Decision Notice &
Finding of No Significant Impact
Pronghorn Migration Corridor Forest Plan Amendment

USDA Forest Service
Bridger-Teton National Forest
Wyoming

Decision and Reasons for the Decision

Background

The pronghorn (*Antilocarpa americana)* that summer in Jackson Hole migrate annually between there and wintering areas in the Green River basin. Documented round trip migration distances from 175 to 330 miles make this the longest known terrestrial animal migration in the 48 contiguous states. Typically, the pronghorn migrate through the corridor in April or May and again in October or November. These pronghorn are a part of the impressive panorama of free-ranging native Rocky Mountain mammals in northwest Wyoming. This landscape and its wildlife draw tourists from around the world and support a robust regional economy.

A significant portion of the full migration route of these pronghorn is within the Bridger-Teton National Forest. The Forest portion extends from the Forest boundary near the Green River Lakes Road north of Pinedale in Sublette County, Wyoming to the Forest boundary with Grand Teton National Park northeast of Kelly in Teton County, Wyoming. It includes approximately 47,000 acres within the Pinedale and Jackson Ranger Districts of the Bridger-Teton National Forest.

Managing this migration corridor to facilitate continued successful movement of pronghorn will help ensure protection of this herd and its migration. The purpose of this amendment to the Bridger-Teton National Forest Land and Resource Management Plan (Forest Plan) is to ensure that projects, activities, and facilities authorized by the Forest Service on National Forest System lands within the corridor allow for continued successful pronghorn migration.

It should be noted that the Forest Service by itself cannot guarantee continued successful migration of this herd over the entire migration route. There are numerous factors beyond Forest Service control such as activities on lands under other jurisdictions within the migration route.

Decision

Based upon my review of the Environmental Assessment (EA), I hereby amend the Bridger-Teton National Forest Land and Resource Management Plan by 1) designating a Pronghorn Migration Corridor as shown on the attached map; and 2) adding the following standard, "All projects, activities, and infrastructure authorized in the designated Pronghorn Migration Corridor will be designed, timed and/or located to allow continued successful migration of the pronghorn that summer in Jackson Hole and winter in the Green River basin." This amendment does not

remove any current Forest Plan direction for the area encompassed by the corridor; it simply designates the corridor and adds the above standard. This amendment makes no decisions about the compatibility of specific uses with the pronghorn migration, but requires that all uses be found to allow continued migration before they are authorized.

Activities currently authorized by the Forest Service within this migration corridor, including livestock grazing operations, coexist with the currently successful pronghorn migrations, so changes to current activities and infrastructure are not required by this amendment.

Before future activities can be authorized, a determination must be made that the activity will allow continued successful migration.

It is important to note that, while the full length of the pronghorn migration route includes lands under various jurisdictions, this Forest Plan amendment applies only to National Forest System lands within that larger corridor. Furthermore, the amendment does not constrain activities on private land within the Forest boundary.

Reasons for the Decision

I have decided to create the Forest Plan amendment because it meets the purpose and need of ensuring that Forest Service authorized activities and infrastructure allow continued successful pronghorn migration in the corridor. Furthermore, I find that there are no unacceptable impacts from the amendment. As noted above, activities currently authorized by the Forest Service within the corridor coexist with successful migration, so changes to current activities will not be required by this amendment.

Other Alternatives Considered

In addition to the selected alternative, I considered the No Action alternative. Under the No Action alternative there would be no Forest Plan amendment and current management plans would continue to guide management of the area. This alternative does not meet the purpose and need of ensuring that Forest Service authorized activities in the corridor allow continued successful pronghorn migration.

Public Involvement

The proposal was provided to the public and other agencies for comment in a Scoping Statement dated March 6, 2008. The proposal was listed in the Bridger-Teton Schedule of Proposed Actions on April 1, 2008. Comments were received from government entities such as the Bureau of Land Management, Grand Teton National Park, and the Wyoming Game and Fish Department; from livestock associations and permittees; from conservation organizations; and from many private citizens. Using the comments received from scoping, the interdisciplinary team developed the issues that were addressed in the EA.

Approximately 19,400 emails were received supporting the proposed amendment. Several livestock interests were concerned that the proposal could negatively affect livestock grazing operations. Because current grazing operations coexist with successful migration, current grazing operations will not be affected by this amendment. Future grazing operations will need to be designed to allow continued successful migration. Some conservation organizations

wanted specific restrictions added to the amendment such as a decision that no oil and gas leasing be authorized in the corridor. This amendment makes no decisions about the compatibility of specific future uses with the pronghorn migration, but requires that all future uses allow continued migration. I feel that this meets the purpose and need of the amendment.

Finding of No Significant Impact

After considering the effects described in the EA, I have determined that this amendment will not have a significant effect on the quality of the human environment considering the context and intensity of impacts (40 CFR 1508.27). Thus, an environmental impact statement will not be prepared. I base my finding on the following:

1. My finding of no significant impacts is not based on a belief that the benefiscial effects outweigh significant adverse impacts. Rather, it is my finding that there are no significant adverse impacts.

2. There will be no significant effects on public health and safety, because the amendment is limited in scope and does not authorize any specific activity on the ground that could affect public health or safety.

3. There will be no significant effects on unique characteristics of the area, because the amendment is limited in scope and does not authorize any specific activity on the ground that could impact the unique characteristics of the area.

4. The effects on the quality of the human environment are not likely to be highly controversial because there is no known scientific controversy over the impacts of the project.

5. The effects are not highly uncertain, and do not involve unique or unknown risk.

6. The action is not likely to establish a precedent for future actions with significant effects.

7. The cumulative impacts are not significant; this is addressed in the EA.

8. The action will have no significant adverse effect on districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places and will not cause loss or destruction of significant scientific, cultural, or historical resources. This plan amendment authorizes no specific actions on the ground that could cause such effects. Future actions proposed within the migration corridor will still be subject to National Historic Preservation Act Section 106 review by the BTNF and the Wyoming State Historic Preservation Office.

9. As discussed in the Biological Assessment (BA) for this amendment, the action will not adversely affect any endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species act of 1973. The BA documents a determination of “no effect” on the Canada lynx and on the Kendall warm springs dace, the only threatened or enangered species in the area.

10. The amendment does not threaten a violation of Federal, State, and local laws or requirements for the protection of the environment.

Findings Required by Other Laws and Regulations

This decision to amend the Forest Plan is consistent with the National Forest Management Act and its implementation regulations. Because the amendment does not result in significant changes to multiple-use goals and objectives for long-term land and resource management, the proposed amendment is considered to be "non-significant" according to the planning regulations at 36 CFR 219.14(2). Therefore, this amendment is authorized in this Decision Notice. The amendment is also consistent with the Forest Plan's goals, objectives, and specific management direction for the Forest, Management Areas, and Desired Future Conditions. As noted in the Decision section, this amendment does not remove any current Forest Plan direction for the area, it simply adds an additional standard to the corridor.

Implementation Date

This amendment will be implemented 7 days after the legal notice of this decision has been published in the Casper Star-Tribune and the appeal period has begun.

Administrative Review or Appeal Opportunities

This decision is subject to appeal pursuant to 36 CFR 217.3. Appeals must meet the content requirements of 36 CFR 217.9. A written appeal must be postmarked or received by the Appeal Reviewing Officer within 45 days of the date of publication of the legal notice of this decision in the Casper Star-Tribune. Appeals must be sent to: Regional Forester, Intermountain Region USFS, 324 25th Street, Ogden, Utah 84401; by fax to 801-625-5277; or by email to: appeals-intermtn-regional-office@fs.fed.us. Emailed appeals must be submitted in rich text (rtf) or Word (doc) and must include the project name in the subject line. Appeals may also be hand delivered to the above address, during regular business hours of 8:00 a.m. to 4:30 p.m. Monday through Friday.

Contact

For additional information concerning this decision or the Forest Service administrative appeal process, contact John Kuzloski by mail at the Bridger-Teton National Forest, P.O. Box 1888, Jackson, WY 83001; by email at jkuzloski@fs.fed.us or by phone at (307) 739-5568.

/s/ Kniffy Hamilton May 31, 2008

CAROLE 'KNIFFY' HAMILTON Date
Forest Supervisor
Bridger-Teton National Forest

USDA

United States
Department of
Agriculture

Forest
Service

May 2008

Environmental Assessment

Bridger-Teton National Forest

Land and Resource Management Plan Amendment:

Pronghorn Migration Corridor

Bridger-Teton National Forest
Sublette and Teton Counties, Wyoming

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SUMMARY

The Bridger-Teton National Forest proposes to amend its 1990 Land and Resource Management Plan (Forest Plan) to allow continued successful migration of the pronghorn (*Antilocarpa americana)* that summer in Jackson Hole and winter in the Green River basin in Wyoming. The Forest Plan Amendment would designate a Pronghorn Migration Corridor and create a standard requiring that projects, activities and infrastructure authorized by the Forest Service in the corridor be designed, timed and/or located to allow continued successful migration. The migration corridor to which this amendment would apply extends from the Forest boundary near the Green River Lakes Road north of Pinedale in Sublette County, Wyoming to the Forest boundary with Grand Teton National Park northeast of Kelly in Teton County, Wyoming. It is within the Pinedale and Jackson Ranger Districts of the Bridger-Teton National Forest.

Because the proposal would not result in significant changes to multiple-use goals and objectives for long-term land and resource management, the proposed amendment is considered to be "non-significant" according to the planning regulations at 36 CFR 217. Therefore, the amendment can be authorized in a Decision Notice after completion of this Environmental Assessment (EA). In this EA, the Forest Service evaluates the Proposed Action and the "No Action" alternative of not amending the Forest Plan.

Based on this EA, the responsible official will decide whether or not to amend the Forest Plan as described. The Responsible Official is the Forest Supervisor of the Bridger-Teton National Forest Kniffy Hamilton.

INTRODUCTION

Document Structure

The Forest Service has prepared this Environmental Assessment in compliance with the National Environmental Policy Act (NEPA) and other relevant Federal and State laws and regulations. This Environmental Assessment discloses the direct, indirect, and cumulative environmental impacts that would result from the proposed action and alternatives. The document is organized into four parts:

- *Introduction:* The section includes information on the history of the project proposal, the purpose of and need for the project, and the agency's proposal for achieving that purpose and need. This section also details how the Forest Service informed the public of the proposal and how the public responded.
- *Alternatives, Including the Proposed Action:* This section provides a more detailed description of the agency's proposed action as well as any alternatives. These alternatives were developed based on significant issues raised by the public and other agencies. This discussion also includes possible mitigation measures. Finally, this section provides a summary table comparing the contents and the environmental consequences associated with each alternative.
- *Existing Conditions:* This section describes the existing conditions of the pronghorn migration corridor and livestock grazing operations in the corridor.
- *Environmental Consequences:* This section describes the environmental effects of implementing the proposed action and alternatives. Within each section, the affected environment is described first, followed by the effects of the No Action Alternative that provides a baseline for evaluation and comparison of the other alternatives that follow.
- *Consultation and Coordination:* This section provides a list of preparers and agencies consulted during the development of the environmental assessment.

Additional documentation, including more detailed analyses of project-area resources, may be found in the project planning record located at the Forest Supervisors Office in Jackson.

Background

The pronghorn that summer in Jackson Hole migrate annually from wintering areas in the Green River basin. Documented round trip migration distances from 175 to 330 miles make this the longest known terrestrial animal migration in the 48 contiguous states. The corridor has been used by pronghorn for at least 6000 years (Berger, et al. 2006). Typically, the pronghorn migrate through the corridor in April or May and again in October or November. These pronghorn are a part of the impressive panorama of free-ranging native Rocky Mountain mammals in northwest Wyoming. This landscape draws tourists from around the world and supports a robust regional economy.

Purpose and Need for Action

A significant portion of the full migration route is within the Bridger-Teton National Forest. Managing this migration corridor to facilitate continued successful movement will help

ensure protection of this herd and its migration. The purpose of this proposal is to ensure that projects, activities, and facilities conducted by or authorized by the Forest Service within the corridor allow for continued successful pronghorn migration.
The Forest Service cannot by itself guarantee continued successful migration of this herd because there are numerous factors beyond Forest Service control such as activities on lands under other jurisdictions within the migration corridor. On January 30, 2007, Forest Supervisor Kniffy Hamilton, signed a "Pledge of Support" to work with others to help ensure protection of the migration route. This proposal supports that larger effort.

Proposed Action

The Forest Service proposes to designate a Pronghorn Migration Corridor as shown on the attached map and to facilitate continued successful migration in that corridor. To that management end, projects, activities, and infrastructure in the corridor would be designed, timed and/or located to allow continued successful migration of pronghorn through the corridor. Presently, activities within the Forest corridor are not compromising the annual migrations, so no changes to current activities are anticipated.

It is important to note that while the full length of the migration route includes lands under various jurisdictions including Bureau of Land Management, State, and private lands in Teton and Sublette Counties, this Forest Service proposal applies only to Forest Service System lands within that larger corridor. In addition, the proposal does not constrain activities on private land within the Forest boundary.

Decision Framework

Given the purpose and need and the analysis contained in this EA, the deciding official will review the proposed action and the alternatives and decide to amend the Forest Plan as described, to amend the Forest Plan with some adjustments, or not to amend the Forest Plan.

Public Involvement

The proposal was provided to the public and other agencies for comment in a Scoping Statement dated March 6, 2008. The proposal was listed in the Bridger-Teton Schedule of Proposed Actions on April 1, 2008. Comments were received from government entities such as the Bureau of Land Management, Grand Teton National Park, and the Wyoming Game and Fish Department; from livestock associations and permittees; from conservation organizations; and from many private citizens. Approximately 19,400 emails were received supporting the proposal. Livestock interests were concerned that the proposal could negatively affect their operations. Some conservation organizations wanted specific restrictions added to the amendment such as a decision to make oil and gas leasing unavailable in the corridor. Using the comments received from scoping, the interdisciplinary team developed issues to be addressed in this EA.

Issues

The Forest Service separated the issues into two groups: significant and non-significant issues. Significant issues were defined as those directly or indirectly caused by implementing the proposed action. Non-significant issues are identified as those: 1) outside the scope of the

proposed action; 2) already decided by law, regulation, Forest Plan, or other higher level decision; 3) irrelevant to the decision to be made; or 4) conjectural and not supported by scientific or factual evidence. The Council on Environmental Quality (CEQ) NEPA regulations require this delineation in Sec. 1501.7, "…identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (Sec. 1506.3)…" The full comment letters and a list of non-significant issues and the reasons for categorizing them as such are contained in the project record.

As for significant issues, the Forest Service identified 2 topics raised during scoping:

1. The effect of the proposed action on pronghorn migration through the corridor.
2. The effect of the proposed action on livestock grazing operations.

ALTERNATIVES, INCLUDING THE PROPOSED ACTION

This chapter describes and compares the alternatives considered. It includes a description of each alternative and a map of the proposed action. Some of the information used to compare the alternatives is based upon the design of the alternative and some of the information is based upon the effects of implementing each alternative.

Alternatives

Alternative 1 – No Action

Under the No Action alternative, current management plans would continue to guide management of the area. There would be no Forest Plan Amendment.

Alternative 2 – Proposed Plan Amendment

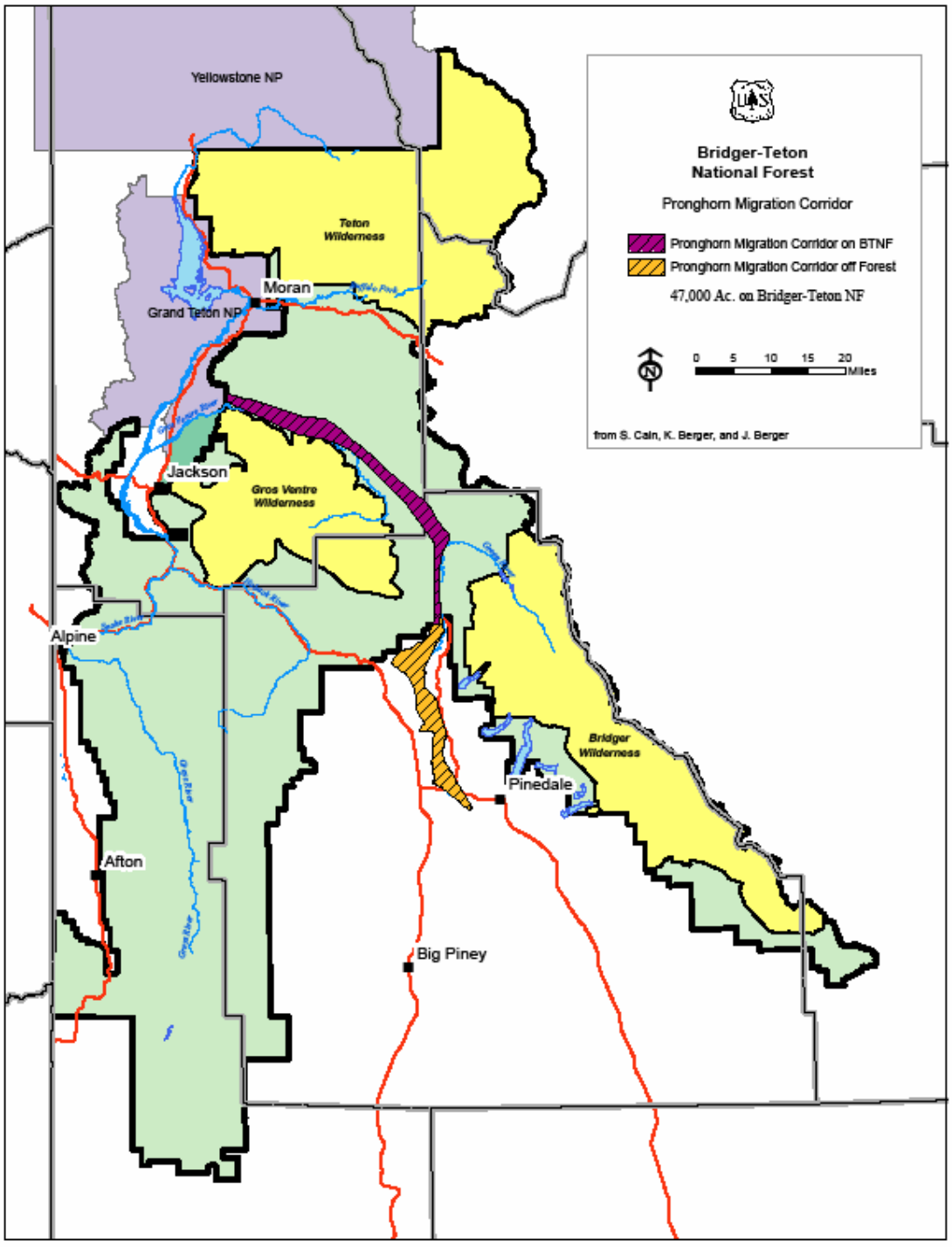
Under this alternative, the Forest Service would manage the pronghorn migration corridor, encompassing approximately 47,000 acres as shown on the map, to facilitate continued successful migration of the pronghorn that summer in Jackson Hole and winter in the green River basin. To that management end, the proposed Forest Plan amendment would add a standard requiring that projects, activities, and infrastructure in the corridor be designed, timed and/or located to allow continued successful migration of pronghorn through the corridor. Therefore, this amendment would require that such a determination be made prior to Forest Service authorization of projects, activities, and infrastructure in the corridor.

Because the proposed amendment would not make site-specific decisions or authorizations, the analysis of effects in this EA cannot be site-specific or project-specific. However, this amendment would require site-specific analysis at the project level of the effects of specific activities and infrastructure on pronghorn migration. Based on that site-specific analysis, a determination that the activity or infrastructure would allow continued successful migration would have to be made for the activity or infrastructure to be authorized.

Presently, activities within the Forest portion of the migration route are not compromising the annual migrations, so changes to current activities will not be required by this amendment.

It is important to note that, while the full length of the migration route includes lands under various jurisdictions including Bureau of Land Management, State, and private lands in Teton and Sublette Counties, this Forest Service proposal applies only to Forest Service System lands within that larger corridor. Furthermore, the proposal does not constrain activities on private property within the Forest boundary.

Figure 2. Pronghorn Migration Corridor



NOTE: The proposed Forest Plan Amendment only applies to Forest Service System lands.

Comparison of Alternatives

This table provides a summary of the differences between the alternatives.

Table 1. Summary Comparison of Alternatives.

	Alternative 1 – No Action	Alternative 2 – Proposed Plan Amendment
Alternative	No Amendment to the Forest Plan	Amendment designating corridor and requiring that activities/infrastructure allow continued successful pronghorn migration
Current Activities	Current activities continue	Current activities continue (because migration is currently successful)
Future Activities	Future activities authorized under current management plans	Future activities (recreation, grazing, vegetation treatment, etc.) authorized only if they allow continued successful migration
Private Land	Activities on private land are not constrained	Activities on private land are not constrained
	Summary of Effects Analyzed Below	
Pronghorn Migration	Possibility that future activities could inhibit migration	Activities authorized only if they allow continued successful migration
Livestock Grazing Current Activities	Current activities not affected	Current activities not affected (because migration is currently successful)
Livestock Grazing Future Activities	Future activities not affected	Future activities somewhat limited -- must allow continued successful migration

EXISTING CONDITIONS

Existing conditions are described for the two significant issues identified by the Interdisciplinary Team based on responses to scoping.

1. Pronghorn Migration

Pronghorn antelope utilize sagebrush and grassland habitats in Wyoming. The pronghorn corridor contains spring, summer, and fall range for a limited number of pronghorn from the Sublette herd unit (#401), which is the most migratory pronghorn population in the United States. No winter range is present. The pronghorn corridor also provides a crucial migration route that links the Jackson Hole area summer range with winter range near the Pinedale Mesa, and additional ranges to the southeast. Specifically, these pronghorn utilize a route that runs along the west side of the Green River from the Forest boundary north to Bacon Ridge and Bacon Creek and continues into the Gros Ventre River drainage.

2. Livestock Grazing Operations

Current livestock grazing operations coexist with successful pronghorn migration in the corridor. The corridor crosses two active cattle allotments, the Upper Green River and the Upper Gros Ventre. It also crosses two forage reserves. Three other active allotments are adjacent to the corridor. The permitted period of use on the Upper Green River allotment is from June 18 to October 8, and on the Upper Gros allotment it is from June 16 to October 15. Pronghorn typically move through the corridor in April or May and again in October or November, so there is very little overlap of livestock grazing with pronghorn migration. Research on livestock grazing and pronghorn indicates that they are not incompatible (Yoakum, et al *in* Krausman 1996). While there are numerous range management fences in the corridor, they do not preclude successful pronghorn migration. Successful grazing operations help to maintain open space on private land; subdivision development creates numerous impediments to migrating wildlife (Holz 2008, personal communication).

ENVIRONMENTAL CONSEQUENCES

For the two significant issues, this section summarizes the potential effects of the alternatives. It also presents the basis for the comparison of alternatives summarized in the table above.

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1. The effect of the proposed action on pronghorn migration through the corridor.

Direct and Indirect Effects

Alternative 1 – No Action

Under Alternative 1, pronghorn will continue to successfully use the corridor in its present condition. The future beneficial impacts that would result from implementation of the Forest Plan Amendment would not be realized. Future projects within the corridor would not be required to facilitate continued successful migration. This could have long-term negative impacts on pronghorn if projects were to block, alter, or highly delay pronghorn migration through the corridor on Forest.

Alternative 2 – Proposed Plan Amendment

Under Alternative 2, pronghorn will continue to successfully use the corridor in its present condition. The future beneficial impacts that would result from implementation of the Forest Plan Amendment would be realized. Future projects within the corridor would be required to facilitate continued successful migration. This would have long-term positive impacts on pronghorn by assuring successful future pronghorn migration on Forest.

Cumulative Effects

Projects that could cumulatively impact pronghorn within the migration corridor include range improvements and vegetation treatments; in particular, existing and future range

improvement projects and vegetation treatments in pronghorn habitat within the migration corridor. Potential future and existing projects on Forest include:

- Existing range improvement structures (i.e. fences)
- Proposed Gros Ventre allotment range improvements
- Proposed Bacon Ridge vegetation treatments
- Lower Gros Ventre habitat enhancement project
- Proposed Gros Ventre mineral exploration (precious metals)

Keep in mind that existing range improvement structures and management practices within the corridor currently do not inhibit successful pronghorn migration on Forest.

Alternative 1 – No Action

Current and future range improvement structures, vegetation treatment and other projects within the corridor would not be required to facilitate continued successful migration. This could have short-term and long-term negative cumulative impacts to pronghorn. Short-term cumulative impacts could include temporary displacement or delaying migration while vegetation treatments are taking place. Long-term cumulative impacts could include migration being blocked, altered, or highly delayed by range improvement structures, vegetation treatment and other projects. Also, vegetation treatments could improve pronghorn habitat within the corridor, by improving habitat condition and increasing "open space" that pronghorn prefer.

Alternative 2 – Proposed Plan Amendment

Current and future range improvement structures, vegetation treatment and other projects within the corridor would be required to facilitate continued successful migration. As a result, any potential negative cumulative impacts from future projects in the corridor would be reduced or removed with implementation of the Forest Plan Amendment. Also, vegetation treatments could improve pronghorn habitat within the corridor, by improving habitat condition and increasing "open space" that pronghorn prefer.

This analysis of effects on pronghorn migration is based on Cory Mlodik's specialist report that is contained in the project record.

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2. The effect of the proposed action on livestock grazing operations.

Direct and Indirect Effects

Alternative 1 – No Action

Under Alternative 1, grazing operations would continue to be managed under law, regulation and policy and guided by specific Allotment Management Plans and Annual Operating Instructions. Proposed changes to grazing operations would be evaluated in terms of law, regulation, and policy. There would be no Forest Plan Amendment requiring that activities and infrastructure allow continued successful pronghorn migration.

Alternative 2 – Proposed Plan Amendment

Under Alternative 2, grazing operations would continue to be managed under law, regulation and policy and guided by specific Allotment Management Plans and Annual Operating Instructions. Because current grazing operations, including structures, on/off dates and rotations, coexist with successful pronghorn migration, this proposed amendment will not require changes to current grazing operations.

With the creation of this Forest Plan Amendment, future activities and infrastructure, including those associated with livestock grazing, would only be authorized if they were determined to allow continued successful pronghorn migration. Compared to Alternative 1, this may limit the range of future activities and infrastructure that could be authorized. However, if future activities and infrastructure are designed, timed or located in a way that allows continued successful migration, they would be acceptable. The most typical range structural improvements are fences, and these can be designed to allow the movement of pronghorn.

Cumulative Effects

Existing and reasonably foreseeable activities that could cumulatively impact grazing operations within the migration corridor include current and future range improvement structures, establishment of the forage reserves in 2007, and vegetation treatments. Specific potential future and existing projects on Forest include:

- Existing Range Improvements (i.e. fences)
- Gros Ventre Allotment Range Improvements

Alternative 1 – No Action

Considering existing conditions and reasonably foreseeable future activities, it is expected that, without the proposed amendment, grazing operations in the corridor will remain stable. Grazing operations will continue to be managed under federal law, regulation, and Forest Service policy and be guided by specific Allotment Management Plans and Annual Operating Instructions.

Alternative 2 – Proposed Plan Amendment

Considering existing conditions and reasonably foreseeable future activities, it is expected that, with the proposed amendment, grazing operations in the corridor will remain stable. Because current grazing operations coexist with successful pronghorn migration, the amendment will not affect current operations. Therefore the proposed amendment contributes very little to any cumulative effect on current operations. Grazing operations will continue to be managed under federal law, regulation, and Forest Service policy and be guided by specific Allotment Management Plans and Annual Operating Instructions.

As described, the amendment has the potential to limit the range of possible future operations, but that effect is also expected to be small given the lack of overlap between migration and livestock grazing and the opportunity to design, locate or time activities and

infrastructure to allow continued pronghorn migration. The proposed amendment therefore also contributes very little to any cumulative effect on future operations.

CONSULTATION AND COORDINATION

The Forest Service consulted the following during the development of this environmental assessment:

ID TEAM MEMBERS:

Forest Service:

John Kuzloski

Herrick Fox

Cory Mlodik

Joanna Behrens

Faith Ryan

Michael Schrotz

Terry Hershey

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FEDERAL, STATE, AND LOCAL AGENCIES:

Grand Teton National Park:

Steve Cain

Wyoming Game and Fish Department:

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LITERATURE CITED

Berger, Joel, Steven L. Cain, and Kim Murray Berger. 2006. "Connecting the Dots: An Invariant Migration Corridor Links the Holocene to the Present." *Biology Letters* 2:528-531.

Yoakum, J.D., B.W. O'Gara and V.W. Howard, Jr. 1996. Chapter 13: Pronghorn on Western Rangelands, pages 211-226 in Krausman, P.R. (ed.) Rangeland Wildlife. Society for Range Management, Denver, Colorado. 440p.

Holz, B., Wyoming Game and Fish Department, personal communication, 2008.

Pronghorn Migration Corridor - 9/06

Pronghorn Migration Corridor
from S. Cain, K. Berger, and J. Berger

N

0 5 10 Miles

biology letters

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Connecting the dots: an invariant migration corridor links the Holocene to the present

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Numerous species undergo impressive movements, but due to massive changes in land use, long distance migration in terrestrial vertebrates has become a highly fragile ecological phenomenon. Uncertainty about the locations of past migrations and the importance of current corridors hampers conservation planning. Using archeological data from historic kill sites and modern methods to track migration, we document an invariant, 150 km (one-way) migration corridor used for at least 6000 years by North America's sole extant endemic ungulate. Pronghorn (*Antilocapra americana*) from the Greater Yellowstone Ecosystem, like other long distant migrants including Serengeti wildebeest (*Connochaetes taurinus*) and Arctic caribou (*Rangifer tarandus*), move nearly 50 km d^{-1}, but in contrast to these other species, rely on an invariant corridor averaging only 2 km wide. Because an entire population accesses a national park (Grand Teton) by passage through bottlenecks as narrow as 121 m, any blockage to movement will result in extirpation. Based on animation of real data coupled with the loss of six historic routes, alternative pathways throughout the 60 000 km^2 Yellowstone ecosystem are no longer available. Our findings have implications for developing strategies to protect long distance land migrations in Africa, Asia and North America and to prevent the disappearance of ecological phenomena that have operated for millennia.

Keywords: corridors; Pleistocene; pronghorn; *Antilocapra americana*; migration

1. INTRODUCTION

Long distance migration (LDM) in terrestrial vertebrates is an ecological process that has operated globally for thousands, if not millions, of years. Indeed, the possibility of extreme seasonal movements by Alaskan hadrosaurs during the Cretaceous (Hotton 1980) and mammoths during the Late Pleistocene exists although unlikely (Guthrie 1985; Fiorillo & Gangloff 2001). Evidence for Holocene migrations in *Bison priscus* appears stronger (Guthrie 1990). Nevertheless, in today's crowded world, LDMs are quietly disappearing due to explosive human population growth coupled with massive land use changes. In only 40 years, the long migrations of springbok (*Antidorcas marsupialis*) and wildebeest (*Connochaetes taurinus*) in southern Africa have ended (Child & Le Riche 1967; Williamson *et al.* 1988).

Impediments to movements of wide-ranging terrestrial mammals share common anthropogenic traits: railroad lines for Mongolian gazelles (*Procapra gutturosa*) in Central Asia (Ito *et al.* 2005), highways for brown bears (*Ursus arctos*) in North America (McLellan & Shackleton 1988), agricultural fields for wildebeest in the Serengeti (Serneels & Lambin 2001) and hydroelectric dams for woodland caribou ((*Rangifer tarandus*) Mahoney & Schaefer 2002). While species like saiga (*Saiga tatarica*) or chiru (*Pantholops hodgsonii*) (Schaller 1998; Milner-Gulland *et al.* 2001) are threatened by poaching, the overarching problem for effective conservation has been large-scale habitat change.

Among the challenges to retain LDM, three biological uncertainties stand out. First, knowledge about how large-bodied species navigate big and remote landscapes remains limited and local pastoralists and critics of habitat protection are often under the notion that migratory mammals simply move elsewhere and find alternative routes. Second, the relationship between specific migration pathways and population viability remains mostly unknown, a problem exacerbated by the historical lack of appropriate technology to identify which lands, if any, are in need of explicit protection. Finally, beyond spatial uncertainty, populations undertaking LDMs exhibit broad inconsistencies over time. When such variation is large and occurs on an annual, decadal or centurial basis, it will be difficult if not impossible to realistically decide which lands are of highest ecological and conservation value.

Here, we report an invariant LDM corridor in North America's sole surviving endemic ungulate, pronghorn (*Antilocapra americana*). This LDM, at the southern tier of the 60 000 km^2 Greater Yellowstone Ecosystem (GYE), winds through geographical bottlenecks that vary in width from 121 to 700 m and has been traversed for at least 6000 years (Miller & Sanders 2000). Irrespective of location, the identification of unusual, historic and inflexible corridors will facilitate conservation efforts on specific lands.

2. MATERIAL AND METHODS

To characterize the spatial patterns of migratory pronghorn we analysed a total of 11 450 GPS fixes (based on global positioning system technology; Telonics, Mesa, AZ, USA). Animals were captured with a net from a helicopter in Grand Teton National Park (GTNP), Wyoming. The width of geographical bottlenecks was the estimated maximum distance between fixes for any two individuals during passage. Cross-section dimensions of the migration corridor were obtained first by drawing polygons around all locations within a fixed section and subsequently by averaging the outermost distances at which individuals passed 10 evenly spaced geographical increments along the entire corridor. The XTools Pro extension in ArcMap (DeLaune 2000) was used for estimations.

We then contrasted our results to those of corridor width in migratory wildebeest from the Serengeti by applying the same analytical techniques to data in Thirgood *et al.* (2004). To do so, we estimated 63 cross-sections of the wildebeest route (range 1.09–74.79 km) using information on all colour-coded individuals. While this approach introduces a source of bias since the coloured points were not stamped by date, our interest was comparative.

The electronic supplementary material is available at http://dx.doi.org/10.1098/rsbl.2006.0508 or via http://www.journals.royalsoc.ac.uk.

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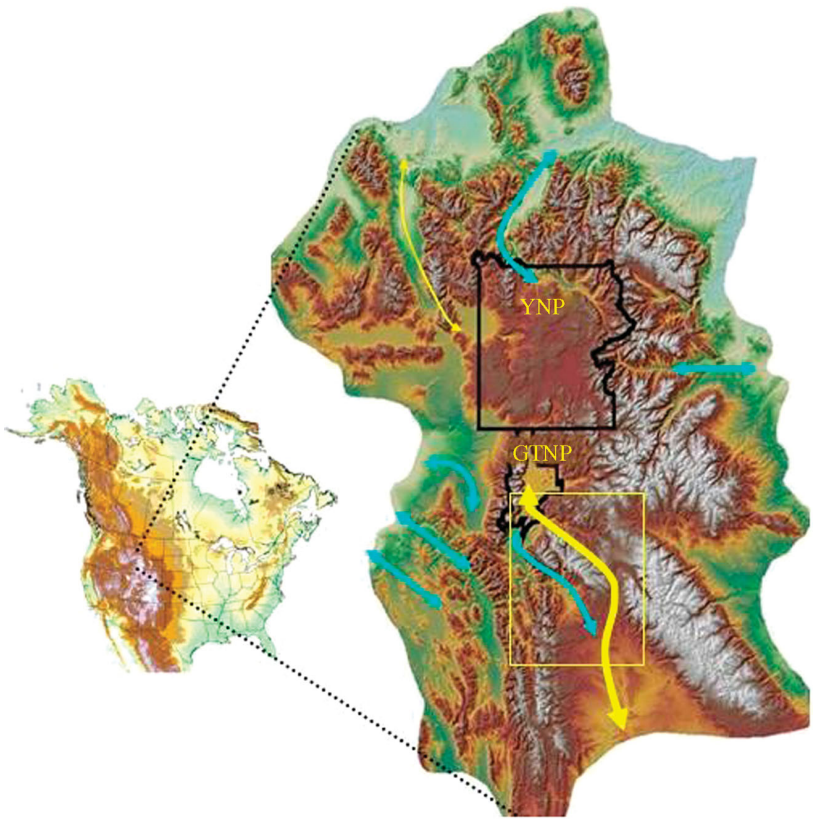

Figure 1. Migration routes (yellow, existing; turquoise, extirpated) of pronghorn in and adjacent to the Greater Yellowstone Ecosystem in relation to yellowstone (YNP) and Grand Teton (GTNP) national parks. Yellow line thickness reflects relative susceptibility to loss. The inset (box) highlights study region of invariant migratory corridor in the upper Green River basin (see figure 2).

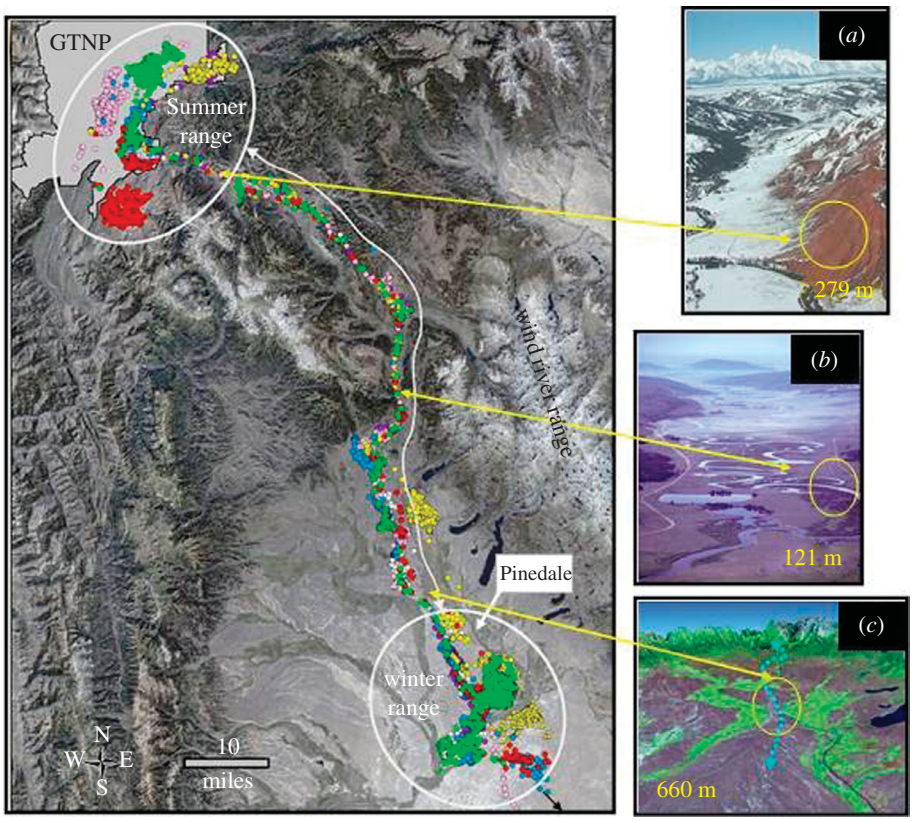

Figure 2. The migration corridor between GTNP and winter ranges in the upper Green River basin of Wyoming. Dots reflect *ca* 11 450 points of 10 colour coded adult female pronghorn. Insets (*a–c*) reflect geographical bottlenecks (yellow circles) and locations along migration route. Enhanced imagery in (*c*) depicts rivers (green) to east and west of Trapper's Point hunting site where 6000 year old pronghorn bones were recovered.

3. RESULTS

Although pronghorn migration routes in and out of the GYE have been reported (Berger 2004; Sawyer *et al.* 2005), 6 of 8 routes have been lost (figure 1), due primarily to habitat conversion for agriculture or roads or reservoirs through canyons. Only a single remaining route connects animals that summer in GTNP, a 121 000 ha natural area supporting all native ungulates and carnivores, to suitable wintering areas in the upper Green River basin (figure 1). The narrow corridor appears invariant (figure 2), for all animals that move northward to reach the park used the same pathway though not moving in synchrony and up to one month apart.

The longest linear round-trip movement exceeded 560 km and all animals moved through high elevation passes at 2700 m and tapered river valleys. Movements were rapid, involving shifts from summer ranges at *ca* 2075 m in elevation to slightly higher but less snowy winter ranges at 2370 m approximately 150 km south (figure 2). Autumn migration averaged 3.3 (+2.0 s.e.m.) days. In contrast, spring migration was nine times longer (29.9+6.9 s.e.m. days), as animals followed receding snowlines (see http://www.wcs.org/yellowstone/pronghorn_migration for on-line animation of empirical data on the mechanics of travel through the corridor).

Navigation of the corridor necessitated passage through bottlenecks that varied in width from 100 to 300 m (*a–b*) to 610 m (*c*) (figure 2). Historically, the Trapper's Point bottleneck (*c*) was *ca* 2000 m wide, tightly constrained by the flow of two rivers and hunted by indigenous Americans during three discrete Mid-Holocene procurement episodes up to about 6000 years ago (Miller & Sanders 2000). Recent residential development has nearly halved the area available for travel through this bottleneck. The mean width used by pronghorn along the entire 150 km route between the GTNP boundary and Trapper's point was 1.91 (+0.118 s.e.m; $n=137$; range 0.10–5.47) km.

The possibility of adoption of alternate routes is low and neither supported by evidence on the collapse of previously existing pronghorn migrations (figure 1) or our empirical results. For instance, analyses of 16 bi-directional spring and autumn migrations revealed an invariant use of the corridor. Of note is the unsuccessful apparent attempt to use an alternate route (see http://www.wcs.org/yellowstone/pronghorn_migration for on-line animation) during spring migration. After blockage by a highway and multiple efforts to cross a 3500 m mountain chain, a collared female retraced her course and subsequently followed the historic and still functioning corridor to reach summering grounds.

While estimates of corridor width are unavailable for most migratory species, annual variation characterizes chiru and caribou (Schaller 1998; Griffiths *et al.* 2002). When cross-sections of the route of migratory wildebeest from the Serengeti are contrasted with pronghorn, mean corridor width in the former is substantially greater (34.62; +2.25) km. The *ca* 18-fold difference in width and the attendant variability during the past few decades (Thirgood *et al.* 2004), has important implications about how and where to allocate subsequent conservation efforts.

4. DISCUSSION

The availability of GPS technology has enhanced biological knowledge while creating opportunities for conservation, especially for species such as manatees (*Trichechus manatus*), humpback whales (*Megaptera novaeangliae*) and African elephants (*Loxodonta africana*) where conflicts with humans continue to intensify (Wilson *et al.* 2004; Douglas-Hamilton *et al.* 2005; Pomilla & Rosenbaum 2005). Although ecological phenomena such as migration are fascinating, challenges to their persistence will arise because of the increasing demand of humans for habitable space. This creates an urgent premium to identify lands crucial for protection.

Our documentation of an invariant migration corridor is noteworthy for two reasons. First, not only is this migration of archeological and cultural importance, but the round-trip movement involves three geographical bottlenecks through which every individual (200–300) of an entire park population must pass. Any obstruction is likely to extirpate pronghorn from GTNP, a supposition bolstered by the loss and failure to re-establish historically used pathways to and from the region's two national parks, Yellowstone and GTNP (inset in figure 1).

Second, the current migration persists in a country with nearly 300 million people and where current national energy policy is reducing biological diversity on public lands (Ehrlich 1994; Berger 2003). For instance, some migrants cross areas that nurture petroleum development, which at full scale will fragment parts of routes that pronghorn have used for millennia. Given the rarity of relict migrations among terrestrial mammals in the Western Hemisphere in excess of even 100 km (Berger 2004) and a desire of most American citizens to maintain a semblance of ecological integrity in national parks (Soule *et al.* 2003), the invariant route we report that still involves part of an ancient pathway should warrant protective action.

Nevertheless, there are issues of scale, size and ecological function. Unlike the Serengeti with its migratory wildebeest, zebra (*Equus burchelli*) and Thompson's gazelle (*Gazella thomsonii*) or Arctic caribou where hundreds of thousands or more move long distances, why should a mere 200–300 migratory pronghorn be of concern? After all, it is common knowledge that there are more pronghorn than people in the State of Wyoming.

Two issues are germane. First, the protection of this migration corridor is more than symbolic. If obstructed, whether by petroleum development, housing or other factors, an entire population from a national park will be eliminated, leaving a conspicuous gap in the function of native predator–prey interactions there. Second, ecological processes are being sacrificed globally, some as a consequence of death by a thousand cuts and others by massive and rapid changes in land use. In an era with few conservation victories, particularly in developed

countries, if biological diversity is to be promoted in less-developed countries, we must maintain equal or greater concern for local wildlife conservation by establishing the permanent protection of corridors, whether they are ancient and still functioning or new. Our report of an invariant migratory route suggests that when corridors persist, when they are narrow and when temporal variability in use is low, it should be easier to enact robust conservation measures.

We thank the National Park Service, the Rocky Mountain Cooperative Ecological Studies Unit, the Greater Yellowstone Coordinating Committee, K. Tonnessen, M. Maj, B. and N. Weber, R. F. Bowyer, R. Easterbrook, S. and L. Robertson, A. Toivola and the Liz Claiborne and Art Ortenberg Foundation and Wilburforce for support or comments. The GIS Laboratories of the Wildlife Conservation Society, the National Park Service and Sky Truth offered advice and assistance. T. Segerstrom and H. Sawyer have selflessly contributed data and insights. Photos of bottleneck are courtesy of F. Camenzind and J. Catton.

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WYOMING GAME AND FISH DEPARTMENT

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May 30, 2008

Carole "Kniffy" Hamilton
Forest Supervisor
Bridger-Teton National Forest
P.O. Box 1888
Jackson, Wyoming 83001

Dear Kniffy,

This letter follows from a conversation with Michael Schrotz, who was interested in the Wyoming Game and Fish Department's perspective on various aspects of pronghorn migration. As you know, a small segment Sublette Antelope Herd migrates from winter ranges as far south as Interstate 80 near Rock Springs to summer ranges as far north as Jackson Hole. I am pleased with your initiative for the conservation and protection of this important migration, and offer my partnership in this effort.

There are numerous fences between Trapper's Point and Jackson Hole, and while the migration corridor continues to pass pronghorn and other wildlife, there is still opportunity to modify fences to improve passage of wildlife without compromising their effectiveness in containing livestock. The Department has implemented fence modification projects in areas where passage could be improved on private, state, and federal lands. We do not have a detailed inventory for future work, but are aware that interest in this by government and non-government organizations is high. While I do not have detailed knowledge of all Forest fences, I was impressed with a fence near Buffalo Meadows, in the vicinity of the old inter-forest boundary between the Bridger and Teton Forests. Pronghorn migration is largely through a gate in that fence during times of year when livestock are not present, but the fence would be perfectly passable were the gate closed.

Livestock grazing and movement do not directly influence pronghorn migration because of the times of the year when pronghorn migrate. Indirectly ranching has a huge influence on migration corridor conservation, both on private and public lands. They contribute to the open space necessary for pronghorn migrations through the upper Green River Valley, and without a vibrant ranch economy we will suffer loss of open spaces and impediments to pronghorn movements because of subdivision. As ranch operations on the west side of Pinedale became less viable as Pinedale grew, property owners were motivated to subdivide. The West Pinedale pronghorn migration has nearly been lost. Development creates numerous impediments to migrating wildlife, including buildings, fences, dogs, and overall increased human activity. Increased traffic flow is one of the most important impediments to the West Pinedale pronghorn migration.

Pronghorn hunting has not had an overall impact on migrations; later hunting seasons are sometimes an effective management tool in harvesting herd segments that are not hunted while distributed on private lands, but are accessible to hunters as they migrate through public lands. I would not anticipate that increasing awareness of the migration corridor (a designated corridor) would impact hunting strategies or harvest success at all. Much migration occurs when hunting seasons are closed.

I am pleased with your Path of the Pronghorn initiative, and also pleased to partner with the Forest Service to conserve and protect pronghorn migrations.

Sincerely,

Bernard Holz
Regional Wildlife Supervisor

BH08031

cc: File

RANGELAND WILDLIFE

Paul R. Krausman, Editor

The Society for Range Management
1839 York Street
Denver, Colorado 80206
1996

Chapter 13
PRONGHORN ON WESTERN RANGELANDS

J. D. Yoakum, B. W. O'Gara, and V. W. Howard, Jr.

INTRODUCTION

The pronghorn (*Antilocapra americana*) evolved in North America over the last 20 million years (Fig. 1). They are truly North American, occurring no where else in the world (O'Gara 1978). Pronghorn existed with bison (*Bison bison*) in legendary numbers when Lewis and Clark made their historic journey across the continent (Fig. 2). The vernacular name pronghorn will be used throughout this chapter, for some antelope species from Africa now are free-roaming in North America, and in some places, both inhabit the same rangelands (Yoakum and O'Gara In Press).

To better understand this endemic species, first we will discuss its distribution, abundance, and habitat requirements. A review of how pronghorn were almost extirpated in the 1800s, and increased > 3,200% in the twentieth century, is testimony of the species adaptability to living with humans on contemporary rangelands and to changes in wildlife management techniques to benefit pronghorn. Understanding habitat requirements of the pronghorn is the key to managing and perpetuating the species; therefore these components will be discussed in detail.

Today, it is postulated that 98% of pronghorn share their habitat (Fig. 3) with domestic livestock (Yoakum and O'Gara 1990).

FIGURE 1. An adult buck pronghorn with large horns grazes with a small herd of does on rangelands today just as pronghorn have for centuries. Photo by J. D. Yoakum, courtesy of Western Wildlife.

An estimated 60% live on private lands with the remainder on government-administrated lands. Knowledge of the relationships of pronghorn to livestock is consequently of major import, and

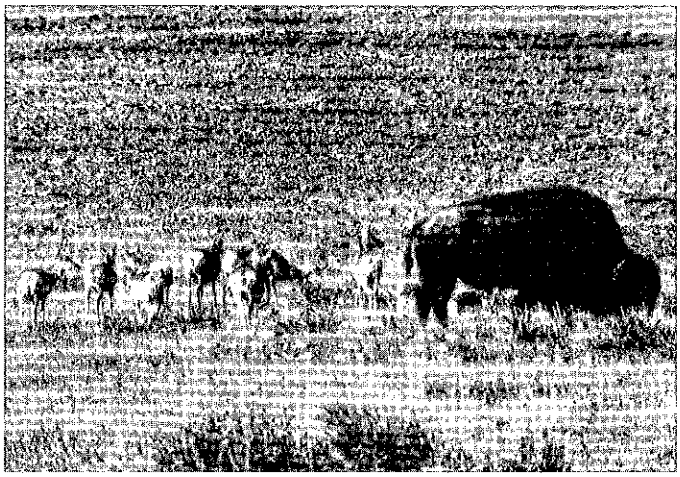

FIGURE 2. Historically, pronghorn frequently grazed with bison in the grassland biome, however few herds experience this relationship today. Photo by D. Kitchen.

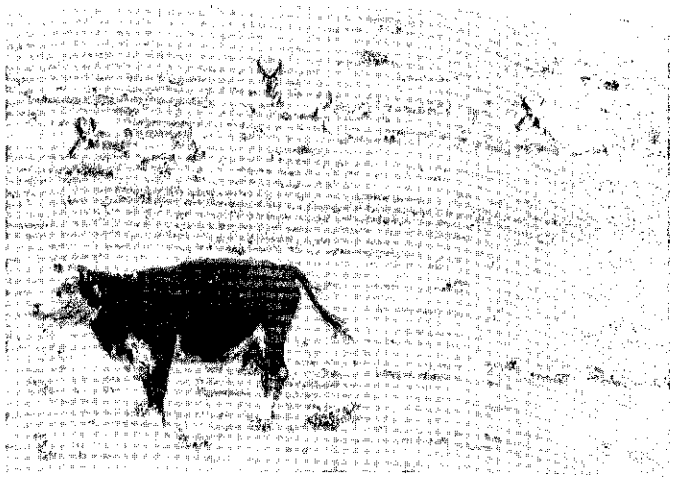

FIGURE 3. Today, most pronghorn occupy western rangelands with domestic livestock. Photo by George Andrejko, courtesy of the Arizona Game and Fish Department.

we will emphasize these influences. It is necessary to understand basic biological characteristics of pronghorn and various livestock to understand compatibility and competition, foraging characteristics, problems of disease transmittal, and values to modern society. Likewise, managers need to know how rangeland practices such as vegetation manipulation, water development, or fences affect the welfare of pronghorn to plan and implement effective management on private and public rangelands.

Within the past 2 decades, an increased number of technical papers have been published on pronghorn and livestock relationships (Yoakum 1975, 1980; Smith and Beale 1980; Kindschy et al. 1982; Roebuck 1982; Pyrah 1987; Anderson et al. 1990*a*,*b*; Howard et al. 1990; Yoakum and O'Gara 1990; O'Gara and Yoakum 1992; Mosley 1994; U.S. Fish and Wildlife 1994). Others are currently being published (Pyle and Yoakum In Press, Yoakum 1995, Yoakum and O'Gara In Press). Many were generated to provide increased information for species-management plans, land use plans, environmental impact statements, or testimony for litigation in courts. Our objective is to provide a review of currently available literature and major endeavors in progress concerning scientific and management reports documenting the habitat requirements of pronghorn, relationships of pronghorn to livestock, and welfare of pronghorn resulting from management, particularly habitat improvements, and cultural practices common on western rangelands.

PRONGHORN AND RANGELANDS

Distribution

When Euro-Americans began to explore North America, they found pronghorn from the plains of south-central Canada (i.e., Alta., Sask., Manit.), south through most of the western United States, to 160 km of Mexico City, Mexico (Fig. 4) (Nelson 1925). Herds ranged from the Mississippi River to the Pacific Ocean in central California. Further south, herds extended from the Gulf of Mexico in Texas to the Pacific Ocean in Lower California. Pronghorn populations reached greatest densities with

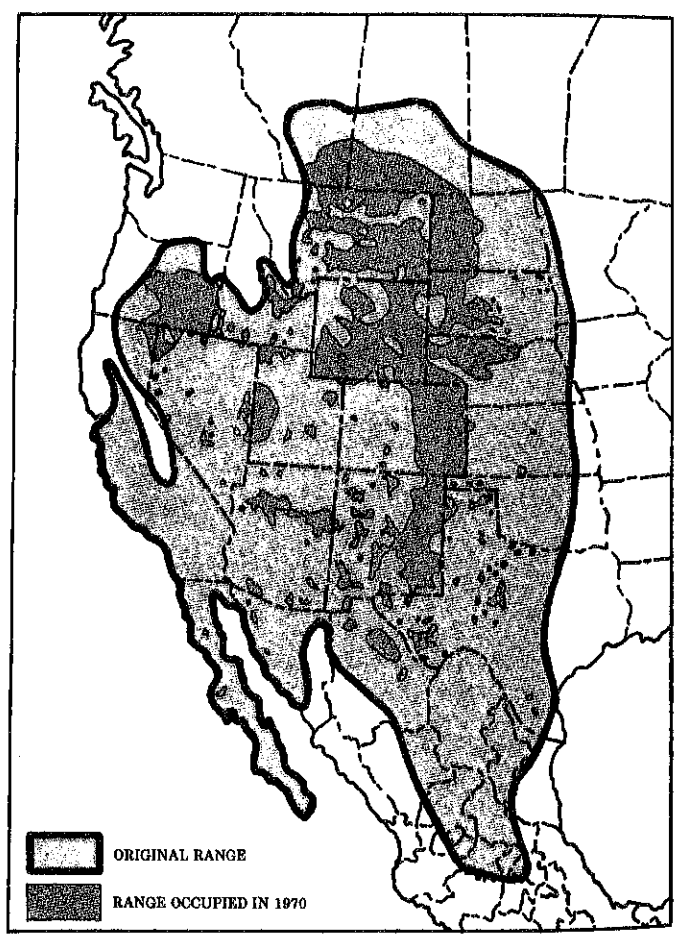

FIGURE 4. Historical and contemporary range of pronghorn. "Original range" adapted from Nelson (1925). Not all areas within these boundaries were occupied. Range occupied in 1970 modified from Yoakum (1978).

bison on grasslands of the Great Plains. Smaller populations occupied intermountain and desert regions. They did not occur east of the Mississippi River in the tallgrass prairies and woodlands (Yoakum 1978).

Today, pronghorn occupy many of their historic rangelands, but in greatly reduced numbers (e.g., perhaps there is 1 pronghorn today where >60 existed in 1800). More herds now are confined to smaller isolated habitats, unable to make historical seasonal movements because of freeways, railroads, fencing, and other constraints of modern civilization. The endemic pronghorn is the most representative big game species dependent upon western rangelands. Bison, elk (*Cervus elaphus*), and deer (*Odocoileus* spp.) use western rangelands but also occupy forested areas. Only the pronghorn is predominantly limited to American rangelands from Canada to Mexico (O'Gara and Yoakum 1992).

Abundance

Nelson (1925) estimated there were 30 to 60 million pronghorn at the beginning of the nineteenth century. Some reports indicate they were as numerous or possibly more abundant than bison (Seton 1927, Grinnell 1929).

During the late 1800s, herds were hunted relentlessly by sport and commercial hunters who killed animals regardless of sex or age. The biocide led some conservationists to believe the species was doomed to extirpation (Grinnell 1929). Much of the best habitat was lost to the plough, and pronghorn movements became increasingly restricted by sheep-tight fences and other man-made impediments. Pronghorn also were subjected to livestock diseases and parasites to which they had little resistance. Numbers dropped from an estimated 35,000,000 in 1800, to perhaps 13,000 in 1910 (Yoakum 1978). Then a concerned public enacted protective laws and supported conservation and management. Within a decade, the population more than doubled, and their continued recovery has been one of the remarkable success stories of wildlife management in North America.

All regulated sport hunting was curtailed until numbers increased sufficiently to sustain viable populations. Capturing and translocating pronghorn to unoccupied historic rangelands became a major management practice. Water improvements were developed by the thousands as a product of multiple-use in areas where drinking water was scarce. With controlled hunting, rangeland improvements, and wildlife enhancement projects, pronghorn populations prospered. From 1924 to 1984, pronghorn increased > 3,300% (Table 1). They are now second only to deer in abundance and harvest in the United States. A similar story exists for Canada, with accelerated population increases for the last 60 years. However, there has been a continuous decrease in populations in Mexico. Although fully protected by law since the 1920s, herds in Mexico apparently are not effectively protected from illegal hunting and loss of habitat to human occupation. This has resulted in all 3 subspecies in Mexico (*A. a. mexicana*, *A. a. sonoriensis*, and *A.a. peninsularis*) being classified as endangered. Of the total pronghorn population in North America, < 1% is classified as endangered; the populations in Mexico or on rangelands along the Mexico-United States border (Yoakum and O'Gara In Press).

Habitat Requirements

Several recent studies have presented pronghorn distribution by biome (Yoakum 1972, Sundstom et al. 1973, Yoakum and O'Gara In Press). Currently, 68% of the herds inhabit grasslands, 31% shrub-steppes, and 1% deserts.

Pronghorn occupy rangelands from sea level to 3,300 m in elevation. Only small populations inhabit environments at the extreme limits of elevations, whereas the majority occur in habitats from 1,200 to 1,800 m. Highest densities occur on rangelands averaging 25-40 cm of precipitation/year. Some subspecies live in areas of less precipitation, but densities are lower. Most pronghorn rangelands receive some snow; however, when snowfall exceeds >40 cm, pronghorns have difficulty obtaining sufficient forage. Prolonged winters with deep snow are the major cause of mortality for northern herds because of insufficient quality forage, excessive wind chill, and human-made obstacles impeding movement to areas with less snow (O'Gara and Yoakum 1992).

Rangelands maintaining high pronghorn densities have drinking water available every 1.5-6.5 km (Sundstrom 1968, Kindschy et al. 1982, Yoakum In Press *a*). Small herds can exist >8.0 km from water, but Sundstrom (1968) found that 95% of more than 12,000 pronghorn were within 6.5 km of water. Pronghorn usually obtain drinking water from springs, streams, lakes, potholes, water catchments, troughs, or snow. When succulent vegetation is available, about 1 L of water/day appears sufficient. However, during dry, hot summers, an individual may require 4 to 6 L/day (Sundstrom 1968, Yoakum In Press *a*).

The average daily intake of air-dry forage/44 kg pronghorn is 1.0-1.5 kg (Zarn 1981). Pronghorn are opportunistic feeders, selecting palatable, nutritious, succulent forage. They are dainty, selective feeders, taking small bites of preferred leaves, flowers, and terminal parts. Rarely do they feed extensively in one place, but move frequently as they forage. According to Wagner (1978), pronghorn consume < 1% of forage produced on western rangelands in the United States. Similar estimates were made by Kindschy et al. (1982) in Oregon and by Longhurst et al. (1983) in Nevada.

More than 200 diet studies of pronghorn have been reported in the literature. However, only 21 of those presented data regarding diet selection in relation to availability of vegetation yearlong (Yoakum 1990). Nine studies were conducted in grasslands, 11 in shrub-steppes, and 1 for desert. For all biomes, grass was the least preferred forage class (0.2 preference rating). Forbs consistently had the highest preference rating (3.8-5.8). Feeding preferences for shrubs were 1.4-1.6. These analyses indicate that pronghorn prefer forbs, then shrubs, and seldom eat grasses (Fig. 5). Thus, management should promote an abundance of preferred forb species on pronghorn habitats. However, an abundance of less preferred forbs and much reduced grass cover resulting from excessive livestock grazing is detrimental to pronghorn welfare.

The pronghorn has specific habitat requirements. Greater populations occur in grasslands and shrub-steppes with large expanses of flat, or low rolling terrain without major physical barriers to seasonal movements (Table 2). The quality and quantity of vegetation also appear to be major factors affecting pronghorn densities. Habitat quality for pronghorn is directly related to proper percentages, quantities, and distribution of physio-

TABLE 1. Estimated populations of pronghorn in Canada, Mexico, and United States from 1924 to 1984 (Yoakum and O'Gara In Press).

Country	Years				Change 1924-1984		
Province or State	1924[a]	1964[b]	1976[c]	1983-84[d]	No.	%	% population
Canada							
Alberta	1,000	16,000	17,000	21,500	20,500	2,050	2
Saskatchewan	300	4,300	5,300	10,000	9,700	3,250	1
Total	1,300	20,300	22,300	31,500	30,200	2,300	3
Mexico							
Chihuahua	700			307	–393	–56	T
San Luis Potosi	600			15	–585	–97	T
Sonora	600			63	–537	–89	T
Coahuila				12			T
Lower California	500			64	–436	–87	T
Total	2,400	1,200	1,000	461	–1,939	–81	T
United States							
Ariz.	700	10,000	7,300	9,000	8,300	1,200	T
Calif.	1,200	2,700	5,000	6,800	5,700	500	T
Colo.	1,200	15,200	31,000	57,500	56,300	4,900	5
Id.	1,500	4,700	13,300	21,500	20,000	1,300	2
Kans.	10	100	1,100	1,200	1,100	11,000	T
Mont.	3,000	95,000	71,200	161,500	158,500	5,300	15
Nebr.	200	9,000	9,800	9,000	8,800	4,400	T
Nev.	4,300	4,500	6,500	9,800	5,500	130	T
N.M.	1,700	22,500	26,900	30,000	28,200	1,700	3
N.D.	200	14,200	8,100	5,700	5,500	2,700	T
Okla.	20	200	200	400	200	100	T
Oreg.	2,000	8,900	11,300	14,000	12,000	6,000	1
S.D.	700	27,400	35,500	67,000	66,300	9,500	6
Tex.	2,400	9,400	10,500	12,000	9,600	400	1
Ut.	700	1,000	2,600	6,000	5,300	800	T
Wyo.	7,000	140,000	168,000	608,000	601,000	8,600	58
North American Total[e]	30,500	386,300	431,600	1,051,400	1,020,600	3,400	100

[a] All populations rounded to closest 100 except Kansas and Oklahoma (Nelson 1925).
[b] All populations rounded to closest 100 (Yoakum 1968).
[c] Yoakum (1978).
[d] Data for Canada and U.S. are 1983 (Yoakum 1986); Mexico is 1984 (Gonzales and Laffon 1993).
[e] Rounded to closest 100.

graphic and vegetative characteristics; too little or too much of any component may be a major factor limiting pronghorn production and survival. For example, Ellis (1970) compared pronghorn population dynamics for the shrub-steppes of the Great Basin with the grasslands of the Great Plains. Ellis (1970) noted fecundity was 190 fawns/100 producing does for both ecosystems. Fawn survival was twice as high and grass and forb production was higher on the Great Plains than in the Great Basin. Nutritive values (particularly protein) of grasses and forbs were greater than shrubs during late spring and early summer. Ellis (1970) concluded that fawn survival was twice as high on the Great Plains because of abundant, nutritious grasses and forbs during late gestation and early lactation. Thus, the reduced availability of herbaceous forage, partly because of consumption by livestock, apparently resulted in rangelands of lower carrying capacity for pronghorn in the Great Basin.

RELATIONSHIPS WITH OTHER RANGELAND WILDLIFE

Wild animals (including predators, rodents, rabbits, and other herbivores) have coexisted and interacted with pronghorn for centuries. King (1955), Koford (1958), Costello (1970) and Cid et al. (1991) speculated that prairie dogs (*Cynomys* spp.) enhanced grasslands for pronghorn by consuming grasses and disturbing soils, thereby increasing the abundance and variety of forbs. Lovaas and Bromley (1972) found the reverse, report-

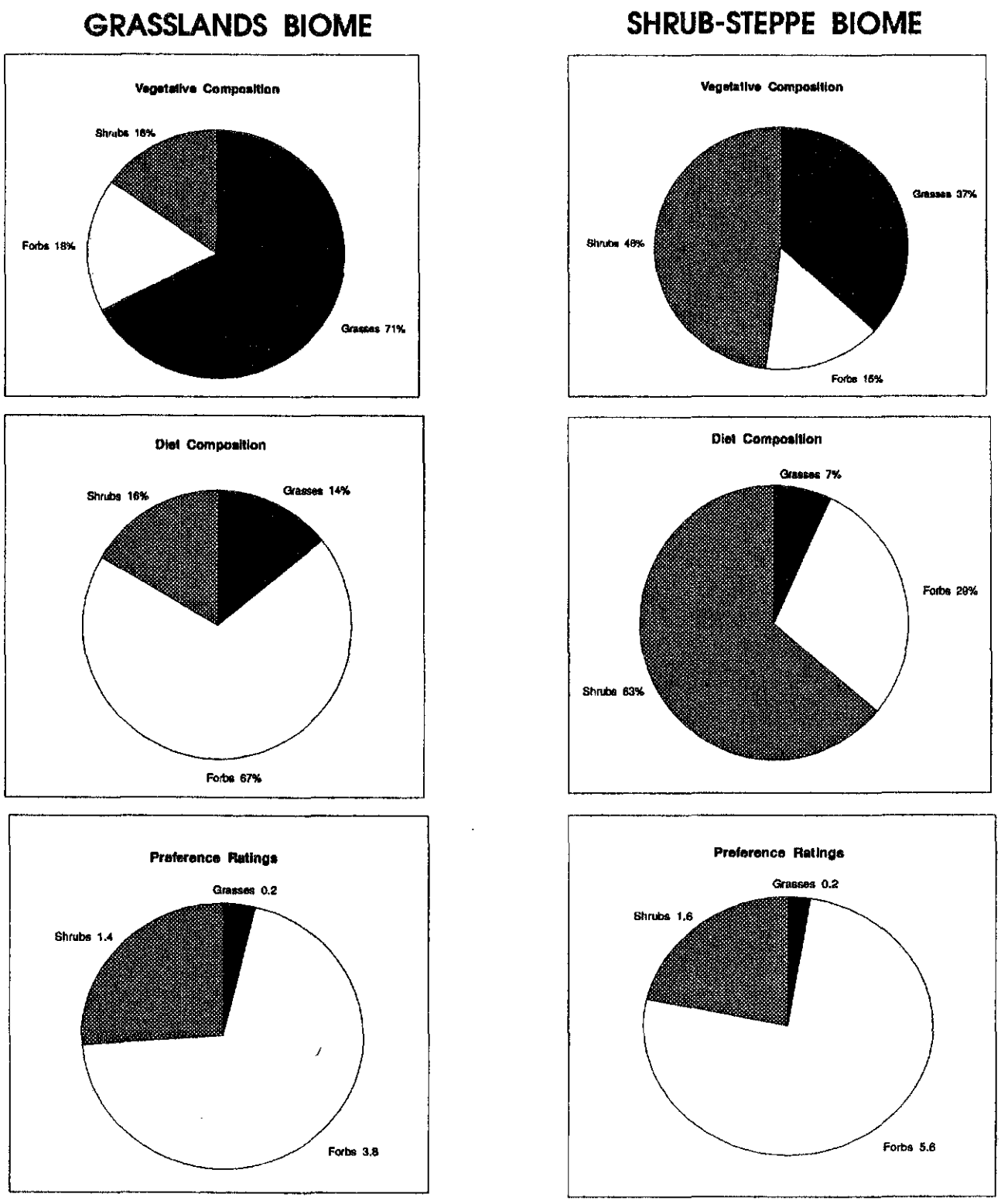

FIGURE 5. Comparison of vegetational composition, diet selection, and preference ratings for pronghorn on grassland and shrub-steppe biomes (modified from Yoakum 1990).

ing that prairie dogs degraded vegetation conditions and competed with pronghorn for preferred forage.

Predatory birds and mammals kill some pronghorn, but predation usually is significant only on marginal rangelands or sites where predator numbers are high in relation to pronghorn numbers. Most predator losses occur among fawns 1-3 weeks of age, while separated from their dams (O'Gara and Yoakum 1992). As pointed out by Hornocker (1970), if suitable habitat is not available for a prey species, no amount of predator management will bring about flourishing populations of that prey species.

TABLE 2. Habitat factors and requirements for pronghorn in grassland and shrub-steppe biomes (Yoakum and O'Gara in Press).

Habitat	Pronghorn Requirements	
Factor	Grassland Biome	Shrub-steppe Biome
Abiotic		
1. Physiography	Large, expansive area (40 km minimum), low rolling terrain, no major physical barriers, slopes < 30%	
2. Climate		
Precipitation	25-40 cm	20-30 cm
Snow depth	25-40 cm	25-40 cm
Temperature	Not a major problem, as herds inhabit hot, semi-arid areas to cold alpine steppes	
3. Soils	Not a determining factor except in relation to soil/site vegetation production	
4. Water (drinking)		
Quantity	1.0-5.5 l/day	1.0-5.5 l/day
Distribution	1.5-6.5 km	1.6-6.5 km
Biotic		
1. Vegetation		
Forage consumption	1.0-3.5 kg air-dry forage/day	1.0-3.5 kg air-dry forage/day
Ground cover	60-80% vegetation	30-50% vegetation
Plant spp. composition	50-80% grasses	5-15% grasses
	10-20% forbs	5-10% forbs
	<5% shrubs	10-35% shrubs
Plant spp. diversity	10-20 grasses	5-10 grasses
	20-60 forbs	10-70 forbs
	5-10 shrubs	5-10 shrubs
Height	25-45 cm	25-45 cm
	>65 cm unfavorable for most habitats	
Succulence	The more availability year-round the better for all forage classes	
Communities	Greater variety and diversity important (i.e., meadows, playas, wildfire burns)	
2. Animal		
Wild ungulates	Few competition or compatibility problems	
Predators	Pronghorn may be reduced or limited in areas of low densities or isolated herds	
Mankind	Suitable habitat being usurped. Increased construction of barriers (mainly fences) Predator control, water developments, and alfalfa plantings beneficial. Livestock commensal in grasslands: competitive for forage in shrub-steppe and desert biomes	

Bison and pronghorn lived commensally prior to the arrival of Europeans; both ungulates used the forage and water on the vast grassland prairies (O'Gara and Yoakum 1992). Apparently bison did not coexist with pronghorn historically in the Great Basin or on deserts. Schwartz and Nagy (1976) compared diets of bison and pronghorn in Colorado, and attributed diet differences to the species rather than the rangeland (Table 3). McCullough (1980) studied niche separation for bison and pronghorn in Montana and determined that diet overlap was minimal: bison consumed mostly grasses while pronghorn ate forbs and shrubs. Bison disturbed dominant grass communities by trampling, wallowing, and grazing that resulted in greater production of forbs and shrubs favored by pronghorn.

Range and habitat overlap between elk and pronghorn occurred more in pristine times than it does now. Buechner (1950*a*) observed elk and pronghorn foraging together and noted no acts of aggression and little dietary overlap (Table 3). Bailey and Cooperrider (1982) reported that the greatest seasonal dietary overlap between these 2 species in Colorado was during winter (59%), with less in the spring (33%), summer (38%), and fall (31%). McCullough (1980) found little overlap in the niches occupied by elk and pronghorn in Montana. There was little competition for space, water, or forage. Elk foraged primarily on grasses, whereas pronghorn preferred forbs and shrubs; consequently, dietary overlap was low (11.3%).

Pronghorn occur on rangelands with whitetail and mule deer; however, their distributions usually do not overlap (Buechner

TABLE 3. Dietary overlap for forage classes between pronghorn and bison, white-tailed deer, mule deer, elk, and wild sheep (Yoakum and O'Gara In Press).

Species	Reference	Location	Biome	% dietary overlap			
				Grasses	Forbs	Shrubs	Annual
Bison	Buechner (1950*b*)	Wichita Mountains National Wildlife Refuge, Okla.	Grassland	1.0	1.0	—	2.0
	Schwartz and Nagy (1976)	Pawnee Grasslands, Colo.	Grassland	41.0	3.0	0.0	44.0
	McCullough (1980)	National Bison Range, Mont.	Grassland	2.8	1.4	0.1	4.3
Elk	Buechner (1950*b*)	Wichita Mountains National Wildlife Refuge, Okla.	Grassland	0.1	24.0	0.0	24.1
	McCullough (1980)	National Bison Range, Mont.	Grassland	2.9	4.6	3.8	11.3
	Bailey and Cooperrider (1982)	Trickle Mountain, Colo.	Shrub-steppe	3.5	11.5	45.5	60.5
Whitetail deer	Buechner (1950*b*)	Wichita Mountains National Wildlife Refuge, Okla.	Grassland	0.0	99.0	0.0	99.0
	McCullough (1980)	National Bison Range, Mont.	Grassland	2.9	24.8	18.5	46.2
Mule deer	Barmore (1969)	Yellowstone National Park	Shrub-steppe	16.6	9.2	52.0	77.8
	McCullough (1980)	National Bison Range, Mont.	Grassland	2.3	27.1	33.3	62.7
	Hanley (1980)	Northeast Calif. and Northwest Nev.	Shrub-steppe	2.3	4.2	82.3	88.8
	Bailey and Cooperrider (1982)	Trickle Mountain, Colo.	Shrub-steppe	3.5	10.2	79.5	93.2
	Hansen (1986)	Sheldon National Wildlife Refuge, Nev.	Shrub-steppe	5.0	31.0	39.0	75.0
Wild sheep	McCullough (1980)	National Bison Range, Mont.	Grassland	2.9	12.3	11.4	26.6
	Bailey and Cooperrider (1982)	Trickle Mountain, Colo.	Shrub-steppe	3.5	6.2	56.6	66.3
	Hansen (1986)	Sheldon National Wildlife Refuge, Nev.	Shrub-steppe	5.0	32.0	14.0	51.0

1950*b*, McCullough 1980, and Bailey and Cooperrider 1982). All have similar diets (primarily eating forbs and shrubs) but overlap is minimal because of differences in habitats occupied (Table 3). Behavioral interactions were minimal because pronghorn were generally diurnal while deer were crepuscular and nocturnal.

Three studies reported diets for wild sheep (*Ovis canadensis*) and pronghorn (McCullough 1980, Bailey and Cooperrider 1982, Hansen 1986) (Fig. 6). McCullough (1980) found little overlap in space occupied and little competition for forage between these 2 species in Montana. Bailey and Cooperrider (1982) noted overlap was greatest in Colorado during winter (67%) and least in summer (42%). Hansen (1986) found diets of pronghorn and wild sheep in Nevada to have an annual overlap of 51% with the greatest overlap involving forbs (32.0%).

Decker (1978) reported ≥ 10 species of wild, exotic ungulates were established in the United States. Most were deer, sheep, goats, and pigs occupying forested, mountainous ecosystems. Only the gemsbok (*Oryx gazella*) is a member of the antelope subfamily Antilopineae and inhabits open rangelands similar to pronghorn habitat. Gemsbok were translocated during the 1970s to the White Sands Missile Range in southcentral New Mexico (Pederson 1989) where they are free-roaming and coexist with

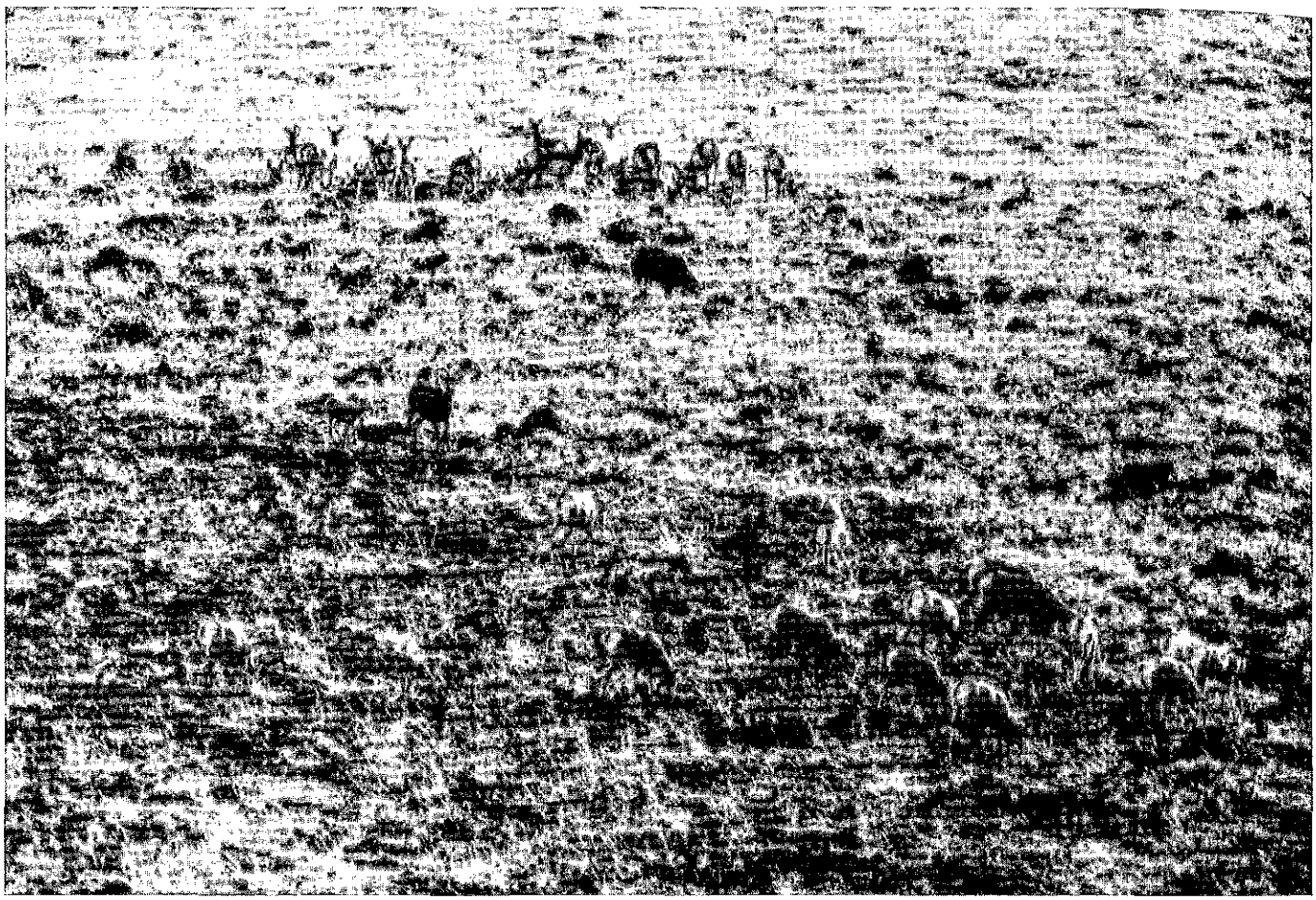

FIGURE 6. Pronghorn and bighorn occupy a prescribed burn and non-burned rangelands on the Hart Mountain Antelope Refuge in southcentral Oregon. Photo by Bill Stormont, courtesy of the U. S. Fish and Wildlife Service.

pronghorn. Smith (1994) did not observe gemsbock mingling with pronghorn, although they were frequently within 0.8 km of each other. There was similarity in forage species consumed; however, overlap was only 0.19.

RELATIONSHIPS WITH LIVESTOCK

It has been postulated that 98% of pronghorn populations share rangelands with domestic or feral livestock at some time during a year (Yoakum and O'Gara 1990). Livestock on western rangelands are either domestic animals including cattle, sheep, and horses; or feral stock, primarily horses. Goats, pigs, and burros occur in low numbers and their impact to the pronghorn is minimal.

Interactions between livestock and wild ungulates were documented by Wagner (1978), who compared historic and contemporary populations in the western United States. He calculated that the livestock animal unit months (AUMs) during 50 years in the mid-1900s was the highest in history, while that of wild ungulates (i.e., bison, bighorn, deer, elk, and pronghorn) was < 10% of what it was 125 years ago (Fig. 7).

Livestock grazing may alter pronghorn habitats more than any other human-controlled activity (Leftwich and Simpson 1978, Kindschy et al. 1982) by changing vegetation structure and composition. Pyrah (1987) suggested that livestock grazing in central Montana lowered habitat quality and decreased carrying capacity for pronghorn. When pronghorn and livestock grazed grasslands in southeastern New Mexico, they used many of the same forage species. Pronghorn did not switch to less preferred forage classes and were adversely affected when forbs

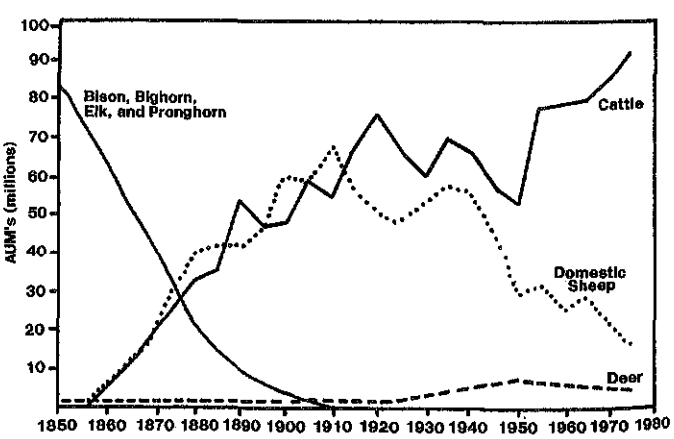

FIGURE 7. Conjectured demand for AUMs of forage by wild and domestic ungulates on western rangelands in the United States from 1850 to 1975 (modified from Wagner 1978).

and shrubs were depleted through drought or heavy livestock grazing (Howard et al. 1990).

Pronghorn use of plants noxious to livestock has been well documented (Einarsen 1948, Buechner 1950*a*, Hoover et al. 1959, Smith and Beale 1980), and pronghorn may be considered beneficial to livestock on rangelands for this reason. Many plants eaten by pronghorn are noxious to livestock because they cause injury or are unpalatable. Spines of bull thistle (*Cirsium* spp.), Russian thistle (*Salsola* spp.), and cacti make these plants less palatable to livestock, but pronghorn frequently eat them. Pronghorn consumed 11% cacti annually in Colorado (Hoover et al. 1959) and 28% in New Mexico (Smith 1994). Plants noxious to livestock but consumed by pronghorn include: woolly locoweed (*Astragalus mollissimus*), larkspur (*Dephinium* spp.), lupine (*Lupinus* spp.), death camas (*Zigadimus* spp.) in Oregon (Einarsen 1948); locoweed (*Astragalus* spp.), woody senecio (*Senecio* spp.), Riddell groundsel (*Senecio* spp.), in Texas (Buechner 1950*a*); cocklebur (*Xanthium* spp.), snakeweed (*Gutierrezia* spp.), bull thistle, Russian thistle, cacti, chokecherry (*Prunus* spp.) in Colorado (Hoover et al. 1959); tarbush (*Flourensia cernua*) in Texas (Hailey 1979); and halogeton (*Halogeton* spp.) in Utah (Smith and Beale 1980). Of 103 plants listed by Buechner (1950*a*) as eaten by pronghorn, 51 were unpalatable and 21 were considered poor forage for livestock, while only 28 were considered poor forage for pronghorn. Most of the plants unsuitable for livestock were relished by pronghorn.

Many references describe pronghorn relations with cattle, sheep, and horses. The effects of these livestock on pronghorn, including compatibility, competition, and disease-parasite factors, are species-specific. Competition, when used in the ecological sense, is an ambiguous term that can denote various meanings and concepts; therefore, we use Wagner's (1978) definition: interspecific competition is an interaction in which 2 species require the same resource, always at the expense of 1 or both.

Cattle

Most authors cited little agonistic behavior between cattle and pronghorn (Einarsen 1948, Buechner 1950*a*, Hoover et al. 1959, Schwartz 1977, Hailey 1979, Salwasser 1980, Kindschy et al. 1982, Roebuck 1982). Most investigations reported a nonaggressive association while feeding, drinking, or resting. However, Pyrah (1987) reported pronghorn generally avoided using pastures concurrently with cattle: 75% of 9,530 observations of pronghorn were in pastures without cattle. Parturient does avoided cattle during the fawning season, resulting in selection of less favorable fawn-production sites in Nevada (McNay and O'Gara 1982).

Competition for forage between cattle and pronghorn generally is minor on grasslands in fair to good ecological condition. Their diets were sufficiently different that little overlap occurred (Table 4) and averaged < 26% for the grassland and shrub-steppes. However, apparently serious competition for forage can occur in spring and summer between cattle and pronghorn in the Great Basin (Ellis 1970). Ellis (1970) reported that habitats grazed by cattle had lesser quantities of forbs and grasses for gestating and lactating pronghorn, resulting in reduced fawn production. Severe competition for forage occurred between pronghorn and cattle in Texas when a drought resulted in intensive use of forage (Hailey 1979). Cattle were given supplemental feed (pronghorn were not), resulting in heavy use of the vegetation. Livestock fences prevented pronghorn from moving to adjacent rangelands, and they turned to nonpreferred, toxic shrubs resulting in large losses and low recruitment. Roebuck (1982) studied pronghorn and cattle forage relations on rangelands in good condition in the Panhandle of Texas. Pronghorn were attracted to pastures with preferred forage regardless of the presence or absence of cattle. Greatest dietary overlap was for forbs during summer. Supplemental feeding of livestock resulted in low spring and winter forage competition. The low overlap for all forage classes and seasons suggested competition was not important on rangelands in good condition.

Exposure to diseases is a concern when pronghorn and cattle share rangelands because their spatial distribution usually overlaps. There is concern that either species may serve as a reservoir for diseases that affect the health of the other (O'Gara In Press). Pronghorn have been repeatedly checked for brucellosis and anaplasmosis but no cases have been confirmed. Blue tongue is probably the most serious disease of pronghorn, and cattle are a primary reservoir for this disease. Cattle do not develop clinical or acute symptoms, but are chronic carriers (Thorne et al. 1983). Leptospirosis causes some mortality in pronghorn, but insufficient evidence exists to implicate either pronghorn or cattle as a primary reservoir of infection (Collins et al. 1981).

Domestic Sheep

Investigators are not in agreement concerning competition between pronghorn and domestic sheep. Einarsen (1948) stated pronghorn usually avoided bands of herded sheep. Gregg (1955) observed pronghorn feeding near isolated, small bands of sheep that were away from herders or dogs. Similarly, Buechner (1950*a*) stated there was no psychological incompatibility between the species. Severson et al. (1968) reported pronghorn and domestic sheep relations in Wyoming and found no apparent stress to either as a result of the other's presence. Both often were seen grazing and drinking together, but pronghorn tended to vacate areas where sheep were herded. This reaction was believed to have resulted from the activities of the herder and dogs because pronghorn returned soon after the herded sheep moved away.

The potential for forage competition between pronghorn and domestic sheep was reported first by Taylor (1936) and subsequently supported by others (Buechner 1950*a*, Hoover et al. 1959, Russell 1964, Taylor 1975, Schwartz and Nagy 1976, Hailey 1979, Smith and Beale 1980, Howard et al. 1990). Buechner (1950*a*) reported intense competition for preferred forbs, supplemental feeding of sheep on rangelands (thus maintaining artificially high populations of sheep), and restricted pronghorn movements because sheep-tight fences limited population increases and distribution of pronghorn. Schwartz (1977) found that pronghorn and sheep ate many of the same species and that crude protein levels of ingested forage for both ungulates were similar (4-12%).

TABLE 4. Forage class dietary overlap among pronghorn and cattle, horses, and domestic sheep (Yoakum and O'Gara In Press).

Class of Livestock	Reference	Location	Biome	% dietary overlap			
				Grasses	Forbs	Shrubs	Annual
Cattle	Buechner (1950*a*)	Trans-Pecos, Tex.	Grassland	4.0	7.0	9.0	20.0
	Campbell (1970)	Southwest, Mt.	Grassland	3.0	20.3	1.6	24.9
	Becker (1972)	Winnett, Mt.	Shrub-steppe	3.0	13.0	0.0	16.0
	Taylor (1975)	Rawlins, Wyo.	Shrub-steppe	7.1	0.2	39.4	46.7
	Schwartz and Nagy (1976)	Pawnee, Colo.	Grassland	46.3	2.0	6.0	54.3
	Hanley (1980)	Northeast Calif. and Northwest Nev.	Shrub-steppe	4.1	3.4	3.7	11.2
	Smith and Beale (1980)	Southwest, Ut.	Shrub-steppe	0.0	0.0	27.0	27.0
	Beasom et al. (1982)	Roswell, N.M.	Grassland	4.0	15.2	1.3	20.5
	Roebuck (1982)	Panhandle, Tex.	Grassland	2.5	19.0	8.5	30.0
	Bailey and Cooperrider (1982)	Trickle Mountain, Colo.	Shrub-steppe	3.5	5.0	14.0	22.5
	McCarty (1982)	Little Lost-Birch Creek, Id.	Shrub-steppe	3.0	2.0	11.0	16.0
	McInnis (1984)	Burns Junction, Oreg.	Shrub-steppe	9.4	4.6	0.2	14.2
	Hansen (1986)	Sheldon Naitonal Wildlife Refuge, Nev.	Shrub-steppe	5.0	9.0	1.0	15.0
Horses	Meeker (1979)	Sheldon National Wildlife Refuge, Nev.	Shrub-steppe	3.0	23.0	2.0	28.0
	Hanley (1980)	Northeast Calif. and Northwest Nev.	Shrub-steppe	2.5	5.2	5.0	12.7
	Bailey and Cooperrider (1982)	Trickle Mountain, Colo.	Shrub-steppe	3.5	2.0	31.0	36.5
	McInnis (1984)	Burns Junction, Oreg.	Shrub-steppe	13.5	2.1	0.3	15.9
	Hansen (1986)	Sheldon National Wildlife Refuge, Nev.	Shrub-steppe	5.0	6.0	0.0	11.0
Sheep	Buechner (1950*a*)	Trans-Pecos, Tex.	Grassland	4.0	19.0	10.0	33.0
	Severson et al. (1968)	Red Desert, Wyo.	Shrub-steppe	3.2	2.6	28.4	34.2
	Campbell (1970)	Southeast, Mt.	Grassland	3.0	27.3	25.3	55.6
	Taylor (1975)	Rawlins, Wyo.	Shrub-steppe	7.1	1.2	39.9	48.2
	Schwartz and Nagy (1976)	Pawnee, Colo.	Grassland	46.3	18.0	3.3	67.6
	Smith and Beale (1980)	Southwest, Ut.	Shrub-steppe	0.0	0.0	46.0	46.0
	McCarty (1982)	Little Lost-Birch Creek, Id.	Shrub-steppe	3.0	14.0	39.0	56.0
	Beasom et al. (1982)	Roswell, N.M.	Grassland	4.0	50.2	6.0	60.2

Percentages of dietary overlap in several studies (Table 4) vary from moderate to heavy (33-67%). A study of pronghorn-sheep forage competition conducted during the early 1980s in New Mexico, determined that livestock used as much as 40% of available forbs (Howard et al. 1990). As forbs declined in number or decreased in moisture content, livestock increased their use of grasses. This suggested that the potential for competition primarily was for forbs. Data on diet similarity supported this premise. Dietary overlap was highest when forbs were most available and lowest when they were least available. Clary and Holmgren (1982) reported moderate use by domestic sheep during the dormant winter period left shrubs unfavor-

able for pronghorn until spring regrowth occurred on the cold desert of southwestern Utah.

Bever (1957) reported 30-40% losses of pronghorn fawn crops on rangelands heavily grazed by domestic sheep in South Dakota. Bever (1957) also reported that pronghorn had higher parasite loads on rangelands grazed by domestic sheep than rangelands grazed by cattle. In Wyoming, illness and deaths of pronghorn fawns have been attributed to parasitic infections that were prevalent on rangelands grazed heavily by sheep. Blue tongue, a disease fatal to domestic sheep, is also probably the most serious disease of pronghorn; neither species is an important reservoir for this disease, because few animals survive to become carriers (O'Gara In Press).

Horses

Domestic and feral horses occupy rangelands with pronghorn (Yoakum and O'Gara 1990). Two studies in Nevada (Meeker 1979, Berger 1986) reported the degree of aggressive behavior between these ungulates (Table 4). Meeker (1979) noted both animals watered freely together, with pronghorn giving ground only when directly approached by horses. No aggressive action between species was noted during the study. Berger (1986) investigated pronghorn and feral horse relations for several years and recorded various instances when pronghorn were displaced by horses.

Horses predominantly feed on grasses while pronghorn prefer forbs and shrubs. Five studies listed dietary overlap as low to moderate (11-36%), suggesting that competition for food was limited (Table 4). In Idaho, Autenrieth (1982) reported that year-round foraging by feral horses was probably the most important cause of range degradation. Salwasser (1980) noted that high numbers of horses competed with pronghorn for early spring grasses and forbs in Great Basin environments. No reports of disease or parasite relations between pronghorn and horses were found in the literature.

RESPONSES TO RANGELAND PRACTICES AND IMPROVEMENTS

Rangeland management practices and improvements can be beneficial or detrimental to pronghorn populations, depending upon how they are planned and implemented. Techniques that maintain or improve habitat requirements of pronghorn will be beneficial; however, if biological requirements of pronghorn are not met, then any management action can detrimentally affect pronghorn production and survival.

Vegetation Manipulation

After 10 years of restoration, Plummer et al. (1968) reported dominant shrublands and pinyon-juniper (*Pinus* spp.-*Juniperus* spp.) communities can be rehabilitated for pronghorn and mule deer. This requires control of dominant shrub and tree species, followed by seeding a complex mixture (>6 species each) of grasses, forbs, and shrubs. More favorable results for wildlife can be produced with greater plant diversity. The more diverse the plant communities are, the more the biological requirements of pronghorn are met (Yoakum 1980, Kindschy et al. 1982, Yoakum and O'Gara 1990, O'Gara and Yoakum 1992).

The Vale Project on public lands in southeastern Oregon is one of the most extensive rangeland restoration projects carried out to date on pronghorn habitats (Heady and Bartholome 1977, Heady 1988). This large-scale, 11-year, program treated 205,000 ha for shrub control and artificially seeded 108,000 ha. Crested wheatgrass (*Agropyron cristatum*) was the predominant species planted; however forbs, primarily dryland alfalfa, and shrubs were planted in 26 seedings. Fifteen years later, nontreated vegetation areas had a vegetation composition averaging 52% grasses, 3% forbs, and 45% shrubs, and a mean height of 71 cm. Plowed and seeded (with crested wheatgrass and dryland alfalfa) sites had 76% grasses, 11% forbs, and 13% shrubs with an average height of 46 cm. The treated lands met pronghorn habitat requirements better than the untreated areas. This analysis was based upon comparisons of similar lands surrounding the treated areas, and estimates of pronghorn populations obtained from aerial censuses by the state wildlife agency. During the early years of the project (1962-64), the pronghorn herd averaged 1,420/year in the project area. Following treatment practices (1972-74), the herd increased 83% to 2,600, while herds on adjacent nontreated lands increased < 30%. Similar results for treated and untreated lands were reported in other areas of Oregon (Kindschy et al. 1982) and Nevada (Yoakum 1980).

Improvements that change native vegetation composition or structure to large monocultural grasslands of coarse, introduced perennial grasses usually produce poor habitat for pronghorn (Reeher 1969, Yoakum 1980). Pronghorn prefer soft textured grasses, such as Sandberg bluegrass (*Poa sandbergii*). Treatments of large areas require pronghorn to travel long distances to obtain preferred shrubs during the early years of plant succession. Seeded monocultures frequently provide low densities and varieties of forbs and shrubs vital to pronghorn during all seasons.

Vegetation changes resulting from wild or prescribed burns can be beneficial to pronghorn (Deming 1963, Yoakum 1978, Kindschy et al. 1982, Courtney 1989, O'Gara and Yoakum 1992, U.S. Fish and Wildlife Service 1994, Gruell 1995, Pyle and Yoakum In Press). This is especially true when extensive, tall, dense shrub communities are burned, resulting in increased grass and forb production. Courtney (1989) reported frequent use of burned grasslands by pronghorn in Alberta (i.e., Fig. 6).

Water Developments

Pronghorn use water developments with domestic livestock (Sundstrom 1969, Yoakum In Press *a*). Studies in Utah (Beale and Smith 1970) suggested that water developments supported pronghorn where natural water sources were limited, particularly during dry seasons or drought years. Such developments should be placed every 2.5-4 km to meet requirements of pronghorn (Taylor 1972).

Hundreds of small reservoirs have been constructed on public lands through cooperative funding by state wildlife and federal land management agencies, and private sources. Such developments often are natural in appearance and serve a variety of wildlife. Part of each reservoir should be fenced to

exclude heavy grazing by livestock. Another water development of high value to pronghorn is the trench reservoir. These are used by pronghorn, especially during late summer and hot weather when vegetation becomes desiccated and physiological requirements for water increase (Yoakum 1980).

Fences

Fences can be major obstacles limiting or restricting pronghorn movement to food and water or to escape from deep snow (Yoakum and O'Gara 1990, Mosley 1994). These impediments to seasonal movements can be disastrous for northern (Spillett 1965) and southern herds (Buechner 1950*a*, Hailey 1979). Most fences on western rangelands are constructed to control livestock. How fences are constructed can have an impact on pronghorn and other wildlife. As early as the 1870s, Caton (1877) reported pronghorn characteristically go under barbed-wire fences rather than through or over them.

Recommendations for wire fences that allow pronghorn easy passage are provided in research reports and agency guidelines (Spillett 1965, Mapston and Zobell 1972, U.S. Bureau Land Management 1985, O'Gara and Yoakum 1992). Specifications for construction of barbed wire fences that allow pronghorn to go under the bottom wire have been established (Fig. 8). Many kms of "sheep-tight" or woven-wire fences, have been built to control domestic sheep. These have become barriers to pronghorn mobility. The "wolf-type" fence constructed with woven and barbed wire to control coyotes on domestic sheep rangelands in the Southwest completely restrict pronghorn movements (Yoakum 1980). The biological and legal implications of the wolf-type fence are well documented in legal hearings held during April 1978 (Gist Ranch, New Mexico 6-78-1, 21 Aug 1978). The conclusion was that wolf-type fences were legal on public lands prior to passage of the Federal Land Use and Management Act of 1976; however, this law mandated multiple-use on rangelands administrated by the U.S. Bureau of Land Management, and such fences now violate that law.

In some areas of the Southwest, stockmen encircle water sources with fences to trap or redistribute livestock (Yoakum 1980). Closed gates restrict pronghorn from the water and sometimes force movements to other rangelands. These enclosures are constructed of woven wire, >6 barbed wires, or snow-control fencing. These fence structures detrimentally affect pronghorn, especially fawns inexperienced in negotiating such barriers. Such fencing of water holes may violate the same basic principle of multiple-use as wolf-type fences.

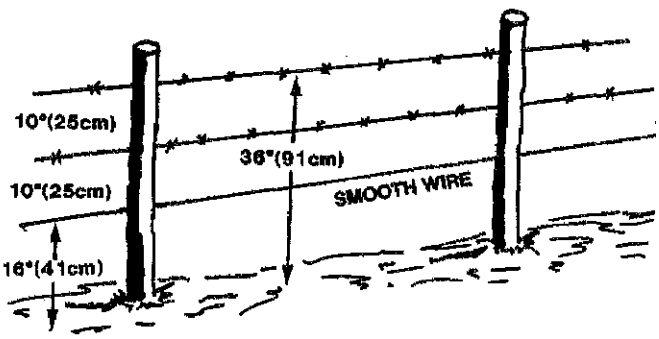

FIGURE 8. Suggested construction specifications for barbed-wire fences on rangelands occupied by pronghorn and cattle (adapted from Kindschy et al. 1982).

The feasibility of constructing special facilities that allow pronghorn passage through livestock fences was investigated in Wyoming (Spillett 1965, Mapston and Zobell 1972) and in New Mexico (Howard et al. 1990). A structure called an "antelope pass" was developed that allows some movement by pronghorn. However, the authors were adamant that the structures needed to be improved for safe pronghorn passage because some fawns broke legs in the structures.

Wildlife biologists in Idaho adjusted barbed wire fences to allow seasonal movements of pronghorn on rangelands mutually used with livestock (Anderson and Denton 1980). Height of the lower wire was raised above the ground 46-96 cm. This had special merit in habitats receiving snow depths >30 cm, which can restrict pronghorn movement under fences, and at times entrap individuals.

A second legal test dealing with pronghorn and livestock fences resulted when a wire fence was constructed around approximately 3,885 ha of private and public lands near Rawlins, Wyoming. The fence prevented movement of pronghorn to critical winter habitat; many died of malnutrition when unable to move to adjacent rangelands to obtain forage. The case was tried before the U.S. District Court, and the presiding judge found the woven-and-barbed wire fence in violation of the federal Unlawful Inclosure Act of 1885. The appellant appealed the ruling to the Tenth Circuit Court of Appeals where it was upheld, then appealed again to the United States Supreme Court which recognized the decision of the District Court (O'Gara and Yoakum 1992).

Livestock Grazing Systems

Livestock grazing systems are planned strategies to maintain or improve carrying capacities and systematically manage livestock. Effective management systems should consider the control of livestock, range improvements, determining how many livestock will use a certain rangeland, seasons of use, monitoring studies, physiology of plants, and the effects and needs of other uses on the rangelands. A number of grazing systems have been developed (Stoddart and Smith 1958, Heady and Child 1994, Holechek et al. 1994), and are increasingly used in rangeland management.

Two livestock grazing systems were designed to improve forage for pronghorn and other wildlife in the Great Basin (U.S. Fish and Wildlife Service 1970, 1980; Anderson et al. 1990*a*,*b*). Various designs of deferred livestock grazing were used over a 25-year period. However, subsequent assessments disclosed that apparently these livestock grazing systems did not enhance preferred forage for pronghorn; consequently, they were terminated (United States Fish and Wildlife Service 1994, Pyle and Yoakum In Press, Yoakum 1995).

For rangelands used by pronghorn and livestock, the following guidelines are recommended for design of livestock grazing systems.

1. When allotting forage, the habitat requirements of pronghorn should be considered.
   a. Adequate amounts of preferred plant species should be reserved as forage for pronghorn. These include grasses, forbs, and shrubs determined from diet studies in the same or similar ecosystems. Consideration should be given to proper use of key forbs and shrubs. Make sure that these are not grazed beyond their physiological tolerance levels.
   b. Forage should be reserved for a reasonable number of pronghorn. Reasonable numbers should be based on the average herd population for the past 30 years, the average forage production for the past 15 years, and management objectives for herd size determined by wildlife and land management agencies.
   c. Proper amounts of forage should be apportioned for a reasonable number of animals for specific sites and seasons of use. Special attention should be given to reserving sufficient quality forage for critical sites (i.e., natal areas, winter use areas, movement corridors, and others).
2. Drinking water should be available during all seasons pronghorn are in the area.
3. Fence construction should meet specifications to allow movements year-round for all pronghorn age classes.
4. When livestock grazing systems are designed using the "key plant species" concept, forbs and/or shrubs preferred by pronghorn should be included as key species.
5. Livestock use should be limited on pronghorn natal areas during the fawning season.
6. Livestock grazing systems that restrict, alter, limit or deleteriously affect the habitat requirements of pronghorn should include mitigating measures and alternate procedures for enhancing pronghorn habitat.

Livestock grazing systems on public lands should consider various renewable resources. Each resource is valued differently by various segments of society and decisions should reflect the will of the public. The responsibility of the resource manager is to make sound decisions based on objective analysis of alternatives and consequences.

Animal Equivalents

Managers often need to exchange use of forage for different grazers on the same rangeland. Various methods of calculating exchange ratios (i.e., animal equivalents) have been used, but none have been completely satisfactory (Heady and Child 1994). Heady and Child (1994) were of the opinion that a cow-pronghorn ratio of 1:6 has been used on rangeland more than any other, and appears to be a reasonable expression of the relative impact of these ungulates upon the rangeland.

During the 1988 joint meeting of the Interstate Antelope Conference and the Pronghorn Antelope Workshop, Kniesel (1988) presented a paper reviewing past procedures and practices for using equivalent ratios for pronghorn. He stressed the variation in AUM equivalents currently used by management agencies; e.g., 105 pronghorn = 1 cow in Colorado, 59 pronghorn = 1 cow in Idaho, 38 pronghorn = 1 cow in Texas, 7-14 pronghorn = 1 cow in Oregon, and 5 pronghorn = 1 cow in Montana. He attributed the wide variation in AUM equivalents to different methodologies and information used. Some investigators primarily used weight differentiations, while others included considerations such as dietary overlap, condition of rangelands, and other factors. He concluded that assessing AUM equivalents for pronghorn and livestock is still a problem, because there is little agreement between various state and federal agencies applying exchange ratios in forage allocations for multiple-use programs.

MANAGEMENT RECOMMENDATIONS

Increasing human populations result in ever increasing demands for land resources and products. On western rangelands, this demand requires management practices that produce optimum sustained yields of livestock and wildlife. Management procedures developed over the past 50 years provide techniques to maintain sustained yields of livestock and pronghorn while protecting the rangeland resources. This requires coordinating management practices for both classes of animals. Standards for livestock husbandry and pronghorn enhancement have been developed, but have been poorly coordinated. Despite this, production of both has increased during the last half century. Now, the task is to manage these rangeland resources on a sustaining basis. We have worked with this challenge and suggest the following.

1. Many rangelands can produce concurrent dense populations of pronghorn and livestock. The key is maintaining these rangelands in good ecological condition. Pronghorn and livestock thrive in subclimax habitats, but production decreases for both when excessive livestock grazing produces poor rangeland conditions.
2. Management plans need to incorporate the requirements of livestock and pronghorn simultaneously. Past practices have not always recognized the critical habitat requirements of pronghorn. Managers must be knowledgeable of these requirements and implement practices to meet them, while also providing the much less restrictive requirements of livestock.
3. We cannot emphasize too strongly that, if managers maintain or improve quality habitats, animals have a good chance to maintain healthy condition and numbers. Time is required to discover, understand, and implement techniques to maintain rangeland conditions. Healthy rangelands normally produce healthy animal populations.
4. Based upon our experiences, the following guidelines will help maintain dual use by pronghorn and livestock on western rangelands.
   a. Both animal groups exhibit tolerance and compatibility when they occur together in reasonable numbers on grasslands in fair to good ecological status. However, consumption of grasses and forbs by livestock from March to August is a major competition problem for pronghorn on many shrub-steppes of the Great Basin and desert regions in poor ecological condition.

b. Natural vegetation should be managed to provide an abundance and variety of forage classes. Most livestock graze grasses; pronghorns primarily consume forbs and shrubs. Rangelands producing mixtures of grasses, forbs, and shrubs will best serve livestock and wildlife. The challenge is to maintain existing rangelands in good ecological status with native vegetation. When deteriorated sites require rehabilitation, practices that restore vegetation to natural diversity are more desirable than practices that bring about monocultures and other unnatural conditions.
c. Practices that increase availability of long-term drinking water sites are highly beneficial to both animal groups (see chapter 23). Water should be available every 1.5-6.5 km. Water improvements can be designed in a number of ways; however, those that simulate natural waters are favored and cause fewer problems.
d. Both pronghorn and livestock experience problems with predation, diseases, and parasites. Managers need to recognize how these factors affect the animals and coordinate control techniques beneficial to both groups.

SUMMARY

Pronghorn coexist with wild, domestic, and feral animals on western rangelands. Each group exhibits different degrees of compatibility and competition.

Relative to wildlife, it appears bison and pronghorn occupy similar habitats but have little dietary overlap. Deer, elk, and wild sheep have greater dietary overlap, but differing spatial distribution greatly decreases competition. The recent introduction of exotic antelope to historic pronghorn habitats has received limited study.

Competition with cattle and horses on grasslands in good ecological status does not appear to be a major problem, when these animals are stocked at proper levels. This is primarily the result of food partitioning. However, there appears to be serious competition for grasses and forbs from March to August in the Great Basin and deserts. Cattle may act as a reservoir for bluetongue, a disease highly fatal to pronghorn.

Competition for forage appears to be most likely between pronghorn and domestic sheep, as both consume large quantities of forbs and shrubs. Domestic sheep also carry many diseases and parasites common to pronghorn.

An area of potential conflict between livestock husbandry and pronghorn management is rangeland improvements. Forage manipulation projects that maintain or increase plant diversity and control shrub height can be highly beneficial to pronghorn; however, projects resulting in monocultures of exotic, coarse bunchgrasses have little value. Fences to control livestock can be built to allow pronghorn movements, or they can become barriers. Woven-wire fences commonly used on sheep pastures often are barriers to pronghorn movements. Most water developments have been beneficial to pronghorn.

Livestock grazing systems can be designed to be beneficial or detrimental to pronghorn. Plans that recognize forbs and shrubs as key plants for pronghorn are favored over plans centered on grasses as key species.

Animal equivalents are used for allotting forage on western rangelands. However, the methods and practices for this technique vary and need refinement.

Livestock benefit from pronghorn use of noxious plants. Reciprocal values are received by pronghorn when intensive predator control programs are conducted on rangeland to protect livestock.

The last 50 years have indicated pronghorn, other wild ungulates, and livestock can live together successfully on western rangelands in good ecological status. With enlightened management, few problems of compatibility or competition occur for forage, water, or space. Pronghorn and livestock can be the epitome of sympatric ungulates during contemporary times on managed western rangelands.

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