

The Pinal County Wildlife Connectivity Assessment: Report on Stakeholder Input

April 2013



Bighorn sheep on highway in Arizona, photo by George Andrejko

Arizona Game and Fish Department



In partnership with the Arizona Wildlife Linkages Workgroup

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Stakeholder identified species:
Sonoran desert tortoise
Photo by A. Owens
Arizona Game and Fish Department



Stakeholder identified species:
Bighorn sheep
Photo by Geof Moss and Tim Downs
Arizona Game and Fish Department



Stakeholder identified species:
Cactus ferruginous pygmy-owl
Photo by G. Andrejko
Arizona Game and Fish Department

RECOMMENDED CITATION

Arizona Game and Fish Department. 2013. The Pinal County Wildlife Connectivity Assessment: Report on Stakeholder Input. Phoenix, AZ.

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PARTNERS:

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Arizona Department of Transportation, Arizona Game and Fish Department, AZTEC Engineering, Bureau of Land Management, Defenders of Wildlife, Northern Arizona University, Sky Island Alliance, U.S. Department of Transportation Federal Highway Administration, U.S. Fish and Wildlife Service, USDA Forest Service

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For providing logistical assistance and on-site support during the workshop.

DEFINITIONS

*Note: Terms in this list are highlighted in **bold** where they first appear in the text.*

Arizona Missing Linkage – A subset of wildlife linkage zones identified in the statewide Arizona's Wildlife Linkages Assessment and county-level assessments, developed into detailed modeled corridors based on methods analyzing suitability characteristics of the landscape developed by Beier et al. (2007).

Diffuse movement area – A type of wildlife linkage in which animals move *within* a habitat block across a relatively broad area, rather than *between* habitat blocks through a well-defined linkage.

Habitat block – A relatively large and unfragmented area of land capable of sustaining healthy populations of wildlife into the foreseeable future.

Habitat connectivity – The extent to which an area of the landscape facilitates ecological processes such as unrestricted movement of wildlife. Habitat connectivity is reduced by habitat fragmentation.

Habitat fragmentation – The process through which previously intact areas of wildlife habitat are divided into smaller disconnected areas by roads, urbanization, or other barriers.

Important crossing area – A crossing identified by stakeholders as being important for wildlife movement across barriers, including canals, major roads, and highways.

Landscape movement area – A type of wildlife linkage in which animals move *between* distinct habitat blocks; the area may be relatively broad or through a well-defined linkage.

Riparian movement area – A type of wildlife linkage that includes vegetation, habitats, or ecosystems that are associated with bodies of water (streams or lakes) or are dependent on the existence of perennial or ephemeral surface or subsurface water drainage. Riparian linkages facilitate movement of both terrestrial and aquatic wildlife species. These can also include xeroriparian habitats (washes) that potentially only have surface water for a brief period (i.e. few hours a year) but may contain concentrated vegetation.

Umbrella species – In this report, refers to a group of species that represent the movement needs of all wildlife species within a linkage design or through a crossing structure. May also be known as focal species.

Wildland block – Used interchangeably with habitat block.

Wildlife corridor – This term is often used interchangeably with “wildlife linkage” as we do in this report. Some biologists define the term “corridor” more narrowly to represent features such as canyons, ridgelines, riparian areas, and other landscape features that constrain or “funnel” wildlife movements into more restricted paths.

Wildlife linkage – An area of land used by wildlife to move between or within habitat blocks in order to complete activities necessary for survival and reproduction. Also referred to as a “wildlife movement area” or “wildlife corridor.”

EXECUTIVE SUMMARY

This report and the accompanying Geographic Information System (GIS) datasets summarize the results of the workshop held in Florence, Arizona in 2010. At this workshop, stakeholders representing a broad range of organizations and interests identified and mapped the locations of important wildlife linkages across Pinal County. Participants included biologists, land managers, planners, and other professionals from federal, state, tribal, private, and non-governmental organizations. The workshop was supported by partnerships between the Arizona Game and Fish Department (AGFD) and the Arizona Wildlife Linkages Workgroup. This multi-agency, multi-disciplinary effort was undertaken to encourage biologists and non-biologists alike to incorporate information about wildlife linkages and strategies for their conservation into transportation corridor and project planning as well as other community projects including land-use decisions. The workshops provided a forum for stakeholders to learn more about wildlife connectivity, outline the general locations of wildlife linkages on large maps, and provide descriptive information about each linkage on datasheets. Participants also identified the locations of barriers such as highways and railroads that may interfere with wildlife movement. The hand-drawn linkages were then digitized with GIS software and refined following an additional opportunity for stakeholder review. The linkages were then further refined to eliminate redundancy for this report.

This report provides background information on the importance and benefits of conserving wildlife linkages for both people and wildlife in Pinal County and describes the methods used during stakeholder workshops and in developing the accompanying GIS products. It includes a series of maps generated from the digitized stakeholder data that depict the general locations of wildlife linkages and potential barriers to wildlife movement within Pinal County. The maps are followed by tables with descriptive information about the habitat areas each linkage connects, the species each linkage serves, and known threats and potential conservation opportunities associated with each linkage. *The information in this report reflects the views and expertise of workshop participants and likely does not represent an exhaustive mapping of all important wildlife linkages across Pinal County.* It should instead be considered an initial assessment of wildlife movement patterns to be supplemented in the future by further analysis and refinement that includes additional expert input, GIS-based linkage modeling, and research studies of wildlife movement patterns.

The maps and GIS data in this report illustrate approximate locations of wildlife movements on the landscape and should be regarded as the starting point for further consultation with AGFD and other wildlife and land management agencies, preferably during the early stages of project planning. While the impetus for this report originated from the community's interest in promoting environmentally-sensitive transportation projects, this report and associated GIS data provide a framework for professionals across a range of disciplines to identify and incorporate opportunities for maintaining and enhancing **wildlife connectivity** within project areas in Pinal County. *We hope this report stimulates detailed planning and collaborative on-the-ground actions for conserving wildlife linkages.*

BACKGROUND

The abundant sunshine and great natural beauty of Arizona draws large numbers of visitors and new residents each year. The state has grown rapidly in recent decades with its human population expected to double from almost 6½ million in 2010 to approximately 13 million by 2050 (Arizona Department of Administration 2006, U.S. Census Bureau 2011). Much of that growth will likely be concentrated throughout the “Sun Corridor” connecting Tucson, Phoenix, and areas of central Yavapai County, including Pinal County. From 1980 to 2006, 83% of Arizona’s population growth occurred in Maricopa, Pinal, and Pima counties (Arizona Department of Transportation 2010a). Pinal County is currently home to a population of nearly 400,000 people, which is 109.1% more than in 2000, making it the third largest county in Arizona and the second fastest-growing county in the US during this period (U.S. Census Bureau 2011).

Pinal County is located in central Arizona and much of it is within the Arizona Upland Sonoran Desertscrub Subdivision and Lower Colorado River Valley Subdivision; to a lesser extent within the Semidesert Grassland, Interior Chaparral, Madrean Evergreen Woodland and Great Basin Conifer Woodland (Brown and Lowe 1982). The Nature Conservancy’s Ecoregional Assessment (TNC 1995) included Pinal County in the Sonoran Desert and Apache Highlands Ecoregions and identified several conservation areas within the county. The Sonoran desert is the wettest of all North American deserts with a bimodal rainfall pattern, and when combined with the local basin and range physiography and close proximity to higher elevation biomes, it’s not surprising that the Sonoran desert supports high biodiversity and is considered one of the Earth’s most biologically-valuable, and most vulnerable, ecoregions on a global scale (Olson and Dinerstein 1998). Within Pinal County, a broad array of vegetation communities supports a high diversity of wildlife species--from that commonly occur to species of conservation concern and those listed as threatened or endangered under the federal Endangered Species Act.

In Arizona, surface waters and their extensive system of connected washes play an important role for wildlife—both by providing habitat, shelter, food, and water, and by facilitating movements on a daily or seasonal basis. Overall, the diversity of wildlife associated with Sonoran desert biotic communities and riparian habitats in Arizona are some of the highest in the United States (Hoffmeister 1986; Marshall et al. 2000). All of the surface waters in Pinal County are considered to be ephemeral—including those categorized as significant such as the Gila River, Santa Cruz River, San Pedro River, and Queen Creek (Pinal 2001). This is due to none of the streams exhibiting perennial flow. The Gila River flows west across the north central area of the county and is considered the north eastern boundary. The Gila River is ephemeral through the county and only flows in response to flooding or releasing of water from the dams. Queen Creek is a large tributary that flows into the Gila River and is also considered ephemeral. The Santa Cruz River flows north from Pima County and joins the Gila River near the north western corner of the county and flows only during significant flood events. The San Pedro River flows northwest throughout the eastern portion of the county into the Gila River exhibiting surface flows only during flooding but does contain subsurface flows that are considered perennial. There are two large groundwater sub basins in the county with 5 portions of other sub basins (*Figure 1*). In and of themselves, these rivers and washes provide crucial habitat and movement corridors for a large variety of desert wildlife including desert mule deer, javelina, bobcats,

mountain lion, as well as many small mammals, birds, reptiles, fish, and amphibians. Riparian habitats associated with these rivers and washes also support species such as the bald eagle and Yuma clapper rail that are designated as threatened, endangered, or otherwise sensitive.

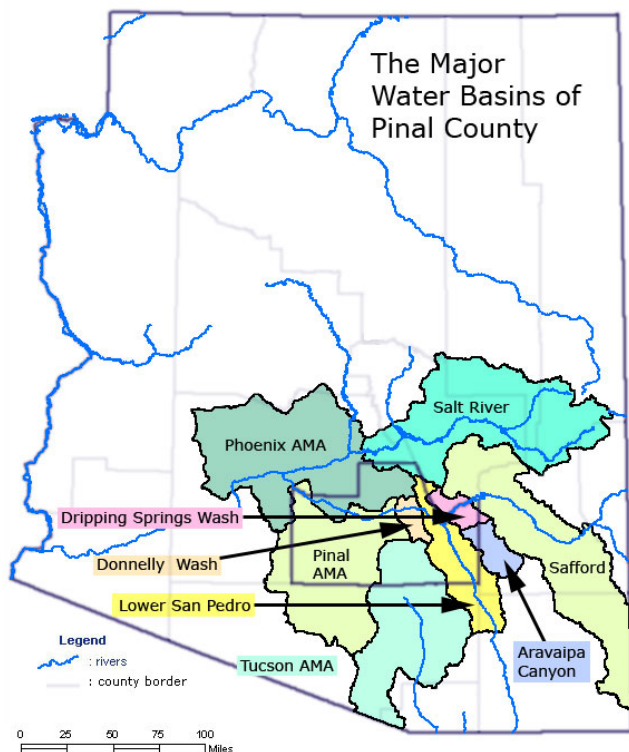


Figure 1: ADWR check your water supply

The combination of spectacular scenery and a comfortable climate in Pinal County create the conditions most desired for urban development. As a result, the characteristics of some of the region's most beautiful and ecologically productive landscapes are being dramatically altered by human development and infrastructure.

WHY WE NEED WILDLIFE LINKAGE PLANNING IN PINAL COUNTY

POPULATION GROWTH

Arizona's growing human population and expanding infrastructure has consequences for the wildlife species in Pinal County and for the habitats on which they depend. While human development and disturbance can adversely affect wildlife by causing direct loss or degradation of habitat, the disruption of wildlife movement patterns is a less obvious, but equally important, consequence. Most of the available lands in the county are either private (26%) or state trust (35%) lands with federal (18%) and reservation (20%) ownership making up the rest (Pinal 2007) (*Figure 2*). Areas of State Trust Lands reside under the state charter as the State Land Department has the responsibility on behalf of beneficiaries to assure the highest and best use of trust lands. Fair market value must be obtained under the federal act and state mandate, for all transactions that include sales and commercial leasing. These revenues benefit public education.

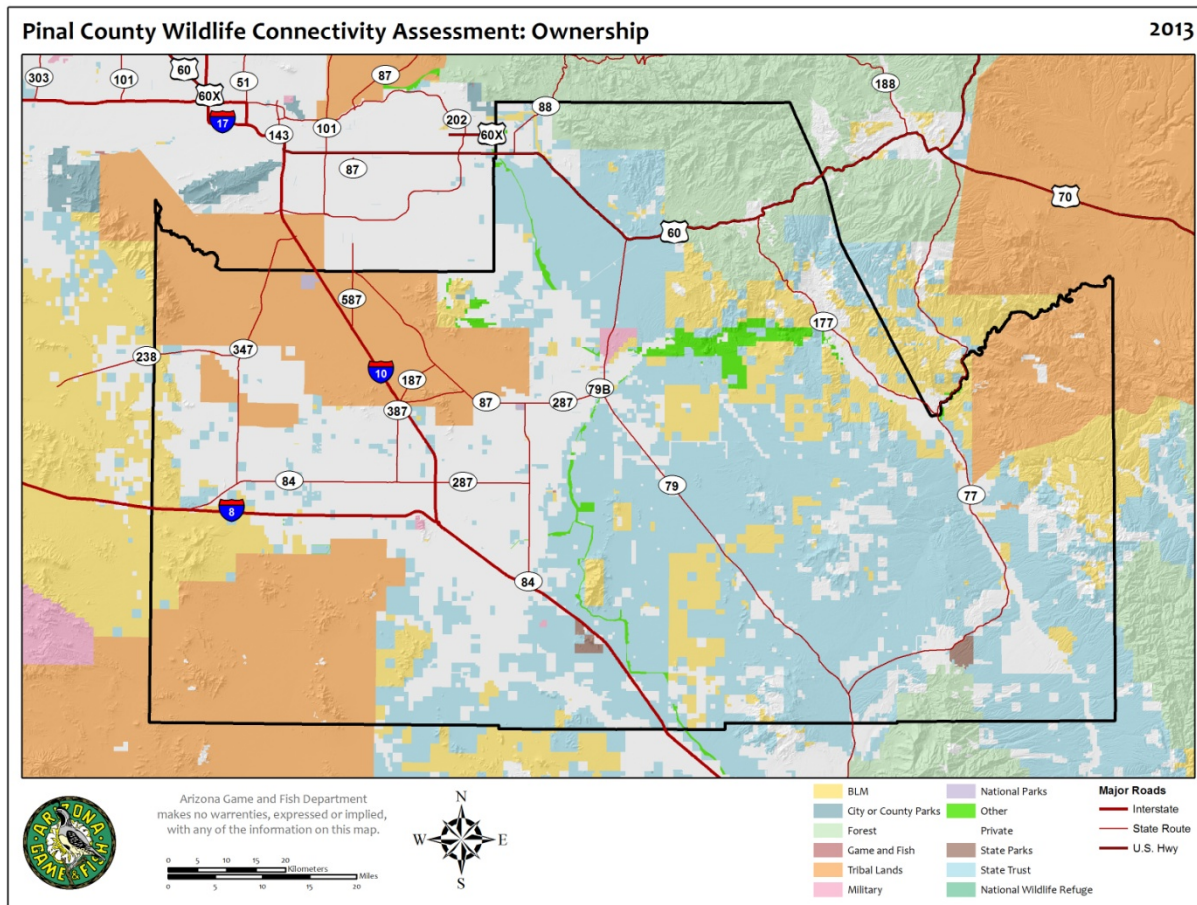


Figure 2 : Land ownership in Pinal County

An example where a vision has been adopted in the county through the Comprehensive Plan (2009, amended 2011 to include conceptual land use) as a long term build out, includes Superstition Vistas: 275 square miles between Apache Junction and Florence within undisturbed desert habitat. The planning area is equal to Gilbert, Mesa, Chandler and Tempe combined and would include a wide range of diverse development from very high to very low densities. This would also include activity centers of high intensity mixed uses (employment, shopping, medical, educational, etc.). Most of the developments being proposed and/or planned are between the Gila River community and the Tohono O' Odham and west of State Route 87. These are centered on the incorporated areas of Maricopa, Casa Grande, Eloy, Coolidge and Florence clustering near access to high capacity transportation corridors (existing and planned).

All animals move across the landscape to varying extents in order to acquire the resources necessary for survival: food, water, protective cover, and mates. Mountain lions, bighorn sheep, Arizona gray fox, coyote, javelina and mule deer roam over vast expanses that can encompass thousands of acres, while smaller animals such as the Sonoran desert tortoise, burrowing owl, and Tucson shovel-nosed snakes engage in essential movements in a much smaller area. There is also variation in the temporal patterns of animal movement: some animal movements occur on a daily basis, while seasonal migrations may occur annually, and the dispersal of young from their

natal sites to secure new breeding territories happens only once in an individual's lifetime. Man-made barriers have been shown to have an impact on wildlife movement patterns (*Figure 3*), some to the degree that their presence may affect the long-term persistence of wildlife populations (Noss 1983, Wilcox and Murphy 1985, Noss 1987, Bennett 1999, Henle et al. 2004, Noss and Daly 2006).

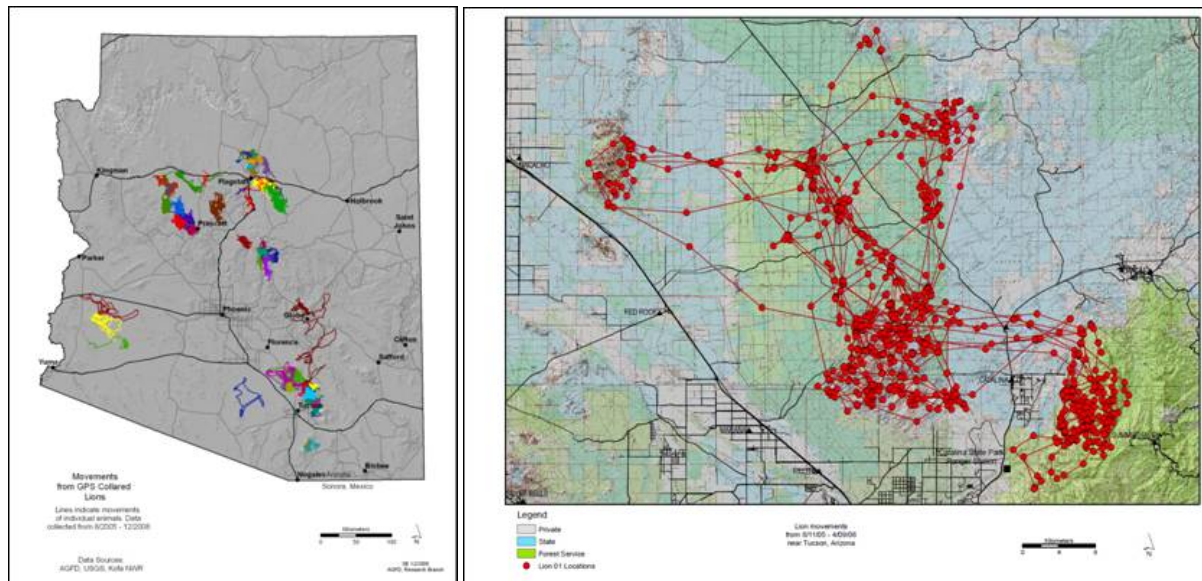


Figure 3a and b: *a.* A series of satellite telemetry studies conducted by the Arizona Game and Fish Department, the United States Geological Survey, the United States Fish and Wildlife Service, and the University of Arizona shows that highways act as barriers to lion movements across Arizona. Each color track represents the movements of a different lion. This barrier effect can isolate populations, potentially reducing genetic diversity and reproductive success over time. *b:* This lion, collared in the Catalina Mountains north of Tucson, crossed State Routes 77 and 79 on multiple occasions and approached but did not cross Interstate-10. Movement data from this project was used in the design of the Tucson-Tortolita-Santa Catalina Mountains Linkage. Construction of crossing structures along SR 77 to accommodate this linkage is expected to begin in 2014.

The following touches on other barriers that, in combination with urban development, have the potential to specifically interfere with wildlife movement and interrupt wildlife connectivity within Pinal County.

TRANSPORTATION INFRASTRUCTURE

County transportation plans have ramped up to improve existing transportation corridors and to construct other aspects of the transportation network that will support increased traffic and public transportation demand due to the anticipated population growth in Arizona. Many existing transportation corridors such as Interstate 10, AZ Loop 202 San Tan, US 60 and State Route 79 are being evaluated for improvements. Each new road built or existing road improved increases traffic volume, thereby increasing the potential for wildlife-vehicle collisions and other **habitat fragmentation** effects. However, as each new or existing road project goes through the planning process, the opportunity to accommodate the needs of wildlife also increase. Provided here are some examples of the planning processes currently underway within and around Pinal County. Additional details for many of the plans are available in [Appendix I](#).

Many government officials and the public have recognized two related transportation system challenges in Pinal County: 1.) how to meet travel demand on major routes that cross the county,

and 2.) how to meet travel demand from growth within the county. Studies of population growth, travel volume demand, and road capacity are underway at a variety of scales to determine where road improvements or new road infrastructure construction should begin.

Cross-county travel demand has come from the growth of communities like Gilbert, Queen Creek, and San Tan, the expansion of the William's Gateway Airport, and the development of new communities such as Superstition Vistas. The Arizona Department of Transportation (ADOT) and US Department of Transportation's Federal Highways Administration (FHWA) have begun studies for potential new transportation routes such as the North-South Corridor study for travel between US 60 in Apache Junction and I-10 near Eloy (ADOT 2011), State Route 24 for travel between the loop 202 east to SR79 and the I-11& Intermountain West to Las Vegas. Another important component of this planning comes from the ADOT Passenger Rail Corridor Study, which is a study of a high capacity travel option and associated corridor between Tucson and Phoenix. While these new routes are mostly within nearby counties, they would inevitably increase traffic into and within Pinal County.

To address increased travel demand from within Pinal County, short range and long range regional transportation plans continue being developed that will guide the investment of regional transportation resources in local roadway, bus, pedestrian, bicycle, aviation, freight, and rail facilities to stimulate growth. The Pinal County Comprehensive Plan shows areas of high traffic flow (*Figure 4*), in terms of roads, railways, and aviation. Refer to Appendix I for list of various transportation studies, plans, projects within Pinal County (note this list is not exhaustive).

UTILITY INFRASTRUCTURE

The growing population in Arizona will also bring increased energy demands. The development of wind and solar energy facilities, utility corridors, and other energy-related infrastructure may be considerable over the next several decades. In 2012, the Bureau of Land Management and Department of Energy completed a new policy framework for utility-scale (>20 megawatt) solar energy development on BLM lands, which governs and guides the future of this rapidly growing form of energy development across millions of acres of land in the sun-rich state of Arizona. Concurrently, the Arizona BLM's Restoration Design Energy Project delineated low-conflict zones across multiple land ownerships where utility and sub-utility solar and wind development will be incentivized. A recently published review paper by the United States Geological Survey (Lovich and Ennen 2011) concluded, "...it appears that insufficient evidence is available to determine whether solar energy development, as it is envisioned for the desert Southwest, is compatible with wildlife conservation". While this study reveals a void of scientific studies quantifying the effects of this relatively new form of energy development on wildlife, some of the known primary impacts of this form of development (i.e. habitat conversion, fragmentation, and disturbance) have been studied extensively elsewhere and have been shown to affect habitat quantity, quality, and connectivity. The expansion of renewable energy development in the West would also spur new development and retrofit of energy transmission infrastructure.

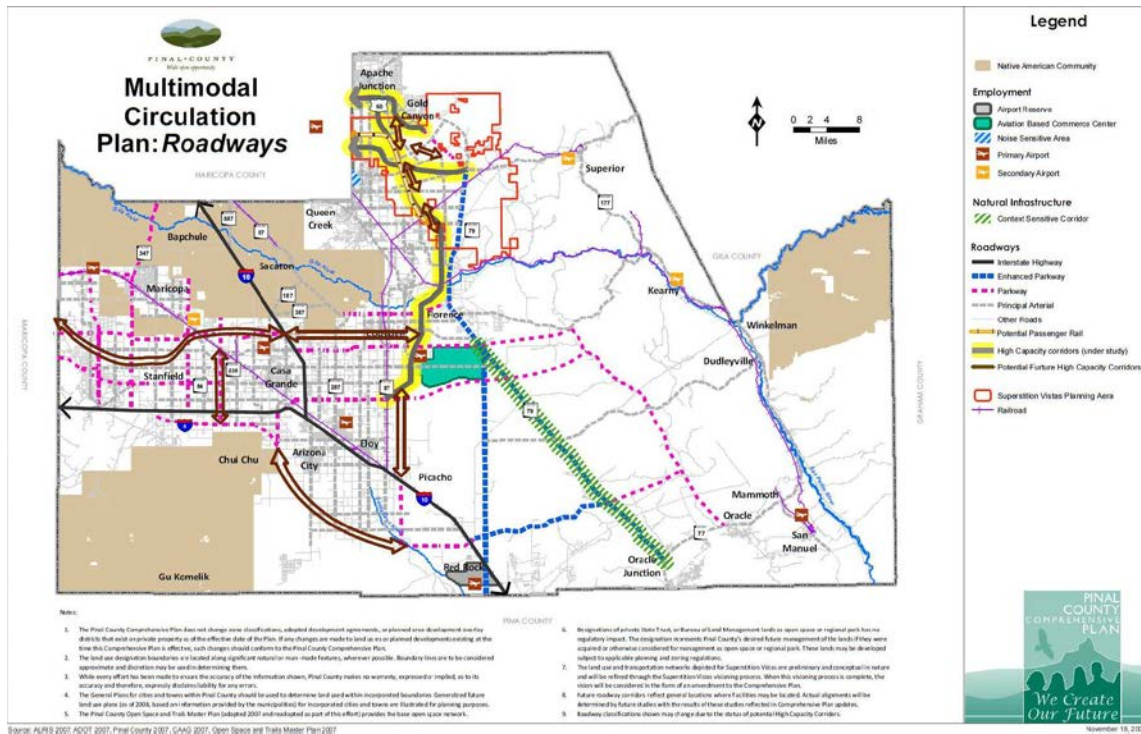


Figure 4: Pinal County Multimodal Plan

WHAT WILDLIFE CONNECTIVITY MEANS

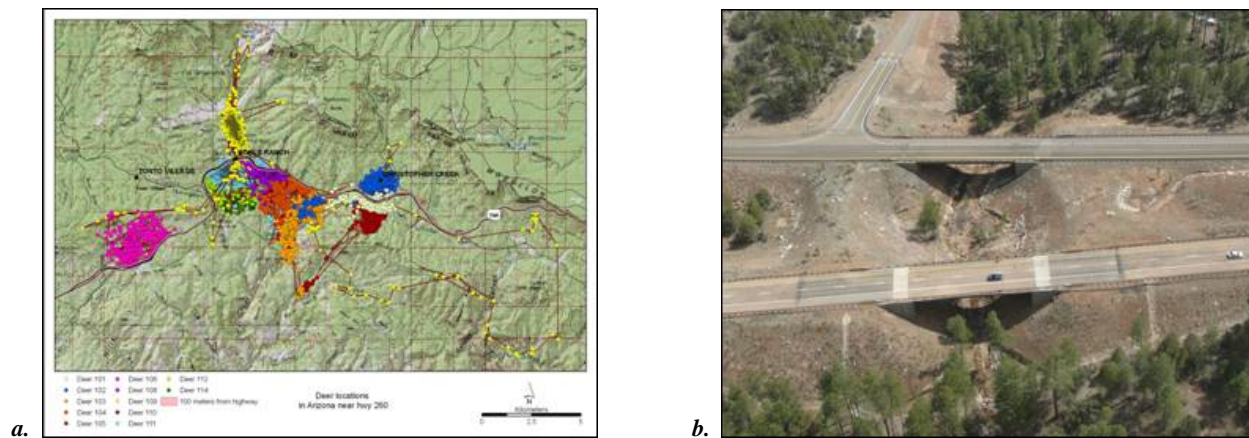
The process through which previously intact areas of habitat are divided into smaller disconnected areas by roads, urbanization, and other barriers is known as habitat fragmentation, which decreases the degree of habitat connectivity of the landscape for wildlife. The disruption of animal movement by habitat fragmentation presents problems for Arizona's wildlife, ranging from direct mortality on roadways to the genetic isolation of separated populations. This disruption of animal movement patterns also negatively affects human welfare by increasing the risk of wildlife-vehicle collisions and the frequency of unwanted "close encounters" with wildlife. However, the effects of habitat fragmentation can often be mitigated by identifying and protecting areas that wildlife use for movement, known as **wildlife linkages** or **wildlife corridors** (Beier and Noss 1998, Bennett 1999, Haddad et al. 2003, Eggers et al. 2009, Gilbert-Norton et al. 2010). Ridgelines, canyons, riparian areas, cliffs, swaths of forest or grassland, and other landscape or vegetation features can serve as wildlife linkages. Wildlife linkages are most effective when they connect (or are located within) relatively large and unfragmented areas referred to as **habitat blocks** or **wildland blocks**. Habitat blocks are areas large enough to sustain healthy wildlife populations and support essential biological processes into the future (Noss 1983, Noss and Harris 1986, Noss 1987, Noss et al. 1996).

In order to distinguish between different types of wildlife movement, wildlife linkages are broken down into several categories within this report.

- **Landscape movement areas** refer to a type of wildlife linkage where animals move between habitat blocks.
- Animals may also move *within* a habitat block rather than through a well-defined corridor, a type of wildlife linkage we identify as a **diffuse movement area**.

- **Riparian movement areas** refer to a type of wildlife linkage where animals move primarily through riparian habitat, including desert washes classified as xeroriparian habitat.
- Often, wildlife use crossings, such as culverts or overpasses, to move between habitat blocks or through riparian habitat where barriers exist. Stakeholders also indicated potential crossing areas along the Central Arizona Project canal.

Wildlife linkage planning should include conservation of wildlife linkages and the habitat blocks they connect, and, in most cases, require the implementation of multiple strategies such as land acquisition, community planning for developments, open space conservation, and habitat restoration. Installation of roadway mitigation features including wildlife crossing structures and fencing to funnel wildlife to crossing structures (*Figure 5*) are important considerations that are best incorporated into the early planning stages of transportation and development projects that way they are built into the design phase as part of the project.



Figures 5a and b: Along Arizona State Route 260 near Payson, ungulate-proof fencing linking a series of highway underpasses effectively increased the permeability of the highway for white-tailed deer by 425% while reducing wildlife-vehicle collisions by greater than 80% at an estimated cost savings of \$1 million dollars annually (Dodd et al. 2007) **a:** White-tailed deer movements along SR 260 show the barrier effect to the deer. Each color represents an individual deer's movements. **b:** An underpass near Kohl's Ranch utilized by white-tailed deer. (Map & Photograph: Arizona Game and Fish Department).

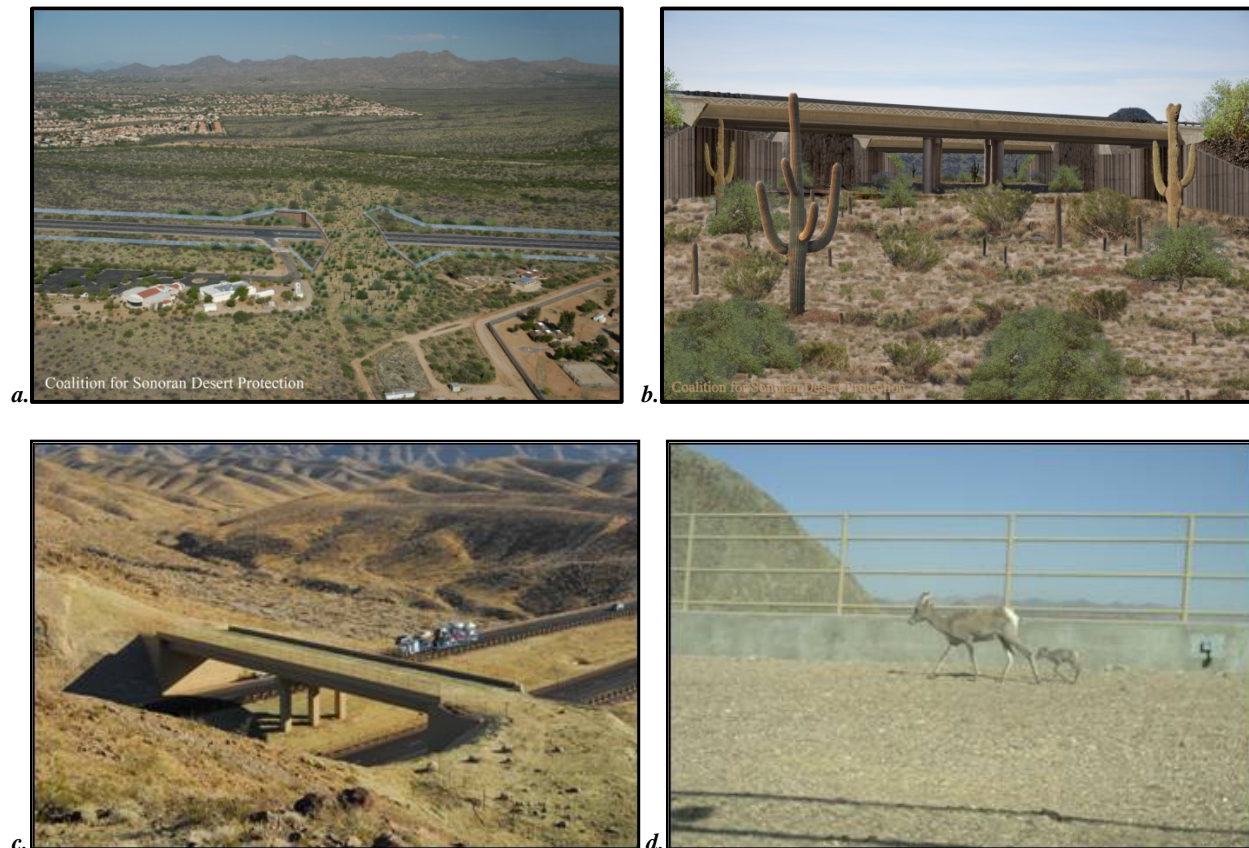
BENEFITS OF WILDLIFE LINKAGE PLANNING

Identifying and conserving habitat connectivity by maintaining wildlife linkages can provide many important benefits for both humans and wildlife.

BENEFITS TO WILDLIFE

By preserving the ability of wildlife species to move between or within habitat blocks, linkages allow animals to access essential resources such as food and water during their daily activities. They also allow longer seasonal migratory movements between summer and winter habitats and facilitate the dispersal movements of animals in search of mates or breeding sites. Linkages that connect otherwise isolated populations help prevent small populations from extinction (Laurance 1991, Beier and Loe 1992), help maintain genetic diversity, and reduce the risk of inbreeding (Beier and Loe 1992, Bennett 1999). Habitat connectivity also helps ensure that critical ecological processes such as pollination and seed dispersal, which often depend on animal

intermediaries, are maintained. In some cases the linkages themselves may sustain actively reproducing wildlife populations (Perault and Lomolino 2000, Beier et al. 2007). Linkages are also expected to play an important role in helping animal populations adapt to and endure the effects of climate change by allowing animals to shift their range with latitude or elevation as vegetation communities change their distribution and suitable environmental conditions shift on the landscape (Hannah et al. 2002, Glick et al. 2009).



Figures 6a and b, c and d: *a.* Wildlife overpasses, like the one in this artist rendering, will facilitate wildlife movement over State Route 77. This overpass and two underpasses were funded for construction by the Regional Transportation Authority of Pima County in 2009. *b.* Wildlife underpasses are important parts of wildlife connectivity planning and increase the permeability of a road or railroad for wildlife while greatly reducing the threat of vehicular collisions. Crossing structures are most effective when they are designed to meet the needs of species known to use the linkage. Many times underpasses, in the form of bridges or culverts, are already in existence under certain stretches of road but need to be modified to accommodate wildlife. This artwork depicts a proposed modification of an existing abandoned railroad underpass on I-10. (Artwork: Courtesy Coalition for Sonoran Desert Protection). *c.* Along U.S. Highway 93 near the Arizona/Nevada border, ungulate-proof fencing linking a series of 3 highway overpasses. *d.* Overpasses allowing desert bighorn sheep to safely move between the Colorado River and a critical block of Black Mountain desert sheep habitat. Post construction monitoring efforts are underway to assess affects on permeability (Photographs: Arizona Game and Fish Department).

Knowledge of wildlife linkage locations helps inform project planners about what appropriate mitigation needs to occur for roads that affect many wildlife species. Roadway mitigation features such as crossing structures and parcel acquisitions, can be expensive and should be designed and implemented to accommodate “**umbrella species**” which will, by proxy, serve many species’ movements (Beier et al. 2007, Lowery and Blackman 2007). However, certain

species may require specific landscape features (i.e. ridgelines, stream corridors, etc.), vegetation composition and structure, crossing structure designs (i.e. specific length or “openness”), and certain thresholds of human disturbance/activity in order to be functional (*Figure 6*). Planning for effective wildlife crossings must also consider what is going to happen on those lands in the immediate proximity of the crossing, which may also influence priorities for rural and urban open space planning and acquisition. Allowing development to occur near crossing structures and placing structures in locations that do not provide suitable habitat for the target species generally affects their use by wildlife (Beier and Loe 1992).

BENEFITS TO PEOPLE

Maintaining an interconnected network of wildland blocks will provide benefits to the local human communities as well, perhaps most obviously by improving public safety. It has been estimated that approximately 20% of the land area in the United States is ecologically affected by the country’s road network (Forman et al. 2003). The implications of this widespread impact include threats to connectivity and hazards to motorists (Forman and Alexander 1998). One study estimated that each year more than 200 motorists are killed and approximately 29,000 are injured as a result of deer-vehicle collisions in the United States (Conover 1995). Such collisions can cost \$2 billion annually (Danielson and Hubbard 1998). Identifying important wildlife movement areas that traverse transportation corridors prior to the construction of new roads or road improvements allows for the informed siting of wildlife-friendly over- and underpasses that can greatly reduce the likelihood of collisions (Clevenger et al. 2001, Forman et al. 2003, Dodd et al 2007; *Figure 6*). Along Arizona State Route 260, for example, a combination of wildlife underpasses and ungulate-proof fencing reduced elk-vehicle collisions by 80% (Dodd et al. 2007; *Figure 6*). A study by Lowery and Blackman (2007) detected direct road kill or evidence of the presence of 55 unique species along Twin Peaks Road in Pima County.

As the optimal objective of providing wildlife linkages is to maintain the connectivity between wildland blocks, there are circumstances where it is important to accommodate a linkage that, either partially or in its entirety, crosses through urban and suburban environments where open spaces invite (intended or not) passive recreation activities. In such situations, the linkage may also serve as a buffer between developed areas and wildland blocks and can help protect the wildland network from potentially damaging external influences. Incorporating and designing rural and urban greenways and/or open spaces that support wildlife movement into municipal planning efforts also helps retain the natural vistas and aesthetic attributes that Arizona residents and visitors value. Since evidence suggests that some species are sensitive to the presence of humans (Clevenger and Waltho 2000, Taylor and Knight 2003), multi-use buffer zones should be made wide enough to maintain separation between human recreation activities and the needs of the wildlife species using the corridor.

Maintaining linkages that facilitate the ecological health of wildland blocks can also be a significant investment in contributing to the diversity and vitality of an area’s economy and the American economy. The Outdoor Industry Association developed a report in 2012 on “The Outdoor Recreation Economy”. The report recognized outdoor recreation as being critical to the economy through direct spending, manufacturing, finance, retail, tourism, travel and generates jobs. Also emphasized in the report, “Not only is access to quality places to play outside critical to our businesses, it is fundamental to recruiting employers and at the heart of healthy and

productive communities. Open spaces and recreation areas are magnets that draw after-work activity and tourists alike”. The economic value associated with fish and wildlife-related recreation is significant for Pinal County and contributes greatly to Arizona’s economy. A national survey of fishing, hunting, and wildlife-associated recreation has been conducted about every five years since 1955 to evaluate national trends. The survey provides information on the number of participants in fishing, hunting, and wildlife watching (observing, photographing, and feeding wildlife), and the amount of time and money spent on these activities. In the most recent survey, it was reported that in 2011, state resident and nonresidents spent \$2.4 billion on fishing, hunting, and watchable wildlife related recreation in Arizona (U.S. Department of the Interior 2012). In 2001, a county-level analysis of the national survey data revealed that in Pinal County watchable wildlife activities generated a total economic effect of \$96 million, supporting 950 jobs, providing residents with \$27 million in salary and wages, and generating \$2.9 million in state tax revenue (*Table 1*, Southwick Associates 2003). Fishing and hunting recreation generated a total economic effect of \$22.9 million for the County, supporting 296 jobs, providing residents with \$3.8 million in salary and wages and generating \$933,000 in state tax revenue (Silberman 2003). These economic benefits illustrate that conserving our wildlife populations, through efforts such as maintaining or restoring habitat connectivity is also good for business in the County.

Pinal County	Economic Effect	Number of Jobs Supported	Amount in Salary and Wages	Amount in State Tax Revenue
Watchable Wildlife	\$96,000,000	950	\$27,000,000	\$2,900,000
Fishing and Hunting	\$22,900,000	296	\$3,800,000	\$933,000

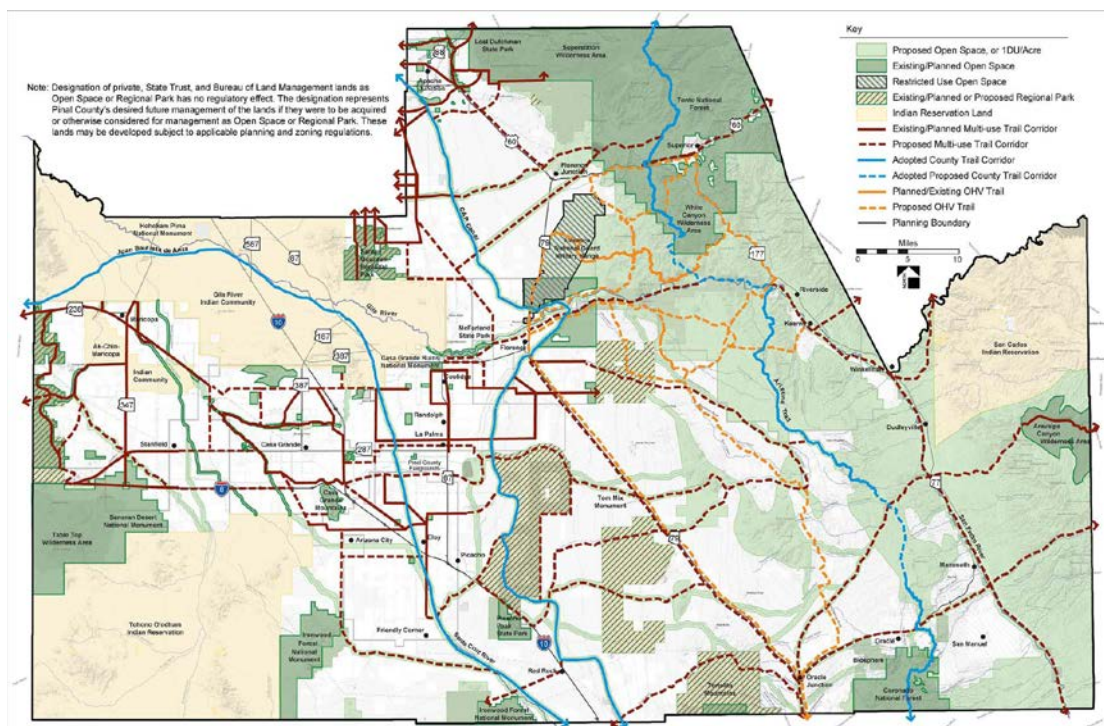
Table 1: Economic benefits of fishing, hunting, and watchable wildlife activities by county. Summarized from Southwick Associates 2003 and Silberman 2003.

OVERVIEW OF REGIONAL PLANNING EFFORTS THAT ACKNOWLEDGE THE IMPORTANCE OF CONSERVING WILDLIFE LINKAGES

There is a long-standing appreciation among local governments, land management agencies, transportation departments, conservation organizations, energy and utility companies, and citizens across Pinal County of the importance of conserving wildlife linkages and mitigating the impacts of barriers on wildlife movement. The Federal Highway Administration and the Arizona Department of Transportation (ADOT) recognize wildlife-vehicle collisions (WVCs) as a serious problem along major northern Arizona roadways, and have supported collaborative research with Department biologists to identify wildlife movement patterns and to design effective mitigation strategies (Dodd et al. 2007, Dodd et al. 2009, Dodd et al. 2010, Gagnon et al. 2010, Gagnon et al. 2011).

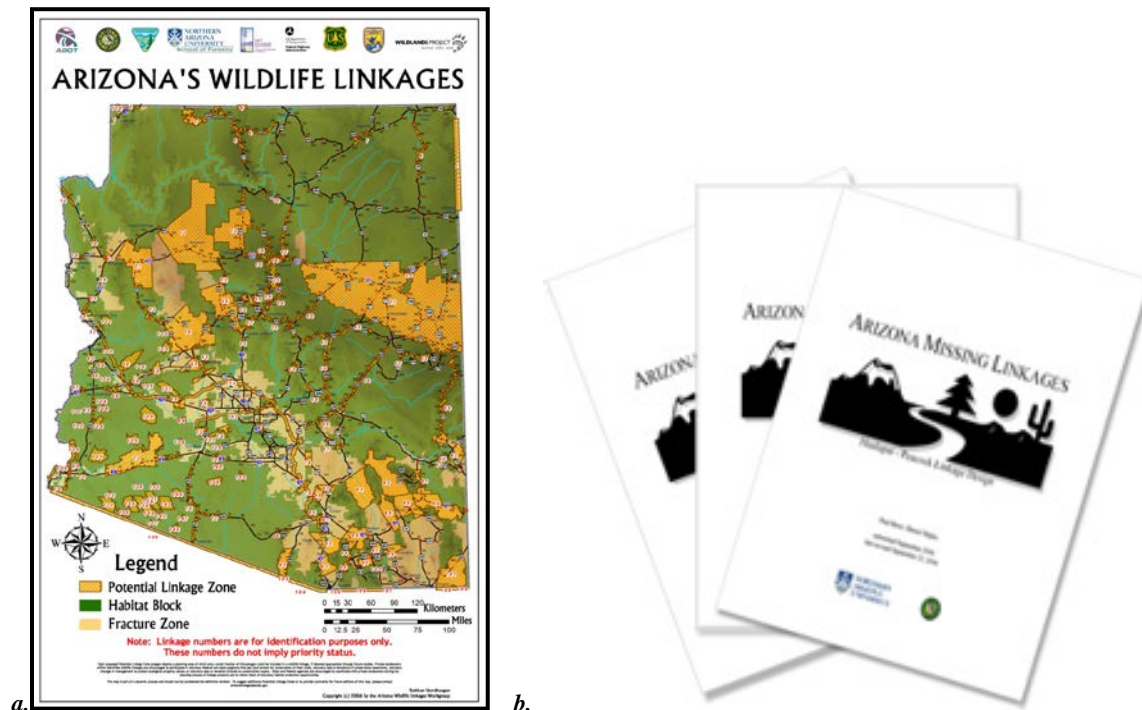
Planning efforts in other areas of Arizona have also begun to incorporate information on wildlife linkages. For example, Pima County’s Conservation Lands System (Pima County 2001), an outgrowth of the widely-acclaimed Sonoran Desert Conservation Plan and adopted as policy in

the County's Comprehensive Plan, includes protection and restoration of wildlife linkages as a key objective in the evaluation of Plan amendments and all land uses requiring rezoning. The Town of Oro Valley incorporated the conservation of an important wildlife linkage in the Arroyo Grande planning area as an amendment to its General Plan (Town of Oro Valley 2008). Most recently, the City of Surprise incorporated the conservation of an important wildlife corridor as an amendment to the General Plan 2030, near the White Tank Mountains (City of Surprise 2011). The need to maintain habitat connectivity for wildlife will only grow as Arizona becomes more developed and populous in coming decades and the likelihood of habitat fragmentation increases. Given the relatively undeveloped status of the several regions in Pinal County at present, it is good timing to integrate knowledge of wildlife linkages and mitigation strategies into land use and transportation planning.



THE PINAL COUNTY WILDLIFE CONNECTIVITY ASSESSMENT

To assemble current knowledge of wildlife linkages and barriers to wildlife movement across Pinal County and to help build collaborative partnerships with local jurisdictions for eventual implementation efforts, AGFD joined with partner organizations (please see Acknowledgments for a list) to initiate the Pinal County Wildlife Connectivity Assessment. This project grew out of prior initiatives including the statewide Arizona Wildlife Linkages Workgroup (AWLW) known as Arizona's Wildlife Linkages Assessment, or AWLA. The AWLA used an expert-based approach to create a statewide map of potential linkage areas and barriers at a coarse scale (Arizona Wildlife Linkages Workgroup 2006; *Figure 8a*). This Pinal County Wildlife Connectivity Assessment represents a continuation of these previous efforts and is intended to identify wildlife linkages at a finer scale that may have been overlooked in the earlier assessment, as well as those that will be useful for regional and local transportation or land-use planning efforts.



Figures 8a and b: (a) Statewide map of wildlife linkages and barriers created for Arizona's Wildlife Linkages Assessment (2006). (b) Certain high priority linkage areas identified in the Arizona's Wildlife Linkages Assessment, such as the Ironwood-Picacho Linkage Design shown here were further refined as represented in the Arizona Missing Linkages and in detailed linkage modeling efforts by the Arizona Game and Fish Department. High priority wildlife linkages defined in this assessment will be modeled using similar methods on a per project basis

METHODS

INITIAL STAKEHOLDER WORKSHOP

In the Spring of 2010, AGFD partnered with Pinal County to host a workshop for stakeholders and experts in the fields of wildlife management and land-use planning. Attendees included private citizens and representatives from consulting groups, federal agencies, state agencies, non-profit organizations, and tribal and local governments. Following a brief series of presentations on wildlife connectivity principles and the goals of the Pinal County Wildlife Connectivity Assessment, stakeholders were instructed to visit one or more of four work stations where a portion of the county was displayed on a paper map. These maps had backgrounds of recent aerial imagery and topographic features and represented the locations of major roads and other important features. Participants mapped important wildlife linkages and areas of known wildlife movement, including diffuse movement areas within habitat blocks and locations where wildlife cross (or may have previously crossed) barrier features between habitat blocks. Participants were encouraged to use additional clear film overlays depicting vegetation type, conservation status, and land ownership as needed for reference. For each wildlife linkage drawn, participants were instructed to fill out a datasheet describing wildlife movement patterns and existing or future land uses that may affect the wildlife in the area (Appendix II).

A consequence of this voluntary, stakeholder-based approach is that not all geographic areas were equally represented by knowledgeable stakeholders and the information we were able to collect about wildlife linkages was more comprehensive in some areas than in others. There may be important wildlife linkages in areas of Pinal County where none appear on our maps, so this absence should be interpreted with caution pending further study. Also, the type and amount of evidence on which each linkage was based varied from isolated personal observations to long-term empirical data from telemetry studies. This variation in the amount and source of stakeholder input available for each linkage may be reflected in the level of detail we were able to provide in the “Wildlife Linkage Descriptions” table below, which is derived directly from the information provided on the datasheet. Thus a relative lack of detail for a given linkage, in terms of species using the linkage, current or potential threats, or additional “Notes” (see below), should not lead to the conclusion that a linkage is not important. Additional information collected in the future should expand these descriptions, as well as point out locations of additional linkages across the County.

GIS DIGITIZING AND EDITING METHODS

Stakeholder linkages from workshops were digitized in GIS and their associated datasheets entered into a database. Some rules or explanations in the section that follow may contain codes indicated by a letter and number combination. These codes can be used to reference particular information in the “Wildlife Linkages Descriptions” section of this report and are used to label linkages on the maps in this report. Project staff used the following guidelines when digitizing stakeholder drawings in GIS:

- Trace contour lines to digitize canyons or hills when a drawing or description indicates a topographic feature is being used.

- Where linkages overlap or fall inside larger linkages, keep only those shapes which provide unique information or show movement in contrasting directions. Otherwise merge the shapes and combine the information from each datasheet (e.g. species using linkage) into attributes for the single merged shape.
- Do not include linkages for which the data provided are insufficient. Follow up with stakeholders whenever possible to obtain needed information about the linkage.
- Examine each digitized linkage and ensure its correct representation based on stakeholder drawings, data, and additional input.
- Categorize each linkage as a diffuse movement area (movement within a habitat block), landscape movement area (movement between habitat blocks), or riparian movement area (movement through riparian habitat) based on the landscape and the data provided by stakeholders.
- Use digitized locations of washes to replace hand drawn riparian movement areas and buffer 0.5 miles on either side for consistent representation on maps. Beier et al. (2006a), used a minimum linkage width of 1 km and 1.5 km in many of their **Arizona Missing Linkage** designs. However, for the purpose of this report a minimum width of 1 mile was used to represent riparian movement areas in order to highlight the area and allow for refinement.
- Do not include specific barriers. Represent generalized barriers on maps.
- Represent Arizona Missing Linkages (2007 – 2008) on maps.

INCORPORATION OF ADDITIONAL DATASETS OR CRITERIA

CENTRAL ARIZONA PROJECT (CAP) CANAL

The CAP canal represents a unique barrier to wildlife movement. The CAP canal is a 336-mile-long system of aqueducts, tunnels, pumping plants, and pipelines constructed by the BOR. As the largest single source of renewable water supplies in the state of Arizona, the CAP canal is designed to bring about 1.5 million acre-feet of Colorado River water per year to municipal and industrial, agriculture, and Native American users. As part of the planning effort for the CAP canal, BOR committed itself to maintaining a 20-foot recreation corridor on the right side of the canal (facing downstream). The intent of the CAP is to include a 10-foot-wide paved, non-motorized path. Pinal County has over 53 miles of CAP canal that is also used as a connection to the Maricopa County Regional Trail System (Pinal 2007). Although the canal is a large barrier, in addition to the recreation corridor, the CAP also maintains many wildlife crossings to help facilitate wildlife movement across it. Stakeholders indicated the Central Arizona Water Conservation District (CAWCD) maintains wildlife crossings through much of the length of the CAP canal, which are important crossing areas for wildlife. Crossing areas along the CAP canal are successful at facilitating movement for at least certain wildlife species, such as mule deer (Tull and Krausman 2001).

ARIZONA MISSING LINKAGES

Following the 2006 AWLW publication of Arizona's Wildlife Linkages Assessment, a sample of the mapped linkages were prioritized and modeled using GIS tools by the Corridor Design Team at Northern Arizona University. This GIS modeling was funded through the Arizona Game and Fish Department Heritage Fund and was based on methods analyzing habitat suitability

characteristics of the landscape (Beier et al. 2007). A series of reports titled Arizona Missing Linkages containing maps of final linkage designs around Arizona were published to help guide transportation and development planning decisions and are available at corridordesign.org. The linkage designs represented in the Arizona Missing Linkages reports are distinguished from the stakeholder-derived data on the maps in this report.

HOW TO USE THIS REPORT AND ASSOCIATED GIS DATA

A SCREENING TOOL FOR WILDLIFE LINKAGE PLANNING

This report and the associated GIS datasets are intended to help transportation planners and engineers, land-use planners, developers, land managers, and biologists incorporate consideration of important wildlife linkages and barriers into their projects. The wildlife linkages contained in the shapefile and shown on the maps are not intended to identify finite boundaries. Instead they illustrate the *general* locations of wildlife movements on the landscape and should be regarded as the starting point for consultation with biologists and land managers including AGFD, the U.S. Fish and Wildlife Service (especially when federally-listed species may be affected), the USDA Forest Service, and other entities as appropriate—ideally in the early stages of project planning. These materials thus comprise a *screening tool* to help identify areas where linkage planning goals or concerns for wildlife connectivity may exist.

It is also important to emphasize that the information in this report reflects the views and expertise of workshop participants, and that these participants had diverse expertise and varying degrees of individual familiarity with wildlife linkages and barriers in different areas of Pinal County. Given that there may have been some areas of the County for which fewer expert participants were present at the stakeholder workshops or for which less is known in general about wildlife movement patterns, this report should not be regarded as an exhaustive representation of all important wildlife linkages. While we have attempted to provide a comprehensive analysis, the information we present will benefit from further refinement through additional stakeholder input, GIS-based linkage modeling, and additional research on wildlife movement patterns.

Clarification should be given as to the species identified within linkages throughout this effort. While the stakeholders were asked to identify species known to the linkage area, these are not exhaustive lists, and may not include species of special concern as identified through AGFD's Heritage Data Management System or Online Environmental ReviewTool (or by other local and federal natural resource agencies). If a linkage falls within a project proponent's area of interest, we recommend utilizing the Online Environmental Review Tool and/or contacting AGFD for further identification of species to consider within a project or planning area. More information on this and other available datasets is provided in the "Other Resources" section below.

To best integrate knowledge of wildlife linkages into planning efforts, we recommend a collaborative approach involving project proponents, local planners, transportation, wildlife and land management agency specialists, citizen groups, and others with an interest in conserving habitat connectivity for wildlife in a manner compatible with regional goals.

GEOSPATIAL (GIS) DATASET

The geospatial dataset associated with this report should be used with GIS software to allow users to incorporate information about wildlife linkages into project planning, construction, or project-level spatial decision-making processes. As explained above, the borders of the linkages in the GIS dataset are not intended to show the exact boundaries of linkages. To obtain a copy of the GIS dataset for use in your project planning effort, please contact the Habitat Program at

AGFD's Mesa regional office at (480)-324-3547 or the Department's GIS Program at gis@azgfd.gov.

OTHER RESOURCES

Additional tools are available from AGFD to help planners identify wildlife resources in a project planning area. These tools include the *Species and Habitat Conservation Guide* (SHCG), a model depicting areas of wildlife conservation potential; and *HabiMap™ Arizona*, an online data viewing platform that serves as an exploration tool for AGFD's wildlife datasets. Site-specific reports on wildlife species of concern and federally-listed threatened and endangered species are available through the *Online Environmental Review Tool*. All of these tools, along with additional resources such as helpful guidelines documents, can be accessed on AGFD's "Planning for Wildlife" web page at <http://www.azgfd.gov/WildlifePlanning>.

For a description of GIS wildlife corridor modeling approaches used in the Arizona Missing Linkages and to download ArcGIS modeling tools developed by scientists at Northern Arizona University, please see the CorridorDesign website at <http://corridordesign.org>. Here you will also find a number of completed wildlife linkage designs produced by the CorridorDesign team through funding provided by the Arizona Game and Fish Department's Heritage Fund.

NEXT STEPS

Future project activities will include using the information in this and other county-level reports to support the development of finer-scale, GIS-based wildlife corridor models using established methodology (Beier et al. 2007, *Figure 6b*). These models will further refine a subset of the stakeholder-identified linkage areas represented in this report based on habitat requirements of focal wildlife species that rely on each linkage and will help identify land parcels of highest conservation priority within the stakeholder linkages—both of which are necessary for a successful implementation phase. Once finalized, these reports will be made available at the "Planning for Wildlife" web page at <http://www.azgfd.gov/WildlifePlanning>. While detailed linkage designs have already been created in Pinal County, we anticipate that the creation of additional fine-scale corridor models and collaborative conservation efforts will be needed in the future as Arizona's developed landscape changes and our knowledge of wildlife habitat use and movement patterns grows.

MAPS

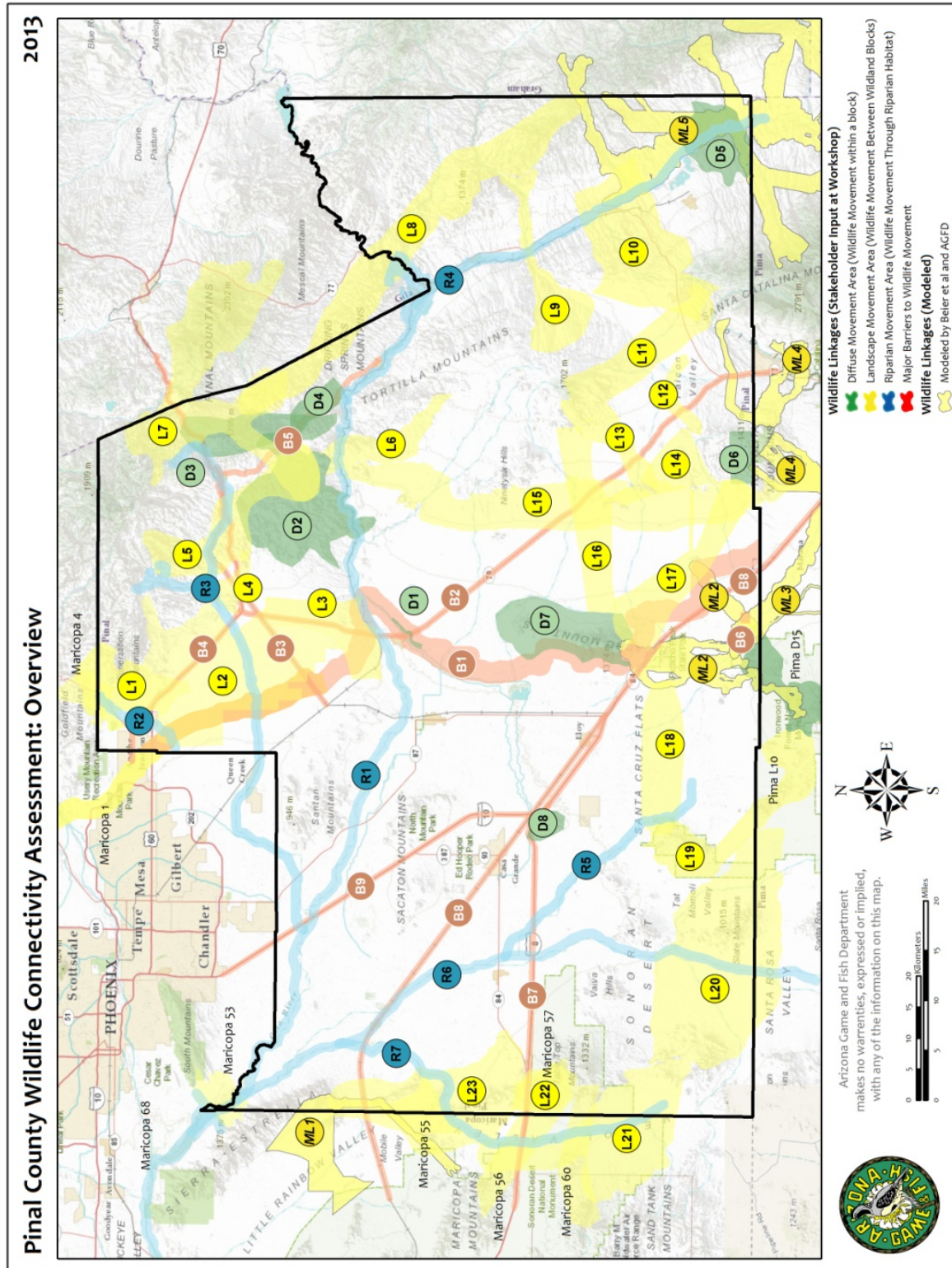


Figure 9: Pinal County stakeholder-identified linkages – County overview

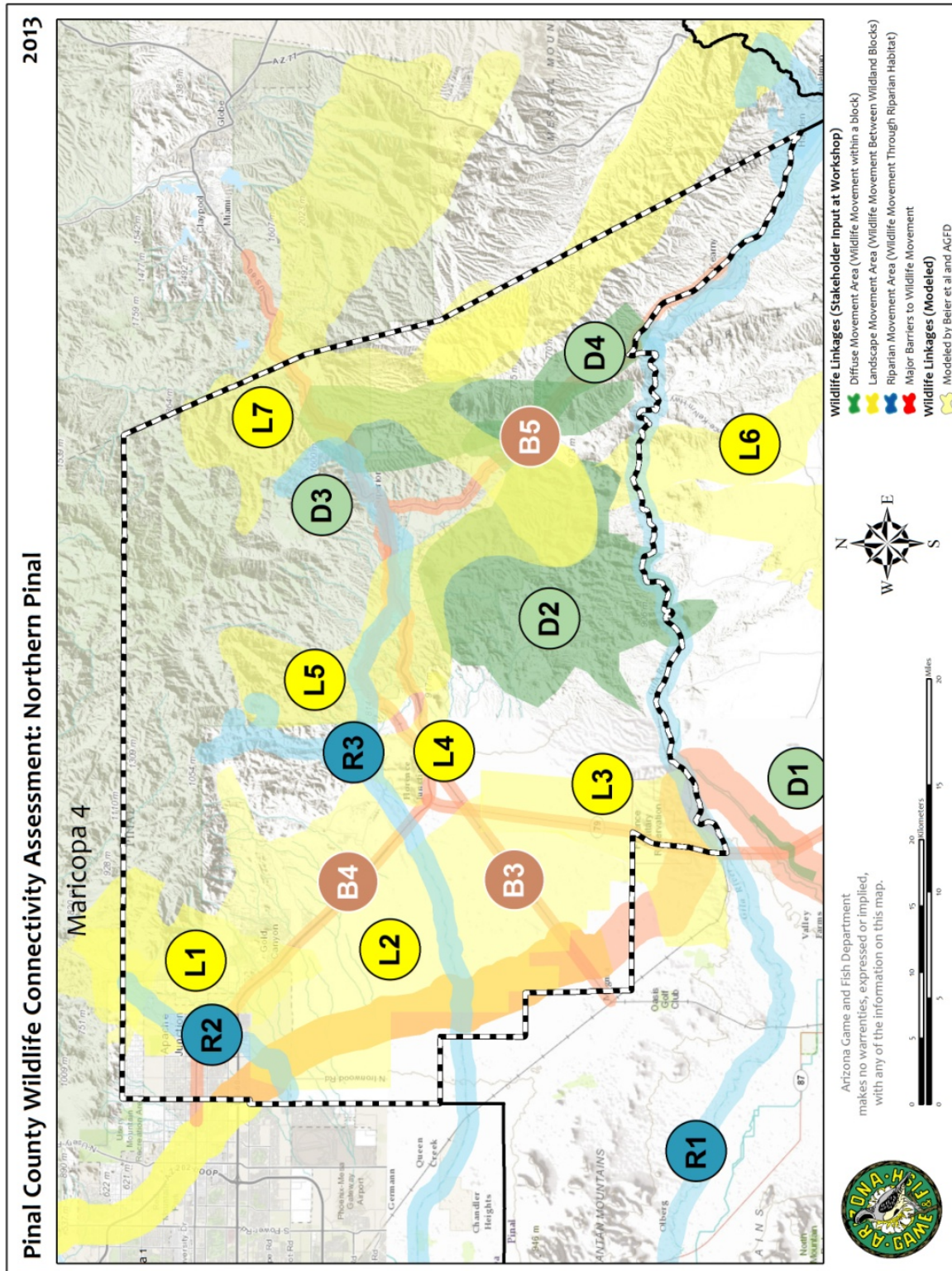


Figure 10: Pinal County stakeholder-identified linkages – Northern

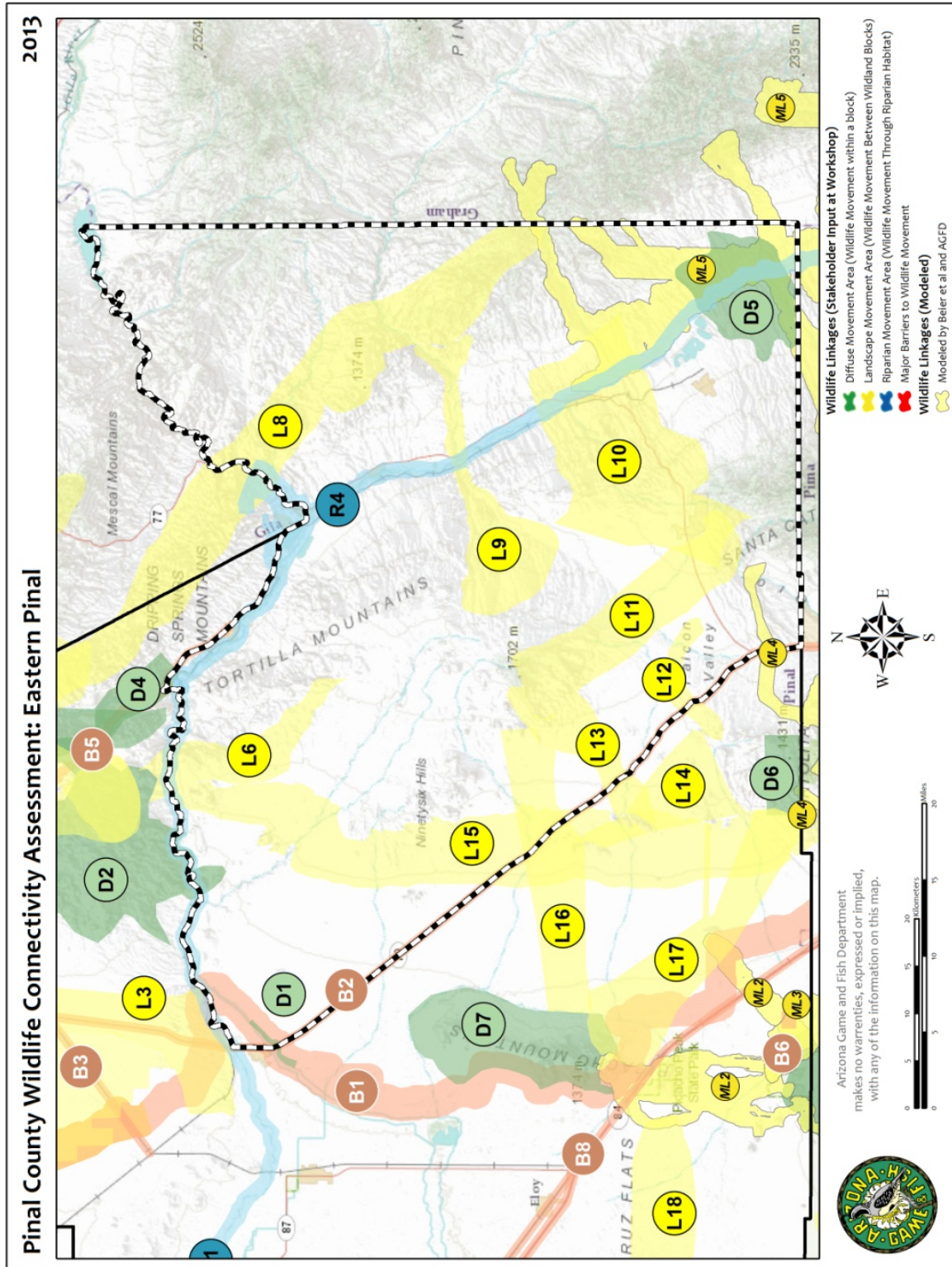


Figure 11: Pinal County stakeholder-identified linkages –Eastern

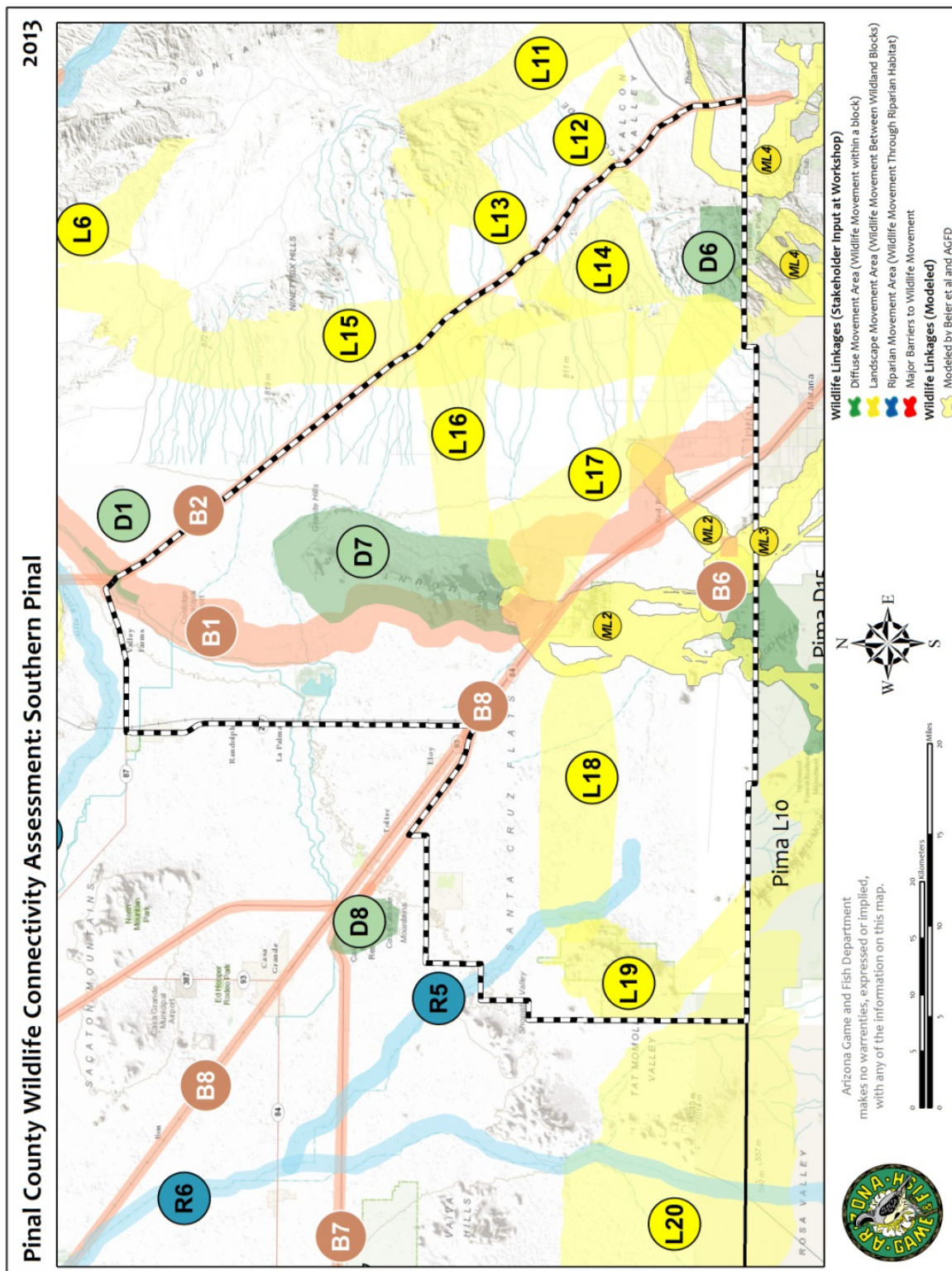


Figure 12: Pinal County stakeholder-identified linkages –Southern

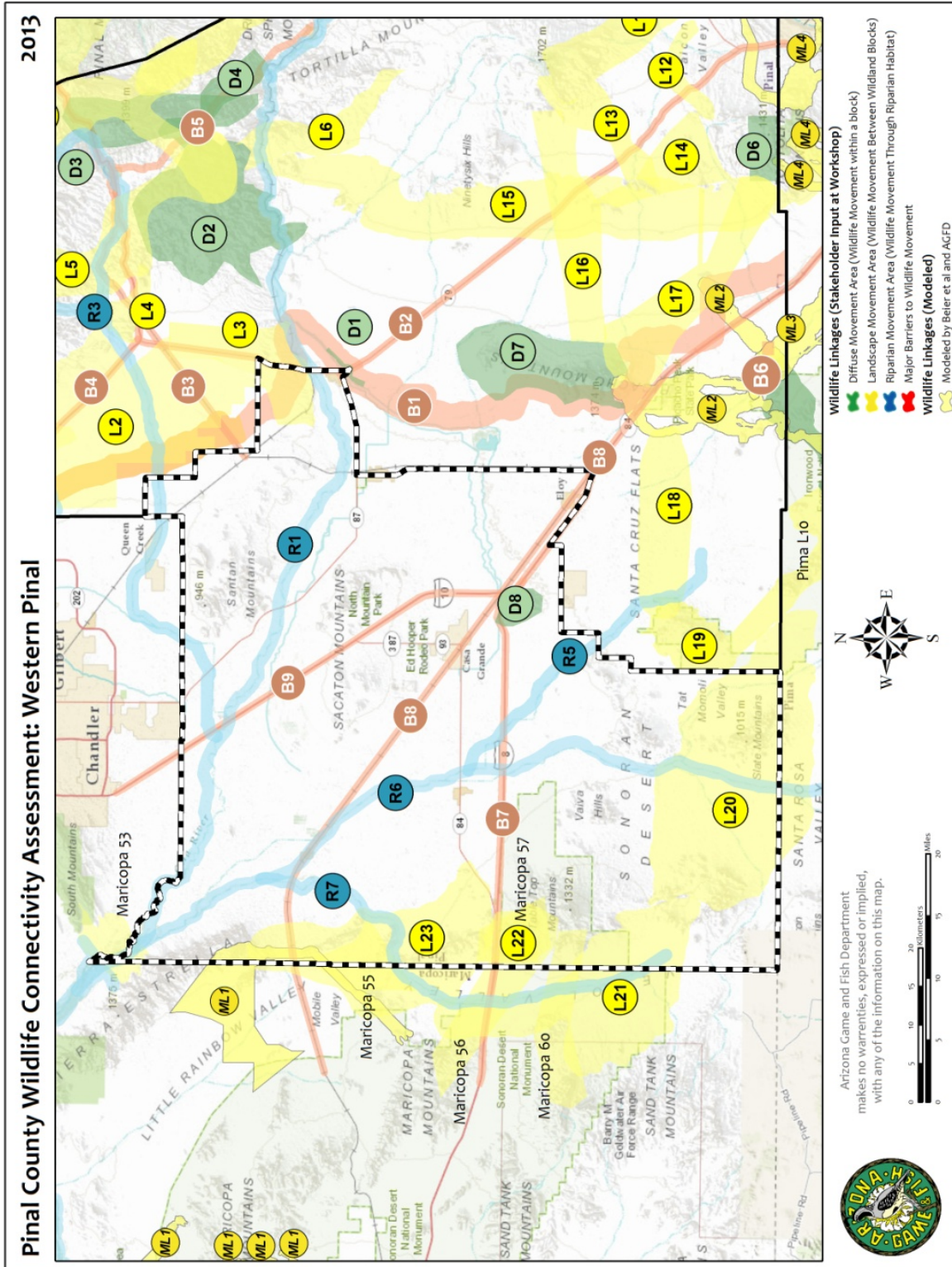


Figure 13: Pinal County stakeholder-identified linkages –Western

PINAL COUNTY WILDLIFE LINKAGE DESCRIPTIONS

PINAL COUNTY DIFFUSE MOVEMENT AREAS: D1-D8 (WILDLIFE MOVEMENT WITHIN A WILDLAND BLOCK)

D1. Southeast of Florence

Species Identified:	Coati, Coyote, Herpetofauna, Rabbit
Current Threats/Barriers:	<ul style="list-style-type: none">• Canal• Roads: SR 79
Future Threats/Opportunities:	None identified at workshop
Notes:	Small animal movement along canal through agricultural and residential/commercial area of Florence

D2. Mineral Mountains

Species Identified:	Bighorn sheep, Desert tortoise, Mule deer, Tucson shovel-nosed snake
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Canal• Invasive species• Military activity• Mining• OHV activity• Pipeline• Powerline• Railroad• Roads: SR 79, SR 802, gravel and paved roads
Future Threats/Opportunities:	Widening of SR 79 and SR 802 and development of military reservation
Notes:	Includes movements as indicated by telemetry data for bighorn sheep

D3. Devil's Canyon

Species Identified:	Mexican spotted owl, Peregrine falcon
Current Threats/Barriers:	<ul style="list-style-type: none">• Mining
Future Threats/Opportunities:	None identified at workshop
Notes:	

D4. Ray Copper Mine

Species Identified:	Gila monster, Herpetofauna
Current Threats/Barriers:	<ul style="list-style-type: none">• Mining• Roads: Hwy 177, Ray Mine Rd
Future Threats/Opportunities:	None identified at workshop
Notes:	

D5. Valley Between Santa Catalina Mountains and Galiuro Mountains

Species Identified:	Black bear, Bobcat, Javelina, Mountain lion, Mule deer, White-tailed deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Mining• OHV activity• Residential development (high and low density)• Roads
Future Threats/Opportunities:	None identified at workshop
Notes:	Drainages and washes concentrate movement across mountain ranges

D6. Tortolita Mountains

Species Identified:	Desert tortoise, Javelina, Mountain lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• OHV activity• Roads (Moore Road, Tangerine Road)
Future Threats/Opportunities:	Road widenings
Notes:	Conservation efforts underway via the Sonora Desert Conservation Plan (Tortolita – Carpenter Ranch, Tortolita Mountain Park)

D7. Picacho Mountains

Species Identified:	From Ironwood Missing Linkage Design (Badger, Bighorn sheep, Black-tailed jackrabbit, Black-tailed rattlesnake, Cactus ferruginous pygmy owl, Desert tortoise, Javelina, Mule deer, Sonoran desert toad, Sonoran whipsnake, Tucson shovel-nosed snake)
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Railroads• Roads (I-10, others)
Future Threats/Opportunities:	High and low density residential developments planned
Notes:	Includes water catchments around Newman Peak; adds habitat block of Picacho Mountains onto north end of Ironwood Missing Linkage Design (Beier et al., 2006b).

D8. Casa Grande Mountains

Species Identified:	None identified at workshop
Current Threats/Barriers:	<ul style="list-style-type: none">• None identified at workshop
Future Threats/Opportunities:	Trails are planned for area
Notes:	May become isolated from nearby development

PINAL COUNTY DIFFUSE MOVEMENT AREAS: L1-L16 (WILDLIFE MOVEMENT BETWEEN WILDLAND BLOCKS)

L1. Superstition Mountains to Goldfield Mountains and Weekes Wash

Species Identified:	Coyote, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none"> • Roads: Hwy 88
Future Threats/Opportunities:	None identified at workshop
Notes:	N/A

L2. Valley north and east of the San Tan Mountains

Species Identified:	Desert tortoise, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none"> • Residential development (Superstition Vistas and Lost Dutchman Heights) • Roads: US 60, Hwy 79
Future Threats/Opportunities:	High and low density residential and commercial development planned
Notes:	Diffuse movement; more concentrated movement along washes

L3. Florence Military Reservation

Species Identified:	Desert tortoise, Tucson shovel-nosed snake
Current Threats/Barriers:	<ul style="list-style-type: none"> • Military activity • OHV activity • Residential development (low density) • Roads (Hwy 79)
Future Threats/Opportunities:	High density residential development in future, potential widening of Hwy 79
Notes:	

L4. Queen Valley – Middle Gila/Mineral Mountains

Species Identified:	Javelina, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none"> • Agriculture • Alternative energy development potential (wind and solar) • Canal • Invasive species • Mining • OHV activity • Pipeline • Powerline • Railroad • Residential development (low density) • Roads: US60, high traffic gravel road
Future Threats/Opportunities:	High and low density residential and commercial development planned in future
Notes:	

L5. Tonto Forest West of Superior through Gonzales Pass

Species Identified:	Bighorn sheep, Desert Tortoise, Hedgehog cactus, Javelina, Mule deer, White-tailed deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Mining• OHV activity• Railroad (north of US 60)• Residential development (low density)• Roads (US 60)
Future Threats/Opportunities:	High density residential development planned in future, Expansion of US 60
Notes:	North-south big game movement corridor

L6. Tortilla Mountains – Ripsey Wash – Donally Wash

Species Identified:	Desert tortoise
Current Threats/Barriers:	<ul style="list-style-type: none">• Mining• OHV activity• Powerline• Roads (Hwy 79)
Future Threats/Opportunities:	None identified at workshop
Notes:	

L7. Canyon Passes between Superior and Globe

Species Identified:	None identified at workshop
Current Threats/Barriers:	<ul style="list-style-type: none">• Mining• Roads (Hwy 60)
Future Threats/Opportunities:	None identified at workshop
Notes:	Major north/south movement corridor, especially along canyon passes

L8. El Capitan – Aravaipa Canyon

Species Identified:	Bighorn sheep
Current Threats/Barriers:	<ul style="list-style-type: none">• Mining• OHV activity• Power lines
Future Threats/Opportunities:	Road proposed (I-10 bypass), potential Sunzia powerline route
Notes:	Bighorn sheep movement north/south

L9. Galiuro Mountains – Tortilla Mountains

Species Identified:	Coati, White-tailed deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Roads (Hwy 77)
Future Threats/Opportunities:	Potential Sunzia powerline route
Notes:	East-west movement through San Pedro corridor along Aravaipa Canyon – Putnam – Camp Grant Wash

L10. Galiuro Mountains – Santa Catalina Mountains

Species Identified:	Bighorn sheep, Black bear, Bobcat, Desert tortoise, Javelina, Mountain lion, Mule deer, White-tailed deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Mining• OHV activity• Powerline Residential development (High and low density)• Roads (Hwy 77, annexation of land along Hwy 77, high traffic gravel road)
Future Threats/Opportunities:	Future low and high density residential developments
Notes:	General east/west movement of large mammals and desert tortoise

L11. Black Mountain – Santa Catalina Mountains

Species Identified:	Mountain lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Residential development (High density)• Roads (Hwy 77, high traffic gravel road)
Future Threats/Opportunities:	None identified
Notes:	

L12. Santa Catalina Mountains – Tortolita Mountains (north)

Species Identified:	Mountain lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Roads (Hwy 77, Hwy 79)
Future Threats/Opportunities:	None identified
Notes:	Large mammal movement through Falcon Valley

L13. Durham Hills – Black Mountains

Species Identified:	Gila monster, Mountain lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Invasive species• Mining• OHV activity• Pipeline• Powerline• Residential development (high and low density)• Roads (SR 79)
Future Threats/Opportunities:	None identified at workshop
Notes:	Mountain lion telemetry movement and habitat

L14. Tortolita Mountains – Suizo Mountains – Durham Hills

Species Identified:	Cactus ferruginous pygmy owl, Desert tortoise, Mountain Lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• OHV activity• Power line• Residential development (low density)• Roads
Future Threats/Opportunities:	High density residential development planned
Notes:	Mountain lion and cactus ferruginous pygmy owl telemetry movement data

L15. Tortolita Mountains – Tortilla Mountains

Species Identified:	Cactus ferruginous pygmy owl, other avian species
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Mining• Railroad• Residential development (high density)• Roads (Hwy 79)
Future Threats/Opportunities:	None identified
Notes:	Potential migratory route for cactus ferruginous pygmy owl and other species, primarily along elevation corridor or 2,400 feet and 2,800 feet with meso-vegetation

L16. Black Mountain – Picacho Mountains

Species Identified:	Bobcat, Cactus ferruginous pygmy owl, Coyote, Deer, Desert tortoise, Fox, Javelina, Mountain lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Invasive species• Landfill• Recreation• Residential development (low density)• Roads (SR 79)
Future Threats/Opportunities:	High and low density residential developments planned
Notes:	Mountain lion and large mammal movements

L17. Tortolita Mountains – Picacho Peak

Species Identified:	Desert tortoise, Mountain lion
Current Threats/Barriers:	<ul style="list-style-type: none">• Recreational activity• Roads (High traffic gravel road, paved road)
Future Threats/Opportunities:	Residential development (low and high density) planned
Notes:	

L18/L19. Picacho Peak – Silver Bell Mountains – Sawtooth Mountains

Species Identified:	Bighorn sheep, California leaf-nosed bat, Cave myotis, Desert tortoise
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Mining• OHV activity• Residential development (low density)• Roads (high traffic gravel road)
Future Threats/Opportunities:	High density residential development planned
Notes:	Bat movement and roosting habitats; Continues through L19 which was also identified at Pima County Workshop (Pima L10)

L20. Ironwood National Monument – Vekol Mountains

Species Identified:	Bats
Current Threats/Barriers:	<ul style="list-style-type: none">• None identified at workshop
Future Threats/Opportunities:	Potential high and low residential development planned
Notes:	

L21. Tabletop Mountains – Little Tabletop Mountains

Species Identified:	Bighorn sheep, Javelina, Mountain lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Grazing• Illegal trafficking• Invasive species (mustard along I-8)• Landfill (north of Hwy 238 along 99th St)• Mining• OHV activity• Pipeline (north of Vekol Valley)• Railroad (south of Hwy 238 with associated fencing and powerline)• Residential development (low density)• Roads: I-8 (with associated fencing and culverts), Hwy 238 (with high traffic volume), Vekol Road (gravel road with high traffic volume and north and south travel), 91st Street, 99th Street
Future Threats/Opportunities:	This area is expected to support future population growth with pressures and development projects such as canals, powerline (north of Vekol Valley), potential wind and solar energy development, high density residential development, commercial development, 303 roadway extension, population growth.
Notes:	Large mammal movement; Sonoran Desert National Monument

L22. Tabletop Mountains – Palo Verde

Species Identified:	Bighorn sheep, Javelina, Mountain lion, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none">• Commercial development (along I-8)• Illegal trafficking• Invasive species (mustard along roads)• OHV activity• Pipeline (north of Vekol Valley)• Powerline corridor• Residential development (low density with potential to increase)• Roads: I-8 (with associated fencing, culverts, and frontage road)
Future Threats/Opportunities:	Potential expansion of 303 from Goodyear to I-8, Higher density residential development
Notes:	Same as Maricopa County linkage number 57

L23. Estrella Mountains – Vekol Valley

Species Identified:	Bighorn sheep, Desert tortoise, Javelina, Tucson shovel-nosed snake, others
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Airfield• Dairy• Feral goats• Mining• OHV activity• Residential development (high density)• Roads: I-8 (Hwy 238)• Solar development
Future Threats/Opportunities:	Potential high and low density residential development in future
Notes:	Same as Maricopa County linkage number 57

PINAL COUNTY RIPARIAN MOVEMENT AREAS: R1-R16 (WILDLIFE MOVEMENT THROUGH RIPARIAN HABITAT)

R1. Gila River

Species Identified:	Beaver, Bighorn sheep, Bobcat, Burrowing owl, Coyote, Gray fox, Javelina, Migratory birds, Mississippi kite, Mule deer, Muskrat, Osprey, Raccoon, Skunk, Southwest Willow Flycatcher, Various amphibians, Various reptiles, Various small mammals, Waterfowl, Yellow-billed cuckoo, Yuma clapper rail
Current Threats/Barriers:	<ul style="list-style-type: none"> • Agriculture • Canals • OHV activity • Urbanization
Future Threats/Opportunities:	Increased OHV activity, Proposed roads (Hwy 303, Hwy 801, I-10 Bypass, etc.)
Notes:	Continuation of as Maricopa County Report Linkage number 68, species and threats listed here were identified in the Maricopa County report and at the Pinal County Stakeholder Workshop; Cultural resource areas with proposed expansion of Casa Grande National Ruins

R2. Weekes Wash

Species Identified:	Coyote, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none"> • Residential development • Roads (Hwy 88)
Future Threats/Opportunities:	High density residential development planned
Notes:	Superstition Mountains to Goldfield Mountains

R3. Queen Creek – Gila River Indian Community

Species Identified:	Coyote, Hawk, Javelina, Mule deer
Current Threats/Barriers:	<ul style="list-style-type: none"> • Agriculture • Canal (CAP, Eastern canal) • Railroad (Union Pacific) • Recreation (golf courses) • Roads (Hwy 60, I-10) • Sand and gravel operations • Urbanization
Future Threats/Opportunities:	Expansion of existing roadways and future freeways planned
Notes:	Queen Creek from dam to Gila River Indian Communities; includes Queen Creek tributaries; Same as Maricopa County Report Linkage number 24; Species and threats listed here were identified in the Maricopa County report

R4. Gila River – San Pedro River

Species Identified:	Various aquatic species, Various avian species, Various riparian species
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Mining• OHV activity• Railroad• Residential (low and high density)• Roads (Hwy 177, various high traffic gravel roads)
Future Threats/Opportunities:	Proposed Sunzia powerline
Notes:	Connects to Pima County Linkage Report R19

R5. Greene Wash and Reservoir

Species Identified:	None identified at workshop
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Illegal trafficking• OHV activity• Residential development
Future Threats/Opportunities:	None identified at workshop
Notes:	Tribal lands; Critical water supply

R6. Gila River to Lake St. Claire

Species Identified:	Coyote, Mountain lion
Current Threats/Barriers:	<ul style="list-style-type: none">• Agriculture• Illegal trafficking• OHV activity• Railroad (Union Pacific)• Roads (Maricopa-Casa Grande Hwy 238 with high traffic)
Future Threats/Opportunities:	Increase in OHV activity; Numerous high density residential developments planned
Notes:	Tribal lands

R7. Vekol Wash

Species Identified:	Arizona mud turtle, Badger, Bighorn sheep, Bobcat, Casque-headed toad, Couch's spadefoot toad, Desert iguana, Desert kangaroo rat, Desert tortoise, Gray fox, Great Plains Narrow-mouthed toad, Great Plains toad, Sonoran desert toad, Javelina, Kit fox, Mountain lion, Mule deer, Red-spotted toad, Sidewinder, Shovel-nosed snake, Sonoran green toad, Various small mammals
Current Threats/Barriers:	<ul style="list-style-type: none">• Illegal trafficking• Residential development (low and high density)• Roads (I-8, Hwy 303, I-10, Hwy 238, Rainbow Valley Road)
Future Threats/Opportunities:	Proposed Sonoran Valley Parkway
Notes:	Same as Maricopa County Report Linkage number 70, species and threats listed here were identified in the Maricopa County report

PINAL COUNTY BARRIERS TO WILDLIFE MOVEMENT: B1-B9

B1. CAP – Central Arizona Project Canal (Continuation of Maricopa County linkage number 1 and Pima County linkage number C3; canal is a current barrier to wildlife movement and future development is anticipated to occur near the canal in the future).

B2. Highway 79

B3. Railroad modification (Species identified at workshop: California leaf-nosed bats, Cave myotis; Future increased traffic of railroad anticipated due to Resolution Copper)

B4. US 60 (Species identified at workshop: Bighorn sheep, Desert tortoise, Mule deer)

B5. US 177 (Species identified at workshop: Bighorn sheep)

B6. 298 La Osa Development (Ironwood National Forest)

B7. Southern Pacific Railroad

B8. I-8

B9. I-10

ARIZONA MODELED WILDLIFE LINKAGES: ML₁-ML₅ (DETAILED/MODELED WILDLIFE LINKAGE DESIGNS)

ML1. Gila Bend –Sonoran Desert National Monument – Sierra Estrella Mountains (Beier et al. 2008)

See Missing Linkage report at http://corridordesign.org/dl/linkages/reports/GilaBendMtns-SonoranDesertNM-SierraEstrella_LinkageDesign.pdf for complete list of modeled species, current and future threats and barriers, and additional recommendations on providing connectivity between these wildland blocks. Note that this linkage design was modified after the publication of the report to avoid private land after careful evaluation of values on different linkage alternatives.

ML2. Ironwood – Picacho Mountains (Beier et al. 2006a)

See Missing Linkage report at http://corridordesign.org/dl/linkages/reports/Ironwood-Picacho_LinkageDesign.pdf for complete list of modeled species, current and future threats and barriers, and additional recommendations on providing connectivity between these wildland blocks.

ML3. Coyote – Ironwood – Tucson Mountains (AGFD 2012b)

See Detailed Linkage report at http://www.azgfd.gov/w_c/documents/CoyoteIronwoodTucson_LinkageDesign_lowres.pdf for complete list of modeled species, current and future threats and barriers, and additional recommendations on providing connectivity between these mountain ranges.

ML4. Tucson – Tortolita – Santa Catalina Mountains (Beier et al. 2006b)

See Missing Linkage report at http://corridordesign.org/dl/linkages/reports/Tucson-Tortolita-SantaCatalina_LinkageDesign.pdf for complete list of modeled species, current and future threats and barriers, and additional recommendations on providing connectivity between these wildland blocks.

ML5. Santa Catalina/Rincones – Galiuros Mountains (AGFD 2012c)

See Detailed Linkage report at http://www.azgfd.gov/w_c/documents/SantaCatalinaRinconGaliuro_LinkageDesign_lowres.pdf for complete list of modeled species, current and future threats and barriers, and additional recommendations on providing connectivity between these mountain ranges.

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APPENDIX I – TRANSPORTATION PLANNING STUDIES IN PINAL COUNTY

Casa Grande Small Area Transportation Study (SATS): This study is being conducted by the City of Casa Grande and is nearing completion at the end of Summer 2007. The purpose of this study is to develop a transportation plan that will guide multi-modal planning and programming on local roads over a 20-year timeframe.

Coolidge-Florence Regional Transportation Study: This study is jointly being conducted by the City of Coolidge and Town of Florence and is nearing completion. The purpose of this study is to develop a transportation plan that will guide multi-modal planning and programming on local roads for short-, mid-, and long-range timeframes.

Eloy SATS: This project will be initiated in Summer 2007 and is being conducted by the City of Eloy to outline the future arterial and high capacity roadway network for the entire MPA.

I-8 and I-10/Hidden Valley Roadway Framework Study: This project is being conducted by the Maricopa Association of Governments (MAG) and was initiated in March 2007. The Hidden Valley study encompasses portions of Maricopa and Pinal counties and will establish a framework for a future transportation network in the study area, as well as provide feedback to local land use and transportation planners on how alternative development scenarios could be part of the regional transportation solution.

I-10 Widening Study, Design Concept Report (DCR) and Environmental Assessment (EA): This study is being conducted by ADOT to prepare a DCR and long-range implementation plan for I-10 from SR 202L to the junction of I-8 and was initiated Spring 2007. The objective of the proposed improvements is to accommodate projected travel demands, provide an acceptable level of service (LOS), and to address access and geometric deficiencies in the project corridor.

I-10 Phoenix-Tucson Bypass Study: This study is being conducted by ADOT to determine whether an alignment for the Phoenix-Tucson I-10 bypass is feasible and if so, designate a preliminary planning corridor for future study.

I-10 Corridor Study, DCR and EA: This study is being conducted by ADOT to prepare a DCR and long-range implementation plan for I-10 from the junction of I-8 to Tangerine Road. The project is approximately 50% complete. The objective of the proposed improvements is to accommodate projected travel demands, provide an acceptable LOS, and to address access and geometric deficiencies in the project corridor.

I-10 Corridor Study for I-8 to Tangerine Road: The goal of this study is to develop a long-range master plan for the I-10 corridor in accordance with the approved regional and local transportation plans; to optimize the traffic operations within the corridor for 2030 traffic demand; to retain local access at existing traffic interchanges, to plan for new interchange locations; and to minimize or mitigate impacts the improvements may have on the surrounding community.

I-10 Phoenix to California Multimodal Corridor Profile Study: The primary purpose and need for this study is to consolidate the myriad of planning documents for the I-10 Corridor (primarily in the MAG region) and develop a clear vision for future transportation needs along the I-10 Corridor.

I-11 & Intermountain West Corridor Study: The Arizona and Nevada Departments of Transportation are working together on the two-year Interstate 11 (I-11) and Intermountain West Corridor Study. Congress recognized the importance of the portion of the Corridor between Phoenix and Las Vegas and designated it as future I-11 in the recent transportation authorization bill, Moving Ahead for Progress in the 21st Century Act (MAP-21). The study includes detailed corridor planning of a possible high priority interstate link between Phoenix and Las Vegas, and high-level visioning for potentially extending the corridor north to Canada and south to Mexico.

Maricopa-Casa Grande Highway Project Assessment: This study is being conducted by the City of Maricopa to implement a transportation solution that improves safety, access, and mobility and addresses current and future congestion in the corridor. This project is in the alternatives evaluation phase.

Maricopa SATS: This study is being conducted by the City of Maricopa as an update to their 2005 SATS. The project was initiated Spring 2007 and will present goals, strategies and facilities to accommodate current and future travel demand in order to develop an efficient multimodal transportation system. Pinal County Corridor Definition Studies: ADOT is conducting a consortium of projects within this study to determine preliminary alignments for the Williams Gateway Freeway, US 60 re-route, and North South corridor. Studies for Williams Gateway and US60 are completed. SR 347 UPRR grade separation feasibility study: this study is being conducted by the city of Maricopa to determine transportation improvements to reduce congestion and increase mobility on SR347, aiming to reduce the number of at grade crossings.

North South Corridor Study: ADOT and FHWA are studying the area between US 60 in Apache Junction and I-10 near Eloy and Picacho. The purpose of the study is to identify and evaluate a possible route to provide a connection between these two areas.

Passenger Rail Corridor Study: A study of a high capacity travel option and associated corridor between Tucson and Phoenix. This summary will provide a basis for ADOT, the Federal Railroad Administration (FRA) and the Federal Transit Administration (FTA) to determine the appropriate scope for the Alternatives Analysis (AA), Tier 1 Environmental Impact Statement (EIS) and Service Development Plan.

Pinal County: Approved 5 year transportation improvement and maintenance program plan FY2011-12 through 2016 and long-range plans (regionally significant routes for safety and mobility and small area studies). These plans identify projects and establish a schedule for planning, construction and maintenance of those projects.

Southern Pinal County/Northern Pima County Corridor Definition Study: The purpose of the ADOT Southern Pinal / Northern Pima Corridors Definition Study is to determine the need for and feasibility of new high-capacity transportation corridors in Southern Pinal County and Northern Pima County. The study recommends the general location of potential corridors for which both need and feasibility are determined. The study recommendations do not identify the exact location of new roads, but identify broad corridor definitions for potential new high-capacity facilities.

SR347 UPRR Grade Separation Feasibility Study: The Arizona Department of Transportation, in conjunction with the Federal Highway Administration and the City of Maricopa, is initiating a study to evaluate alternatives and identify improvements that will improve safety, access, capacity and traffic operations through 2040. The study will evaluate a future grade separation to replace the existing at-grade intersection of SR 347 at the Union Pacific Railroad (UPRR) track.

US 60 Superior to Globe: A study for US Highway (US) 60 is currently underway that will determine the most appropriate action to improve and/or realign US 60 from the Town of Superior at approximately milepost (MP) 222.6 to east of the City of Globe at approximately MP 258.0 in Pinal and Gila counties, Arizona. ADOT, in partnership with the Federal Highway Administration (FHWA), has initiated a Location/Design Concept Study (L/DCR) and Environmental Impact Statement (EIS) to evaluate the proposed improvements to US 60.

US60 Florence Junction to Superior: The study investigates alternatives for improving United States Route (US) 60 between Florence Junction [US 60 / State Route (SR) 79] and the Town of Superior at the intersection of US 60 and SR 177. The purpose of the Design Concept Report is to develop and evaluate alternatives for realignment and/or improvement of US 60 between Florence Junction and the Town of Superior to enhance safety and traffic operational characteristics of the roadway and to meet current and future traffic needs.

APPENDIX II – SAMPLE DATASHEET USED IN STAKEHOLDER WORKSHOPS

PINAL COUNTY LINKAGE DATASHEET

Your name(s) _____

Linkage number: _____

Linkage description (Please try to describe the areas being connected as much detail as possible):

What are the main threats to the linkage? Use a separate line for each major paved road crossing the linkage. **** 1 is least severe and 5 is most severe****

Threat	Severity (1-5)**	Details (Describe the type of threat, area impacted, etc.)
Agriculture (grazing, farming)		
Exotic species invasion		
Canals (with names)		
Mining		
OHV Use		
Pipeline		
Powerline		
Wind energy development		
Solar energy development		
Uranium mining		
Railroad		
High Density Residential Dev.		
Low Density Residential Dev.		
Industrial/Commercial Dev.		
Paved road (with name)		
Paved road (with name)		
High Traffic Gravel Road (with name)		

Describe federal, state, or local support for conserving the linkage (willing land sellers, agencies interested in acquisition, formal conservation planning for the linkage, etc.)

If you have information you would prefer not appear in print but that you are willing to discuss, provide your name and contact information.

Provide details on FUTURE or PROPOSED road or development projects.

Project Name	Road/Hwy Description (e.g., realign 20 mile of existing road, 2 lanes each way) Development description (e.g., 20,000 new homes, plus commercial and industrial areas)	Entitled or Platted?	Funded?	Est. start date	Env. review completed?	Contact person, affiliation (e.g., "John Doe, ADOT PHX")
		Yes/No	Yes/No		Yes/No	

Provide any other helpful information (e.g., location, number, and size of key parcels in the linkage, ongoing restoration projects in the linkage, etc.).

Key contacts for this linkage: Please provide the names of one or more persons we can contact for additional information and future planning efforts.

Name	Affiliation	Phone	Email