. The surrounding areas are private land and are being subdivided for housing development. The development of this area has the potential to disrupt pronghorn and mule deer migrations to winter ranges. Clearly even slight negative impacts from further development in this area could have serious consequences for mule deer and pronghorn that would be felt throughout the upper Green River basin.

Cora Butte Mule Deer and Pronghorn Transition Range
The Cora Butte transition range is located on the north side of the Trapper's Point Bottleneck and contains approximately 10-mi^2 of BLM lands consistently used by thousands of mule deer and pronghorn every spring and fall (Sawyer and Lindzey 2000, 2001). The use of this transition range gives pronghorn and mule deer more foraging options before entering summer and winter ranges (Short 1981). Biologists in the region agree that Cora Butte is of high importance for migrating mule deer and pronghorn (D. Mcwhorter, WGFD, pers. comm.). Figure 8 visually demonstrates the affinity mule deer have for BLM lands near Cora Butte.

Fremont Lake Mule Deer Migratory Bottleneck. The Fremont Lake Bottleneck is a mixture of public and private lands located between the town of Pinedale and Fremont Lake. The BLM parcels should be considered for ACEC designation (Figures 2 and 4). Expanding housing development has narrowed the effective width of this bottleneck to approximately 1 mile. The area contains BLM, USFS, state, and private lands. A minimum of 3,500 deer migrate through the bottleneck twice a year. Continued development within the bottleneck could effectively block mule deer migrations.

LaBarge Creek Native Elk Winter Range. The undeveloped portion of the elk winter range south of LaBarge Creek should be considered for ACEC designation. This represents the last remaining area within the Pinedale Resource Area where elk do not rely on feedgrounds during the winter (D. Stroud, WGFD, pers. comm.). Considering the potential diseases such as brucellosis associated with winter feeding of elk, the LaBarge Creek native elk range serves as an important refuge from disease, as well as providing a control for the study of the spread of disease in northwest Wyoming elk herds. The Wyoming Cooperative Fish and Wildlife Research Unit is in the final stages of an elk study in this area that examines habitat use patterns in the undeveloped area south of LaBarge Creek and developed areas north of LaBarge Creek. These data should be utilized to delineate winter ranges for the specific boundaries for protection by ACEC designation.

Other documented winter and transition ranges within the Pinedale Resource Area are also important to the health of ungulate herds. This includes the 220,000 acre Wind River Front area which is currently off limits to leasing. However, because the impacts of oil and gas activity on ungulate populations remain unclear, we feel it is currently inappropriate to recommend these areas for ACEC designation. Rather, we suggest the BLM implement the Adaptive Management process in these areas (See above recommendations).

Literature Cited

Allred, W.J. 1950. Re-Establishment of Seasonal Elk Migration through Transplanting. Fifteenth North American Wildlife Conference.

Anderson, S.H. 1999. Managing our wildlife resources. Prentice Hall, Upper Saddle River, New Jersey. 540 pp.

Ayers, L.W., A.F. Reeve, F.G. Lindzey, and S.H. Anderson. 2000. A preliminary assessment of mule deer population dynamics in Wyoming. Wyoming Cooperative Fish and Wildlife Research Unit, Laramie.

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

Bruns, E.H. 1977. Winter behavior of pronghorns in relation to habitat. Journal of Wildlife Management 41(3): 560-570.

Cassirer, E.F., D.J. Freddy, and E.D. Ables. 1992. Elk responses to disturbance by cross-country skiers in Yellowstone National Park. Wildlife Society Bulletin 20 :375-381.

Clause, D. 1999. Lower Bear River Watershed Enhancement Completion Report. Wyoming Game and Fish Department, Cheyenne. 87 pp.

Clements, C.D. and J.A. Young. 1997. A viewpoint: Rangeland health and mule deer habitat. Journal of Range Management 50: 129-138.

Cole, E.K., M.D. Pope, and R.G. Anthony. 1997. Effects of road management on movement and survival of Roosevelt elk. Journal of Wildlife Management 61(4): 1115-1126.

Cundy, T. 1989. Big Piney-La Barge Mule Deer Winter Range Evaluation. Wyoming Game and Fish Department, Cheyenne. 107 pp.

Czech, B. 1991. Elk behavior in response to human disturbance at Mount St. Helens National Volcanic Monument. Applied Animal Behaviour Science 29: 269-277.

Deblinger, R.D. 1988. Ecology and behavior of pronghorn in the Red Desert, Wyoming with reference to energy development. PhD Dissertation, Colorado State University, Fort Collins.

De Groot, E. 1992. Fence Inventory Project. Wyoming Cooperative Fish and Wildlife Research Unit and Wyoming Game and Fish Department. 17 pp.

Dieni, S. and S. Anderson. 1997. Ecology and management of aspen forests in Wyoming. Wyoming Cooperative Fish and Wildlife Research Unit, Laramie. 123 pp.

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

Edge, W.D., C.L. Marcum, and S.L. Olson. 1985. Effects of logging activities on home – range fidelity of elk. Journal of Wildlife Management 49:741-744

Edge, W.D., C.L. Marcum and S.L. Olson-Edge. 1987. Summer habitat selection by elk in western Montana: a multivariate approach. Journal of Wildlife Management 51(4): 844-851.

Finch, D. and L. Ruggiero. 1993. Wildlife habitats and biological diversity in the Rocky Mountains and Northern Great Plains. Natural Areas Journal 13: 191-203.

Hayden-Wing Associates. 1991. Review and Evaluation of the effects of geophysical exploration on some wildlife species in Wyoming. Prepared for the Geophysical Acquisition Workshop, Rawlins, Wyoming.

Hiat, G.S. and D. Baker. 1981. Effects of oil/gas drilling on elk and mule deer winter distributions on Crooks Mountain, Wyoming. Wyoming Game and Fish Department. Unpublished Report.

Hoskinson, R.L. and J.R. Tester. 1980. Migration behavior of pronghorn in southeastern Idaho. Journal of Wildlife Management 44: 132-143.

Irwin, L.L. and J.W. Peek. 1979. Relationship between road closures and elk behavior in northern Idaho. Pages 199-204 *In* M.S. Boyce and L.D. Hayden-Wing, eds. North American elk: ecology, behavior and management. Univ. Wyoming, Laramie. 294pp.

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry. 81(9): 592- 595.

_____, and J.E. Canfield. 1991. Habitat selections by Rocky Mountain elk under hunting season stress. Pages 99-105 *In* Christensen, A.G, L.J. Lyon, and T.N. Lonner, comps. Proceedings of elk vulnerability - a symposium. Montana State University, Bozeman. 330pp.

Johnson, B. and L. Wollrab. 1987. Riley Ridge natural gas project, Exxon Labarge project, elk wildlife study report 1979-1987. Bureau of Land Management and U.S. Forest Service Technical Report.

Kuck, L, G.L. Hompland, and E.H. Merrill. 1985. Elk calf response to simulated mine disturbance in southeast Idaho. Journal of Wildlife Management 49:751-757.

Lyon, L.J. 1979. Habitat effectiveness for elk as influenced by roads and cover. Journal of Forestry 658-670.

Manly, B.F.J., McDonald, L.L., Thomas, D.L., McDonald, T.L. and Erickson, W.P. 2002. *Resource Selection by Animals: Statistical Design and Analysis for Field Studies*. Kluwer, Dordrecht.

Morrison, J.R., W.J. de Vergie, A.W. Alldredge, A.E. Byrne, and W.W. Andree. 1995. The effects of ski area expansion on elk. Wildlife Society Bulletin 23:481-489.

Miller, M.E., P.H. Sanders, and J.E. Francis, eds. 1999. The Trappers Point Site (48SU1006): Early archaic adaptations in the upper Green River Basin, Wyoming. Office of the State Archaeologist, University of Wyoming, Laramie. 530 pp.

Morrison, M.L., Block, W.M., Strickland, M.D. and Kendall, W.L. 2001. *Wildlife Study Design*. Springer, New York.

Murie, O.J. 1979. The Elk of North America. Teton Bookshop Press. Jackson, WY.

Nicholson, M.C., R.T. Bowyer, and J.G. Kie. 1997. Habitat selection and survival in mule deer: tradeoffs associated with migration. Journal of Mammalogy 78: 483-504.

Phillips, G.E., A.W. Alldredge. 2000. Reproductive success of elk following disturbance by humans during calving season. Journal of Wildlife Management 64:521-530.

Reeve, A.F. and F.G. Lindzey. 1991. Evaluation of mule deer winter mortality in south-central Wyoming. Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, WY. 147 pp.

Reeve, A.F. 1996. Mule deer response to oil and gas well recompletions and winter habitat use on the Birch Creek Unit, Big-Piney Labarge winter range complex, during winter 1990-1991. Unpublished report prepared for the BLM, Pinedale office and the WGFD, Jackson.

Raper, E., T. Christiansen, and B. Petch. 1989. Sublette antelope study: final report. Annual Big Game Herd Unit Report, Wyoming Game and Fish Department, 124-169.

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

Rowland, M.M., M.J. Wisdom, B.K. Johnson and J.G. Kie. 2000. Elk distribution and modeling in relation to roads. Journal of Wildlife Management 64(3): 672-684.

Ryder, T., L. Irwin, and D. Moody. 1984. Wyoming's Red Rim pronghorn controversy: history and current status. Proceedings from the 11th annual pronghorn antelope workshop.

Sawyer, H. and F. Lindzey. 2000. The Jackson Hole Pronghorn Study. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie. 57 pp.

Sawyer, H. and F. Lindzey. 2001. Sublette Mule Deer Study. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie. 51 pp.

Sawyer, H., D. Strickland, and L. McDonald. 2002. Summary of 2002 project results and scope of long-term monitoring plan to assess potential impacts of energy development on mule deer in the Pinedale Anticline Project Area. Western Ecosystem Technology, Inc., Cheyenne, Wyoming. 37 pp.

Schultz, R.D. and J.A. Bailey. 1978. Responses of national park elk to human activity. Journal of Wildlife Management 42(1): 91-100.

Segerstrom, T.B. 1997. The history and status of pronghorn that summer in Jackson Hole and the upper Gros Ventre River Drainage. Great Plains Wildlife Institute, Inc. Unpublished Report. 31pp.

Sheldon, W.G. 1927. The Conservation of the Elk of Jackson Hole, Wyoming. National Conference on Outdoor Recreation. Washington, D.C.

Short, H.L. 1981. Nutrition and metabolism. Pages 99-127 *in* O.C. Wallmo, ed., Mule and black-tailed deer of North America. University of Nebraska Press, Lincoln, NE.

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

Spillet, J.J., J.B. Low, and D. Sill. 1967. Livestock fences- how they influence pronghorn antelope movements. Utah State University Agricultural Experimental. Station Bulletin 470. Logan. 79 pp.

Thomas, J.W., H. Black, R.J. Scherzinger, and R.J. Pedersen. 1979. Deer and elk. Pages 104-127 *In* J.W. Thomas, ed., Wildlife habitats in managed forests-the Blue Mountains of Oregon and Washington,. USDA Agriculture Handbook No. 553. U.S. Government Printing Office., Washington, D.C. 512p.

Thomas, M.B. 1983. Human demographic impacts on fish and wildlife resources from energy development in rural western areas. USDI, Fish and Wildlife Survey FWS/OBS-88/27.

Van Dyke, F. and W.C. Klein. 1996. Response of elk to installation of oil wells. Journal of Mammalogy 77(4): 1028-1041.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Weller, C., J. Thompson, P. Morton, and G. Aplet. 2002. Fragmenting our lands: The ecological footprint from oil and gas development, A spatial analysis of a Wyoming gas field. Prepared by The Wilderness Society. Available at www.wilderness.org.

Witmer, G.W and D.S. deCalesta. 1985. Effects of forest roads on habitat use by Roosevelt elk. Northwest Science. 59(2):122-125.

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

Wyoming Chapter of the Wildlife Society (TWS). 1990. Standardized Definitions for Seasonal Wildlife Ranges. 14 pp.

Wyoming Game and Fish Department (WGFD). 1999. Sublette Mule Deer 1999 Job Completion Report. Unpublished Report.

Wyoming Game and Fish Department. 2001. Strategic Habitat Plan. Wyoming Game and Fish Department, Cheyenne. 8 pp.

Wyoming Game and Fish Department. 2002. Strategic Habitat Plan Implementation Questionnaire: Jackson/Pinedale Region. Wyoming Game and Fish Department, Cheyenne. 42 pp.

Yoakum, J.D and B.W. O'Gara. 2000. Pronghorn. Pages 559-577 in Demarais, S, and P. Krausman, eds. Ecology and Management of Large Mammals in North America. Prentice Hall, New Jersey.

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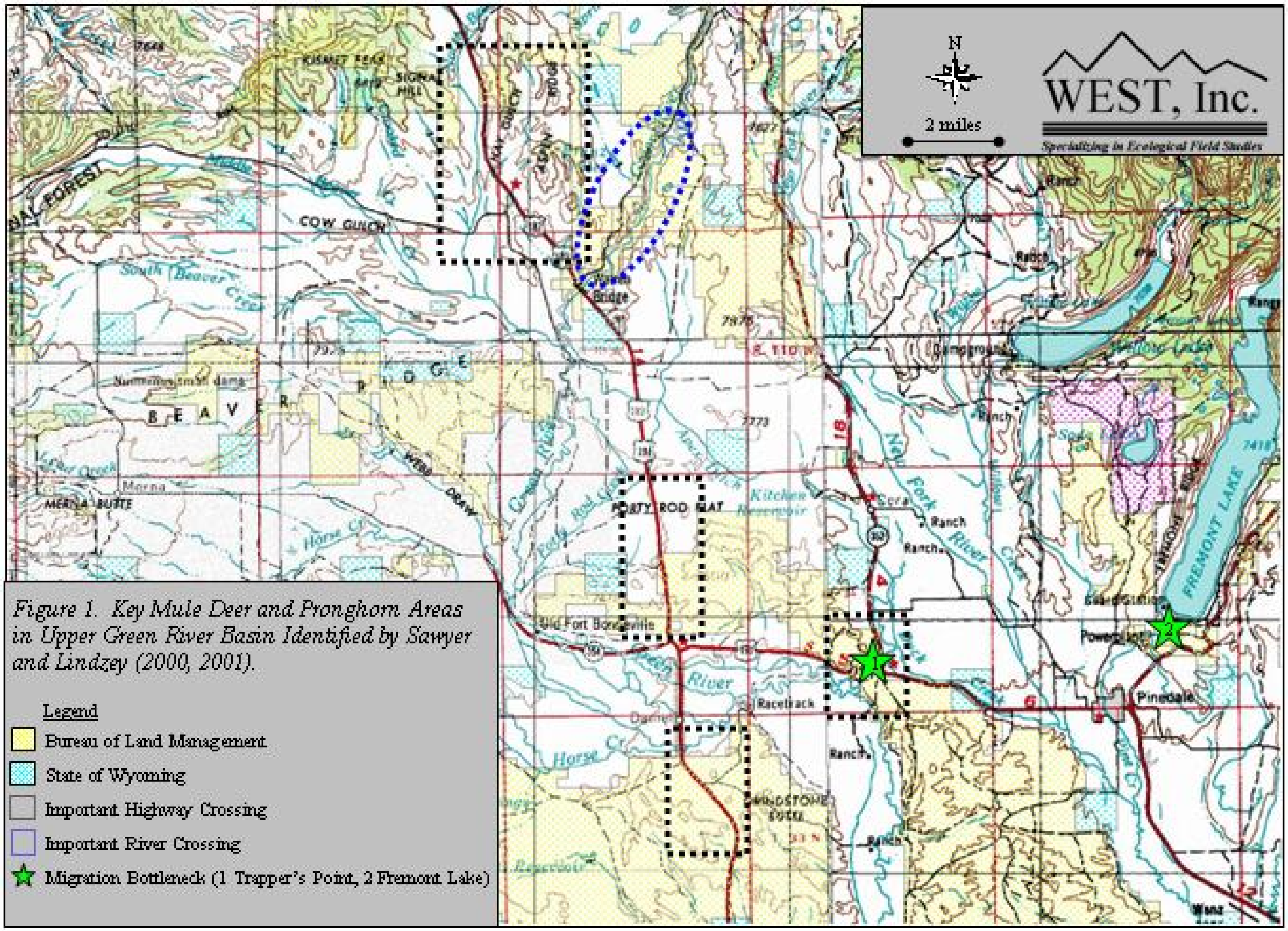

Figure 1. Key Mule Deer and Pronghorn Areas in Upper Green River Basin Identified by Sawyer and Lindzey (2000, 2001).

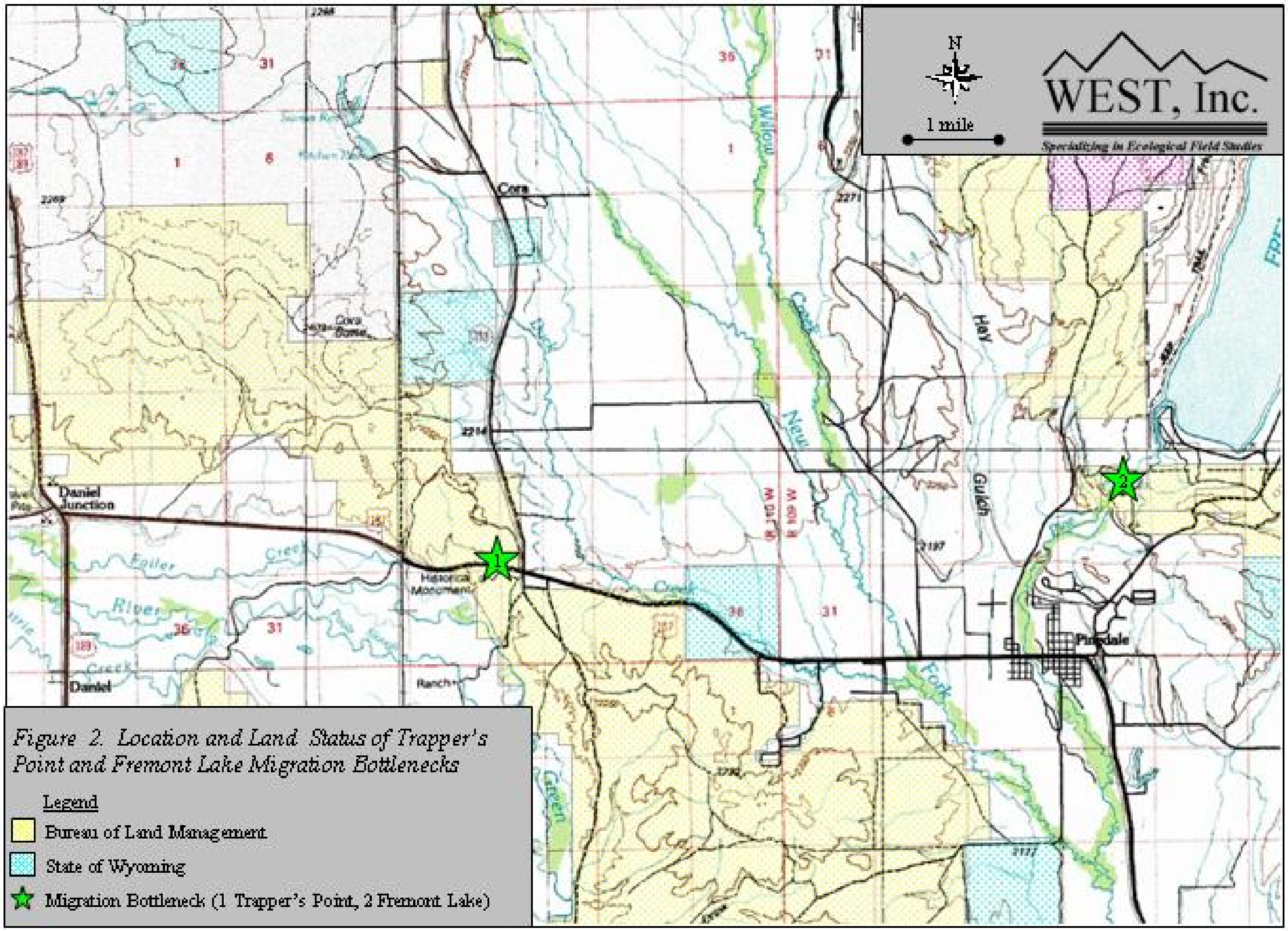

Figure 2. Location and Land Status of Trapper's Point and Fremont Lake Migration Bottlenecks

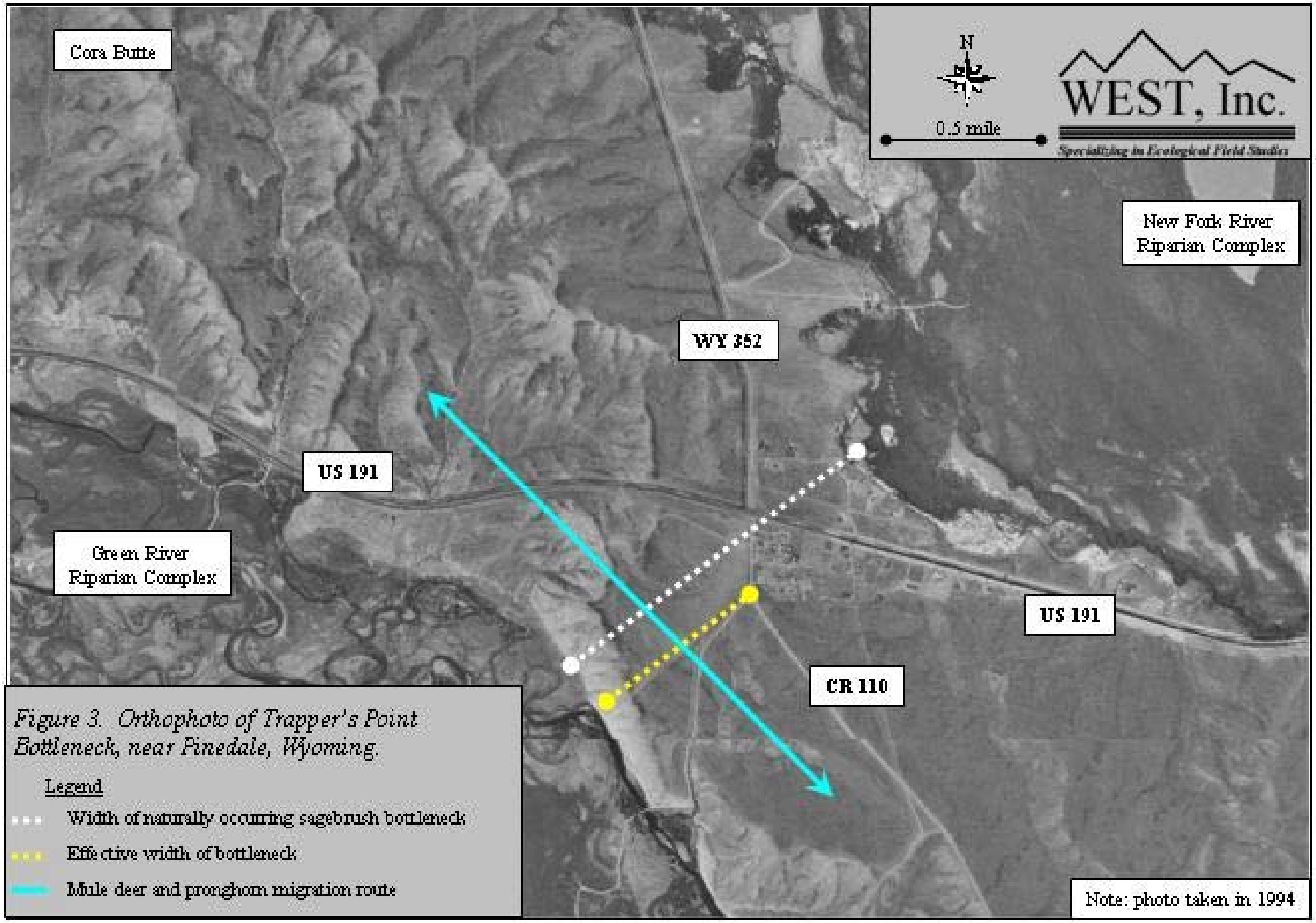

Figure 3. Orthophoto of Trapper's Point Bottleneck, near Pinedale, Wyoming.

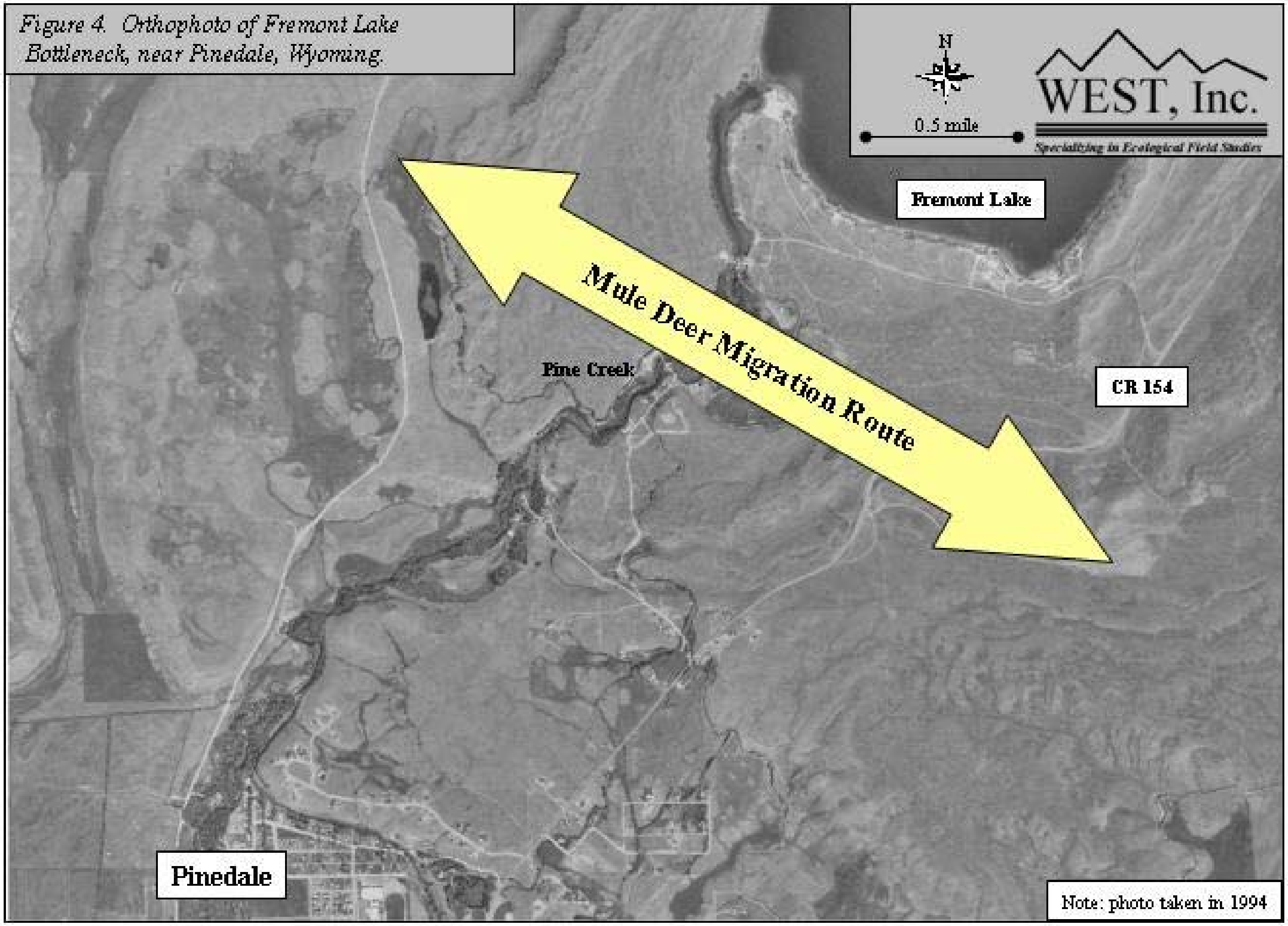

Figure 4. Orthophoto of Fremont Lake Bottleneck, near Pinedale, Wyoming.

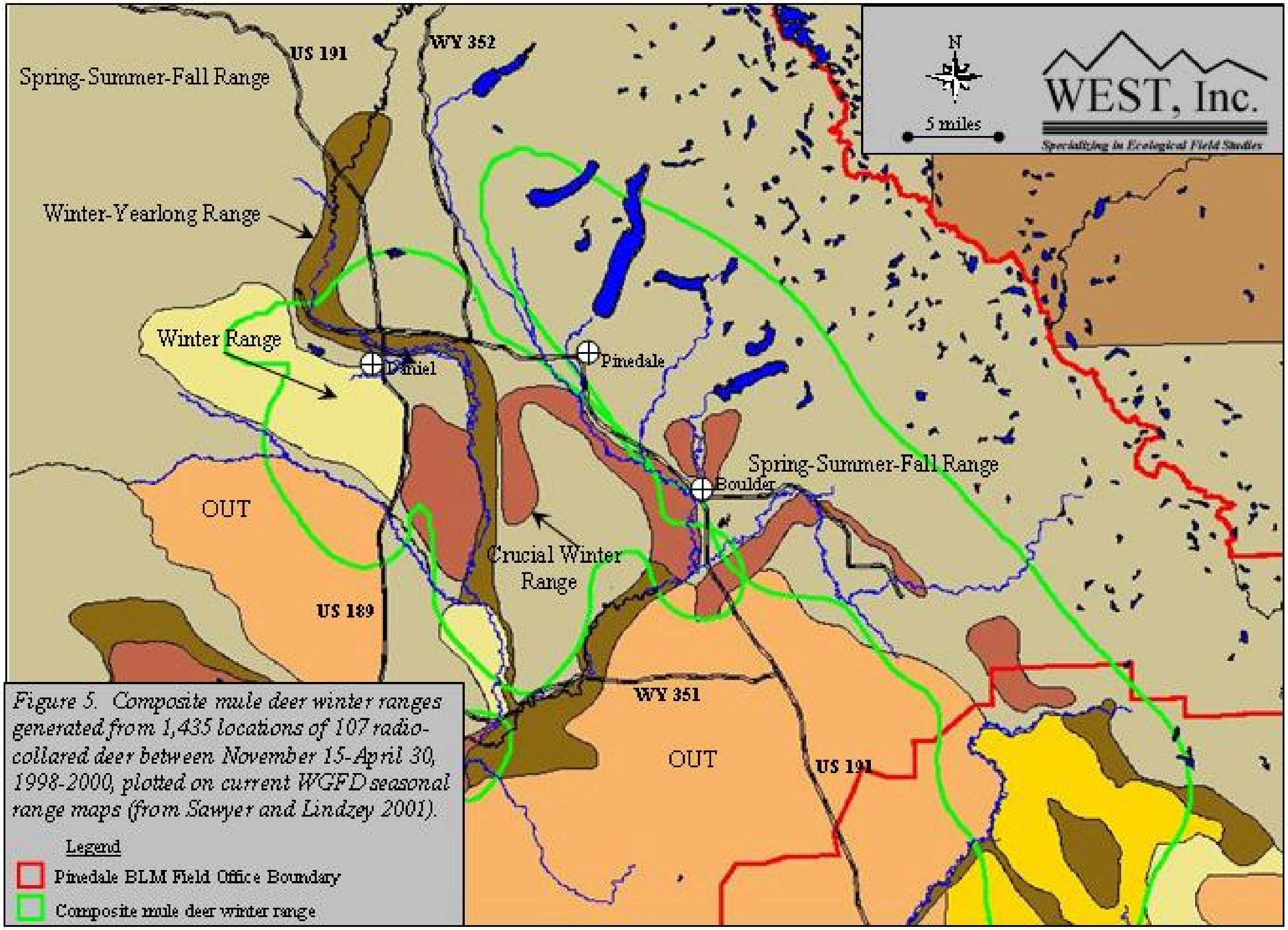

Figure 5. Composite mule deer winter ranges generated from 1,435 locations of 107 radio-collared deer between November 15-April 30, 1998-2000, plotted on current WGFD seasonal range maps (from Sawyer and Lindzey 2001).

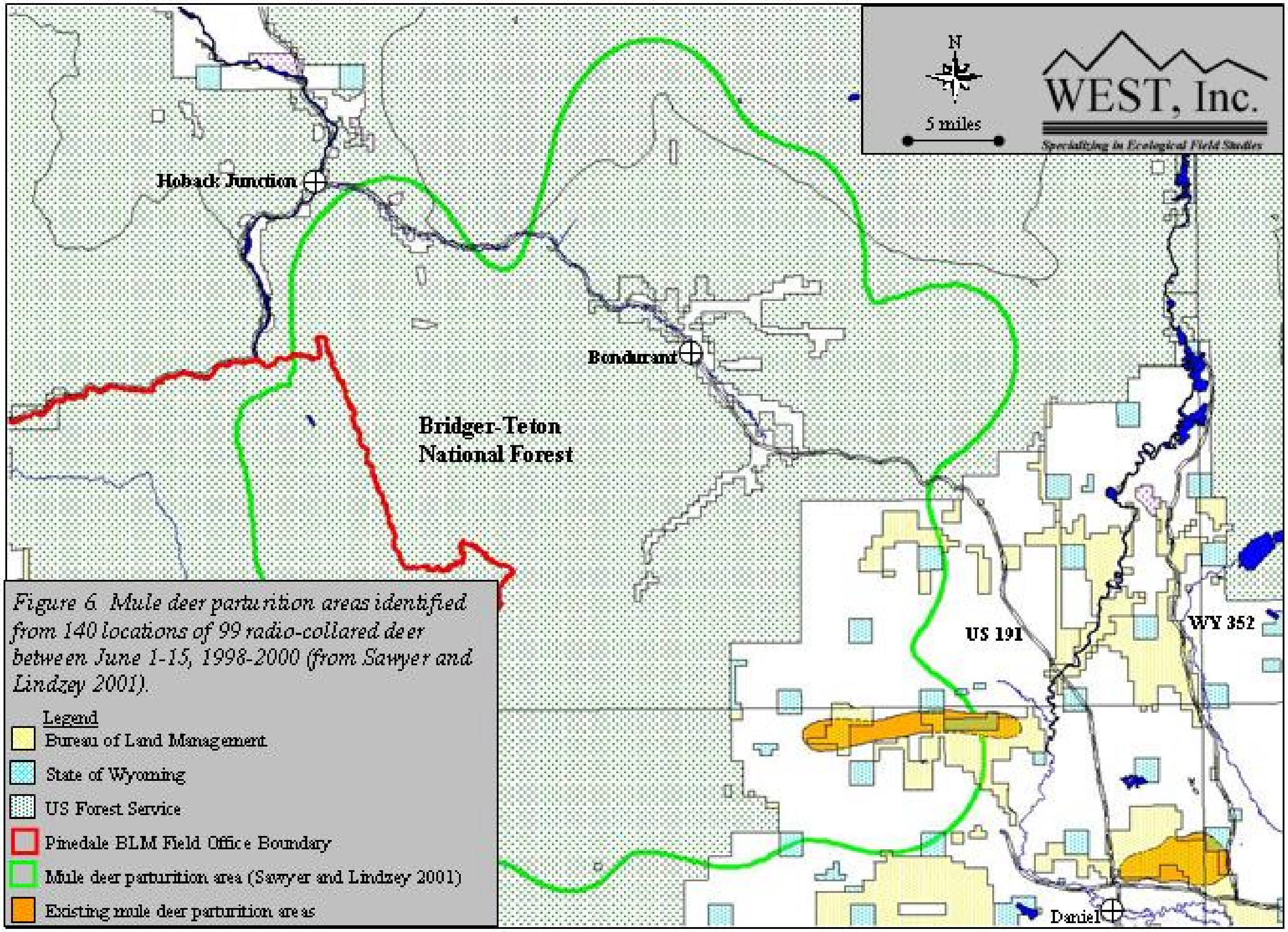

Figure 6. Mule deer parturition areas identified from 140 locations of 99 radio-collared deer between June 1-15, 1998-2000 (from Sawyer and Lindzey 2001).

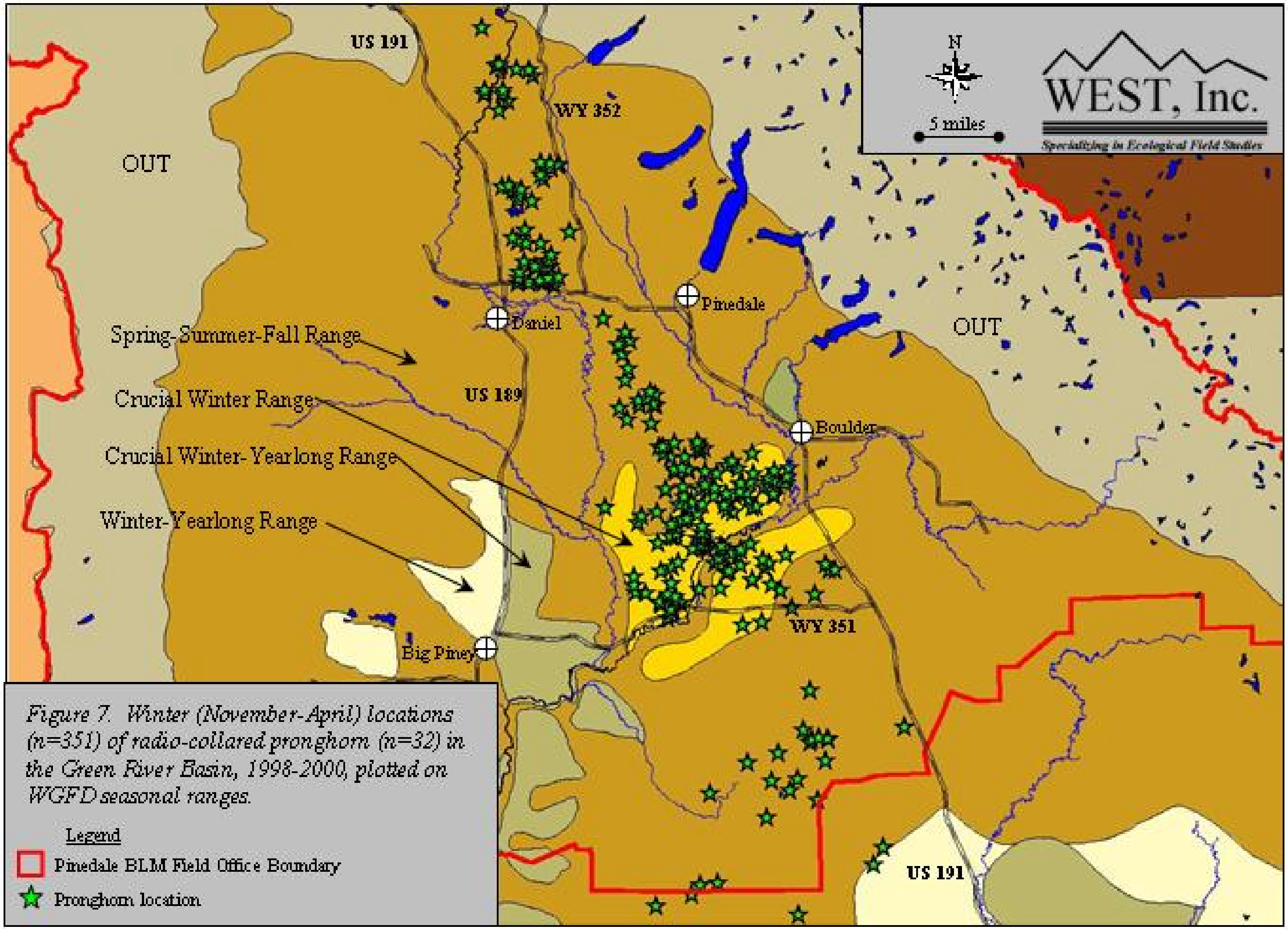

Figure 7. Winter (November-April) locations (n=351) of radio-collared pronghorn (n=32) in the Green River Basin, 1998-2000, plotted on WGFD seasonal ranges.

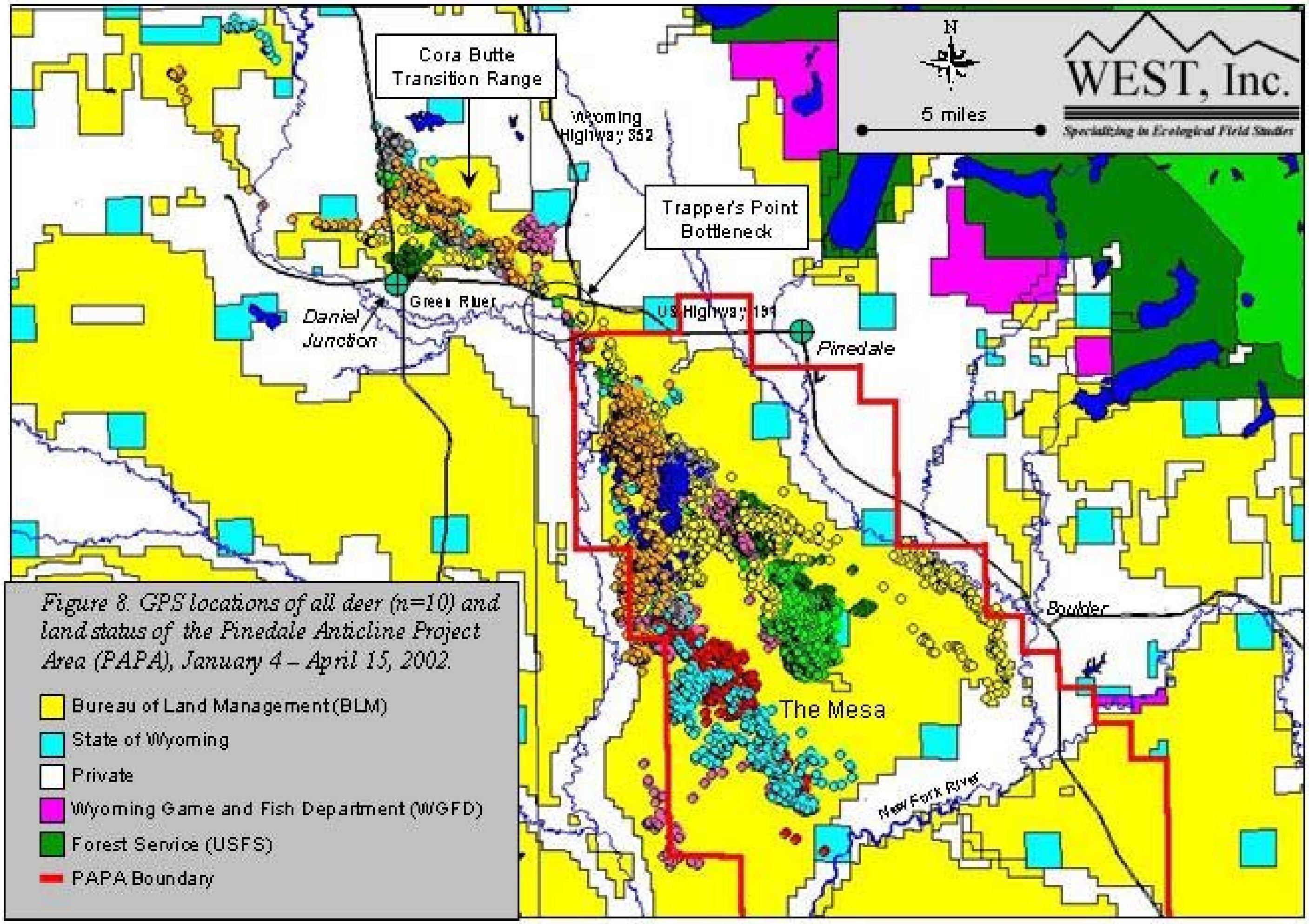

Figure 8. GPS locations of all deer (n=10) and land status of the Pinedale Anticline Project Area (PAPA), January 4 – April 15, 2002.

Appendix A

Review of the Bayesian Habitat Model within the Pinedale Anticline EIS

The Sample Unit

Probabilities must apply to units of some type. Hence to make a statement like P(S) = 0.55 (the prior probability of suitable habitat is 0.55) only applies with a particular definition of a sample unit, in this case a unit of land. If the sample unit changes then the probability is likely to change unless the definition of suitable also changes. However in this study there is no clear definition of the sample unit, which is called either at different times an area (p. 11), a polygon in the GIS (p. 12), or a parcel of land (p. 77). Without a clear definition of the sample unit the usefulness of the study is unclear.

Suitable and Marginal Habitat

Suitable habitat is said to be 'habitat in which animals would probably occur', which might be interpreted to mean that the probability of encountering animals is more than 0.5 in a certain specified amount of time. Obviously this would then depend on the period of time and the sample unit, neither of which have been defined. Similarly, marginal habitat is defined to be 'habitat in which animals may or may not occur but with less certainty than in suitable habitat'. We believe these descriptions require a definition of 'occur' . Without proper definitions of suitable and marginal habitat, it is not possible to evaluate probabilities of these occurring, even if the sample unit was properly defined.

Prior Probabilities

Considering the pronghorn winter habitat model it is stated (p. 15) that

> *We assumed that areas defined by WGFD (the Wyoming Game and Fish Department) as pronghorn crucial WYL (winter year long) ranges provided optimal habitats to wintering pronghorns. Crucial WYL ranges were assumed to be more suitable than marginal. Therefore prior probabilities of P(S) = 0.55 and P(M) = 0.40 were assigned.*

It would seem from this statement that a sample unit in a crucial WYL range has a probability of 0.55 of being suitable and a probability of 0.40 of being marginal. This cannot be correct unless there is a third category of ‘Other’ for which P(O)=0.05, so that the prior probabilities add to one. However, the report makes it clear that a sample unit is either suitable or marginal, and there is no ‘Other’ category. Hence the prior probabilities appear to be invalid.

An alternative explanation is provided by the entries in Table 1.D-1, where in the column headed suitable a value of 0.55 is given for crucial ranges, and a value of 0.45 is given for non-crucial ranges. These do add to one, so it seems that it is being assumed that

$$P(\text{Crucial WYL} \mid S) = 0.55$$

and

$$P(\text{Non-Crucial} \mid S) = 0.45.$$

These are then not the required prior probabilities. Nevertheless, these are the values used for P(S) and P(M) in the example on p. 23 of the report. Thus, there seem to be some considerable confusion about what the prior probabilities mean.

To confuse things more, in the example in Table 1.E-1 the prior probabilities used are P(S) = 0.45 and P(M) = 0.60, adding to more than one, and in the example in Table 1.E-2 they P(S) = 0.55 and P(M) = 0.40, adding to less than one. This is inappropriate, and it appears that Bayes' theorem is being misapplied.

The prior probabilities for the mule deer winter model have the same problems. It is not clear what is meant in terms of sample units and definitions of suitable and marginal habitat. Basically, the prior probabilities seem to be completely subjective and are sometimes invalid because they do not add to one.

Conditional Probabilities

The method for deriving conditional probabilities for different habitat characteristics appears to bear no relationship to what is actually present in the study area. If the sample unit and suitable habitat were properly defined it would be straightforward to obtain from the GIS probabilities like P(High Density Sagebrush | Suitable), as this would just be the proportion of the suitable habitat units that also have the property of possessing high density sagebrush. Even without defining what is meant by suitable habitat, the total proportion of units with high density sagebrush could be calculated, which would help in the assessment of P(High Density Sagebrush | Suitable) and P(High Density Sagebrush | Marginal). Apparently, the conditional probabilities used in the report, like the prior probabilities, are entirely subjective.

In the case of human disturbance there is the interesting assumption (Tables 1.D-1 and 1.D-2) that

$$P(\text{No Disturbance} \mid \text{Suitable}) = 0.50$$

and

$$P(\text{Disturbance} \mid \text{Suitable}) = 0.00.$$

This is not possible, suggesting some serious misunderstanding of what conditional probabilities mean.

Independent Habitat Characteristics

Even if all of the above problems did not exist, there is still a fundamental flaw in the analysis used to assess impact. As stated on p. 11 of the report, the conditional probability of a sample unit being suitable (S) given the environmental conditions (E) is

$$P(S \mid E) = P(E \mid S)\, P(S)/[P(E \mid S)\, P(S) + P(E \mid M)\, P(M),$$

where M stands for marginal, the alternative to S.

The problem here is the calculation of the quantities $P(E \mid S)$ and $P(E \mid M)$. In the report it is done by multiplying together the conditional probabilities for each of eight habitat characteristics, but unfortunately this is only valid if these characteristics occur independently of each other, a fundamental tenant of probability. This assumption is almost certainly not true, and hence the calculated probabilities are probably inappropriate. For example, it seems highly unlikely that within suitable habitat the probability of high density sagebrush is the same for units with all slopes, and units with all aspects, and units at high or low elevations.

To justify multiplying together conditional probabilities as has been done in this report would require evidence that the habitat characteristics occur independently. This would require a proper definition of a sample unit and of suitable and marginal habitats, and a survey of the characteristics of these units over the study area. Given the results of such a study, plus evidence of the amount of use of different habitat units, a satisfactory analysis of the potential impacts of development could be made.

The Appendix

The Appendix is supposed to be an introduction to the use of Bayes' theorem with habitat models. Whereas most of what is in the Appendix is standard, there are some mistakes that should be noted.

First, on p. 77, Section III C, it is stated that without knowledge of where a parcel of land is located, it is equally likely to be suitable or marginal, so that $P(S) = P(M) = 0.5$. This is an example of a common error in using probability theory. It assumes that if there are two possibilities then they must be equally likely. In reality, P(S) is the fraction of all parcels of land that are suitable, and P(M) = 1 - P(S) is the fraction of all parcels that are marginal. With a proper definition of a parcel of land and 'suitable', these could be calculated. It would be quite a coincidence if P(S) was actually 0.5.

The degree of belief Statement D is very confusing. A parcel is said to be within suitable habitat, which would seem to make the probability of it being suitable equal to one, P(S) = 1. However, apparently this just tells us that P(S) > P(M). The problem here, of course, is that 'suitable' has such a vague meaning. All of the statements about degrees of belief seem unsubstantiated and unscientific.

The most serious mistake in the Appendix is the assumption V A on p. 78 that the probability of two events A and B is, in general, P(A) x P(B). As noted above, this is not correct, and is a fundamental flaw in the whole proposed method for using Bayes' theorem. The correct result, which is used in other parts of the Appendix, is that

$$P(A \text{ and } B) = P(A \mid B)\, P(B).$$

which only equals P(A) x P(B) if A and B are independent events. This means that in order to use the proposed the Bayesian approach to habitat modeling, not only must you imagine some conditional probabilities of different types of habitat, given that a sample unit is suitable or marginal. You must also guess at the relationships between all of the different habitat characteristics because in general these are unlikely to occur independently. We question the value of an analysis based on so many critical assumptions without supporting data.