BLM ?
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RESEARCH SCOPE OF WORK

Assessment of Pronghorn Highway Permeability and Movements

Interstate- 17 South of Cordes Junction to Cherry Road

Presented to
HPC Committee
by
Arizona Game and Fish Department
Research Branch

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PROBLEM STATEMENT

Direct and indirect highway impacts have been characterized as some of the most prevalent and widespread forces altering natural ecosystems in the U.S. (Noss and Cooperrider 1994, Trombulak and Frissell 2000, Farrell et al. 2002). Forman and Alexander (1998) estimated that highways have affected >20% of the U.S. land area through habitat loss and degradation. Perhaps the most pervasive impact of highways on wildlife are barrier and fragmentation effects resulting in diminished habitat connectivity and permeability (Noss and Cooperrider 1994, Forman et al. 2003).

Highways block animal movements between seasonal ranges or other vital habitats (Trombulak and Frissell 2000). This barrier effect fragments habitats and populations, reduces genetic interchange (Epps et al. 2005, Riley et al. 2006), and limits dispersal of young (Beier 1995), all serving to disrupt viable wildlife population processes. Long-term fragmentation and isolation renders populations more vulnerable to stochastic events that may lead to extinctions (Hanski and Gilpin 1997). Though numerous studies have alluded to highway barrier effects on wildlife (e.g., see Forman et al. 2003), few have yielded quantitative data relative to animal passage rates, particularly in an experimental (e.g., pre- and post-construction) context, as Dodd et al. (2006 *a*) did for elk (*Cervus elaphus*) along State Route 260 in central Arizona.

Dodd et al. (2006*a*) found that elk passage rates averaged 0.88 on control sections, 0.84 on sections under reconstruction, but dropped to 0.43 when the upgraded State Route 260 was completed and opened to traffic. Permeability documented for other wildlife species has been considerably lower, though Paquet and Callaghan (1996) reported that passage rates for wolves (*Canis lupus*) averaged 0.93 along a low-volume highway; however wolf passage rates averaged only 0.06 along the Trans-Canada Highway. Waller and Servheen (2005) compared grizzly bear (*Ursus arctos*) highway crossing frequency from GPS telemetry to simulated random walk analyses to assess permeability; observed bear crossing frequency was 31% of simulated. Dyer et al. (2002) compared actual road and simulated road network crossing rates; caribou (*Rangifer tarandus*) crossed actual roads <20% as frequently as simulated networks. Compared to these and other large mammal species, the barrier effect from highways appears to affect no species as much as it does pronghorn (*Antilocapra americana*); during extensive VHF-telemetry studies in northern Arizona, Ockenfels et al. (1994) and van Ripper and Ockenfels (1998) never documented a successful pronghorn crossing of a paved and fenced highway.

The fragmentation of northern Arizona's pronghorn herds by highways, along with railways, canals, and human encroachment has contributed to isolation of populations and prevention of seasonal migration, contributing to reduction of pronghorn populations (O'Gara and Yoakum 1992, Sawyer and Rudd 2005). Pronghorn historically roamed freely in North America, including northern Arizona (Yoakum and O'Gara 2000), but populations declined as much as 99% by the early 1900's (Yoakum 1968). In Arizona, populations declined from approximately 45,000 (Knipe 1944) to only 7,500 by 2002 (Arizona Game and Fish Department, unpublished data). With increasing human development and traffic volume on highways within pronghorn habitat that already constitute barriers to pronghorn movement (Ticer et al. 1999) pronghorn are a species of considerable concern.

Wildlife passage structures have shown tremendous benefit in promoting wildlife passage for a variety of wildlife species (Clevenger and Waltho 2000, Dodd et al. 2005), and in conjunction with fencing have reduced the incidence of wildlife-vehicle collisions (Clevenger et al. 2001, Dodd et al. 2006*b*). However, the ability to promote pronghorn passage with such structures has been limited to date, as is our knowledge (Sawyer and Rudd 2005). Though Plumb et al. (2003) documented 70 crossings by pronghorn at a concrete box-culvert underpass in Wyoming (81% in a single crossing), pronghorn overall exhibited reluctance to use the structure and most of the crossing animals accompanied mule deer (*Odocoileus hemionus*) through the underpass; crossing pronghorn comprised a relatively small proportion of the local pronghorn herd.

Yoakum (2004) believed that pronghorn behavioral characteristics might preclude effective use of both underpasses and overpass of high-volume highways. Sawyer and Rudd (2005) reported that "with the exception of Plumb et al. (2003) and several anecdotal observations, we could not find any published of documented information on pronghorn utilizing crossing structures". Still, they believed that large open-span bridged underpasses might be more effective in promoting pronghorn passage than overpasses, though no studies have been done to support this contention. Where effective, underpasses have spanned natural drainages and topography; along I-17 and other highways in northern Arizona, such topographic opportunites may be limited making overpasses more appropriate. Regardless, given the degree to which highways block pronghorn permeability, the depressed nature of current pronghorn populations and the fact that U.S. Highway 89 will be reconstructed in the future to accommodate increasing volumes of traffic, the challenge before us is to determine if and how pronghorn meta-populations in northern Arizona can be reconnected to maintain population viability into the future.

Interstate 17 Study Area

Interstate-17 is the primary highway route connecting Phoenix to Flagstaff. Interstate-17 is the main highway artery serving northern Arizona and supporting the transport of goods along I-40 to the east and west. Interstate-17 is traveled by millions of tourists each year visiting area national parks (NP) and recreation areas, including the Grand Canyon NP, Petrified Forest NP, Sunset Crater National Monument, Glen Canyon Recreation Area, etc. As Arizona continues to grow, traffic on I-17 will also increase dramatically.

ADOT has begun the process to evaluate upgrading and reconstructing key sections if I-17 to address this increased traffic volume and highway safety issues. In 2006, ADOT began environmental surveys along I-17 from New River to Cordes Junction and from the Sedona interchange to Flagstaff (Interstate-40 interchange) to address planned reconstruction. Cordes Junction to SR179 will be the next phase of the project planned for reconstruction. Insights gained from our research project will help determine the best strategies maintaining connectivity and permeability for pronghorn and other wildlife species.

RESEARCH OBJECTIVES AND PROCEDURES

This research project will add greatly to our understanding of pronghorn movements in relation to highways. The overarching goal of this research project is to apply insights we gain on current pronghorn movements and permeability across I-17 to develop strategies to enhance connectivity as part of future highway reconstruction. The specific objectives and associated procedures of this research project include:

1) Assess pronghorn movement patterns and distribution relative to I-17 and determine permeability across the highway corridor,
2) Investigate the relationships of pronghorn highway crossing and distribution patterns to vehicular traffic volume,
3) Assess the degree to which I-17 and other northern Arizona highways have affected gene flow and genetic diversity among pronghorn populations, and
4) Develop recommendations on the need for, location(s) of, and type(s) of wildlife passage structures and other mitigations to enhance pronghorn permeability

Objective 1. Assess pronghorn movement patterns and distribution relative to I-17, and determine permeability across the highway corridor.

This is the primary objective of this research project and we will rely on the application of Global Positioning Satellite (GPS) telemetry. We will employ methodologies developed and reported by Dodd et al. (2006*a*) to assess movements, distribution, and measure pronghorn permeability. Our approach will be to conduct 2 phases of telemetry; the first will use new GPS collars to assess movements and permeability before right-of-way (ROW) fencing is modified (Procedure 1.1.1). The second phase of telemetry (Procedure 1.1.2.) will use refurbished collars to assess movements and permeability after sections of the highway ROW fencing contributes to reduced pronghorn permeability (Sawyer and Rudd 2005). Given the relatively short duration that pronghorn will wear the collars, especially compared to elk (22 months), the use of more costly (80% more) uploadable (to an airplane receiver) "Spread-Spectrum" GPS collars is not justified.

Procedure 1.1. Instrument pronghorn with GPS receiver collars.

Procedure 1.1.1. In the first year of the project, we will attempt to instrument 9 pronghorn with new store-on-board GPS receiver collars on each side of I-17 (18 total). Collars will be installed on pronghorn as close as possible to the highway corridor (preferably within 1 mile of the highway), and distributed among as many different herds as possible along the length of the study section of highway. Pronghorn will be captured by darting or net gunning from a helicopter, aided by a spotter plane. As pronghorn are generally crepuscular/diurnal in their habits, GPS collars will be programmed to receive 8 fixes/day between 0400–2100 hours (1 fix every 120 minutes); this time interval between fixes was sufficient to determine highway crossings (Dodd et al. 2006*a*) and assess relationships to traffic volume (Gagnon 2006). Operational battery life of these collars is projected to be approximately 22 months, and should yield 3,300 GPS fixes/animal (>50,000 total).

Procedure 1.2. Use Geographic Information System (GIS) analysis to determine pronghorn movements, highway crossing patterns, distribution relative to the highway, and to assess permeability across the highway corridor.

Procedure 1.2.1. GPS data will be downloaded to a computer after collars drop from pronghorn on pre-programmed release dates. After downloading, GPS data will be analyzed by GIS using ArcGIS and Animal Movement ArcView Extension software (Dodd et al. 2006*a*).

To determine the frequency of crossings by pronghorn, the length of the study section of highway will be broken into sequentially numbered 0.10-mile segments. Crossings will be determined where successive GPS fixes occur on each side of the highway, with the crossing segment determine to be the one in which the line between the successive fixes falls. Due to the degree to which the highway blocks the free movement of pronghorn (Van Riper and Ockenfels 1998), it is anticipated that relatively few highway crossings will occur, especially compared to elk along State Route 260 in central Arizona (mean = 96.2 crossings/elk; Dodd et al. 2006*a*). As such, determining the relative distribution of pronghorn GPS fixes within buffer zones may yield information of equal importance in assess permeability and determining locations for mitigation measures (e.g., segments with higher proportion of fixes within 0.15 mile of the highway may reflect attempted crossings). GPS fixes will be compiled by the following buffer zones:

- <0.05 mile
- 0.05–0.15 mile
- 0.15–0.31 mile
- 0.31–0.62 mile

To assess highway permeability, we will utilize the same approach as Dodd et al. (2006*a*) to measure passage rates by pronghorn. Passage rate, as a measure of permeability, is determined from the ration of highway crossings to approaches. An approach is considered to have occurred when an animal travels toward the highway and enters the 0.25-km buffer zone; it ultimately may cross or repel from the highway. Separate estimates of passage rate will be calculated and compared for both phases of telemetry.

Objective 2. Investigate the relationships of pronghorn highway crossing and distribution patterns to vehicular traffic volume.

Gagnon (2006) addressed the relationships of elk distribution and highway crossings to traffic volume, with traffic affecting both animal distribution and timing of crossings of elk accessing preferred foraging areas adjacent to State Route 260 (Manzo 2006). For pronghorn which inhabit more open habitat that may be more influenced by elevated noise levels associated with high traffic volumes (FHWA 2006), we hypothesize that traffic volume influences pronghorn distribution relative to I-17. As such, we will investigate these relationships.

Procedure 2.1. We will work with ADOT's data management section to install a traffic counting station midway along the length of the study section, along with automated data transmission capabilities. Traffic data (number of vehicles, average speed, and vehicle types) will be recorded by 15-minute intervals.

Procedure 2.2. Assess the relationship between traffic volume and pronghorn distribution and crossing patterns as determined in Procedure 1.2.1., using the same approach as Gagnon (2006).

Procedure 2.2.1. Both pronghorn highway crossing and distance from the highway will be linked to average traffic volumes for the GPS interval period. Relationships between traffic volume and pronghorn movements will be assess by logistic regression.

Procedure 2.3. Integrate the findings of this research project into a statewide assessment on the relationships of highway traffic volume and noise, and develop a comprehensive model of traffic/noise effects on wildlife. Relatively little information exists on the impact of noise on big game wildlife species, especially compared to birds (FHWA 2006). At this time, this research component has not been funded.

Objective 3. Assess the degree to which I-17 and other Arizona highways have affected gene flow and genetic diversity among pronghorn populations.

Epps et al. (2005) documented reduced genetic diversity and isolation of desert bighorn sheep (*Ovis canadensis*) in southern California tied to the construction of highways. Further, Riley et al. (2006) found that a highway in southern California limited gene flow among bobcat (*Lynx rufus*) and coyote (*Canis latrans*) populations. Given the limited degree of movement documented across highways in northern Arizona (Ockenfels et al. 1994, van Ripper and Ockenfels 1998), there is concern that highways may be contributing to genetic isolation among populations through which highways occur. We hypothesize that the degree of barrier effect and associated genetic isolation is a combined function of the size of the highway and traffic volume.

Procedure 5.1. We will attempt to measure genetic diversity using methods similar to Epps et al. (2005) to infer differences in gene flow across highways in northern Arizona; these methods focus on measuring differences among nuclear and mitochondrial DNA markers.

Procedure 5.1.1. To asses the influence of the traffic volume on genetic isolation associated with highways, we will collect samples for DNA analysis along the following traffic volume gradient of average annual daily traffic [AADT] volume:

Traffic volume class	Highway	General location of sampling	Mean AADT (20003-2005)
High	I-17	North of Cordes Junction	26,967
	I-40	Two Guns to Meteor Crater	18,000
	I-40	Between Williams and Garland Prairie	16,933
Moderately high	US 89	Between Flagstaff and Gray Mountain	7,500
	SR 64	Between Williams and Grand Canyon	4,767
	SR 77	Snowflake to Holbrook	3,137
Moderately low	US 180	East of Valle	1,533
	US 89A	Prescott Valley to fain Road	1,867
Low	SR 87	Clints Well to Winslow	593
	SR 99	South of Winslow	147

Procedure 5.1.2. During the capture of pronghorn associated with the I-17 project, we will collect blood and tissue samples for DNA analysis. Samples will be collected from animals on each side of the highway, and in proximity to the highway where possible (<1 mile away). We also anticipate collecting blood and tissue samples from pronghorn that will be captured and fitted with GPS receiver collars as part of an ATRC-approved research project along State Route 64 and US 89.

Procedure 5.1.3. At the remaining highways, we will collect samples for DNA analysis from each side of the highways and in proximity to the highways where possible (<1 mile away). We will attempt to collect samples from at least 18 individuals (9 on each side of the highways) from each sampled population (Epps et al. 2005). The collection of samples from other highways (other than US 89) will be accomplished with other funding sources.

Procedure 5.1.4. Samples will be analyzed by the Northern Arizona University Environmental Genetics Lab that specializes in DNA analysis. Results will be compiled and modeled similar to Epps et al. (2005).

Objective 4. Develop recommendations to enhance pronghorn highway permeability.

Procedure 6.1. Using all data and information, develop recommendations on the need for passage structures and other mitigations (e.g., funnel fencing, sound walls) to promote pronghorn permeability across I-17. Develop alternatives for pronghorn passage structures to promote permeability, including types and locations for inclusion in design plans for the reconstruction of I-17. Such recommendations will assess the trade-offs associated with underpasses, overpasses, and other options to promote permeability including the role of fencing, etc. Though we do not anticipate documenting a large number of pronghorn crossings of I-17 (especially compared with the nearly 6,000 crossings determined for elk along State Route 260), the data nonetheless will proved invaluable in assessing and developing recommendations on those locations where highway passage structures may promote permeability (Sawyer and Rudd 2005). For instance, along US 93 in northwest Arizona where GPS-telemetry studies were conducted 2003-2006, bighorn sheep crossed the highway relatively few times; however, their distribution patterns adjacent to the highway pointed to those sites where sheep frequently approached (and attempt to cross?) the highway and at which passage structures appear warranted (T. Smith, unpublished data.

PROJECT BUDGET

Budget Item	**Amount**
Equipment/capture	
GPS telemetry collars	40,000
Helicopter capture	10,000
Total	50,000

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LITERATURE CITED

Agresti A. 1996, An introduction to categorical data analysis. Wiley and Sons, Inc, New York, NY.

Dodd, N. L., J. W. Gagnon, S. Boe, and R. A. Schweinsburg. 2005 (in review). Assessment of highway permeability to elk using GPS telemetry.

Ockenfels, R. A., W. K. Carrel, and C. van Riper III. 1997. Home ranges and movements of pronghorn in northern Arizona. Biennial Conf. Res. Colorado Plateau 3: 45-61.

O' Gara, B. W. and J. D. Yoakum. 1992. Pronghorn management guides. Pronghorn antelope workshop, Rock Springs, WY. 101pp.

Plumb, R.E., K.M. Gordon, and S.H. Anderson. 2003. Pronghorn use of a wildlife underpass. Wildlife Society Bulletin 31:1244-1245.

Sawyer H., B. Rudd. 2005. Pronghorn roadway crossings: A review of available information and potential options.

Van Riper, C. and R. Ockenfels. 1998. The influence of transportation corridors on the movement of a pronghorn antelope over a fragmented landscape in northern Arizona. ICOWET 241-244.

Yoakum, J. D. 1968. A review of the distribution and abundance of American pronghorn antelope. Antelope States workshop proc. 3:4-14.

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