Proposal

ASSESSING DIRECT AND INDIRECT EFFECTS OF ROADS: UNDERPASS CROSSING EFFECTIVENESS AND INDIRECT EFFECTS ON SMALL MAMMAL COMMUNITIES

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I. INTRODUCTION

Impacts of Roads

Anthropogenically-created infrastructure has directly impacted 2 million km^2 or about 1.4% of the Earth's surface (Vitousek et al. 1986, 1997). While this may not seem like a large percentage, it would be incorrect to imagine that ecological impacts are restricted to the "physical footprint" of the built infrastructure. Forman (2000) has estimated, for example, that 20% of the land surface in the United States is impacted by roads alone, thereby creating a "virtual footprint".

Roads have profound impacts on the abundance of wildlife species, community diversity, and on ecosystem health and integrity. The most **direct** effect is animal mortality or road kill on roads; direct effects involve primarily the physical footprint of roads. Large animals are probably most noticed by the public when they are hit on roads, but are by no means the animals most frequently hit. In the U.S., data tend to be better for large animal road mortality, thus skewing our perception. Data for both white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*) suggest an estimated 720,000 animals killed on U.S. roads each year (Conover et al. 1995, Conover 1997).

Many smaller species are killed on roads. Data for these species tend to be much more limited in area coverage. Additionally no concerted or organized attempt has been made to extrapolate existing values nationwide. Nonetheless, the number of smaller, less noticed species killed on roads is alarming. For example, Fowle (1990) reported 207 painted turtles (*Chrysemys picta*) killed along a 7 km stretch of road in Montana during a 4-month period. An estimated 32,000 vertebrates along 3.6 km Long Point Causeway near a wetland near Lake Erie, Canada were reported killed by Ashley and Robinson (1996) over a 24-month period. When one looks at the historic record of road mortality, 65% were birds; mammals comprised 25%, and reptiles and amphibians about 8% (Starrett 1938).

The built infrastructure, and especially roads and road networks have large **indirect** effects that are not obvious. To gain perspective and context, one can imagine indirect effects as equivalent to a virtual footprint much larger than its causative physical footprint. The resulting impacts of roaded landscapes include: 1) habitat fragmentation and loss; 2) reduced habitat quality; 3) loss of habitat connectivity; and 4) barrier effects that impact the diverse communities of species that occupy the landscape. In other words, roads and road networks tend to reduce the permeability of the landscape, impacting movement dynamics of species populations, and resulting in smaller, isolated populations that may exhibit complicated dynamics and have a greater probability of local extinction. Typically, Departments of Transportation in the United States and elsewhere have not considered these kinds of expanded, indirect, and virtual effects.

Yet as road building continues, the virtual footprint is already too large and is still increasing. Mitigation to diminish both **direct** and **indirect** effects of roads is what Bissonette (2002) has termed the Cinderella Principle, namely, shrinking the virtual footprint to more closely match its physical presence. It is essential to 'make the shoe fit' in order to restore ecological health and integrity.

This proposal is concerned with **indirect** effects of roads. One complication is that the landscape consequences of the indirect effects are interrelated suggesting that parsing out the contribution of each effect will take a long-term experimental approach. This is not possible or feasible in the time frame available for this project. The null hypothesis that we will test is that indirect effects, taken as a whole have little significant effect on animal response. We define significant as greater than 10% deviation, after background variation has been taken into account. Here are the first level predicted responses classed by indirect effect:

1) If *habitat quality* is reduced, we expect species presence or absence, composition, and relative abundance will change at increasing distances from the road.
2) If *habitat fragmentation* is increased, we expect that measures of heterogeneity, as measured directly from digitized aerial photos or recent satellite images, will change significantly.
3) If there are *increases in edge*, we will be able to document the differences, and we expect that species presence, abundance, and composition will change as a result.
4) If there are *edge buffer effects*, we expect that there will be a zone close to the road where species presence, abundance, and composition will be dramatically influenced.
5) If the roaded landscape results in increased *habitat disconnectedness*, it can be measured. We predict that differences within the landscape matrix will be correlated with different occupancy rates by species.
6) If there are *barrier effects*, we predict that species presence or absence, composition, and relative abundance will be significantly different when both sides of the road are compared.

As is evident from our predictions, assessment of causality to a specific indirect effect is not possible or practical at this time within the time, person power, or funding available, however, the summation of the effects are very easy to document and compare to matched non-roaded landscapes.

II. OBJECTIVES

To verify the existence of indirect effects of roads, I will assess diversity, abundance and densities of small mammal at different distances from the roads. Here are the variables we will measure b***y direct field measurement:***

1) small mammal species presence or absence;

2) small mammal species composition;

3) small mammal species relative abundance

III. STUDY AREA AND METHODOLOGY

The study will be conducted principally in southwestern Utah. The surrounding landscape is comprised mostly of sagebrush and shrub steppe habitats.

To address objective **1**, I will establish transects perpendicular to the road. Each transect will contain 5 trapping webs, of which only the first and last will be sampled this summer to detect differences. If differences are detected, then one or more of the three intermediate webs will be sampled next year See Fig 1. Each web will be centered 200 meters from the preceding, with the first web center 100 m from the road edge. Each web will contain 8 trap lines radiating 50 m. from the center. 1 Victor rat trap and 1 Sherman live trap will be placed at distances of 5, 10, 20, 30, 40 and 50m along each trap line, as well as at the center of the web for a total of 49 Victor traps and 49 Sherman traps. This method allows estimating densities by the distances to the center of the web as proposed by Anderson *et al*. (1983).

Two webs can be established and checked per day, assuming a daybreak start and ending by 10 AM before the temperature becomes lethal for live-trapped animals. Each transect will take 4 days and 3 nights to run. Field personnel will work 8 days on and 6 days off, meaning that 2-3 transects can be established and checked during each field period of 8 days. Each transect involves 3 evening trapping periods of 98 traps for a total of 294 trap nights/transect run. We calculate 7 field periods from May through mid August, with between 14-21 transects established and run. This will result in 8,232 trap nights. Previous experience on a related project (IACUC #1107) suggests we can expect between 13-18% trap success. Because that study was at higher, more mesic and cooler elevations, we expect a lower trap success in southwestern Utah at lower, hotter elevations.

IV. SCHEDULE

JAN-APR 2004	Spring semester classes and preparation of fieldwork.
APR-SEPT 2004	First fieldwork season – Accessing the indirect effects of roads.
SEPT – DEC 2004	Fall Semester Classes and data analysis.
JAN – APR 2005	Spring Semester Classes and data analysis.
APR – SEPT 2005	Second fieldwork season – Accessing both the direct and indirect effects of roads (Spring Migration fieldwork – May / Fall Migration fieldwork – September).
SEPT – DEC 2005	Fall Semester and data analysis.
JAN 2006	Preparation of final report and thesis.

V. REFERENCES

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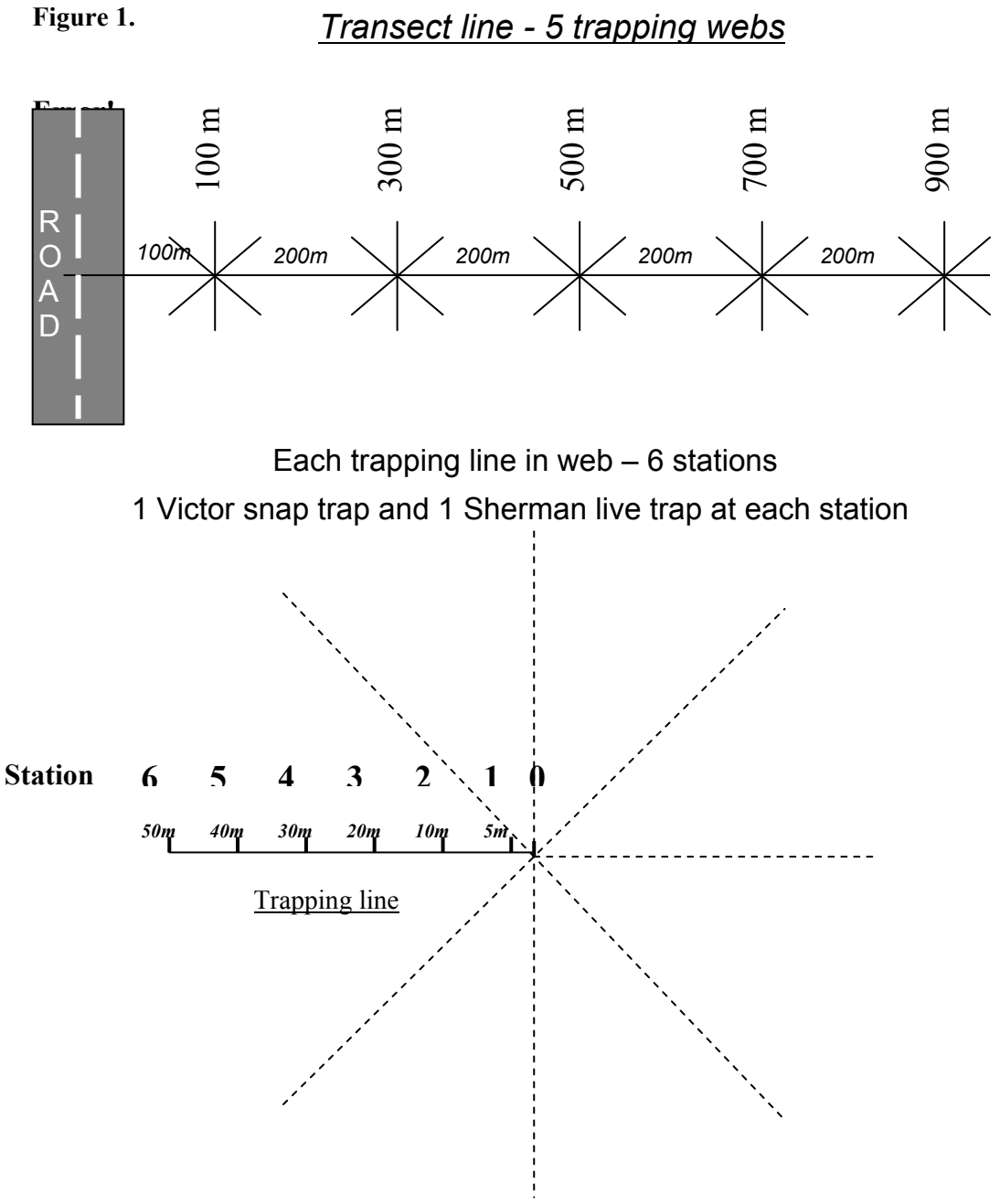
Figure 1.


Transect line - 5 trapping webs
100 m
300 m
500 m
700 m
900 m
ROAD
100m
200m
200m
200m
200m
Each trapping line in web – 6 stations
1 Victor snap trap and 1 Sherman live trap at each station
Station 6 5 4 3 2 1 0
50m 40m 30m 20m 10m 5m
Trapping line