Title
Measuring the Success of Wildlife Linkage Efforts

Permalink
https://escholarship.org/uc/item/4889193p

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Publication Date
2007-05-20
**Introduction**

The objectives of wildlife linkage efforts are to maintain or restore connectivity in wildlife populations. There are many biological factors to assess success of such efforts. These include measuring and monitoring individual movements, genetic flow, population range, and levels of wildlife mortality and conflicts within linkage areas. We cannot define success though without a consensus on the definition of connectivity. We can define connectivity as "...a measure of the ability of organisms to move among separated patches of suitable habitat" (Hilty et al. 2006:50), although the word “separated” in this definition presupposes that these patches of habitat are somehow disconnected. In natural systems where human activities are non-existent, most patches of habitat of value to species are contiguous and connected. Human linear transportation corridors such as highways and railroads, and the resulting human developments along such transportation corridors are the root cause of habitat and population fragmentation and the disconnection between habitat patches.

Most concerns about the impacts of highways and railroads and other linear human features on wildlife populations and ecological systems are related to the biological impacts of such features. As such, measures of success for efforts to enhance connectivity and reduce direct mortality are usually biological in nature. For example: does connectivity for wildlife and natural systems exist and to what extent; is mortality related to these linear features occurring and if so how much? For transportation agencies and corporations such as railroads, biological performance measures are usually viewed as being outside the scope of their authority and/or responsibilities. However, solutions to fragmentation and mortality due to linear transportation features lie with these agencies and corporations. If transportation systems are to be made more permeable to wildlife and mortality along highways and railroads is to be reduced, these agencies and corporations must invest in structures and other systems to increase successful movement. Therefore, anything that can more successfully translate the importance and value of investments in enhancing wildlife connectivity into the performance measures that resonate with transportation agencies and railroads will make such investments more likely. Marketing the need and value of such investments will be more successful by including comprehensive measures of success and performance of these investments beyond strictly biological measures. Efforts to expand measurement of success beyond biological measures will also improve agency, corporate, and public understanding of the benefits of connectivity and linkage efforts.

Linkage efforts across linear transportation features should include measures of success relating to multiple factors including biological measures at the population and ecosystem scale; economic measures at both the individual traveler scale as well as the community and agency/corporate scale; public safety measures at the individual traveler scale as well and the agency/corporate scale; social measures of acceptance and benefits to human quality of life; and political measures of acceptance and measurement of the political will to invest in such efforts and to support sometimes costly measures required for linkage across the landscape. Of these measures, biological, economic, and
public safety measures of success are quantitative in nature and can be directly measured with appropriate numerical approaches. These quantitative measures are by their nature objective and easily comparable temporally and spatially within and between linkage efforts. However, social and political successes are qualitative in nature and their measurement is much more subjective. This does not make social and political measures of success any less important, but it does make measurement more difficult, less comparable temporally and spatially and subject to interpretation.

Figure 1. The four factors necessary for a successful linkage management program.

**Biological Measures of Success**

Wildlife linkage and connectivity efforts are traditionally discussed within the context of biological success. The need to maintain connectivity, after all, is rooted in biological concepts such as island biogeography and metapopulation theory. These theories provide managers and researchers the impetus to consider connectivity in natural resource management decisions. A successful wildlife linkage program requires information on four key issues: why crossing structures and resulting wildlife movement are needed; where the best locations are to maximize the benefits of linkage investments; the optimum design considerations of each linkage investment; and a description of the desired results expected to be achieved by the linkage investment at the population scale and at the ecosystem function scale. The question of why crossing or movement mitigation efforts are necessary is essentially the problem statement described in biological terms. Locations for structures or movement mitigation effort are the stratification of the area to identify the locations of greatest biological impact and importance. The design considerations are the specifics that the highway designer or land manager or land conservation group needs in terms of shape, length, location, and area size to meet the needs of the issue or species of concern. Finally, and perhaps most importantly, there needs to be a detailed description of the expected results of the linkage investment. This description should be at both the population level for the species or groups of species of concern in the area, as well as the ecosystem level for functions that are expected to be restored or maintained as a result of the linkage investment.

Population-level expected results might be described in terms of sex-specific movements for reproduction or dispersal of young or continued occupancy and reproduction throughout a species’ historic range. Ecosystem function might be the expected multi-species predator/prey dynamics, or food web maintenance, or movement to and from seasonally important habitats, or access to habitats in response to climate change, or the need for range changes due to catastrophe such as wildfire. The explicit description of the expected results of the linkage investment is important as it provides the benchmarks with which to design monitoring systems to judge the ecological success of the investment. Without such clear definitions of success, there will be no clear measures available to demonstrate the biological importance of the linkage investment or justify the linkage investment.

A fundamental consideration when assessing movements and impediments to movements is the issue of scale. What might be a significant impediment to a small mammal such as a mouse or a vole may have no impact on larger mammals. Then there is the issue of individual level effects versus population or ecosystem level effects. For our purposes of measuring the success of wildlife linkage we will concentrate on the population and ecosystem scales. We will consider linkage efforts across linear human transportation features successful biologically at the population scale if they maintain and enhance the demographic and genetic viability of populations. We will consider linkage efforts across linear human transportation features successful biologically at the ecosystem scale if these actions enhance ecosystem function in terms of dispersal, historical connectivity, access to seasonal habitats and movement patterns, and maintain opportunities for metapopulation function between presently disjunct blocks of habitat.

The most intuitive measure of success regarding wildlife linkage efforts involves assessing whether individual animals are successfully moving across the landscape among public lands, private lands, and potential barriers or filters to
movement such as highways and railroads. Using traditional radio-telemetry or more modern GPS radio-collars allows insight into individual movements. Movement data from individuals may be used to assess population-level movement patterns, overall population health, and ecosystem function. Such studies can provide evidence of population connectivity by demonstrating sex-specific movement across the landscape, dispersal success, and use of important seasonal habitats. The movements of females of some species like bears are sometimes more sensitive to potential barriers while males still navigate a landscape relatively unimpeded (Procter et al. 2005). Therefore, female use of a linkage area that traverses a potential barrier such as a highway or railroad may be considered the ultimate measure of biological success for certain species at the population scale. Biological success may be defined differently based on the objectives associated with individual projects and efforts. Some managers may consider a wildlife linkage effort a success if dispersal opportunities for individuals across the landscape are maintained. In fragmented ecosystems, inter-population dispersal, or connectivity, of both sexes may be important for population augmentation, rescue, or recolonization within natural (Hanski and Gilpin 1997) and human-caused (McCullough 1996) metapopulations. Because dispersal of young allows for genetic interchange, demographic rescue colonization of new habitats, and/or replenishment of sink habitats, it is an important biological measure of population connectivity and resilience. Seasonally important habitats are also a vital component of population connectivity because they may be required to access breeding grounds, calving grounds, migratory ranges, or seasonally available food and water. Long-term studies of individual movements can provide many population-level statistics regarding connectivity at both a local and landscape scale.

Genetic fragmentation is one of the primary concerns driving natural resource managers to maintain and reestablish connectivity in human-dominated landscapes. As populations become genetically isolated, they are increasingly vulnerable to losses in genetic diversity (due to genetic drift and inbreeding depression), disease, stochasticity, and extinction. Genetic factors are functional and quantitative measures of whether wildlife linkage efforts have been successful. Genetic measures of movement can be obtained non-invasively and are relatively conclusive when compared to other methods of data collection. Identifying individual animals can provide information on how far animals are moving, whether animals are using certain areas, and if genetic fragmentation is occurring. By establishing a grid system sampling design, individual animals may be detected at multiple locations. Such a grid sampling system can document genetic movement across an area over time but does not provide information about the actual movement locations or patterns. Non-invasive genetic sampling can also be used to establish the presence of animals in an area. Finally, genetic signatures can document the level of genetic fragmentation, or genetic distance, and immigration through assignment testing (Proctor et al. 2005). Genetic assignment testing can identify the proportional levels of interchange across barriers, where individual animals originated from, and comparative rates of movement or connectivity between different linkage areas and between different time periods in the same area.

The overall range and distribution of a population is also a good measure of success at the landscape scale. While presence of a species is indication of some level of movement, species persistence requires the presence of reproductive females and successful reproduction. This type of statistic can verify re-occupancy of currently unoccupied historical habitat, re-connection of isolated populations, and responses to environmental change such as global climate change. However, this type of measurement will vary depending on how the distribution is calculated. Presence and sex of animals can be documented by hair capture and DNA analysis (Woods et al. 1999; Taberlet et al. 1999), while documentation of reproduction is best documented by radio monitoring.

Preventing human/wildlife conflicts and human-caused mortality is essential to successful wildlife linkage efforts. As wildlife are forced to move through landscapes that are surrounded, occupied, and used by humans, the potential for conflicts and subsequent wildlife mortality increases. This mortality can come in many forms, including poaching, management removals, legal hunting, and animal-vehicle collisions. Because a successful wildlife linkage area has mortality risk equal to or lower than adjacent suitable habitat patches, quantifying wildlife conflicts and mortality before and after linkage efforts is implemented is a valuable way to measure success of those efforts. One way to measure successful linkage areas will require long-term monitoring of differential mortality of animals that use linkage areas versus those that do not use linkage areas. Another measure of success that is straight-forward is to analyze conflict and mortality data before and after linkage efforts are implemented. Analyzing proportions of populations that cross linear human feature and the number of animal-vehicle collisions before and after mitigation measures is also a useful tool to examine the success of linkage efforts in relation to wildlife mortality (Hardy et al. 2007).

Documentation of the biological success of wildlife linkage efforts is usually expensive and time-consuming to assess with certainty. To judge the success of a linkage area, we need to know not only the number of animals using the mitigation measure, but also the proportion of the population of animals in the area that use the linkage zone successfully. Measurement of proportional use requires having a representative sample of the local population marked and documenting the proportion of these marked animals moving between habitat units. Individual animals can be marked through physical markers (e.g., radio-collars, ear tags, etc.) or genetic analysis. To make valid inferences and conclusions, biological responses to wildlife linkage efforts must be measured for long periods of time and possibly at multiple times in the future (Clevenger and Waltho 2003, Hardy et al. 2007). Long-term studies reduce the chances that environmental stochasticity explains the variation observed more than the mitigation measures. However, more simplistic approaches such as comparing before and after animal-vehicle collision data or documenting presence in or use of an area using passive-infrared cameras may be adequate depending on specific objectives.
Defining success with these measurements of biological factors will vary based on objectives. Because effectiveness is ultimately tied to values (e.g., personal, agency, group, cultural, etc.), there is no single value that determines success. Instead, raw data must be documented and people/agencies can determine for themselves if measures are effective. An animal lover may view crossing structures as effective if animal-vehicle collisions are reduced at any level. A biologist may view a reduction in animal-vehicle collisions as effective if the number of animals is biologically significant to the surrounding local population. Similarly, a Transportation Department official may view a reduction in animal-vehicle collisions as successful if the cost of the structure is less than the monetary value saved in insurance claims, medical bills, hunting fees, etc. as a result of that reduction. Even within the scientific community, there is room for interpretation. For instance, genetic connectivity may be achieved with only 1 or 2 effective migrants per generation but some wildlife managers would argue that population connectivity requires more movement than that to be considered successful.

- Movement across the landscape
- Gene flow (no differences in genetics across barriers)
- Seasonal range access
- Dispersal success
- Female movement
- Access to range expansion needs in response to climate change
- Reoccupancy of historic but unoccupied range
- Reconnection of isolated populations
- Access to resources such as water or food
- Sustainable mortality in linkage areas
- Reduction in wildlife/human conflicts in linkage areas

Figure 2. Examples of direct measures of biological linkage success.

**Economic Measures of Success**

Quantifying the economic benefits associated with wildlife linkage efforts is difficult because many of these are indirect. For example, addressing wildlife linkage needs in the planning stages of highway construction or reconstruction may lead to road or bridge designs that do not have to be renovated in the future. But how do you quantify this hypothetical financial savings? Other potential economic benefits associated with successful wildlife linkage efforts may be in the form of ecological services such as clean water, clean air, and healthy soil communities. Because many of these ecological services are difficult to link directly with specific wildlife linkage efforts, for the purposes of this paper, we review and examine direct economic benefits associated with successful wildlife linkage efforts.

The economic costs and benefits associated with wildlife linkage efforts are distributed among highway departments, public natural resource management agencies, private landowners, and private citizens. A cost-benefit analysis is a common tool used to quantify the potential impacts of a policy or decision in economic terms (Nunes et al. 2003). A cost-benefit analysis, in theory, includes all costs and benefits associated with a particular decision (Bateman et al. 2003). In general, if the benefits are greater than the costs, the policy or decision is a good economic choice.

The most direct way in which highway departments contribute to wildlife linkage efforts is through the installation of wildlife crossing structures. The goal of such structures is to get animals across the highway safely to reduce (or eliminate) animal-vehicle collisions. Hardy et al. (2007) present a method similar to a cost-benefits analysis for evaluating the effectiveness of highway mitigation measures along Hwy. 93 in Montana. They compare the costs of property damage, human injuries, human fatalities, deer fatalities, and removal of deer carcasses to the costs of constructing wildlife crossing structures and fencing (Hardy et al. 2007). This allows transportation departments to know how long it
will take under varying scenarios of reductions in animal-vehicle collisions to result in a cost-effective decision. Hardy et al. (2007) found that crossing structures built along a 46 mile section of Hwy. 93 in Montana would pay for themselves in 10 years if a 90% reduction in animal-vehicle collisions was achieved or in 25 years if a 35% reduction in animal-vehicle collisions was attained. Given that the average life span of a wildlife crossing structure is roughly 75 years, highway departments can monitor reductions in animal-vehicle collisions with a clear objective of what economic success is.

Highway crossing structures provide economic benefits to the average citizen in the form of increased driver safety. The estimated cost in property damage caused by a deer-vehicle collision is $1,840 (Hardy et al. 2007). If human injuries are sustained, the cost of these injuries ranges from $10,000 (Wu 1998) to $206,000 (U.S. Department of Transportation 2002), depending on the severity of the injuries. Finally, the estimated monetary value of a human life ranges from $1,500,000 (Romin and Bissonette 1996) to $3,600,000 (Trawen et al. 2002) with estimates by Schwabe et al. (2002), and the U.S. Department of Transportation (2002) between these two values. Although the percentage of deer-vehicle collisions resulting in human mortalities is roughly 0.5%, this is a significant cost to consider, especially since many would argue that the worth of a human life is beyond quantification.

Public natural resource management agencies stand to benefit from wildlife linkage efforts in a number of economic ways. As planning becomes more interdisciplinary in scope, the conservation of wildlife linkage areas should lead to reduced environmental review and court challenge of land management decisions. By addressing ecological issues related to linkage at the planning stages of a project rather than at the end of the process, natural resource managers will achieve improved efficiency in project planning with minimal biological evaluation delays.

For private landowners, the economic benefits of wildlife linkage efforts are primarily manifest in increased property values and tax incentives. According to some reports, the proximity to open spaces and parks in urban areas can account for 15-20% of a property's value (National Association of Homebuilders 2002). This increase in property values occurs due to the perceived value of adjacent landscapes and native wildlife to wildlife linkage areas and the idea that for many people, location and proximity to recreational opportunities (i.e., open space) is an important factor determining where they buy houses (National Association of Homebuilders 2002). As landowners place parcels of their private property in conservation easements, they may also benefit from improved estate planning and tax incentives provided by federal and state governments.

Public Safety Issues: The Scope of the Problem

Montana, along with most of the Rocky Mountain States, has unique problems in traffic safety. The Rocky Mountain States tend to have high numbers of roadway departure fatalities. A high percentage of miles traveled are at high speeds compared to more urban states, thus increasing the likelihood of fatal or incapacitating injury crashes. The makeup of the vehicle population is also different in the Rocky Mountain States. The percentage of registered pickups, SUV’s and vans is very high in Montana as are fatal crashes involving these vehicle types. Factors such as long trips on rural roads, high travel speeds, lack of seat belt use, and a higher proportion of SUV’s and pickups, push fatality rates upward in Montana and the surrounding states. These factors are much of the reason that states in the Rocky Mountain region show high fatality rates (MDT 2006).

There are several exposure statistics in the area of traffic safety. These include number and type of vehicles, number of licensed drivers by age and gender, physical road miles, population, and the number of vehicle miles driven. Vehicle Miles Traveled (VMT) is the exposure number that appears to have the greatest influence on the amount of traffic crashes that occur in Montana (MDT 2006). Annual VMT numbers have greatly increased over the past few decades. Changes in VMT over time are shown in figure 3.

![Figure 3. Vehicle miles traveled (VMT) in Montana 1945-2005. (MDT 2006).](image-url)
Collisions With Wild Animals or Avoidance

During the twenty year period from 1984 to 2003, the number of reported crashes involving wild animals increased from 468 to 2,012. The key word is “reported”, since many animal crashes are not reported. The long-term trend in animal-vehicle collisions is shown in figure 4.

![Figure 4. Reported animal-vehicle collisions in Montana, 1982-2005.](image)

The Montana Department of Transportation keeps a database, which accounts for wild animals that are picked up off the roadways by the Maintenance Division. The assumption that these carcasses were the result of collision with motor vehicles would seem valid. This count of carcasses provides another estimate of the number of wild animal crashes. These numbers are from three to four times higher than reported crashes (MDT 2006).

Vehicle Miles Traveled (VMT) is the exposure number that appears to have the greatest influence on the amount of traffic crashes that occur in Montana. Note the rates of increase in VMT since 1982 and the number of reported accidents with wild animals over the same time period. Purely in numbers VMT from 1982 through 2004 has increased 40%. Reported wild-animal vehicle collisions during the same time period from 1982 through 2004 has increased by 72%. Also, in the Rocky Mountain States, a high percentage of miles traveled are at high speeds compared to more urban states, thus increasing the likelihood of incapacitating injury or fatal crashes; while at the same time, speed, and its reciprocal travel time, is an important measure of the quality of traffic service provided to the motorist. It is used as an important measure of effectiveness to define levels of service for many types of facilities, such as rural two-lane highways, arterials, and freeway weaving sections (ITE 1999). Speed appears to be one of the primary factors influencing numbers of animal vehicle collisions. According to Gunther et al. (1998), vehicle speed appears to be the most significant factor influencing the frequency of animal-vehicle collisions in Yellowstone National Park. Animal-vehicle collisions in Yellowstone Park occur much more frequently on straighter, wider roads where vehicles traveled faster, regardless of posted speed limits.

Recent research suggests that while the total number of all types of vehicle crashes per year in the United States has remained relatively stable, nationwide animal-vehicle collisions have steadily increased by about 50% between 1990 and 2004 (Huijser et.al. in prep). In the Rocky Mountain States, given the combination of: increasing human populations; increasing vehicle miles traveled; high vehicle speeds; high number of rural roads; stable to increasing wildlife populations; current predominant mode of new construction and reconstruction of roadways not incorporating wildlife mitigation; and wider road surfaces wildlife have to cross, the likelihood that there will be an increasing trend of animal vehicle collisions well into the future seems valid.

Measuring Success Relative to Public Safety

Determinations of effectiveness or success of wildlife crossing mitigation can be measured on human safety values. For example, although monetary values have been placed on human life (Sielecki 2004, Schwabe et al. 2002, U.S. Department of Transportation 2002, Romin and Bissonette 1996), many would argue that a human life is priceless especially to the one who loses it. While it is possible to present measures of effectiveness, effectiveness is ultimately determined by an individual’s or agency’s values (Hardy et al. 2007).
The overall objective of wildlife mitigation measures is to increase the permeability of a transportation corridor to wildlife movement. Success reduces barrier effects and usually reduces road-kills (Forman et al. 2003). State departments of transportation (DOT’s) that have incorporated wildlife mitigation such as crossing structures, wildlife fencing, and wildlife jump-outs, have not always developed clearly defined goals and objectives relating specifically to planned or desired percent reductions in animal vehicle collisions. Therefore, it seems reasonable that in order to assist administrators in defending and justifying expenditures for transportation improvement projects that incorporate wildlife mitigation measures, traffic safety engineers, biologists, researchers, and the public should work to develop common goals and objectives regarding expectations of reductions in animal vehicle collisions associated with various wildlife mitigation measures. Such a process could allow DOTs to compute a cost-benefit analysis of projects to improve safety and permeability.

Cost-benefit analysis has increasingly commanded the attention of professional engineers, government administrators and the judicial system. Criteria have been developed to evaluate public investments in the field of traffic safety (MDT 2007). The concept behind a planned benefit is:

1. The total economic loss as a result of traffic crashes at a specific location is determined by the severity of injuries and the number of crashes; and
2. Specific improvements will yield reductions in traffic crashes.

We believe that the existing formulas used for Safety Engineering Improvement Programs by state DOTs can be used or modified to evaluate projects that incorporate either spot improvements or roadway reconstruction projects that incorporate wildlife amenities.

In the Montana Safety Engineering Improvement Program, fatal and injury accident calculations are combined into a single quotient called “Q”; this complies with FHWA Technical Advisory T 7570.1 (June 30, 1988), Recommended Accident Costs (MDT, 2007). “Q” is used because fatality figures are relatively small and a matter of chance. The State of Montana combines fatal and injury totals to reduce the possibility of selecting an improvement project on the basis of chance. The ratio of injuries to fatalities will vary depending on the general class of locations under study. For example, the ratio for rural secondary roadways is different than the ratio for rural freeways (MDT 2007).

Since “Q” has been defined and fatalities and injuries can be combined, the initial Planned Annual Benefit Formula can be stated, (For purposes of this paper consider applying Animal Vehicle Collision Data into the formula):

Planned Annual Benefit (in dollars) = Q (Afi)Pfi + Cpd (Apd)Ppd

Where:

- Q = average cost per fatal and injury combined
- Afi = average number of annual fatalities or injuries combined
- Pfi = expected percent reduction in fatalities or injuries
- Apd = average annual property damage only accidents
- Cpd = cost per property damage only accidents
- Ppd = expected percent reduction in property damage only accidents

To account for changes in traffic volumes over time, the ratio of the projected annual average daily traffic after improvement to the annual average daily traffic before improvement is computed as follows:

\[
\frac{ADT_a}{ADT_b} = \frac{(1.03)^L + 1}{(1.03)^S + 1}
\]

- L = number of years for life of the project
- S = number of years of crash records used in analysis

This formula accounts for an average annual traffic growth rate of 3 percent. The expected benefit formula now becomes:

\[
B = \frac{ADT_a \cdot Q (Afi)Pfi + Cpd (Apd)Ppd}{ADT_b}
\]

- B = expected Annual Benefit (in dollars)
- ADTa = projected Average Daily Traffic after improvement
- ADTb = Average Daily Traffic before improvement
This now becomes the working formula for planned benefit. For the expected percent reductions (Pfi and Ppd), the expected reductions are determined by several means. However, they are stated as specific objectives for the project under consideration and are derived from:

1. Actual experience with similar projects in other states.
2. Actual experience with similar projects in Montana.
3. Expert judgment or experience.
4. A combination of the above.

In order to calculate a projected Planned Cost:

1. The construction cost of each proposed improvement alternative must be readily calculated.
2. The increased cost of maintenance and operations must be established.

The formula for capital recovery factor is:

$$K = \frac{R(1 + R)^T}{(1 + R)^T - 1}$$

- $R$ = Compounded interest rate
- $T$ = Estimated service life

With the capital recovery factor explained, the formula for annual cost is:

Annual Cost = $[C(K)] + M$

- $C$ = Capital costs
- $K$ = Capital recovery factor
- $M$ = Change in annual maintenance operations costs

Thus, the benefit - cost ratio becomes:

$$\frac{\text{Benefit}}{\text{Cost}} = \frac{\text{ADT}_b \cdot [Q (Afi)Pfi + Cpd (Apd)Ppd]}{[C(K)] + M}$$

The formula above is used for the Traffic Safety Improvement Program and is typically applied to spot improvements over a 0.5 mile segment of roadway. We believe this formula can be used with a broader application when evaluating reconstruction projects that incorporate wildlife mitigation measures.

There are many factors that go into decision making when considering expenditure of public money for transportation related improvement projects. Cost-benefit analysis is only one of them. What this formula does is give an administrator a ratio of the expected or planned benefit in dollars versus the cost in dollars spent. This will also shift the mode of thinking that wildlife mitigation is an add-on cost to the project. By including wildlife mitigation measures into the planning and cost-benefit analysis, transportation agencies will be addressing safety as part of a comprehensive approach through incorporation of goals and objectives that clearly lay out targets for cumulative safety benefits throughout a reconstruction project.

Obviously, relative to wildlife vehicle collisions this formula does not take into account biological benefits, or social or political aspects. It should not be viewed in isolation but part of the larger picture recognizing that departments of transportation can really only effectively control what happens within the highway right of way limits. Confounding variables outside of the highway right of way (land management, land use changes, land use laws (i.e. zoning), game management, re-colonization of predator species) and outside of the control of DOTs can and will influence how much use wildlife crossing structures receive and by which species. However, application of this method would give transportation decision makers another tool to consider when prioritizing projects. As many states work towards mapping linkage areas, obviously there is not enough funding to address all needs. Better tools are needed to assist in prioritizing projects. This approach could help define desired or planned goals and objectives while laying the ground work for comparison of pre- and post-treatment accident analysis.

This leads us back to the precept that success relative to wildlife mitigation measures will be dependent upon how well people work together regarding management and development of public lands, private lands, wildlife populations, and transportation corridors. It requires bigger picture thinking, broader perspectives and people working together. It is hoped that this paper will provoke thought and discussion in order to clearly and adequately define goals and objectives when planning, designing and implementing wildlife amenities into transportation projects and appropriate methods to measure their success.
**Social Values Involved in Maintaining Wildlife Linkage Zones and Measures of Success**

Social values associated with maintaining wildlife linkage zones are similar to those attributed to the necessity of maintaining wilderness areas, open space within our communities, and diverse wildlife populations. There is an inherent value to these conservation efforts, but it is difficult to quantify comprehensive social values of such efforts because social values drive economic decisions and political legislation. Thus, social values are inextricably intertwined with economic and political policies and the decisions society makes.

Historically, public natural resource managers have been conditioned to respond to values expressed by political and social systems that were very sensitive to the economic values derived from resource use and development. Laws or budgets are political system expressions of natural resource values. Wild land use, license sales, effectiveness of nongame wildlife contributions on state tax forms, or newspaper editorials are primarily social system expressions of natural resource values. Of course these values are rarely expressed solely through one system. For example, an Audubon chapter (in the social system) may lobby a state legislature (political system), obtain financial endorsement of corporations (economic system), and encourage its members to write legislators (social and political systems) to increase a state’s non-game management budget (Kennedy and Thomas 1995). Yet today, the economic system is of increasing importance in expressing wildlife values (Kennedy and Thomas 1995). This is reflected in landowner payments for participation in block management hunting programs, wildlife viewing tours, auctioning of trophy big game permits and the outfitting industry providing guided hunts to name just a few. A half century after Leopold and others proposed economic inducements for landowners, their profession and state agencies increasingly are supporting this policy. As in the past, most American wildlife values are still expressed socially and politically through examples such as state and federal laws guiding game and non-game management, stream restoration and wetland restoration projects that restore wildlife values to enhance or diminish others (Kennedy and Thomas 1995).

Some of the more common attributes related to humans that can be associated with linkage zones are quality of life, ethical and moral considerations, recreational values, economic values, and those social values associated with reducing the potential for state or federal intervention while relying more on local initiatives and local land use decision making. A value that is seldom discussed but will be touched upon here is associated with local groups taking action regarding identification and mapping of linkage zones, focal species associated with these linkage zones and sharing of this information with county commissioners, local land use planners, state and federal game management and land management agencies and transportation agencies. Through this investment of time and energy these local groups build “Social Capital” (Pretty and Ward 2001). We will give a brief discussion of how social and human capital, embedded in participatory groups within rural communities can be a central measure of success in maintaining linkage zones necessary for continued persistence of local and regional wildlife populations.

**Background on Common Social Values**

The following discussion of common social values associated with linkage zones has been taken and/or adapted from Duerksen et al. (1997):

- **Quality of Life**: Most people realize that the presence and protection of wildlife improves the quality of their lives, even though the actual value is difficult to assign. This is true even if they never see the protected wildlife. The mere knowledge that wildlife is nearby and that we have contributed to its conservation often improves the quality of our lives.

- **Ethical and Moral Considerations**: Many people feel an ethical and moral imperative to protect wildlife and its habitat from the growing impacts of human development. This thinking goes more in line with the “biocentric world view that accepts intrinsic values in the natural world, independent of utilitarian or direct human value endowment”, (Kennedy and Thomas 1995).

- **Recreational Values**: The conservation of wildlife also contributes substantially to the recreational opportunities available to people. Birdwatching, wildlife hikes, fishing and hunting are only a few of the many recreational activities that depend upon the availability of wildlife and their habitat.

- **Economic Importance**: The protection and preservation of wildlife also contributes to the economic health of a state through tourism and otherwise. Using Colorado as an example, in 1990, an economic impact model developed by the Colorado Chapter of the Wildlife Society estimated that direct spending on hunting and fishing totaled over $570 million (excluding spending by the Colorado Division of Wildlife itself) within the state. When all direct and secondary spending was counted, the figure rose to over $1.3 billion. The $1.3 billion did not include the fact that the opportunity to view wildlife was considered to account for about 20 percent of all general tourism in Colorado.

- **Local Initiatives, State and Local Governments stepping forward, reduced Federal Government intervention and Local Land use Decision making**: Local governments have begun to emerge as prime partners and implementers of effective wildlife preservation programs. This trend is the result of citizens being increasingly involved and vocal with habitat conservation issues at the local level. Because the preservation of wildlife and their habitat contributes to the perceived quality of life for many residents, generates significant revenue through sports and passive tourism, and fulfills a growing sense of a moral obligation to protect wildlife, state and local governments have stepped into the field of habitat protection. Instead of relying on federal wildlife programs,
Social Capital and Local Citizens Groups

Social and human capital, embedded in participatory groups within rural communities can be a central measure of success in maintaining linkage zones necessary for continued persistence of local and regional wildlife populations. In this paper we will link social and human capital in the context of natural capital in the form of linkage zones.

Social and human capital captures the idea that social bonds and social norms are an important part of the basis for sustainable livelihoods (Pretty and Ward 2001). Unlike conventional capital, natural capital (nature's goods and services – cf. Costanza et al. 1997) tends to be at least partially a public good – more correctly, they are complex mixtures of public, club and private goods and so rarely have a market value (Pretty and Ward 2001). Like all public goods, it is difficult to say who is at fault when natural capital declines. Without rules, individuals tend to overuse and under invest in it. They are tempted to take the benefit without contributing anything themselves – in effect, to free-ride (Hardin 1968). When such public goods and services are considered free and so valued at zero, the market signals that they are only valuable when converted to something else. So the profit from converting forest or pastureland into subdivisions is counted on the developer’s balance sheet, but all the lost services (wild foods, fodder grasses, climate regulation, and biodiversity) tend not to be subtracted. Social institutions based upon trust and reciprocity, and agreed norms and rules for behavior, can mediate this kind of unfettered private action (Pretty and Ward 2001). While there are many different descriptions of social capital, Pretty and Ward (2001) identified four central aspects: relations of trust; reciprocity and exchanges; common rules, norms and sanctions; connectedness, networks and groups.

- **Relations of Trust**: Trust lubricates co-operation and reduces transaction costs between people or agencies. There are two primary types of trust: the trust we have in individuals whom we know; and the trust we have in those we don’t know, but which arises because of our confidence in a known social structure.
- **Reciprocity and exchanges**: Coleman (1990) and Putnam (1993) identified two types of reciprocity. Specific reciprocity refers to simultaneous exchanges of items of roughly equal value; and diffuse reciprocity refers to a continuing relationship of exchange that at any given time may be unrequited, but over time is repaid and balanced.
- **Common rules, norms and sanctions**: Common rules, norms and sanctions are the mutually agreed or handed down norms of behavior that place group interest above those of individuals (e.g. zoning densities or setbacks required for developments). They give individuals the confidence to invest in activities with predictability, reduced time delays and legal challenges. Mutually agreed sanctions ensure that those who break the rules know they will be punished. These are sometimes referred to as internal morality of a social system (Coleman 1990), the cement of society (Elster 1989).
- **Connectedness, networks and groups**: Connectedness, networks, groups and the nature of relationships are a vital aspect of social capital. Connectedness manifests itself in different types of groups at the local level and implies connections to other groups in society, from both micro to macro levels (Pretty and Ward 2001; Uphoff 1993; Grootaert 1998; Woolcock 1998; Rowley 1999).

The social and human capital necessary for sustainable and equitable solutions to natural resource management comprise a mix of existing endowments and that which is externally facilitated. External agencies or individuals can act on or work with either individuals or communities to create conditions for the emergence of new local associations with appropriate rules and norms for resource management. If these lead to the desired natural capital improvements, then this again has positive feedback on both social and human capital. For citizens to invest in these approaches, they must be convinced that the benefits derived from group or collective approaches will be greater than those from individual ones. External agencies, by contrast, must be convinced that the required investment of resources to help develop social and human capital, through participatory approaches will produce sufficient benefits to exceed the costs (Pretty and Ward 2001).

In Montana, local citizens groups are examples of the application of social and human capital to the issue of wildlife linkage and they demonstrate social, and to some extent political success, in the support of wildlife linkage. These citizen groups have come to form in the Bitterroot Valley (Bitterroot Wildlife Focus Group), in Mineral County (Mineral County Private Lands Wildlife Movement Working Group), in Missoula County (the Ninemile Wildlife Working Group), and the Blackfoot Challenge. Some of these groups were specifically formed with the assistance of the Interagency Grizzly Bear Committee (IGBC) private lands task force to identify local wildlife movement areas in local communities and across transportation corridors. The Bitterroot Wildlife Focus Group formed as part of the Citizens Advisory Committee associated with an EIS for the Lolo – Hamilton transportation corridor. The Blackfoot Challenge on the other hand is a diverse landowner driven organization that was created to address challenges that local landowners saw coming over 20 years ago. The Blackfoot Challenge has multiple sub-committees that address a multitude of issues, one of which is associated with issues facing local wildlife populations and the valley’s residents.
The advantages of working with local citizens groups to identify, design and manage linkage zones include the following measures of success:

- "Buy in" by local people to build support for common social values or sanctions (zoning regulations in the form of density regulations of subdivisions, setbacks from important linkage features or wildlife movement areas, mitigation for impacts).
- Acceptance of the concept of linkage by local citizens and local political interests (county commissioners, city councils) which can also elevate this support to state and national political levels.
- Involvement of local people in the refinement of linkage areas over time as conditions change on the ground.
- Locally developed and driven information pushed upward and shared with local county planners who conduct subdivision reviews, state and federal land and wildlife management agencies so that they take this information into consideration when making management decisions that could affect a local linkage area, and finally transportation agencies so that as projects come on-line consideration is given to making the roadway more permeable to local and regional wildlife while improving safety to the traveling public through reductions of animal vehicle collisions.

Through interaction with local citizens groups in Montana, we have witnessed first hand that investment in social and human capital can empower and enhance capacities of local communities working toward solving public problems. In the short term (past 5 years) we have seen applied successes forged by all of these local groups. For example, the Bitterroot Wildlife Focus Group cooperated with the Montana Department of Transportation to recommend locations for wildlife crossing structures during the reconstruction of US Hwy. 93 south of Missoula, Montana. The Mineral County Private Lands Wildlife Movement Working Group mapped and ground-truthed wildlife movement areas on private lands near I-90, then created brochures and maps that were distributed to state and federal land management agencies, game management agencies, transportation agencies, local governments, and planning offices for consideration in their respective planning and decision making processes. In fact, county commissioners recently denied a subdivision in Mineral County partially due to the importance of the land as winter range for elk and local residents’ values. Similarly, the Ninemile Wildlife Movement Areas Workgroup mapped wildlife movement areas throughout the valley and across I-90, initiated public education and outreach, created brochures mailed to all local residents, and distributed maps based on local resident knowledge of important wildlife movement areas to state and federal land management agencies, wildlife management agencies, transportation agencies, local governments, and planning offices for consideration in their respective planning and decision making processes.

In the long run, local groups' viability and success will depend on their ability to prevent the “burn-out” feeling that investments in social capital are no longer paying. It is vitally important that agencies and non-governmental organizations continue to seek ways to provide support for the processes that both help groups to form, and help them mature along the lines that local people desire and need, and from which natural environments will benefit. Greater investments in local citizen groups (social goods) can lead to improvements in natural capital.

**Political measures of success**

Political measures of success involve both funding support, recognition of this as an issue, and legislative actions to assist in implementation. Political success also involves the administrators and transportation boards of state DOTs and their willingness to support linkage investment. Three levels of political support are necessary: state DOT administrators and the state transportation boards, county government officials, and Congressional involvement. These can be described as follows:

- Support for linkage planning and management in budget and personnel decisions by DOT administrators and state transportation commissions.
- County planning board considerations of wildlife linkage in long-term county planning and subdivision approval considerations.
- County commissioner support for linkage planning and implementation as valuable to county residents.
- Congressional support for linkage area identification and management in federal agency budgets.
- Congressional support for linkage area monitoring and evaluation in federal agency budgets.

**Summary**

In the long-term, successful implementation of linkage action that meets the needs of wildlife and fish populations and the ecosystems they depend on as well as the needs of transportation planners and the traveling public depends on collaboration and partnerships and the implementation of multiple actions and investments to benefit multiple resources and the public. Such collaboration will benefit multiple interests, not just biological interests. The application of multiple measures of success beyond just biological measures to each linkage investment will promote agency buy-in and acceptance of the investments necessary to create successful linkage and help to build public and political support for this important need.
References


