FIRST YEAR PROGESS REPORT

PREACHER CANYON WILDLIFE FENCE AND CROSSWALK ENHANCEMENT PROJECT
State Route 260, Arizona

Project JPA 04-088

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PROJECT DESCRIPTION

The goals of the *Preacher Canyon Wildlife and Crosswalk Enhancement Project* is to reduce elk and other wildlife highway crossings at grade along the Preacher Canyon Section, reduce the incidence of wildlife-vehicle collisions, and promote wildlife highway permeability. The Preacher Canyon Section, 3.0 miles in length, was the first of 5 highway sections reconstructed along a 17-mile stretch of State Route (SR) 260 in central Arizona. When originally reconstructed, only 0.4 mile of 8-foot ungulate-proof fencing was erected along the section near the 2 wildlife underpasses opening into Little Green Valley. Since reconstruction in late-2001, the incidence of elk-vehicle collisions (EVC) has not changed from before-reconstruction levels.

As part of this enhancement project, existing right-of-way (ROW) fence along approximately 2.5 miles of the highway was modified and extended upward to 7.5 feet to make the fence impermeable to elk and to funnel animals toward the Preacher Canyon bridge (center of the section) and 2 underpasses at the east end of the section. Two cost-effective fence extension designs were used and are being evaluated: 1) barbed-wire extension of the existing ROW fence, and 2) Electro-Braid electric fence installed on and above the ROW fence; the electric fence on the south side of the highway is powered by an AC power drop from existing power line, while the fence on the north side is solar powered, allowing us to evaluate different power sources.

At the west end of the section, no passage structure or topography (e.g., canyon) exists in which to effectively terminate the modified fence; therefore, to address the potential for an "end-run" effect of wildlife being funneled toward and around the west end of the fencing, we implemented a roadway animal detection system (RADS) to detect crossing animals and alert motorists with flashing signs triggered as animals approach and cross the highway. Our RADS application was configured such that a defined wildlife "crosswalk" was created (see Appendix A).

This is an experimental project that integrates and evaluates the efficacy of several new technologies, including different fence designs, various wildlife escape mechanisms to maintain the integrity of the fenced corridor, as well as assessing the utility of the RADS and crosswalk as a potential alternative to a costly wildlife passage structure.

PROJECT EVALUATION

The Arizona Game and Fish Department (AGFD), in cooperation with the ADOT Prescott District submitted a proposal in July 2003 to ADOT's TEA-21 Enhancement Grant program to accomplish the above-described enhancements on the Preacher Canyon Section. The project was approved in early 2004, and comprehensive project planning was completed in 2005; full project implementation was accomplished in February 2007.

A formal aspect of this project is the thorough research evaluation of the effectiveness of the different fence designs, RADS crosswalk, and all other elements of the project. Amendment No. 1 to the Interagency Agreement for ADOT Project No. TEA-260-B(008)A (JPA 04-088) was executed on June 13, 2006, and stipulated that the research evaluation would be conducted by AGFD. It further stipulated that "on or near October 30, 2008, (AGFD will) recommend to the State (ADOT) the need to continue the Project in conjunction with the State by providing to the State an up-to-date summary of the effectiveness of all fences and RADS." This report presents the project status one year after implementation. Continuing research will be conducted and the final report with recommendations will be presented "on or near October 30, 2008."

RESEARCH OBJECTIVES, APPROACHES AND PRELIMINARY RESULTS

The primary objectives of this research study are to evaluate the effectiveness of the experimental components of the Preacher Canyon enhancement project, and include:

1) Compare before and after fencing modification wildlife-vehicle collision incidence on the Preacher Canyon and Lion Springs Sections.

2) Evaluate the effectiveness of the roadway animal detection system in achieving modified driver behavior at the wildlife "crosswalk."

3) Evaluate the operational reliability of the roadway animal detection system when animals enter the wildlife "crosswalk," as well as other project components.

4) Assess the impact of fencing on wildlife permeability across the Preacher Canyon Section highway corridor.

OBJECTIVE 1. Compare before and after fencing modification wildlife-vehicle collision incidence on the Preacher Canyon and Lion Springs Sections.

Achieving a reduction in wildlife-vehicle collisions (WVC) with extended fencing along the Preacher Canyon Section is the primary focus of this enhancement project. With the long-term (>15 years) ADOT collision database and our research project database maintained since 2000, we have a solid before-treatment baseline from which to assess the effectiveness of fencing modification in reducing the incidence of wildlife-vehicle collisions.

Approach

We will continue to document all WVC along the Preacher Canyon Section, as per Dodd et al. (2006, 2007*a*) for a minimum of 2 years, compiling collisions by 10^{th} -mile segment. We will compare the incidence of WVC before fencing was modified to that after fencing was modified using analysis of covariance (ANCOVA), and consider the influence of traffic volume on WVC by incorporating AADT levels as a covariate in the analysis, as per Dodd et al. (2006, 2007*a*).

We will assess and compare the frequency and distribution of WVC in relation to the type of fencing found adjacent to the 10^{th}-mile segment where they occur. This will allow us to compare the efficacy of each type of fencing in preventing collisions. We will compare the incidence of WVC on the fenced Preacher Canyon Section to 2 experimental control sections (Little Green Valley and Doubtful Canyon sections) along SR 260 to assess the relationship to WVC patterns and trends elsewhere along the highway.

We will assess the effectiveness of the RADS at the west fence terminus, and potential presence of a wildlife "end-run effect" by tracking wildlife-vehicle collisions. The presence of a potential collision "hot spot" in proximity of the RADS will be assessed, as well as on the adjacent Lion Springs Section to the west (milepost 258-259). The following table summarizes the baseline incidence of WVC along the Preacher Canyon and Lion Springs sections, including the proportion of single-vehicle accidents involving WVC, from which the effectiveness of the project in reducing WVC will be compared:

Year	Preacher Canyon Section				Lion Springs Section (MP 258-259)		
	Elk VC	Deer VC	Proportion of accidents		Elk VC	Deer VC	Proportion of accidents
2001	10	0	0.36		3	0	1.00
2002	12	1	0.56		2	0	0.33
2003	10	2	0.45		4	1	0.67
2004	12	2	0.27		9	1	1.00
2005	14	1	0.60		7	0	0.67
2006	12	1	N/A		3	0	N/A
Mean	11.7	1.2	0.45		4.7	0.3	0.73

Preliminary results

The barbed-wire extension of the ROW fence from the Preacher Canyon bridge to the Little Green Valley underpasses was completed in November 2006, while the Electro-Braid ROW fence modification from the crosswalk to the Preacher Canyon bridge was completed in early February 2007. Thus, we have over a year of after-fencing evaluation for the barbed-wire fence extension and a year of after-fencing evaluation of the Electro-Braid fence extension.

As per the summary table below, since completion of the fence extension (November 2006-January 2008), there have been 2 WVC recorded along the Preacher Canyon Section of SR 260, 1 each involving an elk and a black bear. The bear was killed along the stretch of highway with barbed-wire fence extension that is "semi-permeable" to passage by animals other than elk that can cross beneath the fence (e.g., deer, bears). The lone EVC occurred in March 2007 soon after the Electro-Braid fence extension was completed; in the 11 months since, no EVC have been recorded along the Preacher Canyon Section. The after-fence modification incidence of EVC represents a near 92% reduction in EVC compared to the 2001-2006 mean (11.7 EVC/year). By comparison elsewhere along SR 260, the incidence of WVC on the 2 control sections combined averaged 6.0 EVC/year 2001-2006; 17 EVC were recorded in 2007, or a 283% increase.

Year	Preacher Canyon Section (fenced)			Lion Springs Section (MP 258-259)		
	Elk VC	Deer VC	EVC change from 2001-2006 mean	Elk VC	Deer VC	EVC change from 2001-2006 mean
2007	1	0	-91.5%	3*	0	-36.2%

*Includes 1 EVC reported by Electro-Braid Fence

Applying an economic assessment similar to that done by Dodd et al. (2007*a*) for SR 260 which used the cost associated with EVC reported by Huijser et al. (2006), the reduction in EVC on the Preacher Canyon Section yielded a $183,000 benefit in its first year, and the benefits will exceed the project costs within 3-4 years if such a reduction in EVC are maintained.

Along the Lion Springs Section (MP 258-259) west of the crosswalk, 3 WVC occurred since the completion of the crosswalk and fencing project (including 1 documented by Electro-Braid Fence; see below), all involving elk during 2007; this is below the 2001-2006 mean of 4.7 EVC/year. Thus, in the first year, we did not note an increase in WVC on the adjacent Lion Springs Section reflecting a "displaced" end-run effect from the fenced Preacher Canyon Section.

No WVC at the crosswalk zone were noted by project personnel or recorded in our collision database. However, video monitoring of the crosswalk by Electro-Braid Fence did record an EVC that occurred just west of the crosswalk, on November 11, 2007, where an elk standing on the centerline was simultaneously hit by vehicles traveling in both directions. The motorist alert signs were not activated as the elk was outside the detection zone, and it appeared that minimal damage to the vehicles occurred. Though an isolated incident, it nonetheless points to the potential for animals to cross the highway outside the crosswalk detection zone.

OBJECTIVE 2. Evaluate the effectiveness of the roadway animal detection system in achieving modified driver behavior at the wildlife "crosswalk."

Success of the Preacher Canyon enhancement project is predicated upon achieving both a response from wildlife with modified highway crossing patterns associated with fencing *and* motorist response to the warning signage associated with the crosswalk in preventing a spike in EVC at the end of the fencing. In assessing motorist response to the RADS and motorist alert signage, we employed the model of potential motorist response developed by Huijser et al. (2006) whereby 2 components of driver response can occur: 1) increased driver alertness, and 2) lowered vehicle speed. Even with minimal vehicle slowing, increased alertness among motorists due to warning signs may enhance reaction time and lead to reduced incidence of WVC. These measures of motorist response are our primary metrics to the effectiveness of the RADS and motorist alert signage.

The east and westbound approaches to the crosswalk differ considerably. The eastbound approach occurs just past where the reconstructed 4-lane divided Preacher Canyon Section narrows to 2 lanes at a curve; vehicles often "jockey" (e.g., exceed posted 55 mph speed limit) for position as the lanes narrow. The westbound variable message sign is visible to motorists approximately 250 feet from the sign after they negotiate the curve. Eastbound, traffic negotiates a 2-lane highway that winds gradually uphill toward the crosswalk approach from Star Valley; the variable message sign here is visible to eastbound motorists >750 feet in advance of the sign.

Approach

Our approach to assessing motorist response to the RADS and warning signage before and at the crosswalk is to conduct paired sampling with and without the variable message board and crosswalk flashing signs activated (by toggle switch), using 15-minute sampling periods. Sampling will continue throughout the year and at all times of the day, though the preponderance of sampling occurs at times when elk are active and typically cross SR 260 (e.g., within 2 hours of sunset and sunrise; Dodd et al. 2006, 2007*a*).

Permanent "Groundhog" traffic counters (Nu-Metrics, Inc.) were installed in the pavement at the wildlife crosswalk to record traffic volume, vehicle types, and vehicle speeds. This data is reported by 15-minute intervals. Temporary traffic "card counters" (Nu-Metrics, Inc.) have also been used to record the same traffic information and compare to the "Groundhog" counter data.

At the same time that traffic speed sampling is conducted, we observe and count the number of vehicles approaching the crosswalk, alternating between eastbound and westbound directions; observers and their vehicles remain hidden from motorists to prevent bias. We count the number of vehicles that exhibit braking as they approach the crosswalk, with the alert signage activated and not activated. We use the difference in the proportion of the vehicles that exhibit braking with and without the signs activated as our surrogate measure of motorist alertness. Westbound counts are conducted at a point beyond where motorists first encounter the signage, while the eastbound counts are done at a point closer to the crosswalk and well after motorists have already encountered the signage.

Preliminary results

Speed reduction. To assess differences in vehicle speeds with and without warning signs activated, we conducted 43 paired 15-minute sampling periods using Nu-Metrics temporary "card counters"; 2,132 vehicles (1,093 eastbound and 1,039 westbound) were counted during these sampling periods. "Groundhog" counter data is being calibrated and analyzed, but preliminary results are not available at this time. The following table summarizes the preliminary results of the traffic speed sampling which found an average 12 mph, or nearly 20% reduction in speed when motorist alert signs were activated:

Warning signs:	Average traffic speed (miles/hour)		
	Eastbound lane	Westbound lane	Both lanes combined
Not activated (off)	61.5	64.0	62.7
Activated (on)	49.2	52.2	50.7
Difference (%)	-12.3 (20.0%)	-11.8 (18.4%)	-12.0 (19.2%)

Average daytime speeds were slightly higher compared to nighttime by approximately 3 mph, both when motorist alert signs were and were not activated. Speed reduction when warning signs were activated differed by <1 mph by time of day, as summarized in the following table:

Warning Signs:	Average traffic speed (miles/hour)	
	Daytime	Nighttime
Not activated (off)	64.3	61.5
Activated (on)	52.8	49.3
Difference (%)	-11.5 (17.9%)	-12.3 (20.0%)

Motorist alertness. To assess differences in motorist braking response with and without warning signs activated, we counted vehicles during 63 paired 15-minute sampling periods accounting for 3,108 vehicles (1,544 eastbound, 1,564 westbound). The results of this sampling, summarized in the table below indicates that, overall, motorists are 6 times more likely to brake when approaching the crosswalk when the warning signs are activated compared to when they were not activated. Motorists traveling in the westbound direction where the signs were encountered in a shorter distance than the eastbound direction showed a higher braking response, with 72% braking with signs activated compared to 8% when signs were off. Thus, it appears that the crosswalk warning signs are meeting their objective in eliciting a response by motorists relative to increased awareness.

Traffic levels in each lane during our 15-minute sampling intervals ranged from 7-101 vehicles and averaged 26 vehicles/period. Traffic volumes had no influence on proportion of vehicles braking; however the proportion of vehicles braking on the weekend (0.74) exceeded those on the weekdays (0.59). This difference may reflect the local traffic becoming habituated to the crosswalk detection system whereas weekend traffic likely is more reflective of tourists that respond to the warning signage.

Warning signs:	Eastbound lane		Westbound lane		Both lanes combined	
	Total vehicles	Proportion braking	Total vehicles	Proportion braking	Total vehicles	Proportion braking
Not activated (off)	738	0.11	730	0.08	1,468	0.10
Activated (on)	806	0.55	834	0.72	1,640	0.64
Difference (%)		+0.44 (400.0%)		+0.64 (800.0%)		+0.54 (540.0%)

OBJECTIVE 3. Evaluate the operational reliability of the roadway animal detection system when animals enter the wildlife "crosswalk," as well as other project components.

Roadway animal detection systems (RADS) are typically complex systems integrating many sophisticated electrical components that require proper design and implementation; often, such systems are prone to operational limitations that can affect system reliability, as described by Huijser et al. (2006). Such problems can range from failure of the RADS to detect crossing animals, sign activation when animals are not present ("false positives"), and failure of the RADS to communicate with and activate warning signage. RADS are subject to a full range of environmental factors that also may affect their reliability, ranging from snow and ice, extremes of heat and cold, etc.; the Preacher Canyon crosswalk RADS is no exception.

Approach

We are assessing RADS reliability by 2 methods: 1) conduct of periodic field visits, and 2) video surveillance of wildlife entering and passing through the detection zone. Periodic visits are made to the crosswalk site during which warning sign operational status is noted from the highway (e.g., activated, not activated, system under repair). When signs are encountered in an activated status, especially during daytime hours, an effort is made to determine whether an animal was present; if no evidence of animals being present exists, such an event is categorized as a "false positive." On each test visit, an observer enters the detection zone and checks to see if the warning signs subsequently are activated.

To assess wildlife use of the crosswalk and RADS reliability, we installed a 4-camera infrared video surveillance system with photo-beam triggers to document use and behavior at the crosswalk, similar to those used at wildlife underpasses elsewhere along SR 260 (Dodd et al. 2007*b*). This system tracks animals entering the crosswalk from the south side of the highway, as well as animals that cross the highway from the north side. This video surveillance system allows us to determine the following:

- Number and species of wildlife approaching and passing through the detection zone.
- The number and proportion of times that animals in detection zone result in the warning signs being activated.
- The number and proportion of animals in the detection zone that cross the highway.
- The number and proportion of animals in the detection zone that cross around the end of the crosswalk fencing and travel along the side of the highway.

Preliminary results

Reliability test visits. The crosswalk RADS, though fully functional by February 2007 to coincide with the erection of Electro-Braid ROW fence modification, required troubleshooting and refinements by the contractor, including replacement of some faulty components outside of their control. As such, we did not begin our reliability test visits until May 2007. Since then, we logged 157 test visits, including days when traffic and braking counts were conducted. As detailed in the table below, we encountered few instances with "false positives" or when the RADS and signs were inoperable; overall, the crosswalk system performed properly on 94% of our test visits.

No. RADS test visits	No. visits (%) RADS operating	No. visits (%) with false positives	No. visits (%) RADS inoperable
157	148 (94.3%)	3 (1.9%)	6 (3.8%)

Video surveillance monitoring. Like the crosswalk RADS, our video surveillance system required troubleshooting after installation, and we encountered initial sporadic data collection which has since been fully resolved. Through October 2007, we recorded a total of 91 total animals on videotape (78 elk, 5 white-tailed deer, 4 javelina, 1 mule deer, 1 mountain lion, 1 raccoon, and 1 unknown). As detailed in the summary table below, of the 85 animals (50 groups) that approached the crosswalk from the camera (south) side, 10 (12%) successfully crossed the highway, and 10 (12%) went around the end of the electric fence and into the highway corridor.

On the 16 occasions where groups of animals (comprising 32 total elk, or 44% of the total observed) traveled to within 50 feet of the highway edge, motorist alert signs were activated all 16 times; on 11 occasions, the signs were already activated when they reached this point, while on 5 occasions the signs were activated later but still before the animals reached the highway. Since November 2007, a substantial number of animals have been recorded at the crosswalk associated with the elk migration period; this data is currently being analyzed.

Wildlife species	Total no. (groups) entering crosswalk	No. crossing highway (%)	No. within 50 feet of highway	No. within 50 feet with signs activated (%)	No. around end of fence (% of total)
Elk	72 (41)	10 (13.8%)	32	32 (100%)	8 (11.1%)
White-tailed deer	5 (4)	0	0	0	2
Javelina	4 (1)	0	0	0	0
Mountain lion	1 (1)	0	0	0	0
Mule deer	1 (1)	0	0	0	0
Other	2 (2)	0	0	0	0
Total	85 (50)	10 (11.7%)	32	32 (100%)	10 (11.7%)

OBJECTIVE 4. Assess the impact of fencing on wildlife permeability across the Preacher Canyon Section highway corridor.

During our first phase of SR 260 Global Positioning System (GPS) telemetry (2002-2004), Dodd et al. (2007*c*) found that the mean elk passage rate (*n* = 15 elk), their metric of highway permeability across the reconstructed Preacher Canyon Section was half (0.43 crossings/approach) that of experimental control sections (0.88) and those where reconstruction was ongoing (0.84). This reduced level of permeability was tied to the barrier affect associated with the widened highway on which traffic traveled on all lanes. In their second phase of GPS telemetry (2005-2006), Dodd et al. (2007*d*) found that on the Christopher Creek Section of SR 260, the elk passage rate dropped from a during reconstruction level of 0.79 crossings/approach to 0.54 after reconstruction but before ungulate-proof fencing was erected. Once fencing was erected, the passage rate rebounded over 50% to 0.82 crossings/approach. Fencing promoted permeability since it funneled elk toward underpasses where Gagnon et al. (2007*a*) found that traffic volume had minimal affect on crossing success compared to when elk crossed the highway at grade (Gagnon 2007*b*). The Christopher Creek Section has a high "density" of wildlife passage structures (1 strucutre/0.7 mile) compared to the Preacher Canyon Section (1 strucutre/1.5 miles); thus, it will be useful to assess the impact of fencing the entire Preacher Canyon Section on permeability with a lower density of passage structures.

Approach

To address the impact of fence modification on elk permeability, we have continued our GPS telemetry assessment. We will use the GPS data from our first phase of GPS telemetry (Dodd et al. 2007*c*) as a baseline from which to compare elk permeability across the Preacher Canyon Section after the ROW fence is extended. We will compare elk movement, crossing patterns , and passage rates before and after fencing, as per Dodd et al. (2007*c*), and determine what proportion of crossings occur at the 3 passage structures. We conducted further before fence-modification GPS assessment, fitting 17 elk with GPS collars in 2005 in advance of project implementation, with some also yielding limited after-fencing data. These collars have since been recovered. To assess after-fencing elk permeability, we fitted 13 elk with GPS collars in summer 2006. These collars are programmed to drop off elk in March 2008, providing approximately 15 months of after-fencing movements data.

We will compare GPS data, analyzed by GIS similar to that previously done by Dodd et al. (2007*c*, *d*) to determine the proportion of GPS fixes within 1.0, 0.5, and 0.25 km of the highway, frequency and temporal distribution of highway crossings, and passage rate for each animal. We will compare crossing and passage rates before and after fencing by analysis of variance (ANOVA), including the proportion of animals that cross at passage structures. We will also compare the frequency and distribution of crossings that occur along the Preacher Canyon Section by fencing type (e.g., Electro-Braid AC and DC powered fence, extended barbed wire, existing standard ungulate-proof fencing) to assess the efficacy of each type of fencing in deterring crossings at grade by elk.

Preliminary results

Once the 13 GPS collars programmed to drop off elk in March 2008 are recovered, we will analyze all GPS data. No preliminary results are available at this time.

DISCUSSION

A year after implementation, the *Preacher Canyon Wildlife and Crosswalk Enhancement Project* appears to be well on track toward meeting its objectives, particularly in reducing the incidence of elk vehicle collisions by >90%. Further, given the complexities of achieving full integration of the experimental RADS and crosswalk components, these systems are performing reliably and effectively in detecting animals and alerting motorists to crossing wildlife. Motorist response with regard to both reduced speed and alertness in response to the warning signs and crosswalk concept has been significant and has contributed to the crosswalk's success to date.

One problematic aspect of the project is the passage of animals around the crosswalk fences, allowing them to enter onto the roadway outside the crosswalk detection zone. Overall, 11% of the elk captured on our videotape breached the crosswalk by passing around the end of the fence. However, these animals accounted for 25% of those that actually approached to within 50 feet of the highway edge. And though an isolated incident, the collision outside the crosswalk recorded by Electro-Braid Fence's video monitoring underscores the potential consequences of this issue. Electro-Braid Fence has proposed the experimental application and evaluation of an "Electo-Mat" tied into crosswalk fencing on each side of the highway to prevent animals from entering into the fenced highway corridor.

At this time, we anticipate no obstacles to meeting the stipulation in Amendment No. 1 to the Interagency Agreement for ADOT Project No. TEA-260-B(008)A that "on or near October 30, 2008, (AGFD will) recommend to the State (ADOT) the need to continue the Project in conjunction with the State by providing to the State an up-to-date summary of the effectiveness of all fences and RADS."

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