Fragmentation Effects of High-speed Highways on Grizzly Bear Populations Shared Between The United States And Canada

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Abstract

Grizzly bear (*Ursus arctos horribilis*) populations in the conterminous United States are grouped into 6 recovery areas, five of which presently have bears. Four of these five areas are contiguous with Canada. High-speed highways bisect many of these ecosystems including the Northern Continental Divide, Cabinet-Yaak, Selkirk, and North Cascades. These highways are habitat fragmentation factors. Highway impacts include vehicle collisions and avoidance of vehicle noise by bears, inhibition of movement by loss of vegetation and changes along highways, fencing and other barriers along or between highway lanes, and the human developments that occur along highways. These highways have the potential to fracture grizzly bear populations across the United States - Canada border by inhibiting movements, increasing mortality, and inhibiting genetic and demographic exchange. Maintaining opportunities for demographic and genetic linkage between United States and Canadian grizzly bear populations enhances survival and recovery potential for grizzly bears. We propose a three phase approach to deal with this issue including: 1) development of information on how grizzly bears relate to and cross highways and development of a conceptual model to identify sites where highway crossings by grizzly bears would be most likely; 2) development of crossing structures and highway design modifications at such specific sites; and 3) monitoring effects of highways on populations of bears and use of mitigation measures by bears in a long-term effort to assure population connectivity.

Keywords: grizzly bear, *Ursus arctos horribilis*, highways, transportation systems,

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Introduction

Grizzly bear populations are currently divided into five separate populations south of Canada (Fig. 1). High-speed paved highways occur within and between habitat of each of these populations. Current distribution of grizzly bears is less than 2% of the former range of the species south of Canada. Historical reductions in range and numbers of grizzly bears were due to human factors including direct killing, habitat loss, and conflicts with human activities. Habitat and population fragmentation resulted. Fragmentation of once contiguous populations increases risks to the survival of these populations. As high-speed highways are "improved," traffic volumes and vehicle speeds increase, fencing along highways increases in height and effectiveness, vegetation is cleared along roadsides, topographic challenges increase as cut slopes and other structural factors accelerate along roadsides, concrete dividers are often placed between lanes, and lane numbers increase. All these factors decrease crossing possibilities for wildlife and increase habitat fragmentation impacts of highways.

Current grizzly populations in the United States south of Canada exist in five areas, four of which are contiguous with grizzly populations in Canada (Figure 1). Maintenance and survival of these United States populations is dependent upon connectivity with Canadian populations. High-speed highways running east-west bisect four Canadian populations and three of four United States populations forming potential fracture zones to contiguous populations of grizzly bears and other large carnivores. Points of fracture in all populations occur along these highway corridors both in Canada and the United States. Efforts to maintain contiguous grizzly bear populations in these areas must focus on highway corridors.

Effects of high-speed highways on numerous species of wildlife are well documented (Bashore and Tzilkowski 1985, Woodward 1990, Dwyer and Tanner 1992, Belden and Hagedorn 1993, Gleason and Jenks 1993, Knight and Kawashima 1993, Reijnen and Foppen 1994, Romin and Bissonette 1996a,b). However effects of highways on grizzly bears are largely unknown. Previous research on grizzly bear/road interactions have been confined to tertiary or unimproved road systems (Archibald et al. 1987, Mattson et al. 1987, McLellan and Shackleton 1988, Kasworm and Manley 1990, Mace et al. 1996). High-speed highways can cause direct grizzly bear mortality through impact with vehicles or indirect mortality through displacement and reduced reproductive potential (Mace et al. 1996). Limitation of highway crossing opportunities for grizzly bears within and between small, isolated populations can have profound demographic and genetic effects (Ralls et al. 1986, Servheen and Sandstrom 1993, Mills and Smouse 1994). Current information is insufficient to specifically describe potential effects of high-speed highways to disrupt or prevent movements within or between occupied grizzly bear habitat.

Understanding And Mitigating The Effects of Highways

Potentially harmful effects of highways may be mitigated by modifications to highway design and placement. However, recommendations for mitigation must be based upon detailed information on specific effects of highways on grizzly bears. Obtaining such specific data requires precise diurnal and nocturnal monitoring of grizzly bears that live near highways, monitoring traffic levels, and detailed information on associated vegetation and topography. Grizzly bears occur at low densities, range widely, and generally occupy steep, mountainous terrain. Previously, technology to collect precise movement data on an animal with these characteristics did not exist. Recent development of the Global Positioning System (GPS) by the military and its subsequent availability in a wildlife collar system now presents the opportunity to collect such data (Biggs et al. 1997). Frequent and accurate positions of instrumented grizzly bears can be obtained day and night and in any weather. Accurate GPS locations (+\- 50m differentially corrected) combined with computer geographic information system (GIS) technology now allows detailed analyses of the effects of highways on grizzly bears.

Mitigation of the impacts of high-speed highways on grizzly bears requires information on spatial and temporal distribution of areas used by bears along high-speed highways and for crossing such highways. If specific use areas and crossing areas can be identified by topographic, vegetational, and temporal characteristics, then highway designers can use such information to place crossing structures in areas of highest use, provided structures can be developed. Such information can also be used to minimize landscape and vegetation modifications which might inhibit use near highways and the ability of animals to cross highways.

The following information would increase the possibilities of mitigating effects of high-speed highways:

- document frequency and timing of highway crossings by grizzly bears and
- describe spatial, temporal, vegetative, and topographic features associated with highway crossing sites;
- determine relationships between frequency and timing of highway crossings and highway traffic volume;
- examine the spatial distribution of documented crossings and identify crossing areas, if they exist, as discrete features;
- if crossing areas exist, determine relationships between crossing areas and natural characteristics of the site including topography and vegetation;
- if crossing areas exist, determine relationships between crossing areas and anthropogenic highway corridor features including human developments, roads, railroads, and bear attractant sources such as human foods;

A Plan of Action

We propose a three phase action plan to address impacts of high-speed highways on grizzly bear populations and habitat across the United States/Canada border in the states of Montana, Idaho, and Washington (Figure 2). This plan of action involves three phases: 1) identify characteristics of grizzly bear habitat use in association with highways and highway crossing sites used by grizzly bears and develop a conceptual model based on these data to predict where crossing is most likely; 2) identify mitigation measures for design of structures or highway designs that will facilitate crossings; and; 3) monitor highway impacts on an ongoing basis to provide feedback and assessment of these impacts. This plan of action is suggested to meet habitat and population effects of these highways on grizzly bears. Without a plan of action, we believe that the future of the remaining grizzly populations will be threatened by the effects of these highways. When combined with impacts of other human activities such as private land development, excessive mortality, and disturbance, high-speed highways can have a serious impact on bear survival.

Identify Characteristics of Highway Crossing Sites Used by Grizzly Bears

The first phase of this action plan proposes identification of the characteristics of highway crossings by grizzly bears. This phase would require description of spacial, temporal characteristics of crossings, as well as understanding the vegetative and topographic features of crossing areas. It is unknown if particular characteristics exist that bears prefer for crossing sites along highways, or if crossing is more random. It seems logical that a relationship between vehicle volume, vegetative cover, highway width, and crossing frequency by bears and other wildlife exists. The location of mitigation measures such as crossing structures or vegetative and topographic features which might require special management to maintain crossing may be identified through this first phase.

Emphasis Areas

These locations have been identified as emphasis areas for data collection and application of the program:

1. U..S. Highway 2 between East Glacier and West Glacier, Montana - This is a major travel corridor and the only high-speed highway bisecting the Northern Continental Divide Ecosystem. It is a 2-lane highway separating Glacier National Park to the north from the Bob Marshall Wilderness complex to the south. Associated roadway topography varies from flat, valley bottom to steep mountainside. The highway crosses the Continental Divide at Marias Pass (elevation 5282 ft.). Vegetation is primarily coniferous forest in western portions of the study area, with open grass/forb/aspen communities in eastern portions. Avalanche chutes, preferred grizzly bear foraging areas (Waller and Mace 1997), occur in numerous locations, often close to the highway. The highway lies in the valley bottom, following the Middle Fork of the Flathead River in the western portion of the study area. A railroad parallels the highway for it's entire length. This railroad line is a major freight corridor between Chicago, IL and Seattle, WA. It is also the primary means of transporting grains from eastern Montana and North Dakota to west coast markets. Trains have been a significant source of grizzly bear mortality. Grizzly bears have been attracted to the tracks by the presence of spilled grain. Small concentrations of seasonal homesites, businesses, ranches, and small communities exist within the highway corridor, but the majority of the area is undeveloped. Significant numbers of bears are presumed to cross the highway as it lies within a high density grizzly bear area (T. Manley, pers. comm.).

2. U.S. Highways 89, 49, and 17 between East Glacier, Montana and the Canadian border. These are high-speed highways on the Blackfeet Indian Reservation near the east boundary of Glacier National Park along the Rocky Mountain east front. Associated roadside topography is flat to steep hillsides. Vegetation is primarily grass/forb/aspen communities with patches of coniferous timber. This highway has lower traffic volumes and fewer homes and businesses than the Highway 2 study area, and lacks an associated railroad corridor. Private ranches and tribal lands border the highway. Seasonal grizzly bear crossings of these highways have been documented by an existing grizzly bear study conducted by the Blackfeet tribe. The Blackfeet Nation will be cooperators in this project.

3. The Trans Canada Highway through Banff National Park in Alberta and associated areas on the Trans Canada in British Columbia. This is the main east-west highway across Canada. Traffic volumes may exceed 10,000 vehicles per day during peak travel periods. Recent improvements in this highway have created a four lane highway and have included wildlife-proof fencing along both sides of the highway. Efforts to develop mitigation crossing structures began with the construction of wildlife underpasses and several wildlife crossing overpasses.

Other highway areas may be selected based on availability of bears and highway characteristics.

Data Collection Methods

Error testing - GPS collars are a new technology. Testing of their functionality has been limited (Rempel et al. 1995, Moen et al. 1996, Bennet et al. 1997, Rumble and Lindzey 1997). To successfully obtain a position fix, the collar must be in line-of-sight of at least 3 satellites in the GPS constellation. Satellites must be spaced widely enough to meet Dilution of Precision criteria programmed within the collar. Satellites closely spaced result in poor locational accuracy. In areas of rugged topography, successful fixes may not be obtained or limited satellite visibility may result in more 2D fixes (no elevation) relative to 3D fixes. Locational accuracy may decline as the proportion of 2D fixes increases. 2D fixes are less accurate than 3D fixes. Further, dense stands of timber may interfere with GPS signals, thus precluding successful fix attainment. Currently, the extent of collar testing has been inadequate to determine the effects of terrain and vegetation on GPS positions. Moen et al. (1996) found no effect on accuracy due to canopy cover or stem density, but observation rate declined with increasing canopy cover. Bennett et al. (1997) found no statistical differences in location error and observation rate due to terrain, canopy cover, or vegetation type. Rumble and Lindzey (1997) found a 50% failure rate in stands where canopy cover > 70%. They suggest a negative linear relationship between tree density and observation rate, but observed no effect due to topography. These 3 studies were conducted in areas of relatively low topographic relief. Prior to capture and collar deployment, a survey of potential study areas will be conducted to evaluate satellite visibility and probability of success. This investigation will be the first study involving the use of GPS radio-collars on grizzly bears in mountainous terrain. Initial testing of GPS collars on Grizzly bears in Yellowstone Ecosystem in Montana, Wyoming, and Idaho showed that fixes can be obtained. Preliminary collar tests in the Middle Fork Flathead River area in Montana have also obtained successful fixes.

Capture - Standard trapping techniques (Johnson and Pelton 1980, Jonkel 1993) will be used to capture grizzly bears within study areas. Trapsites will be placed systematically throughout the study area to obtain a representative sample of resident bears. Only adult bears will be instrumented due to the weight of GPS collars (about 5 lbs.). Capture efforts will occur during spring. Five to seven collars will be deployed in each study area. Females are the preferred experimental unit, although 1 to 2 males will also be collared. Females may be less likely to cross highways, but are more likely to remain in the vicinity of the highway corridor. Males, having much larger home ranges, are more likely to roam far from the highway corridor (Mace and Waller 1997). However, males are vital for the exchange of genetic information between metapopulations (Craighead 1994). Grizzly bears with prior history of habituation or food-conditioning will not be collared or included as study animals. Bears with a history of human habituation may be more likely to cross highways thus confounding research results. However, captured bears may become management bears due to attractants in the corridor. Further, bears captured in the corridor may have an unknown history of habituation, or be offspring of bears with a history of habituation. Instrumented bears demonstrating habituation or food-conditioning will be identified and accounted for in subsequent analyses.

GPS collars - Successful documentation of highway crossings will require a frequent sampling interval. We propose obtaining 1 position fix every 15 to 30 minutes. Such a sampling interval will shorten collar battery life to 20 days. However, by using a collar with an FM link, we can remotely alter the sampling interval to maximize locations during periods of expected crossings, and minimize sampling during periods when crossings are unlikely, thus conserving battery power. Expected battery life will range from 20 days (continuously within highway corridor) to >1 year (never within highway corridor). Field personnel will monitor presence of collared bears within the corridor to determine when GPS sampling intervals should be intensified. All collars will be affixed with a cotton spacer to ensure collar retrieval (Hellgren et al. 1988). Recapture efforts will continue to maintain a sample of marked individuals.

Field Investigations - Field personnel will monitor bears with VHF and GPS equipment. Bear relocation sites and crossing areas will be visited to document the presence or absence of features identified or omitted from digital data layers. Particular efforts will be made to document and describe the location of bear attractants including natural or anthropogenic food concentrations.

Traffic Monitoring - Vehicle counters will be located within each study area to document traffic volumes and temporal distribution of traffic volume. Counters may be required at 6 to 8 sites depending upon the study area.

Data Layers - Detailed digital maps of roads, trails, vegetation types, physiography, topography, and human development will be obtained from the Wildlife Spatial Analysis Lab at the University of Montana. Additional data layers will be developed as needed.

Data Analysis - Home ranges will be developed from locations of each instrumented grizzly bear. We will use multivariate statistical techniques to explore relationships between crossing sites and highway, topographic, physiographic, and disturbance variables. Specific methods used will depend upon the nature of collected data, but may include sampling of random vs. used highway segments to identify unique features; polytomous logistic regression (Manley et al. 1993) to relate features to intensity of use; or compositional analysis (Aebischer and Robinson 1992, Aebischer et al. 1994) to identify preferred features along movement vectors.

Vegetative, topographic, spatial, and temporal features associated with grizzly bears crossing highways, and the results of monitoring grizzly bears use of highway crossing structures on the Trans Canada Highway, will be the basis of a conceptual model to identify combinations of factors that could be used by highway designers. Scale of output would allow highway designers to position crossing structures and special highway design features based on characteristics of the site and knowledge of grizzly bear highway interactions. Landscape level identification of linkage areas can be accomplished with the existing Linkage Zone Prediction Model (LZP) (Servheen and Sandstrom 1993, Sandstrom and Servheen in review, Apps 1997). Site-specific identification of potential crossing areas will be the goal of the predictive model (Figure 3).

Mitigation Measures Identification Methods

Using results from the crossing structure monitoring in Banff along the Trans Canada Highway, and bear behavior and movement data along highways, we will propose a list of crossing structure types and highway design modifications to facilitate crossing . These structures and modifications will be keyed to vegetative characteristics, and other characteristics of the specific site predicted as having a high crossing probability.

Monitoring Impacts on an Ongoing Basis

Impacts of highways on grizzly bears should be monitored on a long-term basis. Radio-collaring of bears along highways, especially in areas where special structures or highway design features have been established is the only means of evaluating effectiveness. This type of ongoing monitoring could reveal gradual changes in population characteristics that may occur as a result of highway impacts. Monitoring could determine the value and acceptance of crossing structures by quantifying their use by bears and other wildlife. It may also be possible to monitor genetics across potential fragmentation features like highways.

Summary

Linkage of grizzly bear populations spanning the United States-Canada border will be dependent upon maintaining linkage across high-speed east-west highways that span these populations. As increasing numbers of vehicles use these highways and increasing highway improvements make these roads more impervious to wildlife, an aggressive program is necessary to maintain linkage for grizzly bears and other large carnivores. The small populations and low reproductive rate of grizzly bears makes them especially vulnerable to habitat and population fragmentation from high-speed highways. We propose a three phase process to identify characteristics of grizzly bear habitat use in association with highway crossing sites and develop a predictive model, identify mitigation measures for design of structures or highway designs that will facilitate crossings, and monitor highway impacts on an ongoing basis to provide feedback and assessment. To ignore this problem and to do nothing will likely assure population fragmentation and a dissolving of linkages between these international grizzly bear populations.

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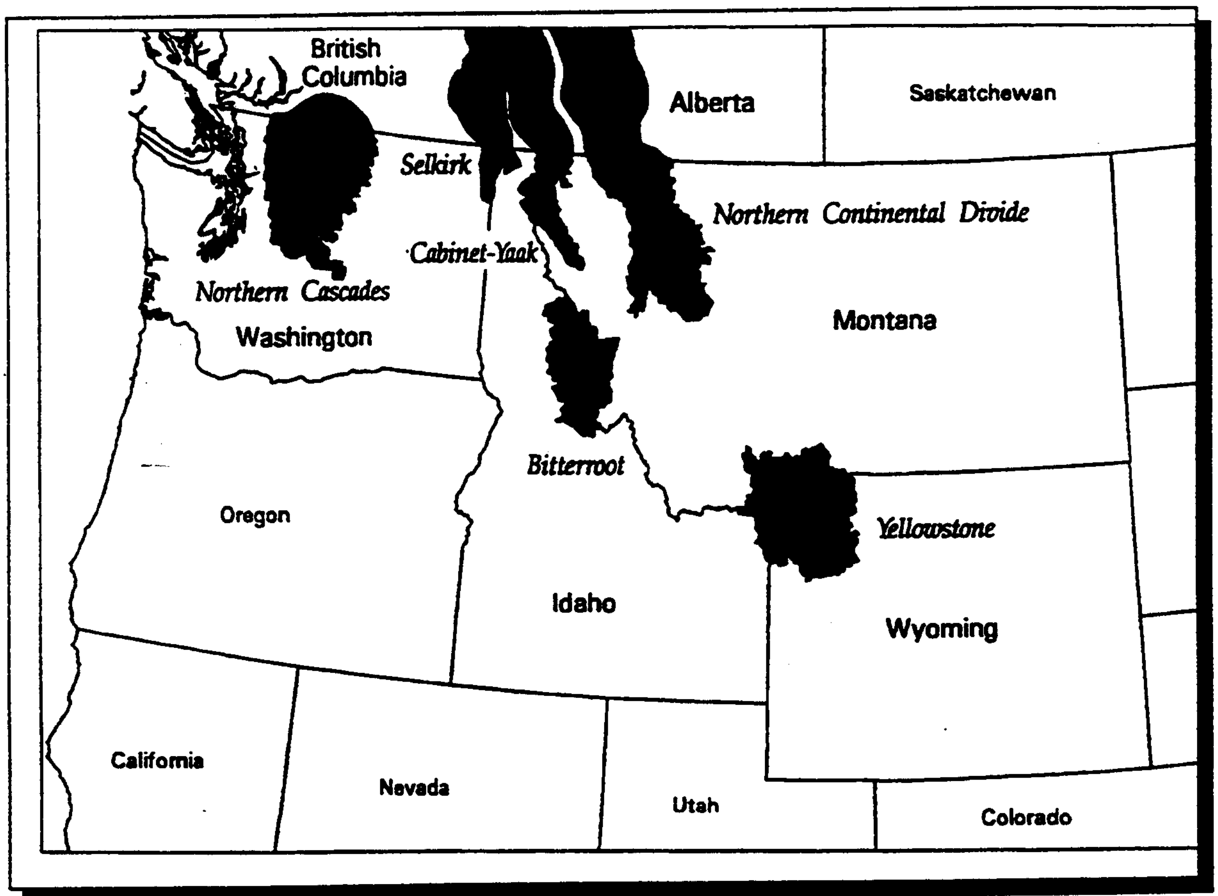

Figure 1. The grizzly bear recovery areas in the U.S. and southern British Columbia and Alberta, Canada.

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The grizzly bear recovery areas in the U.S. and southern British Columbia and Alberta, Canada.

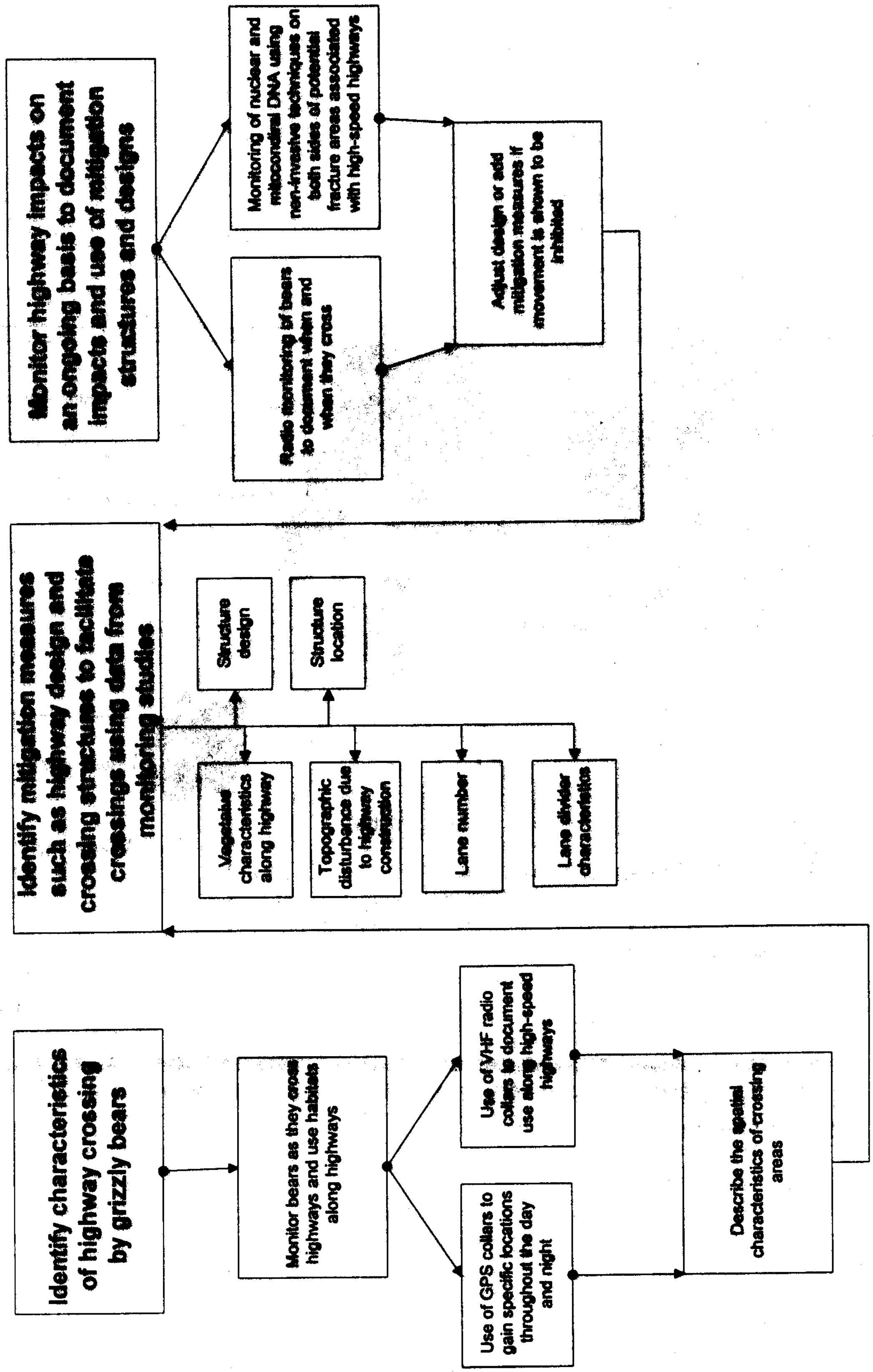

Figure 2.
The three phase approach to addressing the habitat fragmentation effects of high-speed highways.

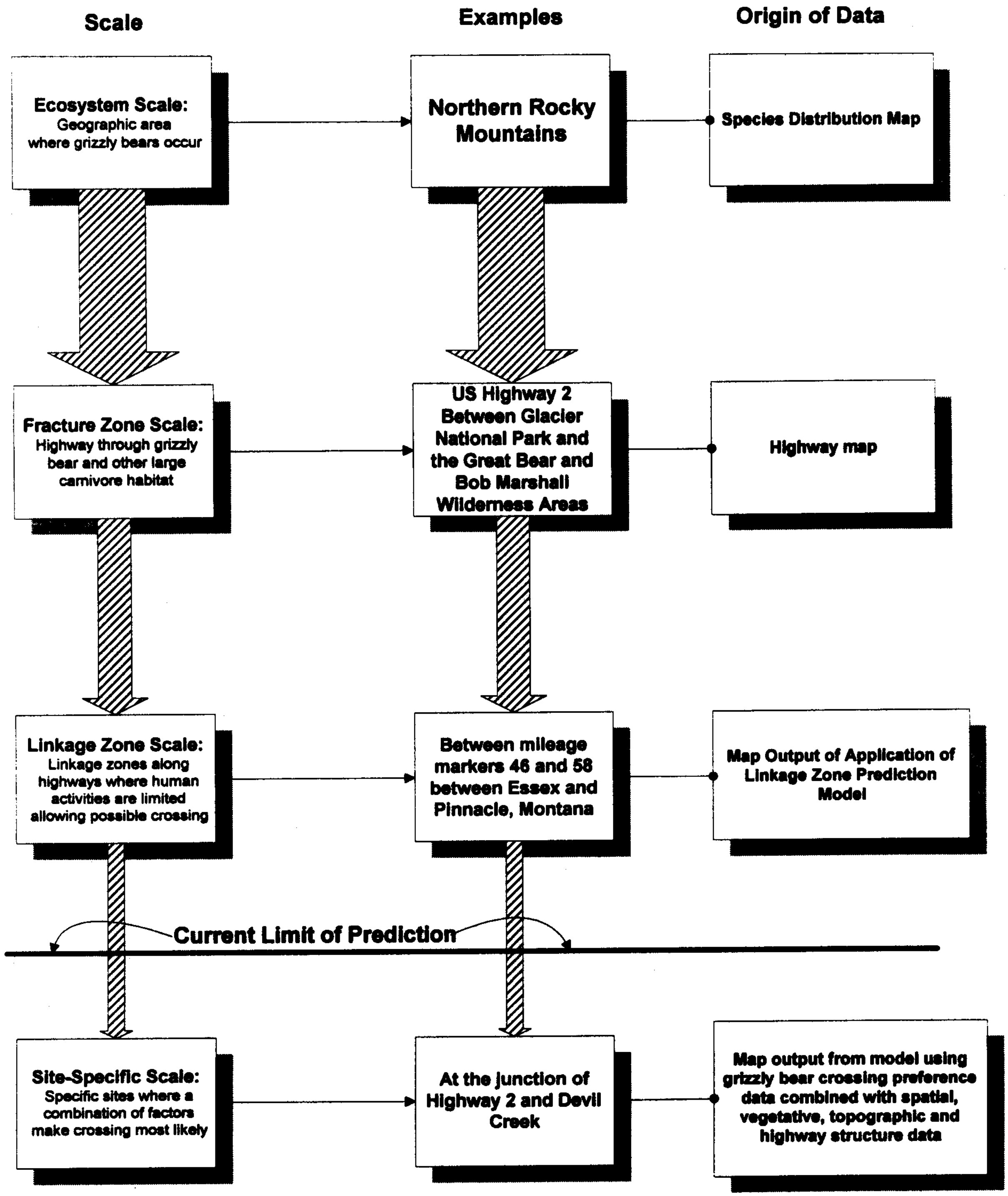

Figure 3.
Scales of resolution for the relationship between grizzly bears and high-speed highways. The current level of resolution is the linkage zone level. The objective of the proposed plan for action would extend the scale to the site-specific level.