STUDY PLAN:
Restoring Landscape Connectivity for American Pronghorn Between Three Northern Arizona Parks: Wupatki National Monument, Sunset Crater Volcano National Monument, & Grand Canyon National Park

A Cooperative Agreement Study by the National Park Service and the Arizona Game and Fish Department
August 26, 2014

NPS 2016 Call To Action Theme: "Preserving America's Special Places" and Action #22: "Scaling Up"
NPS Project Management Information System #188952

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ABSTRACT:

The pronghorn population in Arizona has severely declined since the late 1800's, with the largest impacts over the last 30 years caused by dramatic land development and habitat fragmentation. Pronghorn have great difficulty crossing range fences, and are even more averse to crossing highways. As the climate warms, pronghorn will likely need to range even longer distances to reach quality summer range and available water. Under this project, NPS Natural Resource funding will contribute to a partnership of multiple state and federal agencies, private ranches, and non-profit organizations to reconnect 2,700 square miles of American pronghorn habitat across the Coconino Plateau of northern Arizona. The plateau area will likely remain among the largest protected expanses of viable pronghorn habitat within Arizona, and includes Wupatki National Monument (WUPA), Sunset Crater Volcano National Monument (SUCR) and the south rim of Grand Canyon National Park (GRCA). A series of pronghorn telemetry studies around WUPA since 1992 have highlighted the habitat barrier effect of U.S. Highway 89 (US 89) on the local pronghorn population. Recent genetic research confirms US 89 and other major highways across the plateau are critical long-term movement barriers, with distinct pronghorn subpopulations developing within the habitat blocks they form. Since 2000, the project partners have incrementally implemented a series of projects throughout the project area to modify range and highway right-of-way fences to increase their permeability for pronghorn movements. Landscape level planning and widespread implementation of modification projects was initiated in 2011. Under this Study Plan, pronghorn telemetry data will be acquired to compare movement responses to these habitat connectivity treatments to control data acquired during 2007-2010. The study objectives include testing the effectiveness of the various modifications; developing valid design specifications for pronghorn-friendly highway and range fences; assessing pronghorn habitat utilization in juniper reduction areas; and prioritizing key habitat connectivity areas and corridors, including areas that increase mobility and resiliency under climate-driven habitat change scenarios. The research directly supports planning for a pronghorn passage across US 89 near WUPA, which could be the first of its kind for this species within Arizona. The study results will also be available for planning future pronghorn habitat connectivity actions under fine-scale climate warming scenarios.

I. INTRODUCTION.

The American pronghorn (*Antilocapra americana*), also known as "antelope" in popular Western song and writing, is an iconic grassland species in northern Arizona. The animals are nomadic, and typically range long-distances in search of nutritious forage and available water, which are highly variable from year-to-year in southwestern landscapes (Yoakum and O'Gara 2000). Once roaming the grasslands of the American west in vast herds totaling around 35 million, pronghorn suffered severe population reductions due to over-hunting and habitat loss, with the continental population reaching an estimated low of 30,000 animals in 1924 (Yoakum 1986). Regulation of hunting, reduction of domestic sheep herds, and the adoption of scientific wildlife management principles are cited as reasons the population recovered to a total of one million animals by 1984. Despite this recovery, many areas have experienced frequent population fluctuations, and overall numbers have again declined since 1984 (O'Gara and Yoakum 2004).

In Arizona, the total pronghorn population has declined from an estimated 45,000 individuals in the late 19th century (Knipe 1944) to a recent low of 7,500 in 2002 (Arizona Game & Fish Department (AGFD), unpublished data). Under intensive management, the population recovered to 11,000 by 2007 (AGFD 2007). Many factors have been implicated in this decline, but the most commonly cited contemporary threats are habitat loss and habitat fragmentation associated with dramatic growth and development in Arizona over the last 30 years (Brown and Ockenfels 2007). Unlike deer and elk, pronghorn commonly experience great difficulty crossing conventional range and highway right-of-way (ROW) fences. The animals typically do not jump, but instead crawl under the lowest strand of wire. This is hazardous as the bottom strand is typically barbed and strung low to the ground. Combining fences, roads, and relatively high traffic volumes can further increase habitat fragmentation. Pronghorn are naturally averse to crossing highways, with recent research in Arizona showing few crossing attempts even at moderate daytime traffic volumes (Dodd et al. 2011).

One of the largest remaining expanses of viable pronghorn habitat in Arizona lies on the Coconino Plateau, in the north-central area of the state (Figure 1). Three national park areas occur around the plateau's perimeter – Wupatki National Monument (WUPA), Sunset Crater Volcano National Monument (SUCR) and the south rim of Grand Canyon National Park (GRCA). Visitors to WUPA and SUCR often stop to view and photograph pronghorn, and animals are typically seen on open range along U.S Highway 180 (US 180) and Arizona Route 64 (SR 64) to GRCA. The Coconino Plateau population has also declined, both historically and recently. In 2008, the AGFD estimated approximately 600 animals in the wildlife management units within the greater plateau area, with as few as 140 animals near WUPA and SUCR (AGFD, unpublished data). In addition to the factors for decline cited above, the Coconino Plateau population has been impacted by severe winter blizzards, which drove large numbers into range fences where animals froze to death (White 1969). The most recent decline occurred during the extreme drought event of 2000 through 2002.

Pronghorn telemetry movement studies in the WUPA area over the last two decades provide considerable evidence of the habitat barrier effect of US 89 on pronghorn (Ockenfels et al. 1994, van Riper III & Ockenfels 1998, Bright & van Riper III 2000, Dodd et al. 2011). The highway is the main route from Flagstaff to Page and Lake Powell within GLCA, and is one of three routes to GRCA. The highway has a fenced ROW and Average Annual Daily Traffic of 6,310 vehicles per day (Dodd et al. 2011). In 2002, the Arizona Department of Transportation (ADOT) initiated planning to reconstruct US 89 through WUPA from two to four lanes. To address concerns raised during the planning process about increased habitat fragmentation, ADOT funded research by AGFD from 2007 through 2009 (ADOT 2006). The study assessed: (1) pronghorn movement patterns and permeability across US 89; (2) relationships of highway crossing and traffic volume; (3) influence of highway right-of-way fencing on pronghorn highway crossing patterns; and (4) potential genetic isolation of pronghorn population by northern Arizona highways. AGFD was also tasked with identifying a potential location and conceptual design for a wildlife crossing structure across US 89. The results (Dodd et al. 2011) showed the highway along the western boundary of WUPA currently constitutes a nearly impermeable habitat barrier to pronghorn (Figure 2).

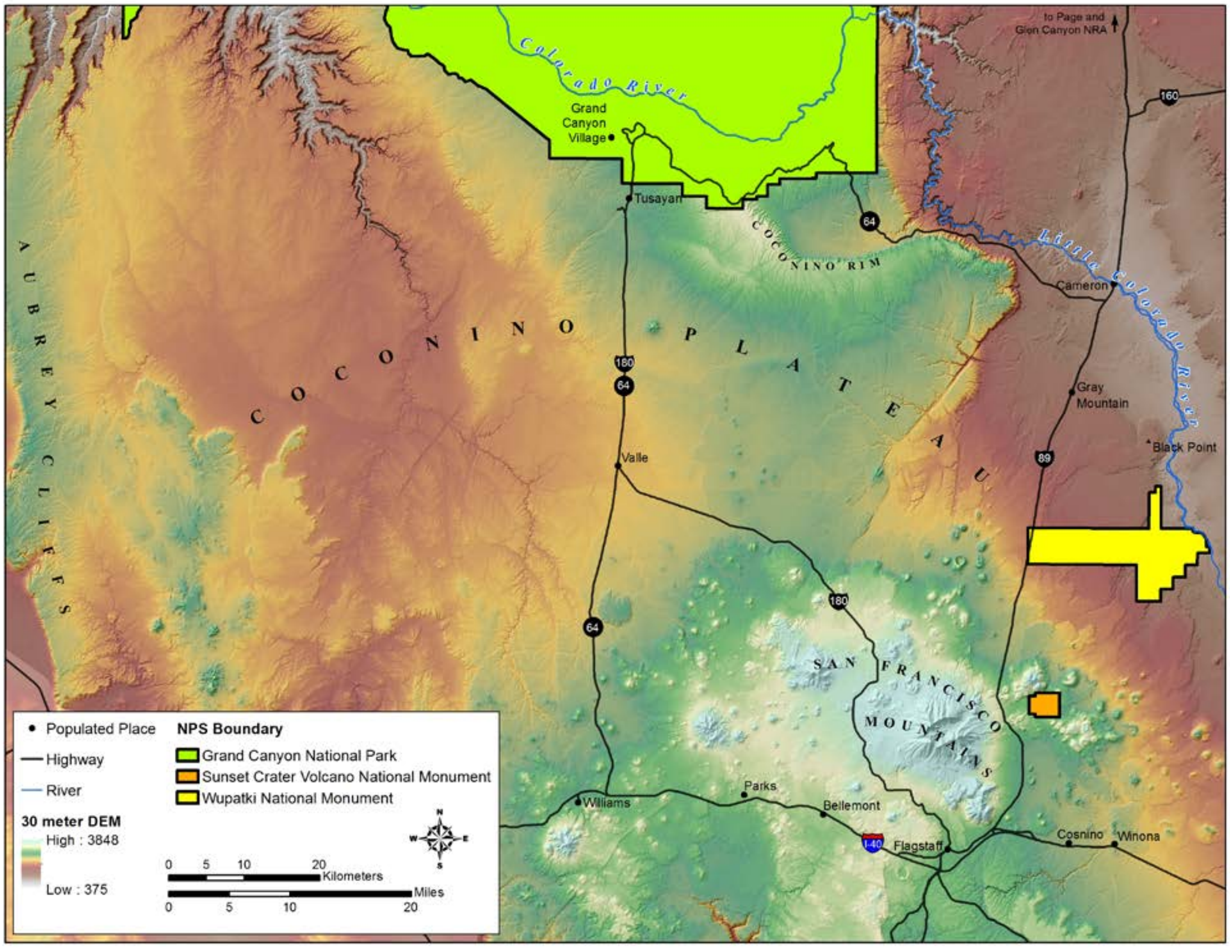

Figure 1. Map of Coconino Plateau and pronghorn habitat study area in north-central Arizona.

While the research was underway, the AGFD, NPS, neighboring CO-Bar Ranch, Arizona Antelope Foundation (AAF), and Coconino National Forest (CNF) implemented a few innovative pilot efforts to modify local range fences. At WUPA, two miles of the ROW fence on both sides of US 89 were removed in 2009 within the monument boundary, where the risk of a vehicle-livestock collision is minimal. The work was timed to allow collection of pre- and post- pronghorn movement data to evaluate whether habitat permeability was enhanced. Although the data are short-term, pronghorn began crossing US 89 within a year after fence removal (Figure 3). Three candidate sites for a wildlife overpass crossing were also identified near WUPA, based upon cumulative pronghorn approaches on both sides of the highway. Data from two other pilot sites demonstrated pronghorn readily utilize fences that have been rebuilt or modified to specifications which promote crossing under them. Movement data also demonstrated that a stretch of US 180 with the ROW fencing set back about one-tenth of a mile, allowed for pronghorn crossings.

As the US 89 study was completed, considerable pronghorn movement data was also acquired across the eastern and central Coconino Plateau. When pooled, the data suggest that pronghorn do not have a large herd-based annual migration route or corridor within the study area. Instead individual animals and smaller bands within the population range nomadically over their lives, with home ranges averaging about 70 square miles. In an unfragmented landscape, home ranges potentially overlap from the WUPA-SUCR area northwestward to GRCA, and even farther west to the Aubrey Cliffs, ensuring opportunities for breeding and genetic exchange across the entire landscape. However, in addition to US 89, the other two routes to GRCA - US 180 from Flagstaff, and SR

64 from Williams, are also pronghorn movement barriers (Dodd et al. 2011). US 89 is also the primary access to Glen Canyon National Recreation Area (GLCA). As traffic has greatly increased over the last thirty years, habitat fragmentation by the highways has resulted in a slight level of genetic isolation, resulting in three subpopulation segments that are bounded by the highways (Sprague 2010). Over future generations of genetic isolation, these small populations will experience reduced fitness and increased susceptibility to environmental challenges.

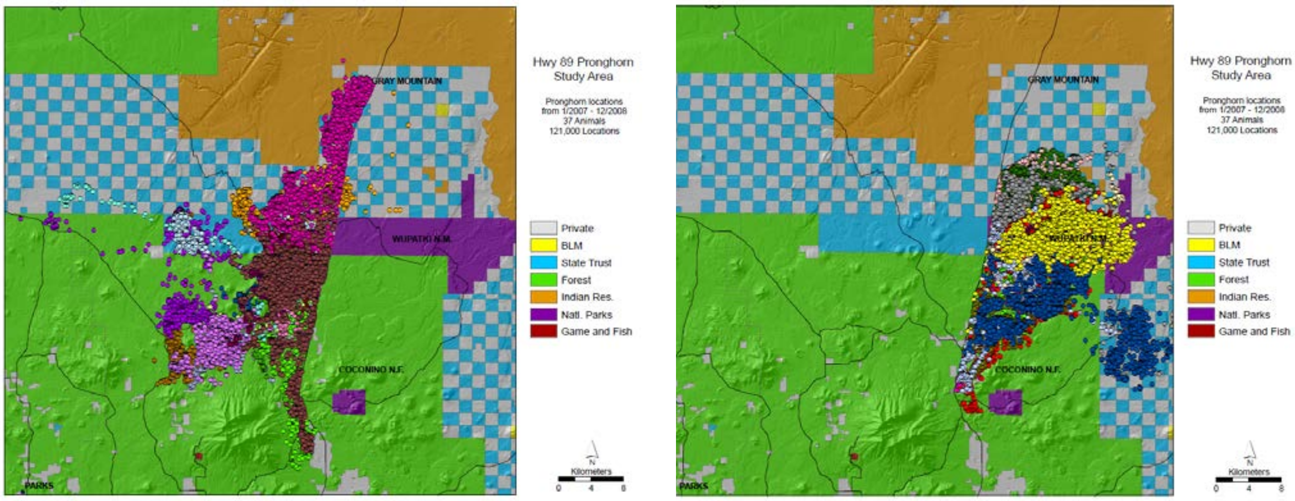

Figure 2. Pronghorn telemetry data collected on both sides of US 89 along the western boundary of WUPA during 2007-2008. The colored dots represent GPS locations from individual pronghorn, demonstrating their inability to cross the highway.

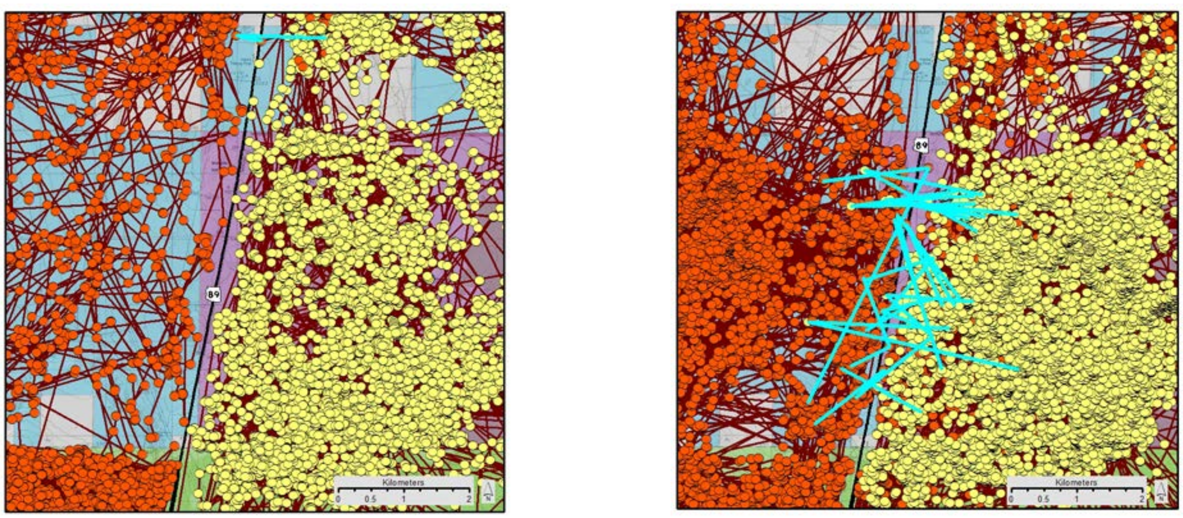

Figure 3. GPS movement data showing success of reconnecting pronghorn populations across US 89. Left map: Prior to removal of ROW fencing (2007, 21 pronghorn). Right map: After fence removal (2008 -2010, 17 pronghorn). The black line is US 89 and the purple area is WUPA, where ROW fences were removed. Each dot represents a pronghorn location, recorded at 2 hour intervals over a 14 hour period each day. Orange dots depict locations for all pronghorn collared west of US 89 and pale yellow dots depict locations for all pronghorn collared east of US 89. Light blue lines indicate pronghorn highway crossing movements as they connect successive locations on opposite sides of the highway. Dark red lines represent non-highway crossing movements. Note the increase in use of the pronghorn range west of WUPA and the increase in pronghorn movements across boundary fences to the south.

As the climate continues warming (IPCC 2007, USGCRP 2009), habitat changes will have important consequences for wildlife, including shifts in the location of suitable habitat and availability of essential resources. Many experts emphasize the need to promote ecosystem resilience and conserve wildlife movement corridors between core habitat areas (Robles & Enquist 2010). Maintaining wildlife corridors can facilitate population range shifts, colonization of new habitat, escape from avoidance of climatic extremes, maintenance of genetic diversity, and successful dispersal (Forman et al. 2003). The impacts of habitat fragmentation from land development, roads, and fences on local, regional, and continental pronghorn populations will likely be exacerbated by climate warming. Under fine-scale change scenarios for the Coconino Plateau area, ponderosa pine and mixed conifer forests are predicted to contract to higher elevation and be replaced by wooded grasslands, meadows, and chaparral (Garfin et al. 2010). Mid-elevation grasslands, the core pronghorn habitat type, are likely to trend toward juniper scrubland and Colorado Plateau arid shrubland. Some shifts are already likely occurring, with the death of millions of conifers on the plateau since the extreme drought of 2000 to 2002 (Floyd et al. 2009, Ganey and Vojta 2011). Winter snowpack is melting earlier (Garfin et al. 2013), reducing the availability of surface water for wildlife during spring and early summer (Seager et al. 2007). The area affected by stand-replacing wildfires is also increasing (Westerling et al. 2006), creating new patches of open habitat at higher elevations.

For pronghorn on the Coconino Plateau, restoring habitat connectivity may increase the ability to survive by fostering movements over a larger area. Pronghorn will likely need to range farther within the region to reach quality summer range and surface water, both of which may become scarcer or more patchy across the landscape. The total area of moderately suitable habitat for pronghorn may remain the same, but trend upslope. The South Rim of GRCA and contiguous area of the South Kaibab National Forest (KNF) is likely to trend toward more suitable pronghorn habitat, along with higher elevation areas across the southern margin of the plateau. Land managers are initiating large-scale fire risk reduction and forest restoration projects in the project area. Just as important, the majority of lands across the area are more likely to remain protected from development over the coming century, as they are largely within national parks, national forests, and large working ranches under conservation easements. However, animals will likely need to range farther, both within and around the periphery of the study area to reach summer range and scarcer water sources, which are also likely to become more variable from year to year.

Movement across US 89 will be crucial to sustaining pronghorn on the eastern side of the highway, including WUPA and SUCR, which has the smallest remaining area of summer range. The research will also contribute to the partnership effort to site a wildlife overpass in the most effective location across US 89. The concept has already been included as an option for further consideration in the Environmental Assessment for upgrading US 89 to a four-lane highway. The most viable locations will be further evaluated. If built, it would be the first of its kind for this species within Arizona, and among the first few in the United States. By participating in this effort to restore landscape scale habitat connectivity and fostering pronghorn adaptability to ongoing ecological changes from climate warming, the NPS can ensure visitors to WUPA, SUCR, GRCA, and the rest of the Coconino Plateau will be able to experience antelope at play on the range for the coming century.

II. OBJECTIVES.

The success of recent pilot range and highway ROW fence modifications has inspired an effort to restore habitat connectivity across the entire Coconino Plateau. The primary partners under this Study Plan include AZGFD, ADOT, CNF, KNF, WUPA, GRCA, CO Bar Ranch, Espee Ranch, Cataract Ranch, and the AAF. The project area encompasses 2,700 square miles, from the Little Colorado River along the eastern boundary of WUPA to the Aubrey Cliffs on the west, and from the flanks of the San Francisco Mountains northward to the South Rim of the Grand Canyon (Figure 1).

NPS Natural Resource Funding will be used to scientifically assess both local and landscape scale pronghorn responses to these habitat connectivity restoration actions, with emphasis on population connectivity between

WUPA and nearby SUCR to GRCA. This will be evaluated using GPS telemetry collars and employing methodologies developed and reported by Dodd et al. (2007). The study objectives include:

(1) Evaluate pronghorn permeability across modified range fencing.

(2) Evaluate changes in pronghorn permeability across highways with realigned ROW fences.

(3) Evaluate changes in pronghorn habitat utilization in areas treated to reduce juniper cover.

(4) Refine and validate the data collection and analysis methods used to determine peak pronghorn passage rates for the fence design variables identified in pilot studies.

(5) Assess pronghorn movement patterns relative to unmodified range and highway right-of-way fences, and vegetative barriers within the larger 2,700 square mile study area.

(6) Prioritize areas for further fence and juniper treatments to connect the best habitat patches within the landscape, including northward across the KNF to the south boundary of GRCA.

III. ENVIRONMENTAL PLANNING.

A. Fence Modification Projects. Fence removal along the US 89 ROW through WUPA in 2009 was completed under a project record with a NEPA Categorical Exclusion. The reconstruction of the WUPA boundary fence to pronghorn-friendly standards at WUPA was completed between 2007 and 2013 under a NEPA Categorical Exclusion and NHPA Determination of “No Effect”. For fence modification outside of WUPA, GRCA and SUCR, AGFD has coordinated with USFS and private land owners on all fence projects on their respective properties. CNF and KNF have provided documentation to satisfy all NEPA requirements including biological and cultural surveys for completed projects and are committed to providing the same before pending projects move forward. AGFD works directly with U.S. Fish and Wildlife Service (USFWS) on a project by project basis to ensure compliance through an Environmental Assessment Checklist, which requires all NEPA and landowner coordination be completed. Similar procedures will occur for upcoming pronghorn captures throughout the study area.

B. Research Permits. As with prior AGFD pronghorn telemetry studies at WUPA and SUCR from 2009 through 2011, a NPS Research Permit will be issued by the Flagstaff Area National Monuments (FLAG), where the resources management staff for WUPA and SUCR are based. The prior permit fell under a NEPA Categorical Exclusion for non-destructive data collection. FLAG anticipates the 2015-2017 telemetry data collection within WUPA and SUCR can also be conducted with similar permitting and NEPA records. Pronghorn collaring and data collection on adjacent lands within the study area will comply with permitting, NEPA, and other procedures for those agencies having respective jurisdiction on those lands (AGFD and U.S. Forest Service). American pronghorn are not listed as Threatened or Endangered, and consultation with the USFWS will not be required. Telemetry data will also be generated on the Kaibab National Forest in proximity to GRCA, which may require a separate NPS Research Permit.

C. Animal Welfare Act and Institutional Animal Research Committee. Under the Study Plan, pronghorn will be captured and fitted with telemetry collars, including within WUPA. Capture, handling, and collaring efforts will be conducted according to written AGFD protocols, which incorporate measures to minimize potential for animal injury and mortality. All project undertakings are subjected to internal AGFD environmental review under these protocols. In addition, Wildlife and Sportfish Restoration Program funding from the USFWS will be utilized on the project, triggering Federal Animal Welfare Act compliance and Institutional Animal Research Committee review. Information for the AGFD and USFWS review will be utilized for the NPS Institutional Animal Care and Use Committee (IACUC) review, which will be completed concurrently as part of the NPS

Research Permit process for WUPA. The Natural Resource Specialist for FLAG will be responsible for coordinating with the AGFD Investigators to submit the needed documentation to Dr. Kevin Castle, NPS IACUC Coordinator. These levels of review are intended to ensure compliance with all existing regulations and accepted wildlife welfare standards.

D. Wilderness Act. In February 2013, the NPS Director concurred with the determination that WUPA is eligible to be evaluated for formal designation as Wilderness. This management requirement was not in effect at the time the study proposal was submitted. As part of the NPS Research Permit review for WUPA, the Study Plan objectives and methods will be evaluated under the Minimum Requirements Decision Guide (MRDG), developed by the Arthur Carhart Wilderness National Training Center and adopted by the NPS as the standard for wilderness compliance. The Natural Resource Specialist for FLAG will be responsible for preparing the MRDG and submitting to the FLAG Superintendent for a decision during the project compliance and Research Permit review process.

IV. PRINCIPAL PROJECT MANAGERS.

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V. IMPLEMENTATION PLAN.

A. Methods.

1. Right-of-way and range fence modifications. In November 2011, a meeting between key stakeholders that included NPS, AGFD, USFS, ADOT and Babbitt Ranches was held to evaluate opportunities to kick off a landscape scale effort to reconnect pronghorn habitat north of I-40. Using all available pronghorn telemetry data from studies conducted from 1992-2011, we identified key locations where ROW and pasture fences were in need of modifications to accommodate pronghorn habitat connectivity (Figure 4). These modifications included fence setbacks along US 89, US 180 and SR 64, removing bottom strands of fencing below 16” and replacing with smooth wire at >16”, and completing removal of unneeded fence. Fence modifications or removal occurred on WUPA, Kaibab National Forest, Coconino National Forest, ADOT ROW and Babbitt Ranches. Most highway ROW modification sites are also identified by local stakeholders in the Coconino County Wildlife Connectivity Assessment (AGFD 2011).

Since 2012, the partners have utilized non-NPS funding and in-kind contributions to modify existing highway right-of-way fences and interior range fences. At WUPA, in 2012 the NPS reconstructed the final two miles of pronghorn-friendly fence around the eastern half of the monument, and removed an obsolete interior ROW fence along the park entrance road, where the adjacent grazing allotment within the Coconino National Forest has been closed to livestock grazing. Grassland restoration efforts conducted by AGFD, AAF, and Babbitt Ranches have continued over the last five years, with prioritization of juniper treatments based upon existing telemetry data. Once fencing projects were underway, additional stakeholders stepped forward to assist in completing modification projects, including the Arizona Antelope Foundation and National Forest Foundation. Estimated project costs, including in-kind and cash contributions for the fence modifications alone, reached nearly $300,000 by the end of 2014.

Fence modification projects to be assessed as part of the study include (Figure 4):

- WUPA modifications (Completed April 2011 – November 2013)
- Blue Shute West Modifications (Completed Summer 2012)
- Kendrick Park – US 180 (Completed May-June 2013)
- Sacred Mountain and CO Bar – US 89 (Completed August 2013)
- Blue Shute East and Butcherknife – US 180 (May14 –June 30 2014)
- Community Tank – KNF (June 2014)
- CNF Pasture and Boundary Fences (August 2014)
- CO Bar Pasture Fences (September 2014)
- Slate Mountain – US 180 (Spring 2015)
- CNF and KNF Pasture Fences (June 2015)

2. Grassland Restoration Treatments. Grassland restoration, primarily through juniper removal, has been underway within the study area for several years. Currently, aggressive projects on the CNF, KNF and CO Bar should substantially enhance available pronghorn habitat and reestablish movement corridors.

3. Pronghorn capture and GPS telemetry. We will capture 50-70 pronghorn using a helicopter-net gun methodology (Finchow et al. 1986, Ockenfels et al. 1994). Pronghorn will be captured in winter (December–January) and fall (September-October) to achieve a sample distribution across seasonal ranges while avoiding pronghorn hunts, minimizing heat-related stress and deleterious effects to late-term pregnancies. Our capture objectives are to: 1) instrument near equal numbers of pronghorn in the five pre-defined subpopulation zones, 2) maximize the spread of collars among different herds within each zone, and 3) capture animals during separate seasons and years if possible totaling as many as four capture efforts.

Captures will be coordinated from a centralized staging area where project personnel will prioritize and track capture efforts. A fixed-wing aircraft and numerous ground spotters will search for pronghorn to minimize helicopter search time. The fixed-wing team will provide additional assistance in the form of herd-following for scenarios in which multiple captures from a single herd are desired. To minimize the risk of capture myopathy and overheating, pursuit times are monitored and the capture team adheres to minimum and maximum chase times which are set in accordance with ambient temperatures. Within the acceptable window, the net-gunner, positioned in the seat behind the pilot, fires the canister-held combustion-propelled net over the target animal that has been separated from the herd. If the net-gunner cannot get a shot off within the allotted time, or if the animal(s) appear overexerted, then the chase is terminated and another target herd is selected.

Upon successful netting of the targeted pronghorn, the restrainer will exit the helicopter and complete the physical immobilization. We will immediately blindfold the pronghorn and proceed to untangle it from the capture net and apply hobbles. Pronghorn will then be fitted with a GPS collar and marked with a numbered, colored ear tag. Tissue samples will be taken from animals' ears with a biopsy punch and preserved for future genetic analysis.

GPS collars will have a battery life of 24-35 months and all collars will have VHF beacons, mortality sensors, and programmed release mechanisms to allow recovery without recapture. Upon release, collars will be recovered by navigating to them in the field using their VHF broadcast signal. As pronghorn are generally crepuscular/diurnal in their habits, GPS collars will be programmed to receive 8 fixes/day between 05:00 and 19:00 hours (1 fix every 2 hours); this time interval between fixes will yield up to 8,500 locations per pronghorn. Overall GPS locations should total 150,000-200,000 and be sufficient to determine highway and fence interaction, habitat selection and identify fine-scale movement corridors.

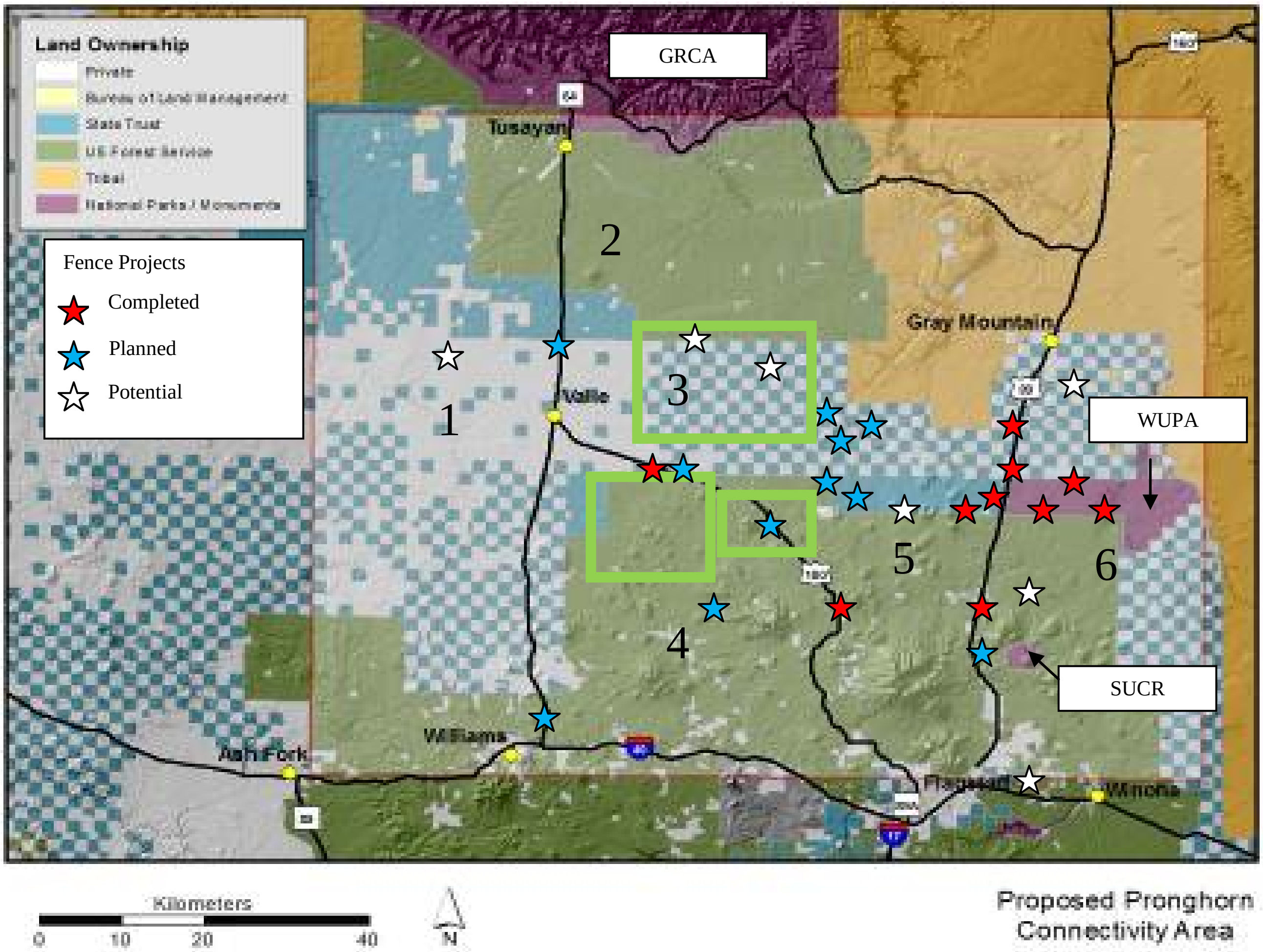

Figure 4. Fence project locations (stars) and grassland restoration (green boxes) within the study area (highlighted) and the six zones where GPS movement data shows separation of pronghorn movements. GPS collars for this study will be placed in these six zones to evaluate increases in interaction between these previously identified subpopulations following fencing and grassland treatments.

4. Data Analysis. The GPS telemetry data to be acquired from 2015 through 2017 will be statistically analyzed to using methods developed on AGFD Geographic Information Systems to evaluate the effectiveness of the following movement barrier reduction and habitat improvement methods.

(1) Evaluate pronghorn permeability across modified range fencing. We will conduct a fence inventory for the focal area of the study where pronghorn GPS data indicates a barrier to movement. This inventory will include pasture fences, NPS and USFS boundary fences, and highway ROW fences. To perform the inventory, we will develop an application/data dictionary for GPS-enabled devices to classify various characteristics of fence lines: status (intact, downed), bottom wire height class (0–12", 12–16", 16", 16-18", 18-20", 20+), bottom wire type (smooth, barbed), tumbleweeds (present, absent), dual fences (present, absent), and proximity to human development (adjacent, non-adjacent). The data dictionary will include point features to record PVC animal passage bars, gates, low spots, cattle guards, and modified jumps. We will perform the inventory before and after modifications for as much fencing as possible in order to allow for a comparison of pronghorn fence permeability pre- treatment to pronghorn fence permeability post-treatment,

Our Geographic Information Systems (GIS) specialist will partition the collected fence features into 0.16-km segment features, carrying forward the appropriate fence characteristic values and attaching values for additional variable fields from other geospatial data layers: vegetative community, aspect, slope, and distance to known water sources. Our GIS specialist will also generate a set of line-segment-features offset from the fence-segment-features, again attaching values for variable fields from other geospatial data layers: vegetative community, aspect, slope, and distance to known water sources. These features will serve as controls to demonstrate pronghorn movements in the absence of fencing obstructions. Our GIS specialist will process pronghorn collar GPS files, deriving movement lines by connecting successive location points. Crossings (of fence and control features) will be identified by selecting movement lines which have a termination point in a different zone than the origin point (opposing sides of a fence). Crossings will be assigned to fence and control segment features for each movement line they intersect.

Mean pronghorn crossing rates will be calculated for all fence segment features and for all control segment features. A temporal framework for treatment analysis will be derived from dates of fence improvement efforts which represent changes in fence characteristics. Each 0.16-km fence segment feature will be assigned to class bins for each defined period within the temporal framework. Fence class availability will be quantified by calculating proportions of each class present in our defined areas (Figure 4) for given time periods bound by fence modification dates. Fence class utilization will be quantified by generating pronghorn fence-crossing tallies for each class present in a defined area and period. This will enable a comparison of observed crossings (utilization) to expected crossings (availability) across various fence characteristic classes.

(2) Evaluate pronghorn permeability across highways with realigned ROW fences. The permeability of fenced highways to pronghorn movements is a function of the permeability of the highways itself, the characteristics of the ROW fences, and the relationship between these three features. The distance between the fences and the road appears to be a critical contributing factor in the permeability of the overall complex. In order to fully evaluate the functionality of ROW fence realignment treatments, we must assess changes in crossing rates of the highway itself and of the ROW fences.

To determine the spatial distribution and frequency of road-crossings by pronghorn, the highways traversing the study area will be partitioned into sequentially numbered 0.16-km segment features. The GIS specialist will identify pronghorn road crossings from the movement lines generated in the evaluation of range fencing permeability by selecting lines that have an origin and terminus on opposing sides of a highway.

To assess highway permeability, we will utilize the approach used along US 89 (Dodd et al. 2011) to measure crossing and passage rates by pronghorn. Passage rate, as a measure of permeability, is determined from the ratio of highway crossings to approaches. This assessment technique will allow for an evaluation of the treatment effectiveness on pronghorn movements and crossings relative to untreated highway segments and pre-treatment rates (for segments where data are available). Permeability of the ROW fences will be assessed using the same methodology as the range fences with the added attribute of distance to highway. The frequency distribution of fence crossings will be evaluated relative to the distance to highway factor using the observed versus expected approach outlined above.

(3) Evaluate changes in pronghorn habitat utilization in areas treated to reduce juniper cover. A GIS layer of juniper treatments for the study area will be compiled with assigned values of treatment type (burn, mechanical removal, etc.) and date of implementation. Pronghorn utilization of these treatments will be derived by evaluating the distribution of pronghorn GPS collar locations relative to these areas and the surrounding habitat. Availability of various habitat variables will be quantified for each of the six pre-defined zones. Habitat variables to be quantified will include treated-grasslands, non-treated grasslands, and pinyon-juniper woodlands. Other variables such as treatment type, time since treatment, elevation, distance to known water source, slope, and aspect may be considered for inclusion in analyses as appropriate.

Pronghorn locations will be tabulated across each zone for the habitat variable values being assessed. We will use an approach such as paired t-tests (Gagnon et al. 2011) or model-averaged regression coefficients and Z-statistics (Horncastle et al. 2013) in order to relate the frequency of pronghorn location occurrences associated with habitat values to the relative availability of that habitat value for each project zone. Where sufficient pre-treatment data is available, tests of pre-treatment versus post-treatment utilization will be conducted.

(4) Refine and validate the data collection and analysis methods used to determine peak pronghorn passage rates for the fence design variables identified in pilot studies. The partitioning of the pilot study's 16+" bottom wire height class for range fence inventories into three classes (16-18", 18-20", 20+") will allow refinement of bottom wire height recommendations which vary from 16" up to 20" in the guidelines of many state and federal agencies without citation of empirically derived support for these minimum heights (AGFD, Colorado Division of Wildlife, Montana Fish, Wildlife, & Park, Wyoming Game and Fish, NRCS, BLM, CNF). The expansion into these classes is included in the fence permeability methods described above. Assessing ROW fence permeability relative to the distance to the highway for all three highways with a minimum of six setback treatment sites will allow for a more robust analysis of this relationship. Methods for assessing ROW fence permeability are described above.

(5) Assess pronghorn patterns relative to unmodified range and highway ROW fences, and vegetative barriers within the larger 2,700 square mile study area. Untreated features will be addressed in each of the treatment analyses using methods described for (a) and (b).

(6) Prioritize areas for further fence and juniper treatments to connect the best habitat patches within the landscape, including northward across the Kaibab National Forest to the south boundary of GRCA. The pronghorn GPS collar location data will be evaluated to locate barriers to movements that persist into the deployment of collars. This will include any treated features that retain a substantial barrier effect and features that were not addressed in the prior rounds of treatments. Geospatial analysis tools will be used to identify quality habitat patches and the barriers inhibiting movements among these patches. Prioritization of mitigating habitat modifications will be recommended to land managers.

B. Tasks, Organization, and Schedule.

July 2012 – June 2015: AGFD, CNF, KNF, NPS, AAF, and Babbitt Ranches implement targeted fence and juniper treatments to improve pronghorn connectivity across the landscape.

April 2013 – November 2013: NPS boundary fence and ROW fence modifications are completed at WUPA.

May 2013: Environmental compliance completed by AGFD and CNF, and select ROW and range fence treatments are implemented on the CNF.

April 2014: Environmental compliance completed by AGFD and KNF, and select ROW and range fence treatments are implemented on the KNF.

June 2014 – September 2014: Scott Sprague, AGFD, coordinates with AGFD Project Evaluation Program, CNF, KNF, and Arizona State Lands Department on respective agency compliance and permitting processes for pronghorn captures and fence inventories.

August 2014 – October 2014: The NPS and AGFD complete NPS Research Permit and compliance review processes for pronghorn telemetry data collection at WUPA and SUCR, described in Section III.

September 2014 – January 2016: Upon completion of respective compliance processes, AGFD will collar 50-70 pronghorn in multiple capture events across the various jurisdictions within the study area. At WUPA, up to six capture days are proposed (typically three hours per day) to deploy collars on a maximum of 25 pronghorn over the entire study period. This will require an estimated one helicopter traverse per animal over grassland habitat within WUPA, with one pilot and two field crew on the helicopter. Flights would not be scheduled on weekends, holidays, or other periods of peak visitation. For collar recovery, one or two biologists would park as close to the retrieval location as possible on designated roadways, and hike in on foot to pick up the collar. Collar recovery could require an maximum of 10 field trips into the WUPA study area over the entire study period. Pronghorn collaring is not proposed for SUCR or GRCA, but some data may be acquired from animals that are collared on adjacent lands. It is also possible that a collar may need to be retrieved within GRCA or SUCR.

September 2014 – January 2017: AGFD and partners will conduct fence inventories across the study area.

April 2015: Environmental compliance will be completed by AGFD and CNF for additional ROW and range fence treatments on the CNF.

January 2017 – June 2017: AGFD completes data analysis and interpretation on the resulting pronghorn telemetry dataset.

June 2017 – September 2017: AGFD prepares and submits draft report. NPS completes draft review. AGFD delivers final report, pertinent datasets, and other products requested under the cooperative agreement.

VI. QUALITY ASSURANCE, QUALITY CONTROL, AND DATA QUALITY OBJECTIVES.

The study and data analysis requires no outside laboratory analysis of specimens or environmental samples. Collection of fence inventory data will be executed using GPS-enabled devices with pre-programmed data-dictionaries to assure adherence to standardized protocol. Fence and collar data will be recovered by project personnel and stored with project leads and in separate backup locations. Copies of the data will be provided to AGFD GIS specialist for analysis. Replicate datasets of animal GPS data files will be provided to the NPS as a product of the study.

VII. FINAL REPORT AND ANNUAL PROGRESS REPORTS.

A detailed report will be submitted to Tanya Shenk, Landscape Ecologist, Wildlife Conservation Branch, NPS Biological Resources Management Division, who is the designated project coordinator. anticipated in June 2017. The report will adhere to established format and standards for an NPS Natural Resource Technical Report Guidance found at: http://www.nature.nps.gov/publications/NRPM

The report which will be peer-reviewed to ensure that information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. The Final Technical Report will be uploaded to the national NPS IRMA database. Reporting requirements will be incorporated into the cooperative agreement with the AGFD Investigators, along with all pertinent data products generated with NPS Natural Resource funding.

VIII. BUDGET.

The budget for FY2015 and FY2016 is presented in the tables below. Most funding will be transferred to AGFD via a cooperative or interagency agreement. Umbrella agreements are already in place for similar research in other NPS areas within Arizona. Note there are two modifications to the original proposal submitted in March, 2012. First, AGFD personnel costs have risen due to recent staff pay increases. Second, FLAG will retain $3500 in personnel costs instead of the proposed $2400, needed to cover the higher graded Compliance Coordinator position to assist with issuing the research permit and managing the compliance record in the NPS PEPC system, and additional time required to prepare the wilderness compliance justification. The funding amount in the transportation budget item (helicopter flight time) has been reduced accordingly. AGFD remains confident the study objectives will be met after these changes.

Table 1. FY2015 Budget.

Item	Description	Qty	Unit	Unit Cost	Item Cost
NPS Personnel	FLAG Compliance Coordinator, GS-11 STF. 1 PP @ $3500 per PP	1	Lump	$3,500.00	$3,500.00
Travel and Transportation Costs	Contribution to Helicopter time, animal capture, Year 1 (8-week Aerial Welfare Checks funded separately by Cooperator).	1	Lump	$6,364.00	$6,364.00
Supplies Costs	All supplies to be contributed by Cooperator	1	Lump	$0.00	$0.00
Equipment Costs	All equipment to be contributed by Cooperator	1	Lump	$0.00	$0.00
Cooperator Costs - AGFD Personnel (includes ERE)	1 each Intern @ 18.36/hr for 3 pay-periods, 1 each Technician at 18.26/hr for 4 pay-periods, 1 each Wildlife Spec II at 33.12/hr for 3 pay-periods, 1 each Wildlife Spec III at 37.65/hr for 2 pay-periods, 1 each GIS Specialist at $41.09/hr for 1 pay-period, 1 each Admin @ 26.57/hr for 0.5 pay-periods.	1	Lump	$23,500.00	$23,500.00
Other Costs - Cooperator Overhead	AGFD Overhead 35% - Calculated on PS only (does not include ERE), NPS IMR project assessment @ 1% = $404	1	Lump	$7,400.00	$7,400.00
Component Net Cost					**$40,764.00**

Table B. FY2016 Budget.

Item	Description	Qty	Unit	Unit Cost	Item Cost
NPS Personnel	FLAG Compliance Coordinator, GS-11 STF. 1 PP @ $3500 per PP	1	Lump	$3,500.00	$3,500.00
Travel and Transportation	Contribution to Helicopter time, animal capture, Year 2 (8-week Aerial Welfare Checks funded separately by Cooperator).	1	Lump	$6,073.00	$6,073.00
Supplies Costs	All supplies to be contributed by Cooperator	1	Lump	$0.00	$0.00
Equipment Costs	All equipment to be contributed by Cooperator	1	Lump	$0.00	$0.00
Cooperator - AGFD Personnel Costs	1 each Intern @ 18.36/hr for 2 pay-periods, 1 each Technician at 18.26/hr for 3 pay-periods, 1 each Wildlife Spec II at 33.12/hr for 3 pay-periods, 1 each Wildlife Spec III at 37.65/hr for 2 pay-periods, 1 each GIS Specialist at $41.09/hr for 2 pay-period, 1	1	Lump	$23,000.00	$23,700.00

	each Admin @ 26.57/hr for 0.5 pay-periods.				
Other Costs - Cooperator Overhead	AGFD Overhead 35% - Calculated on PS only (does not include ERE) = $7,000, NPS IMR project assessment @ 1% = $404	1	Lump	$7,400.00	$7,400.00
Component Net Cost					**$40,673.00**

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