SECTION IX FUTURE DIRECTIONS

To integrate the habitat connectivity needs for wildlife into statewide conservation and transportation planning, further refinement of the coarse scale map of the *potential linkage zones* presented in this document is required. The Arizona Wildlife Linkages Workgroup (AWLW) will oversee those efforts related to analysis, planning, and implementation of linkage designs, however, the actual work and integration of linkage designs into on-the-ground reality will rely on the success of building cooperative relationships with other partners such as land trusts, other federal and state landowners, other conservation organizations, special interest groups, and the public. Currently, it is the intent of AWLW to form advisory groups on an "as needed" basis to address the various stages of linkage analysis, planning, and implementation. This section addresses future directions that AWLW feels are necessary to further define and integrate linkages into conservation and transportation planning statewide.

One size structure does not work for all species.

Additional Potential Linkage Zone Identification and Prioritization

Although a tremendous effort has all ready gone into the development of this assessment and the associated map, there is still more work to be done. The exercise conducted by Region IV of the Arizona Game and Fish Department (AGFD) in the Sonoran Desert Ecoregion must be performed for all of the ecoregions in order to ensure that *potential linkage zones* (see *Table 4-1*) within *habitat blocks* (see *Table 4-1*) as well as those that may have been overlooked are documented. This is a critical component of the process with respect to the construction and development that is beginning to occur in formerly undisturbed areas.

For each additional potential linkage zone identified, species utilizing the linkage will be documented as well as the associated threats. In future analysis, threats will be expanded to include recreational use, off highway vehicle use, transmission corridors and wind power farms. After each is mapped, GIS analysis will be used to determine landownership and biotic communities. Revisions of the Arizona's Wildlife Linkages Map will be available on an annual basis. Updates and revisions as new information becomes available are necessary to maintain the accuracy of this assessment.

Additionally, USDA Forest Service roads and future plans need to be evaluated in the context of wildlife connectivity needs. Also, the *riparian habitat/linkage zones* (see *Table 4-1*) must be refined. Key riparian areas must be identified and prioritized relative to maintaining connectivity.

One of the greatest challenges associated with the identification of potential linkage zones within habitat blocks is enlisting the involvement of the tribal nations. In particular, some of the large areas of the state that have very few identified potential linkage zones are tribal lands, which are included within habitat blocks. A more concerted effort will be attempted for the inclusion of the tribal nations into this partnership.

Linkage Designs

The potential linkage zones identified in this report are planning areas within which a functional linkage(s) must be designed and conserved. In most cases, only a fraction of the land in a potential linkage zone will need to be conserved.

A linkage design will be developed for each *potential linkage zone* defined within this report, and for subsequent *potential linkage zones* that are identified in the future. Each linkage design will include a map of critical land to be conserved, recommendations for structures to facilitate wildlife crossing of roads, railroads, canals, and other human caused barriers, and management recommendations for multiple-use landscapes. AWLW intends to produce linkage designs for 24 of the highest priority potential linkage zones by July 2008 (listed in *Section V Arizona's Wildlife Linkages Prioritization*) pending funding availability.

Noss and Daly (2005) outline two broad approaches to linkage design, which they call seat-of-the-pants approaches and empirical modeling approaches; the latter may or may not use GIS analyses. Seat-of-the pants approaches include selecting: the shortest or most direct route between habitat blocks, the only remaining route (e.g., the Coal Canyon corridor for Chino Hills State Park in California – Beier et al. 2005), routes that include sites of conservation interest (e.g., riparian areas), selecting routes that are easiest to implement (e.g., the largest parcels with willing sellers), and routes based on expert opinion (typically when only one or two focal species are of concern).

Empirical modeling approaches include observations of animal occurrences (including road-kill) in the potential linkage, routes of radio-tagged animals through the potential linkage, least-cost path analysis (described below), or spatially-explicit population models (SEPM – the best known being PATCH – Schumaker 1998). All models developed to date have considered the movement of one or more focal species; models based on ecological processes may be developed in the future. Often combinations of approaches, including

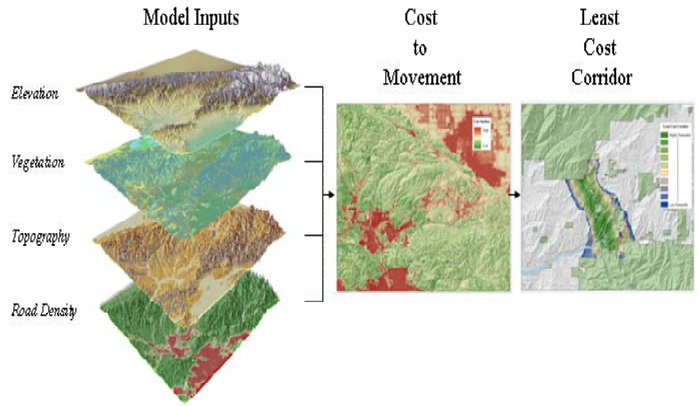
both seat-of-the-pants and modeling approaches, are used to develop a linkage design.

AWLW's approach to linkage design is briefly outlined in the following paragraphs; for more detail, see (Beier 2005) or contact AWLW. The approach uses a broad suite of focal species, least cost corridor analysis (which identifies broad connective areas, instead of the pixel-wide paths produced by traditional least cost path analysis), and a highly simplified spatially-explicit population model called Patch Configuration Analysis.

For each potential linkage zone, a list of 10-20 focal species will be developed, including species that are closely related to ecosystem function or sensitive to linkage loss, such as indicator species, keystone species, area-sensitive species, and umbrella species. Starting with the focal species identified at the 2004 workshops, additional local experts will be consulted to obtain a more comprehensive list. Species will be selected that (a) require inter-core dispersal for metapopulation persistence in this landscape, (b) have short or habitat-restricted dispersal movements, (c) represent an important ecological process (e.g., predation, pollination, fire regime), (d) need connectivity to avoid genetic divergence, (e) might change from being ecologically dominant to ecologically trivial if connectivity were lost, or (f) are reluctant to traverse barriers (e.g., culverts under roads) and would be a useful umbrella for other species sharing this trait.

For each focal species with sufficient data, Least Cost Corridor Analysis (LCCA – Beier et al. 2005) will be used to estimate the optimal location of a landscape linkage between core protected areas based on estimated relationships between the focal species and four landscape features, namely: vegetation/land use, topographic features (e.g., ridge, canyon bottom, flat, or slope), elevation, and road density (miles of paved road per mile^2). Land use (urban, agriculture, disturbed) and paved road density are intended to encompass most of the human activities that affect suitability of linkage habitat. Although other measures (densities of humans, livestock, pets, off-road vehicles) seem attractive, most of these are probably highly correlated with urban land uses or paved road density, and none are readily available in digital format. Literature review and expert opinion will be utilized to parameterize each LCCA model.

Because of lack of data, some focal species will not be able to be parameterized for LCCA models. Therefore a second GIS tool will be used called Patch Configuration Analysis, PCA (Beier et al. 2005), to consider their movement needs. For each species, PCA considers the arrangement of potential patches (areas of suitable habitat large enough to support a breeding pair) and potential population centers (areas large enough to support 50 breeding females) in relation to the dispersal distance of the species. PCA will also be used on the species subject to LCCA analysis as a 2nd tool to evaluate the least-cost corridor.



The final linkage design will consist of the union of the entire habitat patches identified as important for movement of each focal species. Before publishing the linkage design, each linkage area will be visited to assess conditions not evident in the GIS data layers, and especially to evaluate opportunities for crossing structures for roads, railroads, canals, and other barriers that cross the linkage design. Field workers will note local patterns of fencing, outdoor recreation, lighting, livestock husbandry, and pet control. These observations will inform recommendations on land use, domestic livestock, pets, off-road vehicles, artificial night lighting, and recreational activities. As appropriate, restoration of native vegetation, removal of aquatic barriers, rehabilitation of mined areas, and, most especially, improvement of permeability across major roads will be proposed.

Although not included in the initial least-cost corridor analyses, the location of existing crossing structures is important in developing the final linkage design, because these existing structures are locations where improved structures can be located at the lowest cost. The linkage designs will include recommendations for maintenance, enhancement, and construction of wildlife crossing structures. The plans will recognize that mitigation measures will be considered when agencies next make major upgrades to roadways. Even though some improvements may not occur for a decade or more, once connectivity is restored, genomes of all affected species should rapidly recover.

Interactive Linkage Map Tool

As an extension of the map and this report, AWLW is developing an interactive web-based tool. This report will be made available in PDF format in both the original size and in a letter (8 ½" x 11") version on the upcoming website. The map itself will be created so that the potential linkage zones can be accessed. The revisions and previous editions to the map will be included on the website. This is intended to be a dynamic and accessible, user-friendly tool for accessing critical linkage data.

Each potential linkage zone will have its own drop down menu with applicable data. This will include the landownership, biotic communities, focal species, as well as the Arizona Department of Transportation (ADOT) 5 and 20-year projects. Further links will be available to access descriptions of focal species, biotic communities, sources for connectivity resolution and possible structures relevant for different species. This website will be available to all stakeholders for consultation for project development.

The interactive map, which will be web-based as well as created as a stand-alone CD-Rom, will facilitate access to detailed, accurate information and will eventually provide a conduit for improved coordination between agencies and other interested parties. Users will be able to perform queries that will enhance the utility of the tool. Ultimately, it will make available a means for stakeholders to provide comments early in the planning phase of construction. The downfall of relying on mitigation during the environmental review phase of the project development process rather than the early stages of planning is the heavier reliance on offsetting impacts rather than avoidance. Wildlife and other natural resources receive the greatest benefit from a project that proposes avoidance or minimization of impacts, mitigation measures that should be considered foremost in every project. Mitigation during the early phase of planning requires effective inter-agency coordination.

Integrated Planning and Interagency Coordination

In preparing this document, AWLW took into consideration some existing conservation plans by counties (e.g., Pima, Coconino) and nongovernmental organizations (e.g. The Nature Conservancy, Sky Island Alliance). In future editions of this report, greater use of regional and county conservation plans, greenways and open space plans, and similar products is intended. Integrating those wildlife cores and linkages that are addressed in state biodiversity plans, regional conservation plans, greenways and open space plans into a statewide connectivity map becomes increasingly important to maintain a cohesive approach in addressing wildlife concerns.

Coordination among agencies will be even more important in implementing linkage designs and designing appropriate mitigation for projects that affect wildlife movement. Transportation projects provide the greatest opportunities for enhanced interagency coordination. In addition to this, integration and coordination must occur with county and city planning and private developers for all projects, large and small, which have the possibility of impacting wildlife connectivity.

Input by resource stakeholders into transportation and conservation planning addressing critical wildlife habitat needs should occur in the early stages of development while the opportunity still exists for land acquisition or inclusion of construction of permeable passages or structures for wildlife. Each of the identified *potential linkage zones* has threats impacting the viability of wildlife movement that need to be addressed. Some of the *potential linkage zones* have barriers bisecting these areas as well. Once documented, wildlife linkages should be refined and integrated into all types and levels of planning including development, transportation, wildlife management and conservation. Ancillary measures, such as research, monitoring, and maintenance of wildlife crossings also need to take place, which are discussed later in this report. In some cases, it may be necessary to secure natural areas to support wildlife needs.

Outreach

The AWLW will conduct and participate in workshops to elevate the level of awareness in the state with regards to the need for linkage consideration. One of the primary focuses will be the challenge posed by maintaining habitat connectivity. As these potential linkage zones cross multiple designations of land ownership, it is important to involve as many stakeholders as possible, including the State Land Department as well as private landowners. Along with this, the diverse approaches required by different landowners for the coordination of efforts concerning the management of potential linkage zones must be taken into account. At these workshops the utility of the Arizona's Wildlife Linkages Map and its associated report will also be demonstrated.

AWLW participated in the 2005 Rockies Wildlife Crossing Field Course in Payson, Arizona. Examples of regional connectivity analyses were highlighted. The challenges as well as the successes involved with the incorporation of effective wildlife mitigation measures into transportation planning and highway construction in an efficient and economic manner were discussed. Several members of AWLW were part of the planning team as well as presenters for the course. Another conference that members of AWLW participated in both the capacity of planning and presenting was the 2004, 2005 and 2006 Roads and Streets Conference Environmental Emphasis in Tucson, Arizona. A poster presentation describing the efforts of the Arizona Wildlife Linkages Assessment was presented at the 2005 International Conference of Ecology and Transportation in San Diego, California. All of these efforts have been well received.

It is also necessary for biologists to learn about engineering design, construction, and project detail in order to communicate better with engineers about wildlife needs. In the same vein, engineers need to be more informed by biologists about wildlife movement and wildlife structure preferences. A "cross training" workshop is anticipated.

A standard curriculum for a training program will be developed for the use of participating agencies to promote understanding and facilitate integration of consideration of linkage zones into their mainstream-planning regime.

Furthermore, the AWLW would like to serve as a conduit for the State of Arizona to provide resources and act as clearinghouse for information concerning maintaining landscape permeability and ecological connectivity. Relevant connectivity research and technology details will be compiled and distributed to interested parties.

Why engineers need biologists.

Why biologists need engineers.

Elk using highway overpass, Banff National Park, Canada.