MODELING POTENTIAL BROADSCALE WILDLIFE MOVEMENT PATHWAYS WITHIN THE CONTINENTAL UNITED STATES

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ABSTRACT

Wild LifeLines™ depict potential movement pathways in the U.S. between the Mexican and Canadian borders that emphasize the least human modification and highest extant connectivity for wildlife. These pathways are the result of a novel modeling approach that is based on a map of Natural Landscapes built from layers of land cover types, distance to roads, traffic volume, and housing density, and which then identifies the least fragmented connections between remaining natural areas. Wild LifeLines complement identification of cores and linkages within conservation planning boundaries that might secure landscape capacity for broad-scale wildlife movement within extant high-connectivity lands.

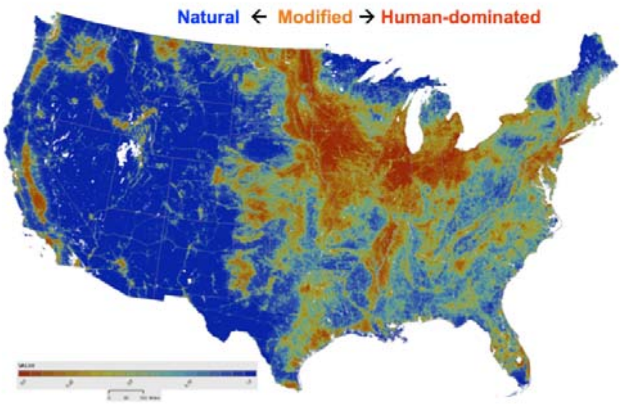
Although Wild LifeLines identify areas important for landscape connectivity, the intent is not to prioritize selection of parcels or local scale linkages, but rather to identify the most efficient existing pathways allowing broad-scale movement. Wild LifeLines is a powerful new expression of places and pathways that are important for maintaining connected landscapes, providing for the movement of wide-ranging species, and facilitating adaptation to climate change.

INTRODUCTION

America's protected areas do not exist as contiguous corridors but as scattered islands of relatively wild habitat surrounded by increasing human modification of the landscape. However, many relatively wild or natural landscapes exist outside of protected areas. These lands serve a vital role in allowing for continued movement and habitation by wildlife. If we are to conserve the existing potential for wildlife movement between undisturbed lands at the landscape, regional, and national scales, what are the pathways along which that movement would best occur? Our goal, therefore, is to provide a broad scale look at landscape connectivity based on landscape naturalness, without a focus on any particular individual species. We assume that wildlife movement will be least restricted across "natural" areas and most restricted across "human-modified" areas.

Wild LifeLines™ are the product of a novel modeling approach that seeks to identify the least fragmented pathways across lands with the best natural condition. We began by mapping *Natural Landscapes* [Theobald, 2010], based on national datasets such as natural land cover types, presence of roads, highway traffic volume, housing density, and others [Figure 1]. We then developed a new method to measure variable resistance to wildlife movement that employs naturalness as a proxy for permeability. Wild LifeLines uses the concept of hydrological flow and asks: "If animals are "dropped" or distributed across the landscape and then are constrained to "flow" across the landscape avoiding human-modified areas, how would they move across landscape? Where would

Figure 1: Natural Landscapes



pathways converge? Note this differs from typical corridor mapping that builds from patches of focal species and computes all possible nearest-neighbor combinations.

As a physical metaphor for this method, rain falling across the top of a mountain begins to run down-slope; as enough water gathers, a headwater stream forms, and begins to incise into the surface. Headwater streams merge to form second-order streams, and so on, until the flows converge to form a river, which represents the accumulation of all flows. As water flows across the surface of the mountain it follows paths of least resistance. Analogously, the dendritic pattern of the Wild LifeLines™ represents the most efficient flow patterns across the landscape if following lands of least resistance (most natural).

MAP PRODUCT The result is a map displaying a branching system of pathways (or Wild LifeLines) representing the highest permeability or highest-scored paths that allow movement across the landscape while avoiding areas of human-modification. The total system of lines can thereby be considered a "wildlife circulatory system" or a "civilization avoidance network" for the nation. [Figure 2]

Wild LifeLines show the accumulation of natural areas as they flow across the landscape. The areas overlain by thicker "arteries" represent convergences of highest likely contribution to connectivity, as a function of both local natural values and the respective cells' positions within the broader network of all locations in the study area. The accumulated values thereby indicate the importance (or priority) of any location to national-scale connectivity. Thinner secondary and tertiary lines represent the best ways for wildlife to get to primary arteries if constrained to move across the most natural areas.

The data can be normalized to state boundaries, as shown for Colorado in Figure 3.

Our analysis is derived from the Natural Landscapes map and is not influenced by the land ownership or protected status of lands. Although protected areas are important elements of conservation reserve systems, they are not sufficient due to their isolation and their utility is uncertain in the face of climate change.

Unlike typical methodologies to examine connectivity, our approach does not attempt to indicate what areas should be cores or linkages (although it can be used to help shape such decisions). The specific acres covered by Wild LifeLines are not necessarily areas of high habitat value. Instead, we identify the shortest and least disturbed pathways across the nation following lands of the highest Natural Landscapes metric. In this sense, the Wild LifeLines method employs an innovative approach that can provide planners with a new way to evaluate conservation priorities, as it focuses on the landscape's capacity to allow for movement. The naturalness value of any given cell and its position relative to project-wide naturalness values determines the relative importance of a location, whereas traditional analyses identify sites based on such factors as their habitat value for specific species or the rarity of the biophysical setting.

Thus, if ultimately our goal is to protect connectivity at the broad, national scale, Wild LifeLines can serve as a guide, from which protection and restoration efforts would likely extend outward. We expect that refinements will be made based on more detailed data for local areas, and to incorporate specific needs for well-known species through "focal species" modeling efforts. Comparable data for Canada and Mexico will help to further refine the specific location of pathways connecting beyond the U.S., but broad patterns are fairly robust to these "boundary effects" – the condition across the borders.

Figure 2: Wild LifeLines™

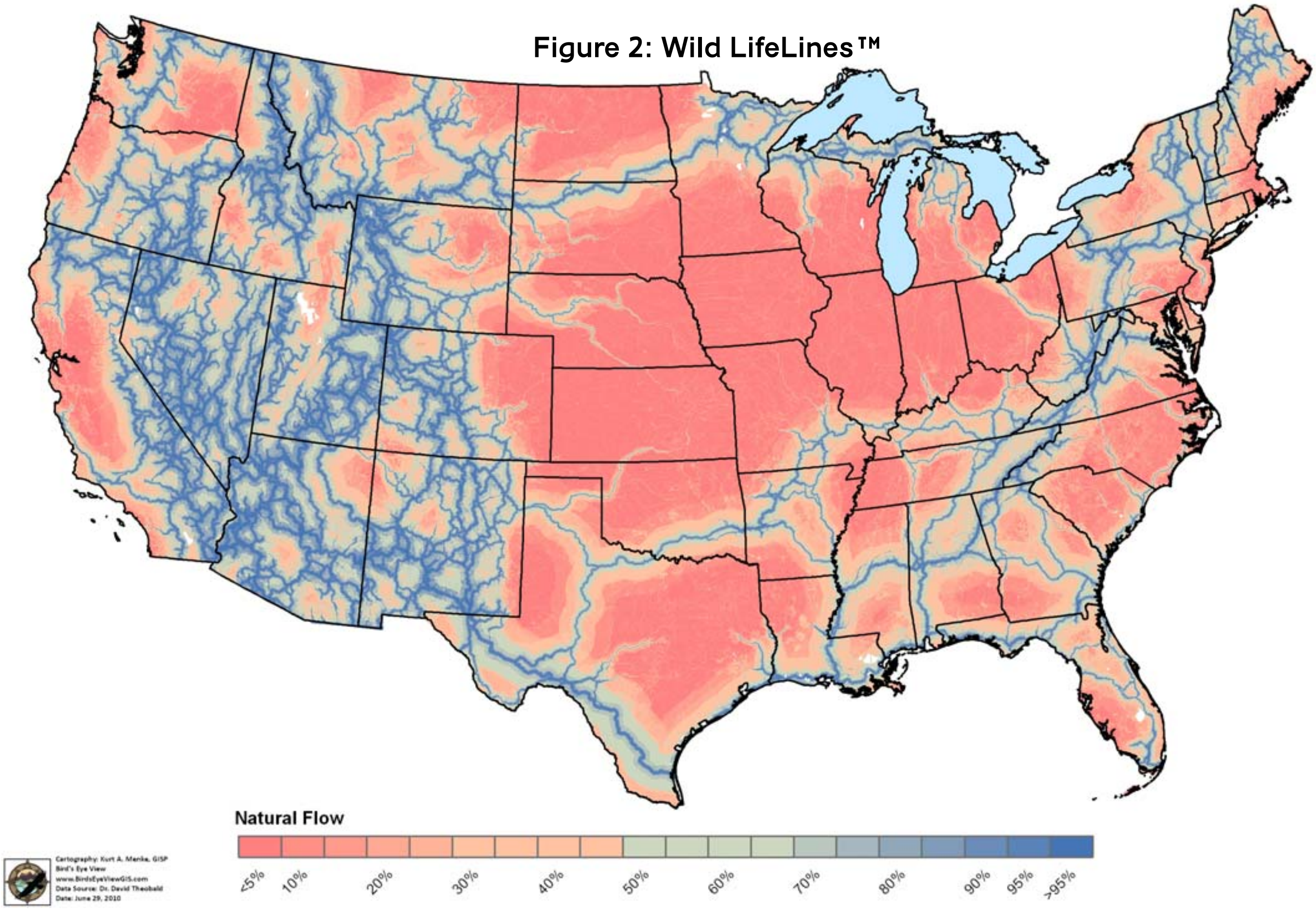
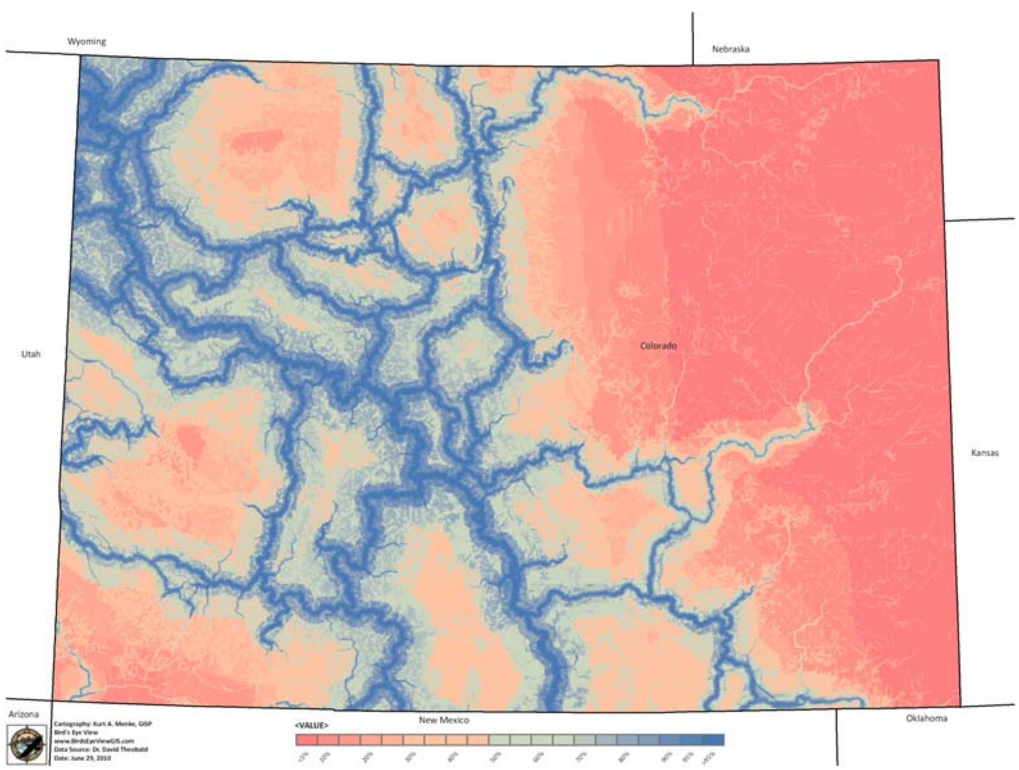


Figure 2: Wild LifeLines^{TM} normalized to Colorado state boundaries.



APPLYING WILD LIFELINES TO LOCAL, REGIONAL, & LARGE LANDSCAPE CONSERVATION INITIATIVES

Wild LifeLines can be employed as a complementary tool to conservation network planning methodologies, and provides information to allow comparative prioritization based on the relative importance of any location within the national scale to all other locations. We believe this will be helpful to organize local conservation efforts, by providing a means for relative valuation of projects' potential to assist in protecting extant connectivity at the national scale. If we are to conserve existing landscape connectivity, it is clear that we should first identify and conserve the least fragmented connections within broader natural landscapes. We stress that this approach complements species-specific approaches and finer-scale analyses.

There are several ambitious large landscape conservation initiatives underway in North America, such as Wildlands Network's *Spine of the Continent (Western Wildway) Initiative* and *Eastern Wildway Initiative*, the *Two Countries One Forest* effort, and the *Yellowstone to Yukon Conservation Initiative.* These are examples of networks of organizations working across political and jurisdictional borders to conserve connected systems of lands. Wild LifeLines can help such initiatives identify which of their proposed new core and linkage/corridor protections within conservation planning boundaries should be prioritized if the goal is to contribute to protection of existing connectivity at broad scales.

Proposed cores or linkages that have been derived from site selection analyses, and which fall along or near, Wild LifeLines could be prioritized for campaigning, assuming other socio-political and ecological factors are considered as well. In regions where no reserve design exists, our analysis helps us identify where to concentrate conservation-planning activity to "fill the gaps." For example, Figure 4 displays the top 10-percentile class Wild LifeLines over the proposed cores and linkages identified in the Southern Rockies Wildlands Network Design, and existing protected areas.

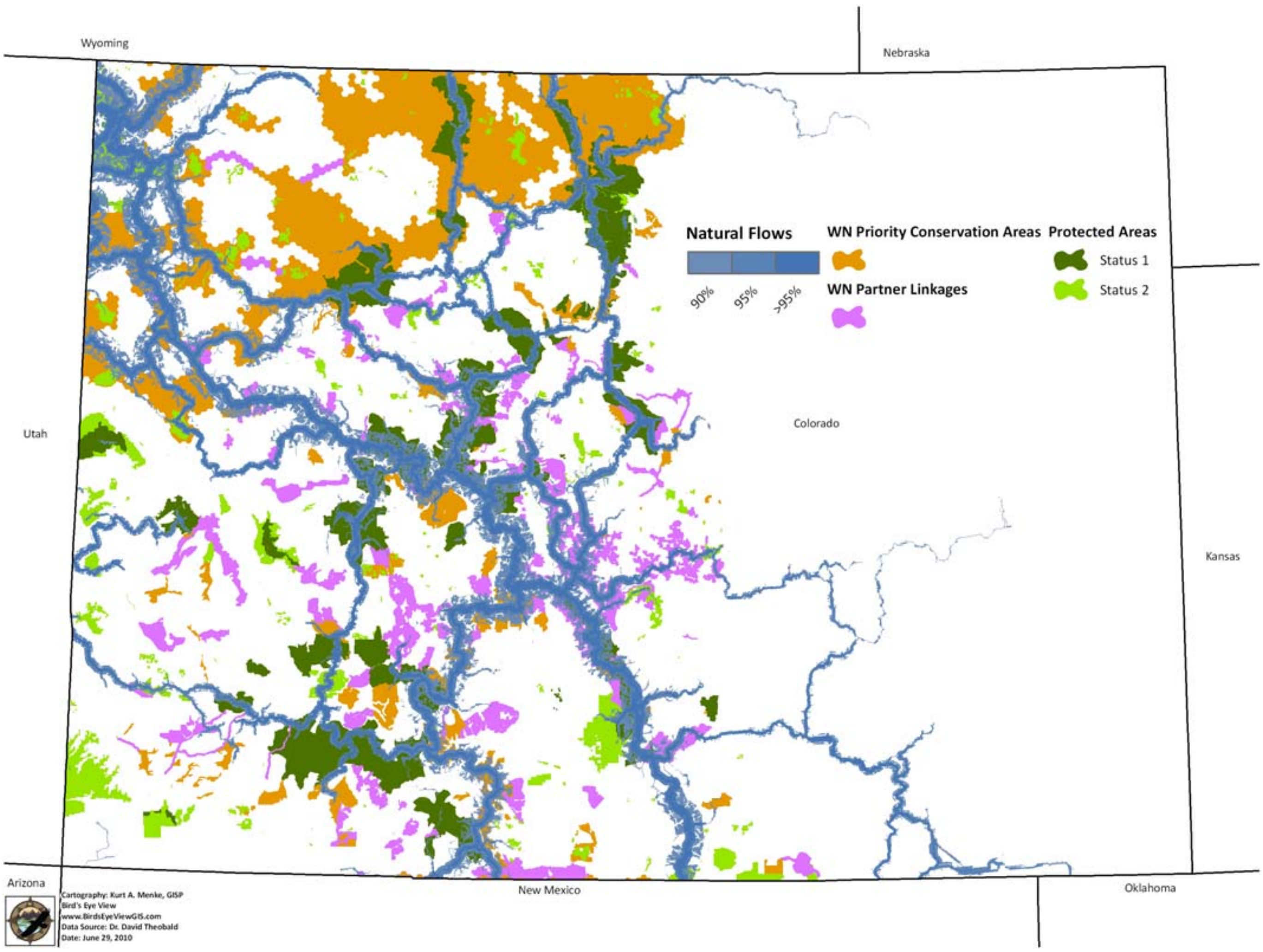
Further, our analysis provides general guidance and priorities for potential highway crossing structure projects, in conjunction with more detailed landscape and field-based information. Figure 5 (back page) identifies locations where roads intersect Wild LifeLines, and these intersections can be sorted by traffic volume.

Land trusts can assess which of their easement or fee simple opportunities would best contribute to the larger context. Our analysis can also help guide preferred locations for restoration projects. For example, given numerous opportunities for landscape restoration in a region, those adjacent to, or directly within, the highest percentile classes of Wild LifeLines could be prioritized due to the contribution that such restored lands would provide to the national scale connectivity pattern.

The model does not assume that wildlife have a destination, but recognizes the need for movement at a variety of scales. This is of particular relevance given that wildlife will be forced to undertake large-scale range shifts over the next decades, Wild LifeLines indicate many of the most valuable pathways to conserve for climate change adaptation.

Lastly, this innovative science-based approach to identifying the most intact landscapes and connections can lay the foundation for funding support. When overlain on Wildlands Network Designs, Nature Conservancy Ecoregional Assessments, or other conservation area designs, Wild LifeLines will provide the best guide available for identifying specific conservation projects that need rapid implementation. Thus they are a means to focus the conversation between local, regional and national agencies and NGOs about where to concentrate implementation activities in the near future. Lastly, our analysis helps identify key areas where we must avoid fragmentation because of these areas' relative importance to national-scale landscape permeability.

Figure 4



CONCLUSION

As our nation and continent are rapidly modified in order to benefit the well-being of human interests in commerce, livestock production, farming, resource exploitation, real estate development, and border security, it is imperative that we quickly identify the most critical lands and the natural pathways between them to help ensure continued resilience of biodiversity. We are pleased to present this new tool to help us meet the mounting challenges facing conservation.

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References:

Theobald, DM (2010) Estimating natural landscape changes from 1992 to 2030 in the conterminous US. Landscape Ecol. Published online May 1, 2010.

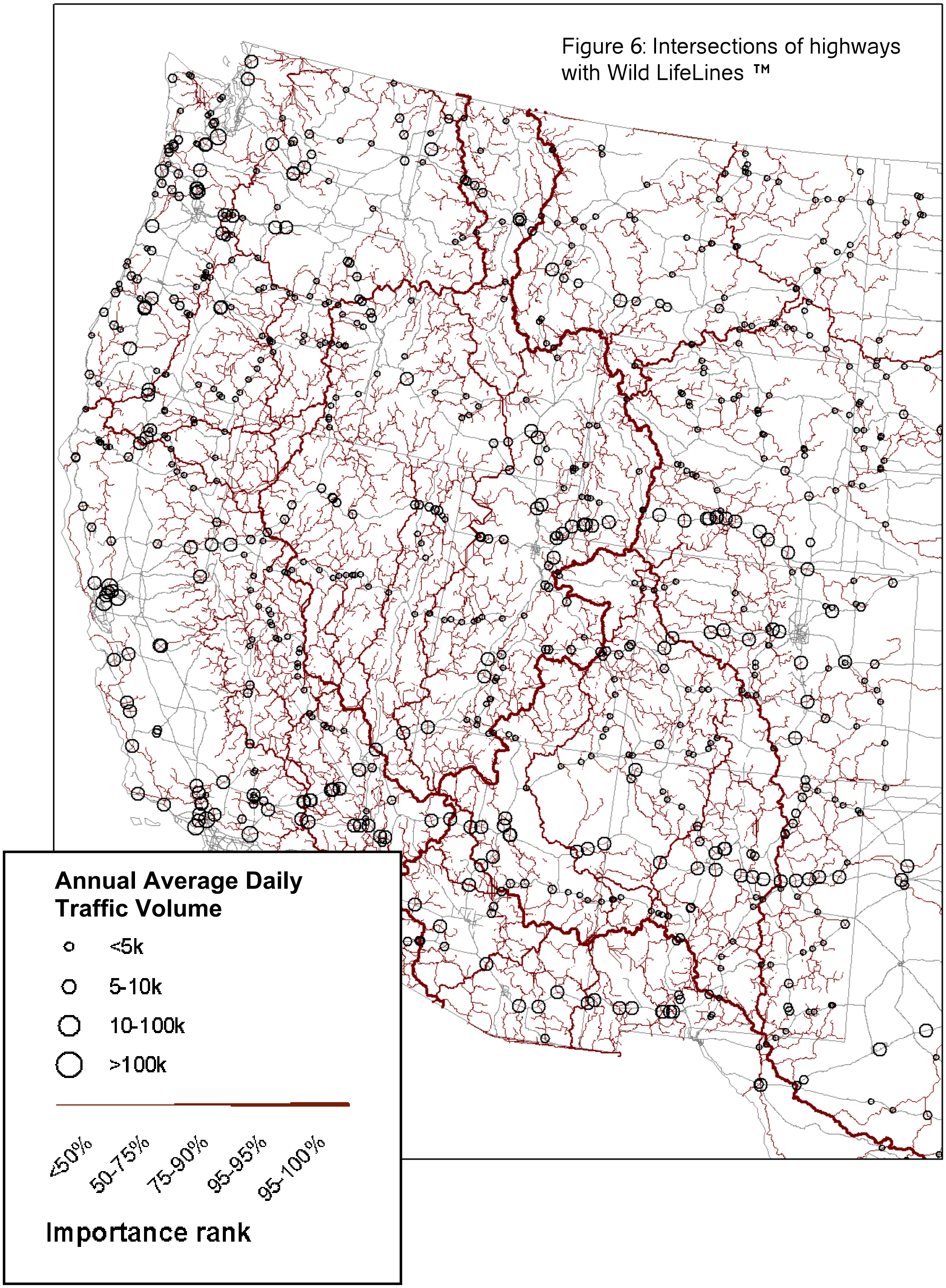

Figure 6: Intersections of highways with Wild LifeLines ™