Transcript Exhibit(s)

RECEIVED
2015 NOV 25 P 12:05
AZ CORP COMMISSION
DOCKET CONTROL

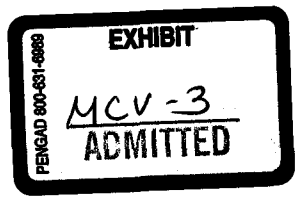
Docket #(s): L-00000YY-15-0318-00171

LS Case No. 171

Exhibit #: MCV 3-27

Volume 5 of 8

Arizona Corporation Commission
DOCKETED
NOV 25 2015
DOCKETED BY



AN ECOSYSTEM CONSERVATION ASSESSMENT OF THE LOWER SAN PEDRO WATERSHED IN ARIZONA

by

Scott L. Wilbor

A Thesis Submitted to the Faculty of the

SCHOOL OF NATURAL RESOURCES AND THE ENVIRONMENT

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

WITH A MAJOR IN NATURAL RESOURCE STUDIES

In the Graduate College

THE UNIVERSITY OF ARIZONA

2014

TABLE OF CONTENTS

LIST OF FIGURES 8

LIST OF TABLES 10

ABSTRACT 11

EXECUTIVE SUMMARY 12

1.0 INTRODUCTION 16
1.1 Objectives of this Study 18
1.2 Lower San Pedro Watershed Environmental Setting 19
1.3 Conservation in the lower San Pedro Watershed 21

2.0 STUDY AREA 24

3.0 METHODS 26
3.1 Networking 26
3.2 Surveys 26
3.3 Spatial Analysis Units 28
3.4 Translation of Survey Responses to Conservation Targets 32
3.5 GIS Spatial Analysis 32
3.5.1 Conservation Targets 32
3.5.2 Climate Adaptation Model 35
3.5.3 Conservation Gap Analysis 36
3.5.4 Species Mapping 37
3.5.5 Conservation Design 38
3.6 Implementation Assessment 39

4.0 RESULTS 40
4.1 Survey Translation to GIS Conservation Target Selection 40
4.1.1 Uplands 40
4.1.2 Riparian Corridors 41
4.2 Natural Resources of Conservation Concern 43
4.2.1 Groundwater Levels Surface Water Availability 43
4.2.2 Landscape Integrity Connectivity 44
4.2.3 Floodplain Integrity Connectivity 45
4.2.4 Upland Watershed Health 46
4.2.5 Riparian Gallery Forest and Mesquite Bosques 47
4.2.6 Valley Grasslands 48
4.2.7 Avian Habitat Species of Concern 50
4.2.8 Native Fish & Aquatic Habitat Non-native Competitors 51
4.2.9 Landscape mosaic 52

TABLE OF CONTENTS - *Continued*

4.3 GIS Spatial Analysis 53
4.3.1 Uplands 53
4.3.2 Riparian and Aquatic 56
4.4 Climate Change Adaptation Model 58
4.5 Gap Analysis 60
4.6 Conservation Design 62
4.6.1 Additional Special Focus Components of the Conservation Design 66
4.7 Implementation Assessment 68
4.8 Conservation Operational Needs 72

5.0 DISCUSSION 74
5.1 Stakeholder Assessment 74
5.2 Ecosystem Spatial Conservation Focus 77
5.3 Conservation Implementation in lower San Pedro Watershed 82
5.4 Evaluation of this Framework 84
5.4.1 Limitations, Mediating Factors, and Further Research Needs 86
5.5 Conservation Design in Review 90
5.6 Lessons & Improvements 92
5.7 Practical Application of Framework in the lower San Pedro Watershed 93
5.8 Practical Application to the field of Large Landscape Conservation 95
5.9 Summary of this Ecosystem Conservation Assessment Framework 96

6.0 CONCLUSIONS 98

7.0 APPENDICES 100
7.1 The Survey 100
Appendix A. Description of the Lower San Pedro Conservation Values Survey 100
Appendix B. Applications of the Survey to Natural Resource-focused Groups: 100
7.2 Spatial Data Preparation & GIS Analysis 101
Appendix C. Spatial Data Preparation 101
Appendix D. GIS Analysis: Conservation Targets 101
Appendix E. GIS Analysis: Climate Adaptation 103
7.3 Eco-community Information 105
Appendix F. Valley Grasslands & Groundwater 105
7.4 Results of GIS Analysis for Conservation Targets (Landscape Elements) 106
Appendix G. Riparian Reach Analysis for Individual Landscape Elements 106
Appendix H. Riparian Reach Analysis for Select Avian Species and Endangered Fish 112

7.5 Views of Conservation Implementation Organizations on Conservation Design 116
Appendix I. Conservation Implementation Survey: Summaries of their Implementation Ideas 116
Lower San Pedro Watershed Alliance & Cascabel Conservation Association, jointly 116
Natural Resource Conservation Districts (Winkelman & Redington) - Lower San Pedro Initiative 117
U.S. Fish and Wildlife Service 118
Arizona Land and Water Trust 119
Arizona State Land Department 120
Audubon Arizona 120
8.0 LITERATURE CITED 122

communities and agriculture (Ffolliott et al. 2004). In a few limited areas along the lower San Pedro River agriculture operations have modified immediately adjacent floodplains and constrained the river channel: in the past century this was more extensive, and many of these areas are now supporting shrub-tree mesquite thickets (Oleksyszyn 2001, Stromberg 2009b).

Upland communities of Sonoran desert scrub and shrub-mixed Sonoran semi-desert grassland and chaparral are threatened by habitat fragmentation, such as by new infrastructure projects and associated vegetation clearing (e.g., a proposed energy transmission line project, the SunZia Southwest Transmission Project), and by new roads and housing development (e.g., recent expansive housing development immediately to the west of the watershed). These latter threats can have landscape-levels effects, such as increased watershed erosion levels, the spread of invasive species, impaired landscape connectivity, and loss of climate-adaptation potential for species through disruption of local or regional movement opportunities.

Climate change, observed by increased annual temperatures of +1.4° F for the upper and lower San Pedro from 1951-2006 (Robles and Enquist 2010), is exacerbating drought conditions from 1996 to present (Richter 2008, ADWR 2013). On-going drought may further limit perennial water reaches and shallow groundwater zones supportive of riparian gallery forests, impact springs and seeps, and stress range conditions throughout the uplands. Riparian corridors can provide the major connectivity linkages of an ecosystem. They provide enhanced cover, shelter, forage and prey resources for dispersing individuals of species within a meta-population structure (Hilty et al. 2006). These same characteristics also allow species to adapt to changing climate by facilitating movement to suitable new habitat conditions or to more restricted climate refugia sites (Beier 2012). Additionally, continuous undisturbed landscape gradients, from valley lowlands to montane highlands, provide diverse physical environments (i.e., "land facets" -suites of geology, soils, and topography) that can promote evolutionary adaptation through a period of climate change (Beier and Brost 2010). Employing an ecosystem resilience adaptation approach is a favored climate adaptation strategy for biodiversity conservation (Morecroft et al. 2012). "Resilience" is defined by the ability of an ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change (IPCC 2007).

1.3 Conservation in the lower San Pedro Watershed

Within the lower San Pedro watershed stakeholders have diverse conservation interests and place value on a large spectrum of the watershed's natural resources. Land and

Based on these results, and continued networking over the study period, I assembled 15 GIS layers representing landscape-grounded conservation values for conservation value/target analysis, plus an additional 11 digital datasets for landscape analysis and climate adaptation modeling (Table 1).

Table 1. GIS spatial data layers and tools used in in landscape conservation prioritization within the lower San Pedro watershed, Arizona.

Data Layers	Source (time period)
Upland	
Grasslands - Apacherian-Chihuahuan Semi-Desert Grassland	NatureServe Terrestrial Eco-communities (2002)
Upland Sonoran Desert - Sonoran Paloverde-Mixed Cacti Desert Scrub	NatureServe Terrestrial Eco-communities (2002)
Riparian	
Surface Water - Perennial Reaches (length)	TNC Freshwater Assessment, TNC of AZ (2010)
Cottonwood/Willow (patches)	Digitized (SRP Imagery 2013, 0.61m res.)
Sycamore/Cottonwood (patches)	Digitized (SRP Imagery 2013, 0.61m res.)
Mesquite Bosque (≥ 5m)	Digitized (SRP Imagery 2013, 0.61m res.)
Valley Grasslands- Apacherian-Chihuahuan Semi-Desert Grassland (>99.9% this type. *Bouteloua sp./Muhlenbergi sp.* and many other grass sp.). Chihuahuan Loamy Plains Desert Grassland (Tobosa grass dominated), Chihuahuan-Sonoran Desert Bottomland and Swale Grassland (sacaton dominated)	NatureServe Terrestrial Eco-communities (2002)
Riparian Species	
Fish Habitat- Endangered Fish Habitat (as a percent of perennial water length by riparian reaches): Gila chub (*Gila intermedia*), Spikedace (*Meda fulgida*), and Loach minnow (*Tiaroga cobitis*)	AZGFD Heritage Program (Sep. 2013, dates 1976-2010) TNC Freshwater Assessment, TNC of AZ (2010)
Fish Habitat- All native fish (as a single coverage): loach minnow (*Tiaroga cobitis*), Spikedace (*Meda fulgida*), Roundtail chub (*Gila robusta*), Gila chub (*Gila intermedia*), Speckled dace (*Rhinichthys osculus*), longfin dace (*Agosia chrysogaster*), Desert sucker (*Catostomus clarki*), and Sonora sucker (*Catostomus insignis*)	AZGFD Heritage Program (Sep. 2013, dates 1976-2010)
Southwestern Willow Flycatcher (*Empidonax traillii extimis*)	U.S. Fish and Wildlife Service (2005-2010)
Yellow-billed Cuckoo (*Coccyzus americanus*)	Tucson Audubon Society, IBA Program (2013) Bureau of Reclamation (2011, 2013)
Gray Hawk (*Buteo nitidus*), Common Black-Hawk (*Buteogallus anthracinus*)	Tucson Audubon Society, IBA Program (2009, 2011) U.S. Geological Survey (2010, 2011)
Bird Habitat (comprehensive of various community and habitat types): Designated Lower San Pedro (Global) Important Bird Area, 2008	Tucson Audubon Society, IBA Program (2013)
American Beaver (*Castor canadensis*)	TNC of Arizona (2013) This study (2013)

Data Layers	Source (time period)
Coati (*Nasus nasua*)	Tucson Audubon Society. IBA Program (2012. 2013) This study 2013
Landscape Analysis	
Hydrological Unit Codes (8: watershed and 12s:sub-basins)- HUC 12s used for Upland Analysis Units and Riparian Analysis Unit mapping	U.S. Geological Survey (2013)
Aerial Imagery. San Pedro River (mainstem. 2ft. res.)	Salt River Project (2013)
Aerial Imagery. Counties of: Cochise. Pima. Pinal. and Graham	National Agriculture Inventory Project. NAIP. 1.0m res. (2013)
Holocene River Alluvium- used for Riparian Analysis Unit mapping	Cook et al. 2009
Digital Elevation Model- used for HLI. TRI. and Elevation Range	U.S. Geological Survey (2013)
Heat Load Index (HLI)- used in Climate Adaptation Modeling	U.S. Geological Survey (2013) Evans et al. 2013 (Feb. 2013)
Topographic Variability- Topographic Roughness Index (TRI). used in Climate Adaptation modeling	U.S. Geological Survey (2013) Evans et al. 2013 (Feb. 2013)
Elevation Range (max)- used in Climate Adaptation modeling	U.S. Geological Survey (2013) Arc-GIS Tools
Springs- Springs & Seeps- used in Climate Adaptation modeling	National Hydrological Database (2004)
Surface Water- Perennial Reaches (riparian. climate adaptation model. and bird & fish group analyses)	TNC Freshwater Assessment. TNC of AZ (2010)
Southeast Arizona Protected Lands	TNC of AZ (2013)
Landscape Analysis Tools	
Arc-GIS 10.2.1 Spatial Analyst Ext.	ESRI. Redlands. CA (2014)
Geomorphometric and Gradient Metrics Toolbox	Evans et al. 2013 (Feb. 2013)

3.3 Spatial Analysis Units

In order to conduct a spatial conservation prioritization analysis of the watershed. I divided the landscape into uplands and riparian corridors. I did this because certain ecological processes that influence eco-community development are different between the uplands and riparian corridors (e.g.. overall greater plant species dependence on groundwater interaction within the riparian corridor). Management and conservation options are also likely to be different based on these geographic divisions. Uplands are the region above the mapped floodplain boundaries of selected riparian corridors (see below). thus spanning in elevation from Sonoran desert-scrub. through chaparral. encinal woodlands. and pine oak. to mixed conifer communities among the included mountainous regions of the watershed. Riparian corridors included the floodplains of the San Pedro River and major tributaries (i.e.. Aravaipa. Hot Springs. Bass. Paige. Buehman. Redfield. Edgar. Copper. Putnam Camp Grant. and Turkey).

I designed analysis units based on sub-basin watersheds of the larger lower San Pedro watershed in order to capture ecological/hydrological processes common to distinct geographical areas (based on recommendations of Moilanen et al. 2009). These sub-basins defined both upland and riparian reach analysis units (reaches based on contributing sub-basin watersheds).. I used the U.S. Geological Survey Hydrological Unit Code 12 sub-basins for my watershed and riparian reach divisions (Figure 2: upland sub-basins, n= 65; Figure 3: riparian reaches, n=42). These sub-basins best encompass key hydrological and ecological processes important to ecosystem function within both divisions. For the uplands, these processes are likely to include similar rainwater infiltration and collection, soil development, vegetation growth, and fire-fuel characteristics. For riparian reaches, these processes are likely to include similar upslope contributing precipitation run-off profile, groundwater sub-flow and surface flow hydrological input, flood disturbance regime, and flood plain development characteristics. I included watershed sub-basins that narrowly intersected with the San Pedro River or Aravaipa Creek, but did not encompass a reach of river, in the adjacent downstream riparian reach. For some tributaries, lower reaches were delineated from upper reaches, as determined by breaks in consistent geomorphology and hydrology. Additionally I digitized the lateral floodplain extent of riparian reaches by use of a background GIS layer of the Holocene alluvium along the San Pedro River, Aravaipa Creek, and lower portions of tributaries (Cook et al. 2009), and used riparian vegetation extent in the upper tributaries.

Page 31 of the PDF Figure 3

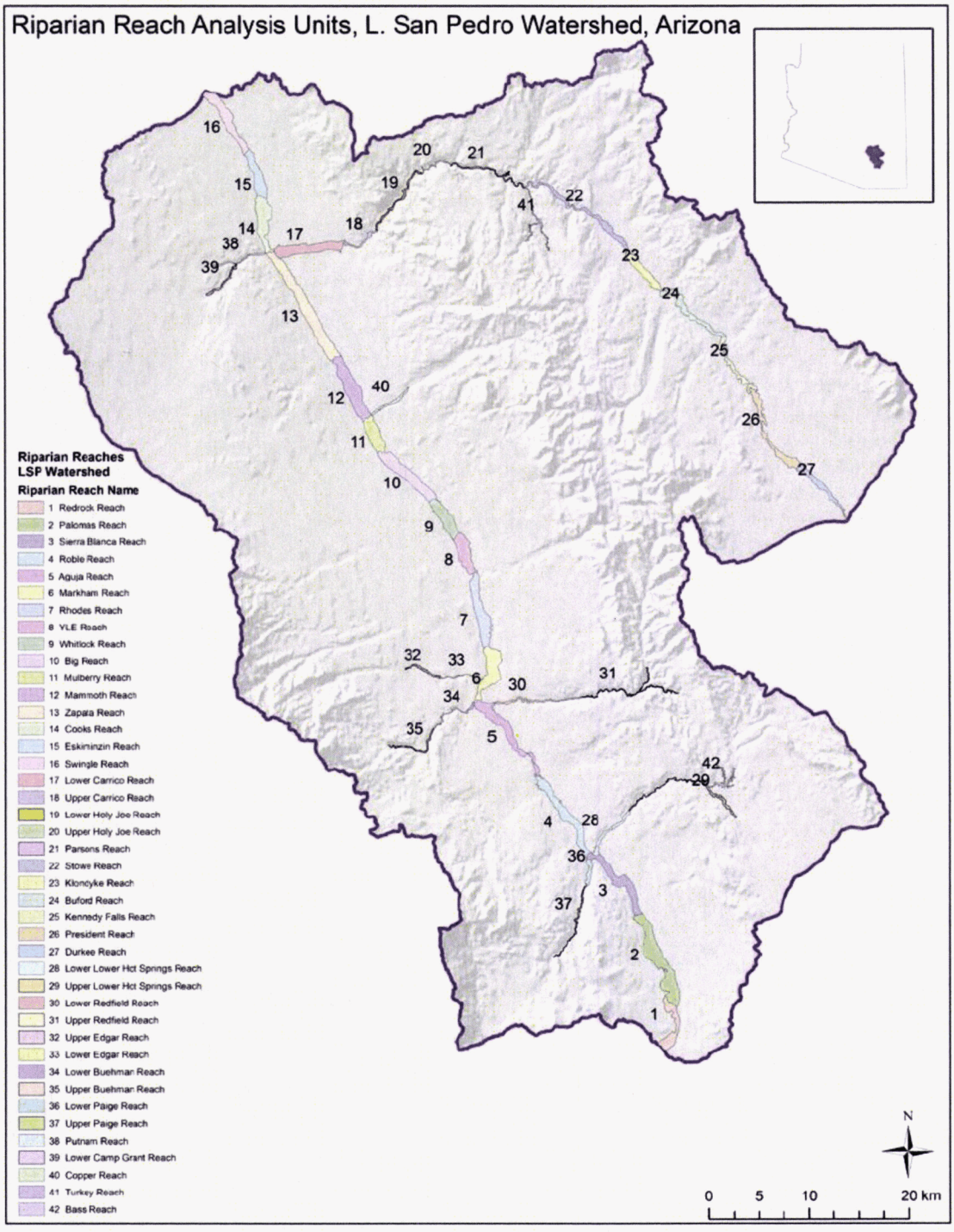


Figure 3. Riparian reach analysis units, in lower San Pedro watershed, Arizona.

3.4 Translation of Survey Responses to Conservation Targets

Based on results of the conservation values survey, I divided the responses into "uplands" and "riparian corridors" categories. I interpreted responses as fitting into landscape-grounded "conservation targets" (based on conservation values); of which many corresponded to available GIS spatial datasets. For example the expressed importance of surface water to biodiversity in riparian corridors was best represented by a perennial water distribution data layer in Arizona available through The Nature Conservancy of Arizona, circa 2009 (TNC AZ 2010). I was able to obtain GIS data layers for most of the commonly cited conservation values for both the upland and riparian corridor survey responses. Certain ecological and hydrological data layers were created through GIS digitizing or analyses (see Appendix C for details).

For certain spatially identifiable conservation values, there were no comprehensive GIS data layers available for the watershed (e.g., Uplands: soil type diversity, Riparian Corridors: groundwater) and for less frequently cited conservation values I chose not to conduct new GIS analyses to generate new data layers. Certain conservation values that were cited by survey respondents (e.g., upland/lowland springs, topographic variability, and elevation gradient), were already (prior to the survey) incorporated into the climate change adaptation modeling, and thus these values were captured in this assessment.

3.5 GIS Spatial Analysis

3.5.1 Conservation Targets

The survey results (from a very small sample of stakeholders) provided a guide to the conservation values of individual stakeholder groups and overall (all-groups) values, based on percentage response values by group and value percentage totals for all groups. The final selection of conservation targets was made by this researcher. In making this decision I based it on the survey's conservation values *totals* for the three stakeholder groups. I noted that water and the natural vegetation communities cited by respondents, best corresponded to GIS spatial data layers that could be readily obtained for perennial waters and land cover vegetation, or could be practically created (i.e. communities could be digitized) within the time constraints of this project. Additionally, a goal of this assessment was to meet the biodiversity conservation interests of the USFWS (as well as the stakeholder groups'), and the species of interest to this agency (i.e., the conservation of riparian-dependent birds and mammals, and aquatic habitat dependent native/endangered fish) could best be captured comprehensively by focusing on a perennial waters and vegetation eco-community conservation target approach. Thus, I

chose for analysis the natural eco-community types commonly cited by the stakeholder groups as conservation targets.

I conducted GIS analysis to present the spatial distribution and quantities (ranked) of conservation targets, in both the upland analysis units and the riparian corridor analysis units (see Appendix D for details). Evaluation of conservation targets for spatial conservation prioritization (i.e., by areal extent, percent, and length) considered the highest statistical tiers, i.e., tier 1 for the upland sub-basins and tiers 1 and 2 in the riparian reaches using Natural Breaks-Jenks (Jenks 1967). Conservation targets within riparian reaches were more skewed towards high values in a select few reaches, thus indicating the need to evaluate the second tier division as well. Riparian connectivity considerations also indicated the need to spatially prioritize more reaches for inclusion in the watershed conservation design.

Natural Breaks-Jenks is a statistical clustering method which optimizes categorization of values into classes or tiers; as such it minimizes the variances within tiers and maximizes the variance among tiers (Jenks 1967). Typically higher values were of higher conservation value; hence tier 1 and 2 levels. I consistently used five Natural Breaks-Jenks classes/tiers in all my analyses (therefore quantity values for tiers vary). Natural Break-Jenks allows for comparability among resources analyzed when the measurement method of quantity varies. Additionally, re-coding Natural Break-Jenks organized data, into a consistent range of values (e.g., 1-5) is facilitated by this statistical method, allowing for the summation of combined target values. Thus, this statistic allowed me to analyze individual and combined conservation targets most efficiently (Table 2).

In order to comprehensively evaluate conservation values for spatial conservation focus among riparian reaches, I weighted landscape elements by the corresponding conservation value survey responses, and then combined them. I first re-coded the actual values from the landscape element analyses for the riparian reaches into classes of 1-5 (from Natural Breaks-Jenks), independently, with five being the highest class (quantity) of the element within riparian reaches. I applied weights from the survey results (the percentage value from the survey results, range 0-1), and then summed these landscape elements values by riparian reach (results range 0-8.0). This allowed there to be a higher score value corresponding to higher conservation value (subsequently tier 1 and 2 levels).

Table 2. Conservation targets analyzed for spatial conservation prioritization within the lower San Pedro watershed, Arizona.

Zone/GIS Layer	Year of GIS layer	Map Unit	Quantity measured
Upland Sub-basin			
Grasslands	2002	30m pixel	percent
Upland Sonoran Desert	2002	30m pixel	percent
Riparian Reach			
Perennial Water	2009	line (perennial)	length
Cottonwood/Willow (c/w)	2013	patch	area
Sycamore/Cottonwood (s/c)	2013	patch	area
Valley Grasslands (vg)	2002	30m pixel	area
Mesquite Bosque (mb)	2013	polygon patch	area
SW Willow Flycatcher/Yellow-billed Cuckoo/Gray Hawk Habitat	2013	line (perennial) and patch (c/w + s/c + mb)	Recode*, then sum
Common Black-Hawk Habitat	2013	line (perennial, tributaries only)	length
Endangered Fish Habitat	1976-2010 (perennial water 2009)	patch and buffered line (End. fish ÷ perennial)	percent
Conservation Value Survey (combo**): Conservation groups, Nat. Resource Profs., Ranchers & Farmers, "all-groups"	2002 (grasslands), 2009 (per. water), 2013 (c/w, s/c, mb)	30m pixel (vg) length (per. water) patch (c/w, s/c, mb)	Recode, apply Weights***, then sum

*Recode: Individual landscape element analysis quantity by Natural Breaks-Jenks (5 classes), recoded correspondingly to 0-5 (5 highest).

**Combo: Combination of the most commonly reported landscape elements of conservation importance from survey.

***Weights: Determined from percentage response for landscape elements by groups and using "all-groups" in total from survey.

3.5.2 Climate Adaptation Model

I evaluated the entire watershed again by HUC12 sub-basins, including riparian corridors, for climate adaptation value to biodiversity following a conservation approach for ecosystem resilience. This analysis was based on a synthesis and simplification of proposed climate adaptation strategies for biodiversity conservation with climate change (Heller and Zavaleta 2009, Hodgson et al. 2009, Mawdsley et al. 2009, Anderson and Ferree 2010, Bier and Brost 2010, Bier 2012, and Morecroft et al. 2012). It was also based on a generalized hotter and drier scenario for the Southwest region within the United States, i.e., continued warming, variable summer monsoon, increased precipitation intensity, and drier winters (Overpeck and Udall 2010).

The USFWS also desired a climate adaptation approach be incorporated into a landscape conservation design developed through this ecosystem assessment. Again, availability geospatial data and practical development geospatial data through analysis, along with the application of climate adaptation biodiversity conservation theory, drove the selection and analysis of this data.

My approach was to prioritize particular landscape features supportive of maintaining biodiversity, and then select for landscape connectivity (e.g., along mountain ranges and cross-valley spanning low to high elevation), thus maximizing adaptive capacity locally and broad-scale. I performed GIS analyses on five landscape variables: heat load index, topographic roughness index, spring abundance (percentage of all springs in the watershed), elevation range (maximum), and perennial water distribution, and I assessed spatial patterns of landscape connectivity, particularly involving water (see Appendix E for details). I developed a six-step rule set for landscape prioritization, focused on selecting the top tiers of landscape features through statistical analysis Natural Breaks-Jenks (Table 3).

Table 3. Six-step rule set for landscape prioritization to develop climate change adaptation model used for lower San Pedro watershed, Arizona. Selection for inclusion in the model is based on characteristics of sub-basin watersheds (HUC 12) (steps 1-5) and riparian reaches (step 6).

Step	Landscape Features/Factors	Measurement	Tier Selection*	Step Action
1	Heat Load Index (HLI) *or* Topographic Roughness Index (TRI)	HLI: lower value pixels > 2 std. dev. TRI: mean	Tiers 1 & 2 (both features)	Select sub-basins, i.e., "HLI-TRI"
2	Spring Abundance (SA) Elevation Range (ER)	SA: percent of watershed ER: maximum	SA: Tiers 1 & 2 ER: Tier 1	Retain from selected HLI-TRI sub-basins
3	Perennial Waters	Presence in sub-basin (> 2km)	n/a**	Retain from selected HLI-TRI sub-basins
4	Connectivity	Spatial adjacency between HLI-TRI "pairs", facilitating cross-valley or mountain ridge connectivity	n/a	Retain from selected HLI-TRI sub-basins
5	Cross-valley Connection	Spatial connectivity to previously selected sub-basins: (HLI+TRI+SA or HLI+TRI+ER)	n/a	Add sub-basins
6	Valley Bottom Perennial Reaches	Presence in valley bottom riparian reaches	n/a	Add riparian reaches (portions with perennial water)

*Natural Break-Jenks (5 tiers).

**Not applicable.

3.5.3 Conservation Gap Analysis

I evaluated the high priority riparian reaches, both priority riparian reaches from combined conservation targets analysis and climate adaptation model additions, for current protection/conservation management status (e.g. conservation easements, ownership status by conservation organization or public agency-county, state, or federal) (TNC of Arizona Protected Area Layer 2013). I conducted a protection/management gap

analysis to determine priority riparian reaches with less than or equal to 20% conservation protection/management (Scott et al. 1987, Scott and Schipper 2006). The conservation gap analysis assessed the top two tiers from the *combined conservation target reach analysis* and the additional *climate reaches*, to assess the conservation coverage (i.e., the land within conservation/protection legal status) of priority riparian reaches and more broadly the conservation of riparian corridors.

3.5.4 Species Mapping

I mapped the spatial distribution of select riparian-associated and aquatic species that USFWS and surveyed respondents viewed as critical/important to conserve in this watershed. Watershed-wide distribution survey information for individual bird and mammal riparian-associated species were lacking and habitat models (based on available vegetation classifications) for these species were found insufficient for this watershed. Therefore, species distributions (where survey records occur), were used as a check on the conservation design proposed in this study, assessing the potential riparian/aquatic habitat quality for the species, and as an ecological indicator of an area's broader biodiversity conservation value (Table 4).

Table 4. Species evaluated for distribution for ecological evaluation of riparian reach priorities within conservation design for the lower San Pedro watershed, Arizona.

Species	Status	Ecological
Birds*		
Southwestern willow flycatcher (*Empidonax traillii extimis*)	Endangered	Riparian -perennial with dense understory vegetation
Western yellow-billed cuckoo (*Coccyzus americanus*)	Candidate	Riparian -multi-tiered forests
Gray hawk (*Buteo nitidus*)	n/a	Riparian -with adjacent tall stature mesquite bosque
Common black-hawk (*Buteogallus anthracinus*)	n/a	Riparian -perennial with pools
Mammals**		
American beaver (*Castor canadensis*)	n/a	Aquatic/Riparian-cottonwood/willow (keystone species: creating ponded water/marshes)
Coati (*Nasua nasua*)	n/a	Riparian -perennial
Fish***		
Gila chub (*Gila intermedia*)	Endangered	Aquatic -pools of smaller streams
Spikedace (*Meda fulgida*)	Endangered	Aquatic -shallow riffles (sand, gravel, substrates)
Loach minnow (*Tiaroga cobitis*)	Endangered	Aquatic -shallow riffles, swift water (cobble substrate)

*Corman and Wise-Gervais 2005

**Pers. obs. 2012-2013

***USFWS Southwest Region. Arizona Ecological Services Field Office. General Species Information.

3.5.5 Conservation Design

A final proposed conservation design considered: 1) climate adaptation priority sub-basin watersheds and riparian reaches by a rule set, 2) riparian reaches evaluated by multiple data layers combined (weighted by survey results) and individual data layers, 3) upland sub-basins with the highest proportion of eco-community types (conservation survey result informed), 4) a review of the conservation coverage gap status of riparian reaches, 5) select species occurrence (field survey result informed), where available, and 6) underlying land use and current settlement pattern assessed by aerial imagery.

3.6 Implementation Assessment

Based on the completed conservation design, conservation implementation organizations were asked for suggestions on the most practical and implementable conservation actions and strategies, particularly considering land ownership and jurisdictions. This assessment was conducted by either personally meeting with implementing organizations or by an email survey. Organizations were provided with a brief summary of the conservation assessment, how the design was derived, and maps showing high conservation focus areas and landscape connections in the watershed. Results were synthesized comprehensively into favored conservation actions/strategies. A table matrix was constructed to subjectively evaluate these actions/strategies' conservation influence (if implemented) on natural resources of high importance to stakeholder groups, which were synthesized from community networking. Conservation influence relates to enhancement/restoration of the resource or long-term conservation of the resource from development or degradation from a variety of stressors.

vegetation and regional wildlife populations (including threatened and endangered species) along the San Pedro River. Conservationists cite the primary threats as the potential for new housing development, and increased agriculture demand occurring with on-going drought.

Native riparian vegetation needs groundwater at accessible root depth for establishment, persistence, and to develop to their potential size and structure. Fremont cottonwoods need groundwater less than 2.6m (8.5 ft.) from the surface and annual fluctuations less than 0.5m (1.6 ft.) (Lite and Stromberg 2005). Mature tall stature velvet mesquite, in order to form *bosques* most beneficial to wildlife, i.e., those 5.0m (16.4 ft.) and greater in height (canopy dominants at 12m) and with a mostly closed canopy, need groundwater at depths 2 to 10m (7-33 ft.) and up to 13.5m, to develop to this height/structure potential (Stromberg 1993, Stromberg et al. 1993, Scott et al. 2006). Sacaton grass (a facultative riparian grassland community) begins to lose access to groundwater at 3m and completely by 4m, but can survive from rainfall when precipitation is sufficient (Scott et al. 2006, Stromberg et al. 2009b). Groundwater discharging to the riverbed surface in arid watersheds, such as the San Pedro River, results in perennial or seasonal perennial reaches of surface water flow (Stromberg et al. 2009a). Surface water flow is responsible for additional biodiversity potential in its support of aquatic niche space, water provision for species, and increased trophic food webs within communities (Stromberg and Tellman 2009).

Major Threat: Urban/suburban development and associated high groundwater water usage.
Secondary Threat: Long-term drought, particularly coupled with increased pumping by current users in the watershed (e.g., increased agricultural requirements). Placement of new wells close to perennial reaches.

4.2.2 Landscape Integrity/Connectivity

Landscape integrity and connectivity is of high value to Conservation groups and Natural resource professionals. Wildlife connectivity among mountain ranges, and facilitating a meta-population structure is a concern for both these groups (e.g., black bears, *Ursus americanus*, mountain lions, *Puma concolor*, coati, *Nasua nasua*, potentially big horn sheep, *Ovis canadensis*, and others). Additionally, Professionals cite landscape connectivity, especially extending over undisturbed elevation gradients, as an important landscape characteristic for species adapting through movement to changing climate conditions. Conservation groups are very concerned about infrastructure projects that impact landscape integrity over a wide swath (e.g., a proposed large-scale transmission line); as well as new roads and development, and the potential pathways for invasive

plant species introduction. Ranchers and farmers would also like to maintain un-fragmented landscape and prevent major infrastructure projects that do not serve the human communities, as this could negatively impact the natural resource base of the watershed (e.g., impact grazing lease lands).

Many wildlife populations are structured in meta-populations that require individuals to periodically disperse to find new mates, enhance sub-population genetic diversity and demographics, and (re)colonize areas (Hilty et al. 2006, Gregory and Beier 2014). Some wildlife populations require movement for annual migrations, and these mostly occur seasonally in response to changes in food availability and/or reproductive opportunities (Hilty et al. 2006). Lastly, species are expected to find landscape linkages essential for adapting to changing climate conditions (Heller and Zavaleta 2009, Mawdsley et al. 2009, Beier 2012, Chester et al. 2012, Groves et al. 2012, Hilty et al. 2012). This expectation is evidenced in the Paleo-ecological historic record as species moved in response to the changing climate conditions of the last glacial maximum period (Dawson et al. 2011).

Major Threat: New infrastructure (e.g., transmission lines and service roads) in the uplands.
Secondary Threat: Current mining and future mining (expansion), and associated service roads. New large-scale residential development projects. Highway development and/or new secondary road development.

4.2.3 Floodplain Integrity/Connectivity

Natural resource professionals and Conservation groups again both emphasized floodplain integrity/connectivity as an important component to a healthy functioning ecosystem. Both groups extend this value to encompass both the mainstem of the San Pedro and its major tributaries (particularly lower reaches). Natural resource professionals promoted the conservation of sufficient active floodplain space for channel movement, floodplain development, and overbank flooding. Professionals promoted the idea that the river needs to continue to meander, unconstrained by levees or bank protection, for ecological function (vegetation dynamics) and ecosystem benefits (flood amelioration, floodplain groundwater recharge). Additionally, they called for the restoration of floodplain space for channel hydraulics where needed. Active restoration of desired channel characteristics was cited as an option to be explored. Conservationists emphasized the importance of ensuring the undeveloped character of riparian corridors for wildlife habitat and movement. Off-road vehicle (all-terrain vehicle) control through floodplains was also cited as a key issue by Conservationists. Ranchers and farmers also

Table 5. Conservation focal areas identified by a stakeholder-based "all-groups" spatial analysis of weighted and combined conservation targets within the lower San Pedro watershed, Arizona.

High Conservation Value Focal Areas	Riparian Reaches*
Northern San Pedro	Swingle, Eskiminzin, Cooks, Zapata
Aravaipa Region	Lower Holy Joe, Parsons, Stowe
Middle San Pedro	Big, Whitlock
Galiuro Canyons	Upper Redfield, Upper-Lower Hot Springs
Lower-Middle San Pedro	Roble
South San Pedro	Palomas

*Names from corresponding HUC12 sub-basins (shortened).

4.4 Climate Change Adaptation Model

I conducted climate change adaptation modeling over the watershed's sub-basins and riparian reaches. The model used a six-step rule set, selecting landscape factors by sub-basins and reaches, promoting biodiversity adaptation to climate change (warmer/drier conditions) following a resilience strategy. This model yielded a landscape design spanning the highlands of the Galiuro Mountains north through to the Aravaipa Canyon region and northwest to the Santa Teresa Mountains, and included five cross-valley connections and four additional valley-to-range elevation gradient connections (Figure 9). One selected sub-basin with aerial imagery identified mining activity and high road density, had to be replaced with a spatially close and similar characteristic alternative sub-basin (i.e., Copper sub-basin replaced with Clark sub-basin).

Page 59 of the PDF and Figure 9

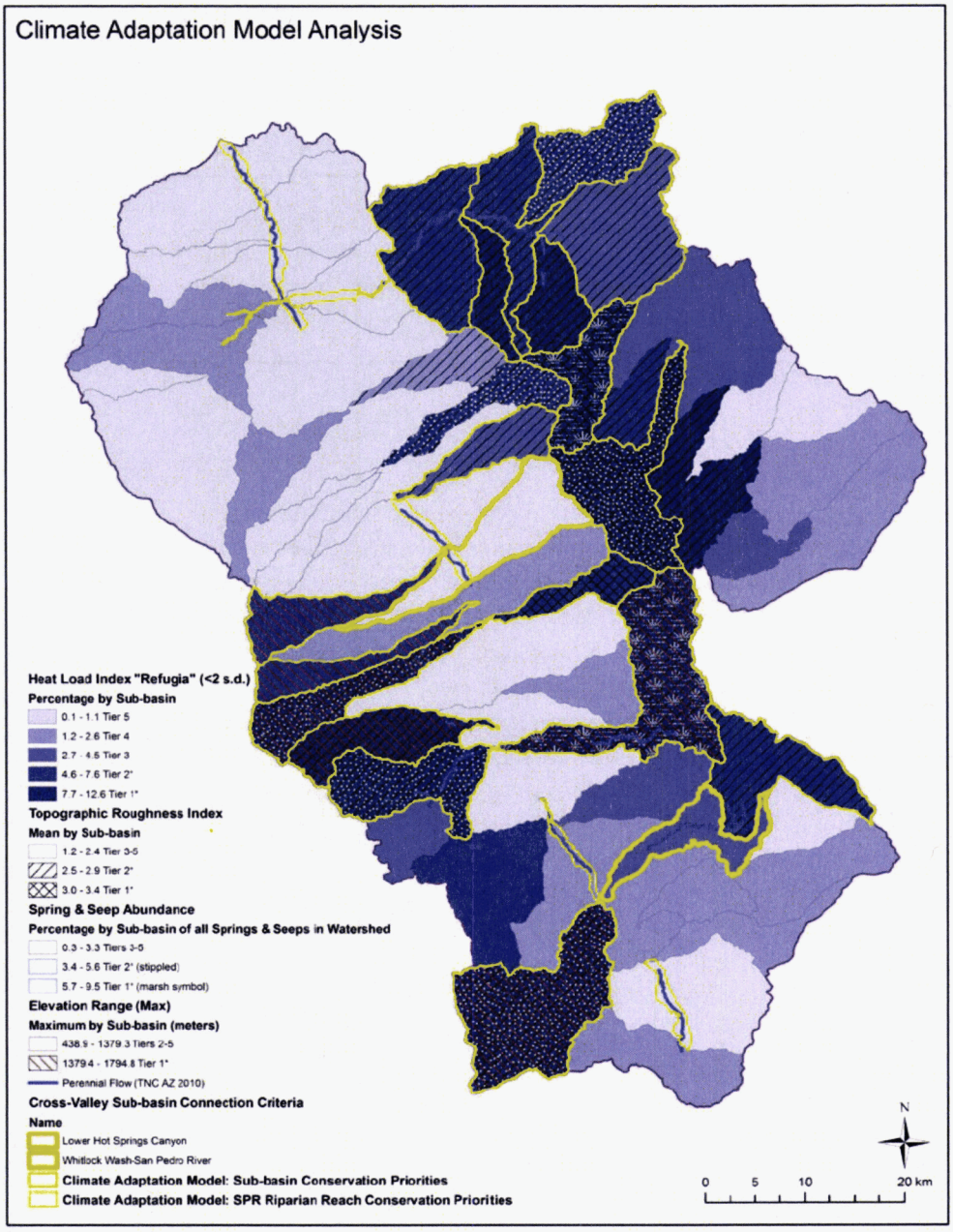


Figure 9. Climate adaptation model for biodiversity conservation developed from a 6-step rule set focused on landscape-level ecosystem resilience for the lower San Pedro watershed, Arizona. Background layer of Heat Load Index (< 2 std. dev. HLI), all tiers, is provided for context. See Table 3 for the six-step rule set selecting sub-basins and reaches (* = tiers for these features were used in the rule set). The yellow outlined sub-basins and reaches delineate the climate adaptation model.

Table 6. Conservation gap analysis of priority riparian reaches. Priority reaches were determined from an "all-groups" multiple conservation target analysis (based from stakeholder groups' conservation values) and a climate adaptation model (see text). Priority reaches were assessed with a "conservation protection/management" spatial layer, and a criteria of 20% or less spatial coverage in conservation land status, in order to highlight high value areas with minimal conservation within the lower San Pedro watershed, Arizona (reaches listed north to south).

"Conservation Gap" Riparian Reaches*	Criteria: "All-Groups" combined conservation targets	Criteria: Climate Change Adaptation Model	Total Area of Reach (Ha)	Present Conservation Coverage** (%)
L. Carrico-Aravaipa Crk.		X	606.9	10.8
U. Carrico-Aravaipa Crk.		X	78.9	17.4
Putnam Wash		X	62.6	4.0
Big-San Pedro R.	X	X	730.0	0.0
Whitlock-San Pedro R.	X	X	437.3	12.5
Lower Edgar Wash		X	37.5	0.3
Lower Redfield Wash		X	139.5	0.3
Upper Page Crk.		X	70.3	0.0
Aguja (s. section)-San Pedro R.		X	85.4	6.0

*Names from corresponding HUC12 sub-basins (shortened).

**Southeast Arizona protected area shapefile from The Nature Conservancy-Arizona Chapter, March 2013.

4.6 Conservation Design

I evaluated tier 1 sub-basins for semi-desert grassland extent (i.e., percent coverage) across the watershed. I included all six sub-basins in the conservation design, prioritized as grassland conservation and management focal areas (Figure 11). I also evaluated tier 1 sub-basins for extent of Upland Sonoran Desert (focus: saguaros) across the watershed. To reduce the selection of these tier 1 sub-basins (7), which covered a large portion of the northern region of the watershed, I chose to set a strategic objective of selecting two sub-basins for conservation focus that would provide a high quality large wildland block of this eco-community type. I thus evaluated each tier 1 sub-basin by the percentage Sonoran Desert within, and chose the sub-basin with the highest coverage and then selected the next largest contiguous tier 1 sub-basin. I additionally checked for road density in select sub-basins, which if found significant would have warranted a different selection set. Two sub-basins in the Aravaipa uplands region, with Sonoran Desert coverage of 54% and 41%, respectively, were identified as conservation focal areas to be included in the conservation design (i.e., Carrico Springs sub-basin encompassing lower Aravaipa Creek and contiguous Zapata Wash sub-basin) (Figure 11).

Page 63 of the PDF and Figure 11

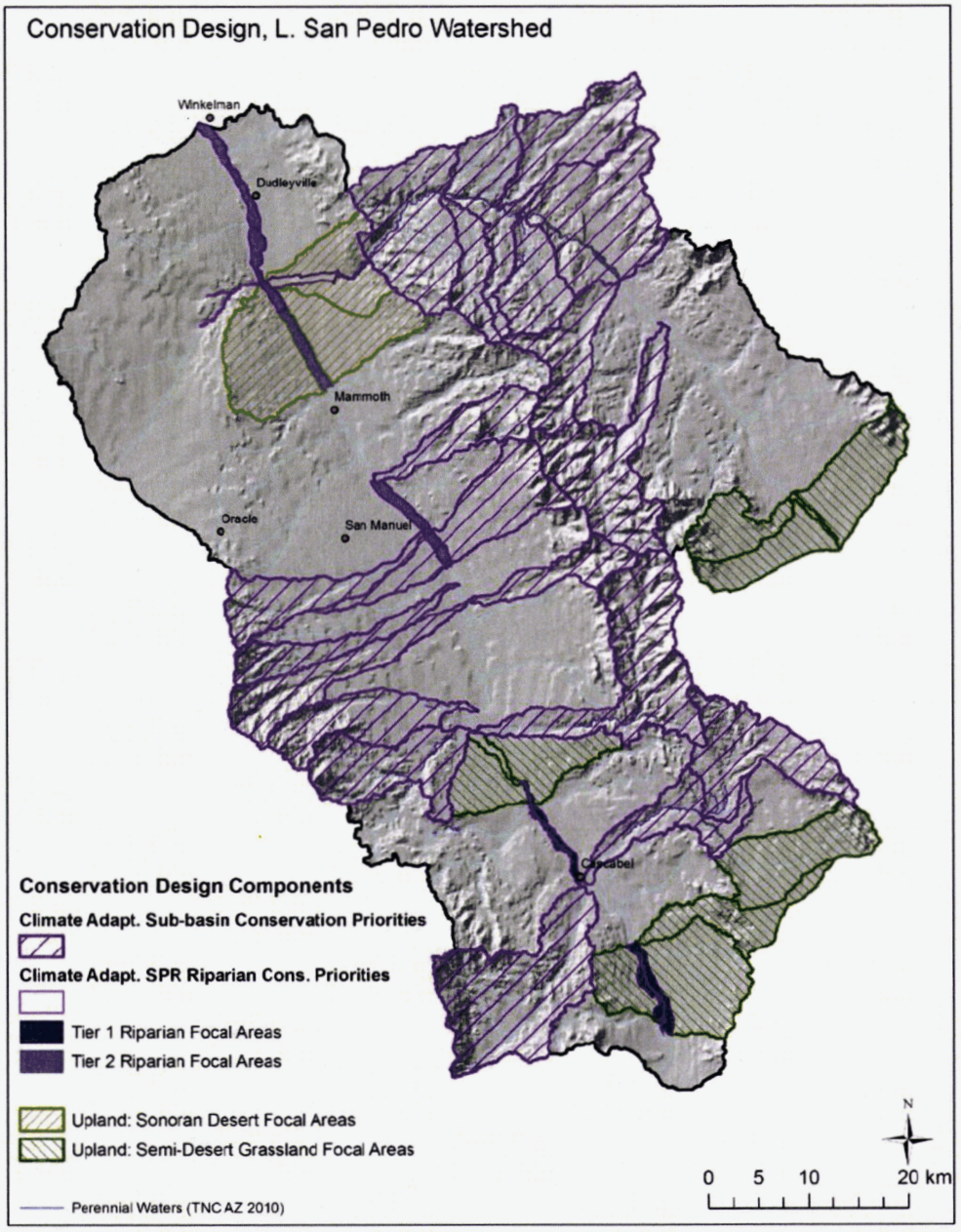


Figure 11. Conservation design encompassing climate adaptation model, riparian focal areas ("all-group" analysis), and upland focal areas for Sonoran desert and semi-desert grassland, for the lower San Pedro watershed, Arizona.

Key components of the landscape conservation design for climate adaptation were the San Pedro cross-valley sub-basin pairs (5) and the adaptation and "refugia" facilitating landscape characteristics captured within the sub-basins of the high mountain ranges. The highest priorities for connectivity conservation focus are the southernmost San Pedro cross-valley sub-basin pair (Paige-Lower Hot Springs) and the two northern most connections across the San Pedro valley (Peppersauce-Whitlock, and Alder/Stratton-Kielberg). An additional high value landscape linkage is the riparian corridor connection through the main tributary (Aravaipa) and into a smaller drainage system to the west of the San Pedro with a perennial spring (Putnam). Three high range contiguous sub-basins in the Galiuro Mountains (i.e., Redfield, Rattlesnake, and Four Mile) have critical landscape components: high topographic roughness, high spring/seep abundance, and higher elevation, all landscape characteristics providing the potential for species adaptation to climate change and to exploit micro-climate "refugia" conditions.

I selected the combined "all-group" high conservation value riparian reaches for inclusion in the conservation design. The selection of this multiple stakeholder grouping sets a priority conservation focus (with applied weights) towards perennial waters (i.e., potential for perennial waters in a given year), existing riparian gallery forest of 2013 (but also high groundwater availability), and to a lesser emphasis the proximal occurrence of mesquite *bosque* and valley grassland. The above combined set also captures high value reaches for riparian-associated birds and endangered fish (see Appendix H, Figures 20-22). An overview map of the conservation design provides additional context showing the widespread distribution of *conservation value* lands throughout the watershed and diversity of landownership and jurisdiction (Figure 12).

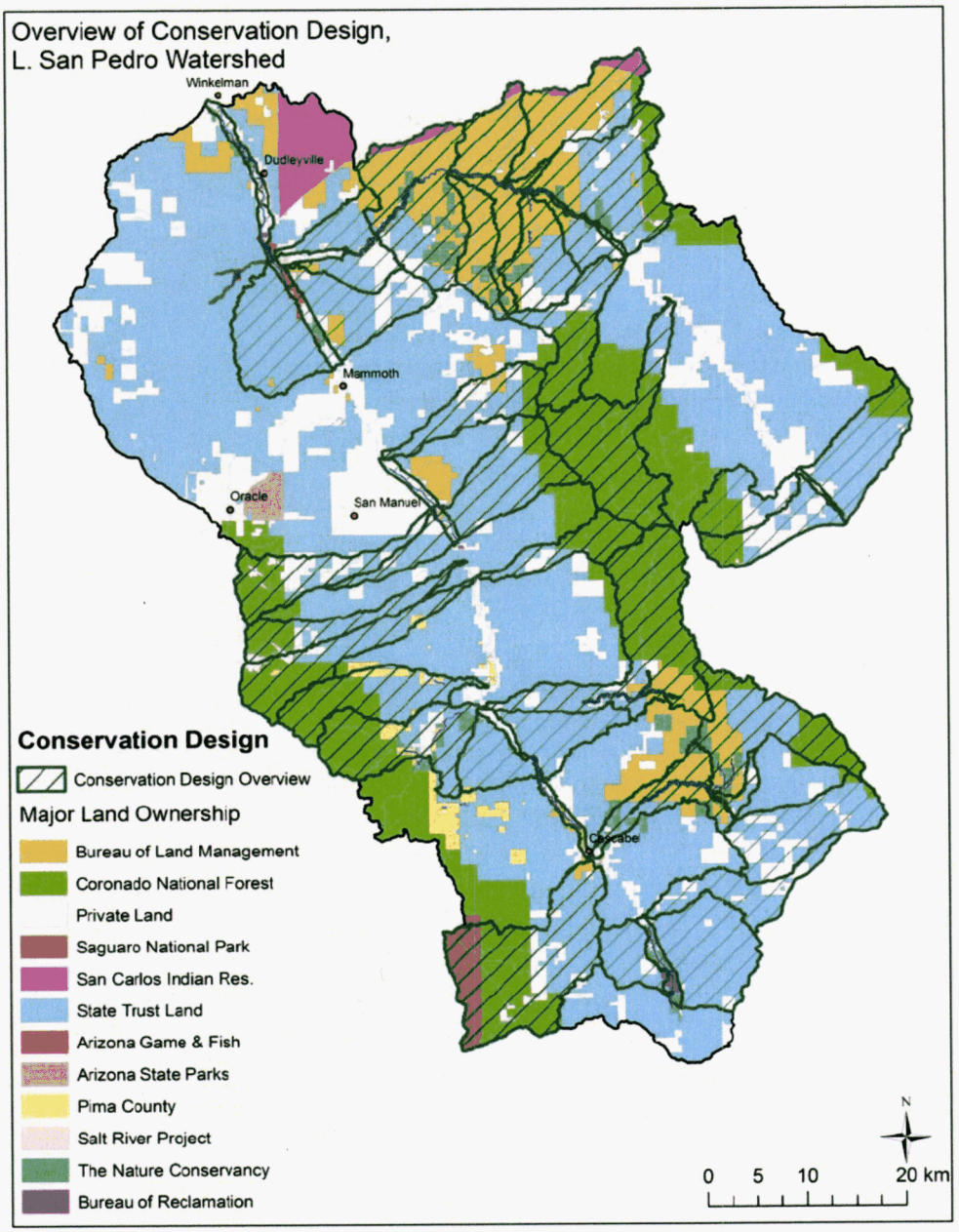
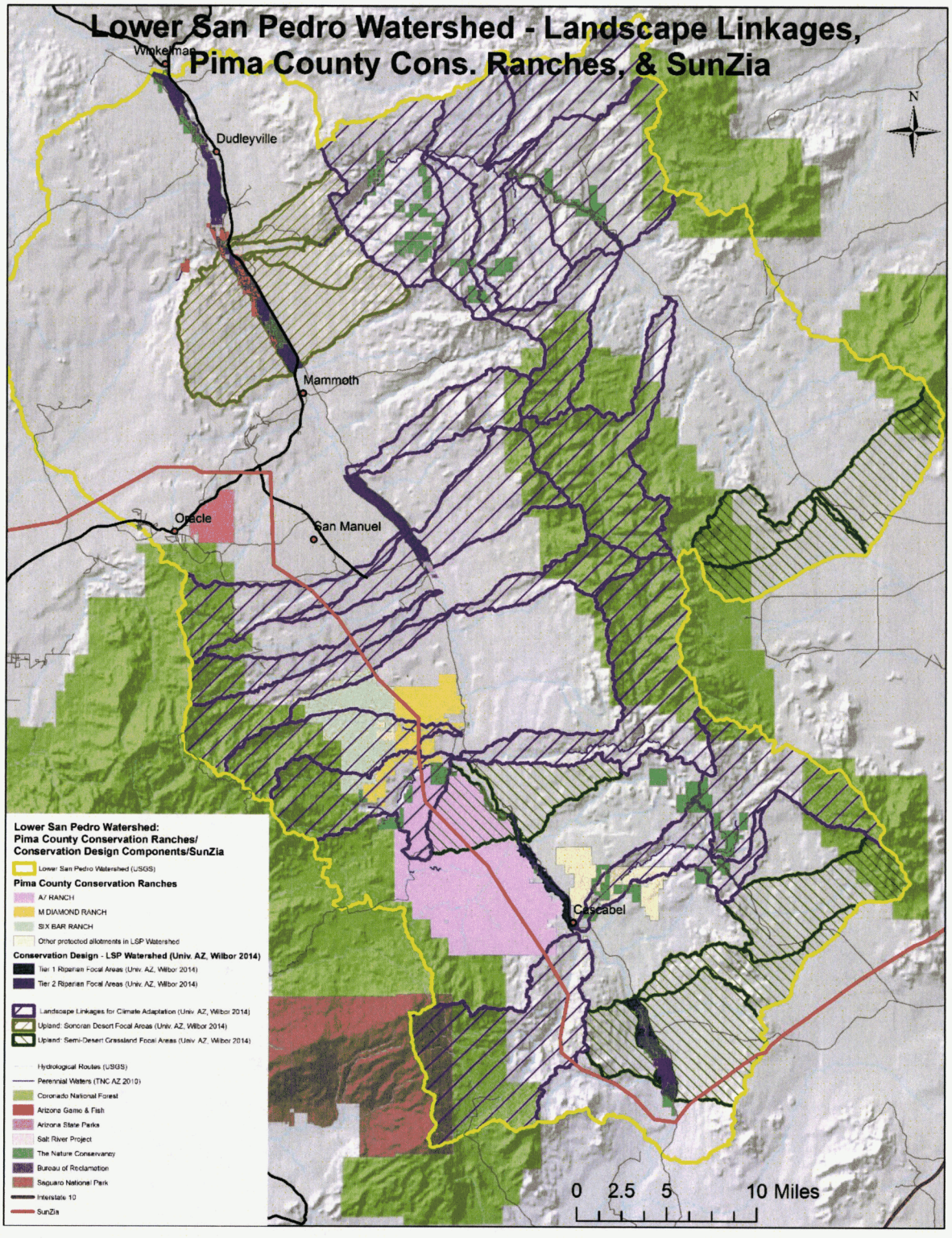


Figure 12. An overview of all lands identified by geospatial analysis from a stakeholder-based survey of conservation values, and a climate adaptation model, that are included in the conservation design for the lower San Pedro watershed, Arizona. Various types of land management and conservation strategies could be employed on these lands depending ownership/jurisdiction.


Lower San Pedro Watershed - Landscape Linkages,
Pima County Cons. Ranches, & SunZia
Winkelman
Dudleyville
Mammoth
Oracle
San Manuel
Cascabel
N
0 2.5 5 10 Miles
Lower San Pedro Watershed:
Pima County Conservation Ranches/
Conservation Design Components/SunZia
Lower San Pedro Watershed (USGS)
Pima County Conservation Ranches
AZ RANCH
M DIAMOND RANCH
SIX BAR RANCH
Other protected allotments in LSP Watershed
Conservation Design - LSP Watershed (Univ. AZ, Wilbor 2014)
Tier 1 Riparian Focal Areas (Univ. AZ, Wilbor 2014)
Tier 2 Riparian Focal Areas (Univ. AZ, Wilbor 2014)
Landscape Linkages for Climate Adaptation (Univ. AZ, Wilbor 2014)
Upland: Sonoran Desert Focal Areas (Univ. AZ, Wilbor 2014)
Upland: Semi-Desert Grassland Focal Areas (Univ. AZ, Wilbor 2014)
Hydrological Routes (USGS)
Perennial Waters (TNC AZ 2010)
Coronado National Forest
Arizona Game & Fish
Arizona State Parks
Salt River Project
The Nature Conservancy
Bureau of Reclamation
Saguaro National Park
Interstate 10
SunZia

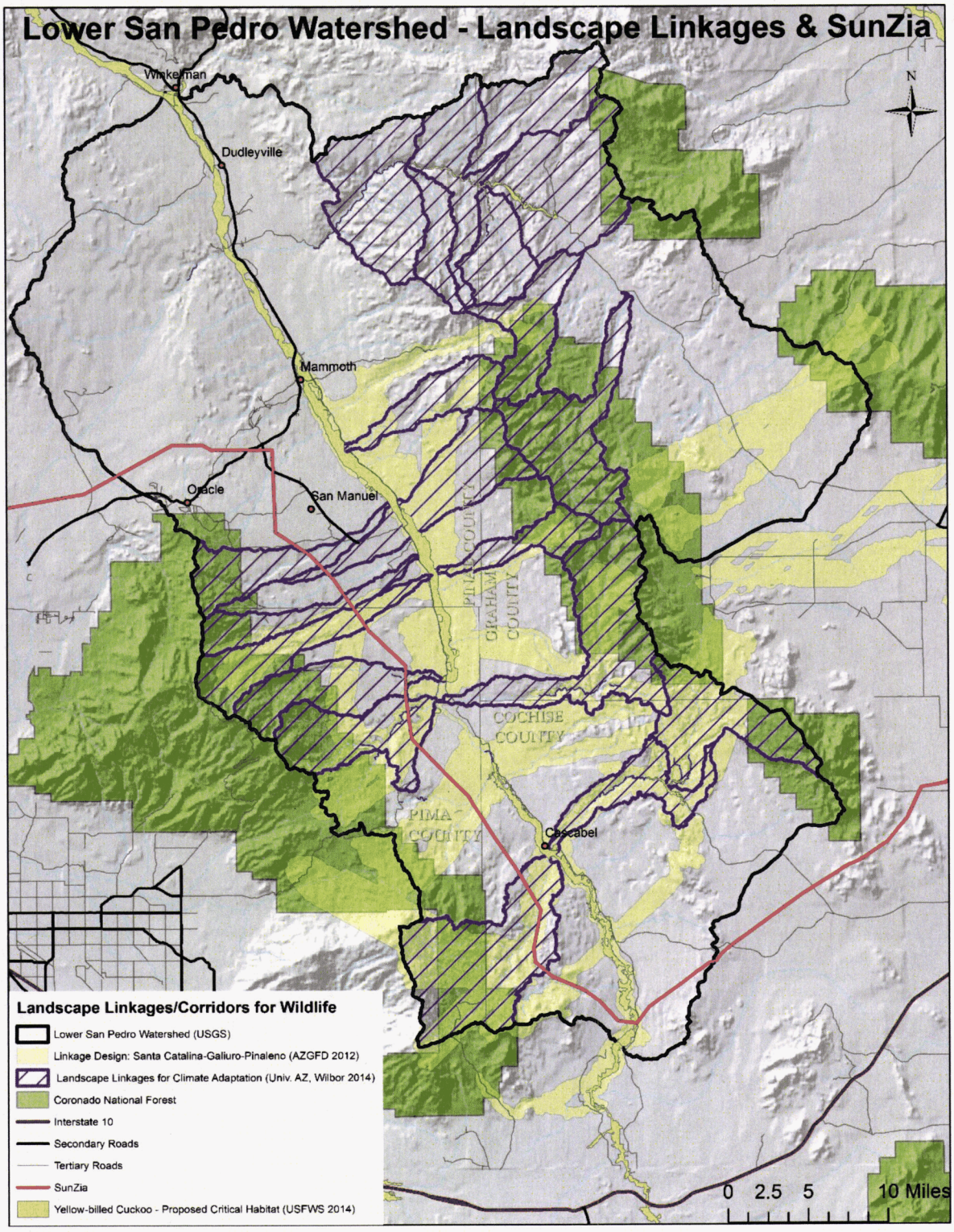

Lower San Pedro Watershed - Landscape Linkages & SunZia
Winkelman
Dudleyville
Mammoth
Oracle
San Manuel
Cascabel
PINAL COUNTY
GRAHAM COUNTY
COCHISE COUNTY
PIMA COUNTY
N
Landscape Linkages/Corridors for Wildlife
Lower San Pedro Watershed (USGS)
Linkage Design: Santa Catalina-Galiuro-Pinaleno (AZGFD 2012)
Landscape Linkages for Climate Adaptation (Univ. AZ, Wilbor 2014)
Coronado National Forest
Interstate 10
Secondary Roads
Tertiary Roads
SunZia
Yellow-billed Cuckoo - Proposed Critical Habitat (USFWS 2014)
0 2.5 5 10 Miles

EXHIBIT
MCV-4
ADMITTED
PENGAD 800-631-6989

A-7 Ranch

Fee lands: 6,829 acres fee lands
State grazing leases: 34,195 acres
BLM grazing permit: 80 acres
Cost: $2,041,933
Acquired: September 15, 2004
Fund: 2004 Bond Funds

Background

The 41,000 acre A-7 Ranch lies northeast of Tucson along Redington Road, between the Catalina and Rincon Mountains and the San Pedro River. The County acquired the ranch from the City of Tucson in 2004. The City had purchased the ranch in 1999. Prior to the City's purchase, the ranch was part of a larger ranch totaling about 96,000 acres known as the Bellota Ranch, which was owned and operated by the Riley-West Corporation for 20 years. The A-7 portion of the Bellota Ranch was sold to the City, while the Forest Service grazing permit was sold to the owners of the Tanque Verde Guest Ranch. Approximately 3,700 acres were sold to The Nature Conservancy. The County's purchase included 65 acres in Cochise County, 471 acres under conservation easement held by The Nature Conservancy, cattle, equipment, buildings and water rights.

Historical and Cultural Resources

In the A-7 Ranch area, the Reeve Ruin site, dating to A.D. 1200-1450, is situated on the terrace overlooking the San Pedro River. Reeve Ruin is defensively located above the San Pedro floodplain and further protected by a series of walls. The site contains a central room block surrounded by two plazas that are bounded by walls and lines of contiguous rooms. More than thirty structures are present, including a possible kiva, or Puebloan ceremonial room, within the central room block. By 1450, archaeological evidence suggests that the valley was largely abandoned. Apache speakers were driven out by Anglo settlers in the 19th century whose ranches today hold the stories of this historic landscape.

Biological Resources

The ranch is located in the lower San Pedro River Valley and includes woodland vegetation communities at higher elevations, semi-desert grasslands at lower elevations, and riparian habitat along the canyon bottoms and the San Pedro River. In addition, the property includes limestone outcrops, perennial and intermittent streams, springs and shallow groundwater areas. Populations of Priority Vulnerable Species such as long-fin dace, lowland leopard frog, and Abert's towhee, exist on the property and provide suitable habitat for several other Priority Vulnerable Species. The majority of the ranch lies within the Biological Core of the Conservation Lands System, with a lesser amount within the Multiple Use Management and Important Riparian Area categories. The location of the property between the Catalina, Rincon, and Galiuro Mountains, provides for a corridor of open lands for wildlife movement back and forth between the mountain ranges.

Management

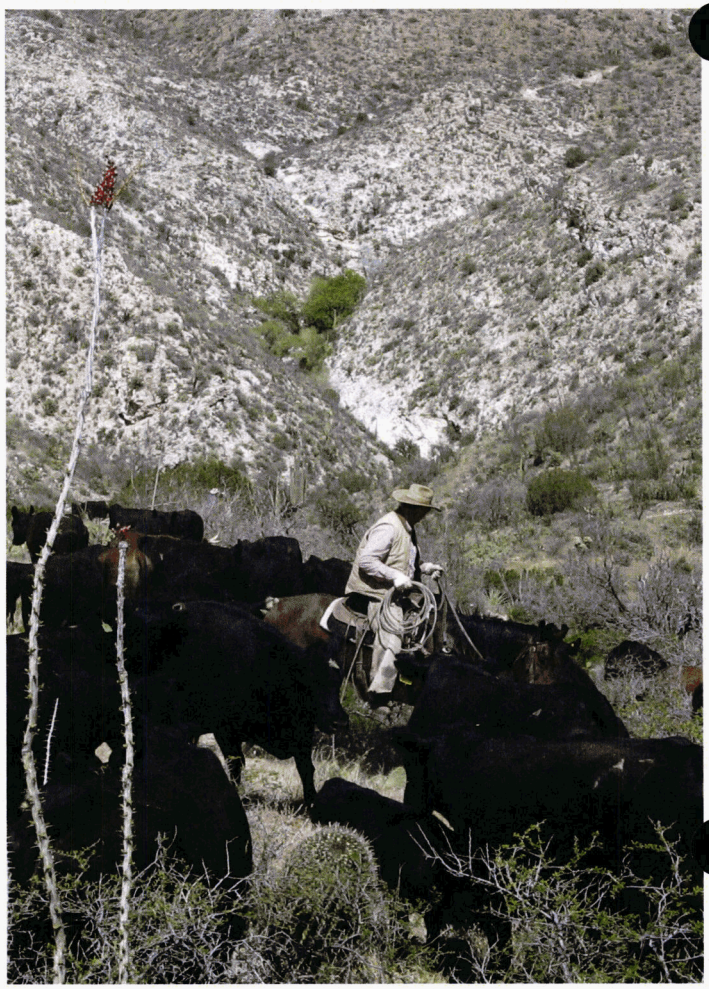
This is the only ranch that the County operates itself with County employees and owns the cattle herd. Pima County is one of only a few county governments that has its own brand - A7. The ranch is currently managed as a cow/calf operation to help offset costs of maintaining the ranch, with a base herd of approximately 300 head. This is about 40% of the allowed use on the State Trust grazing lease lands. The ranch is maintained as a working landscape while protecting and conserving biological and ecological values of the lands. Management activity has primarily focused on monitoring and maintaining a sustainable grazing program while offering recreational use of the ranch by the public. Significant work has been done to enhance the water systems and water storage on the ranch to provide year-round wildlife friendly water for wildlife while at the same time taking pressure off natural springs.

Farm land on A-7 Ranch. Photo by John Sullivan.

Recreation

A-7 ranch offers a wealth of recreational activities. The County has entered into a recreational access agreement with Arizona Game and Fish Department to provide and maintain designated routes to other public lands within and adjacent to A-7 for recreational users. The ranch lands offer camping, hiking, hunting, wildlife viewing, nature study, ATV/ Off Highway vehicle routes, biking, outdoor photography, equestrian trails and access to outdoor open space. Because the ranch is mostly Arizona State Trust lands, recreational users are encouraged to follow all applicable rules, regulations and necessary recreation permit requirements established by State Land as well as those of Pima County Natural Resources, Parks and Recreation (NRPR). Because of its location off Redington Road, A-7 gets significant recreational visits on an annual basis with most of the use in the fall through spring.

NRPR has been converting many old windmills and generator driven water pump systems to solar. This unit helps bring year-round water to over 56 square miles of the A-7 Ranch. Photo by John Sullivan.



County cattle on A-7 Ranch. Photo by John Sullivan.

Ongoing Property Improvements

- The County has put much of its effort in enhancing the basic infrastructure and baseline information available on the ranch.
- Water enhancements and solar generation for power have been two major ongoing efforts.
- Over 50 square miles of the ranch now has a dependable water supply via pipelines and storage tanks.
- Additional vegetative monitoring sites have been established on the ranch and are monitored annually to measure trends in plant community diversity and productivity.
- Additional effort has been made to improve the livestock management system and productivity of the herd.
- Stabilization efforts continue on historic buildings and residences present on the ranch which are still being used as part of the working ranch.

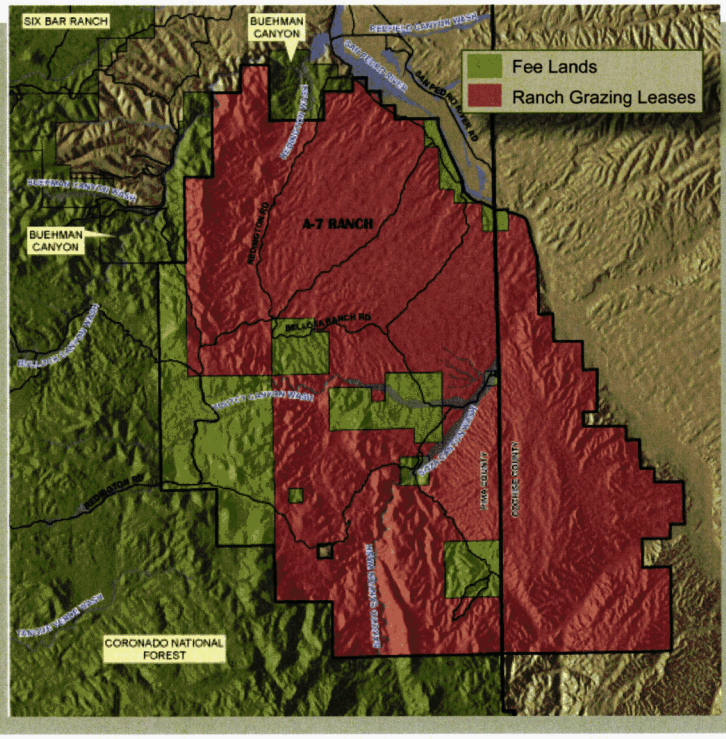
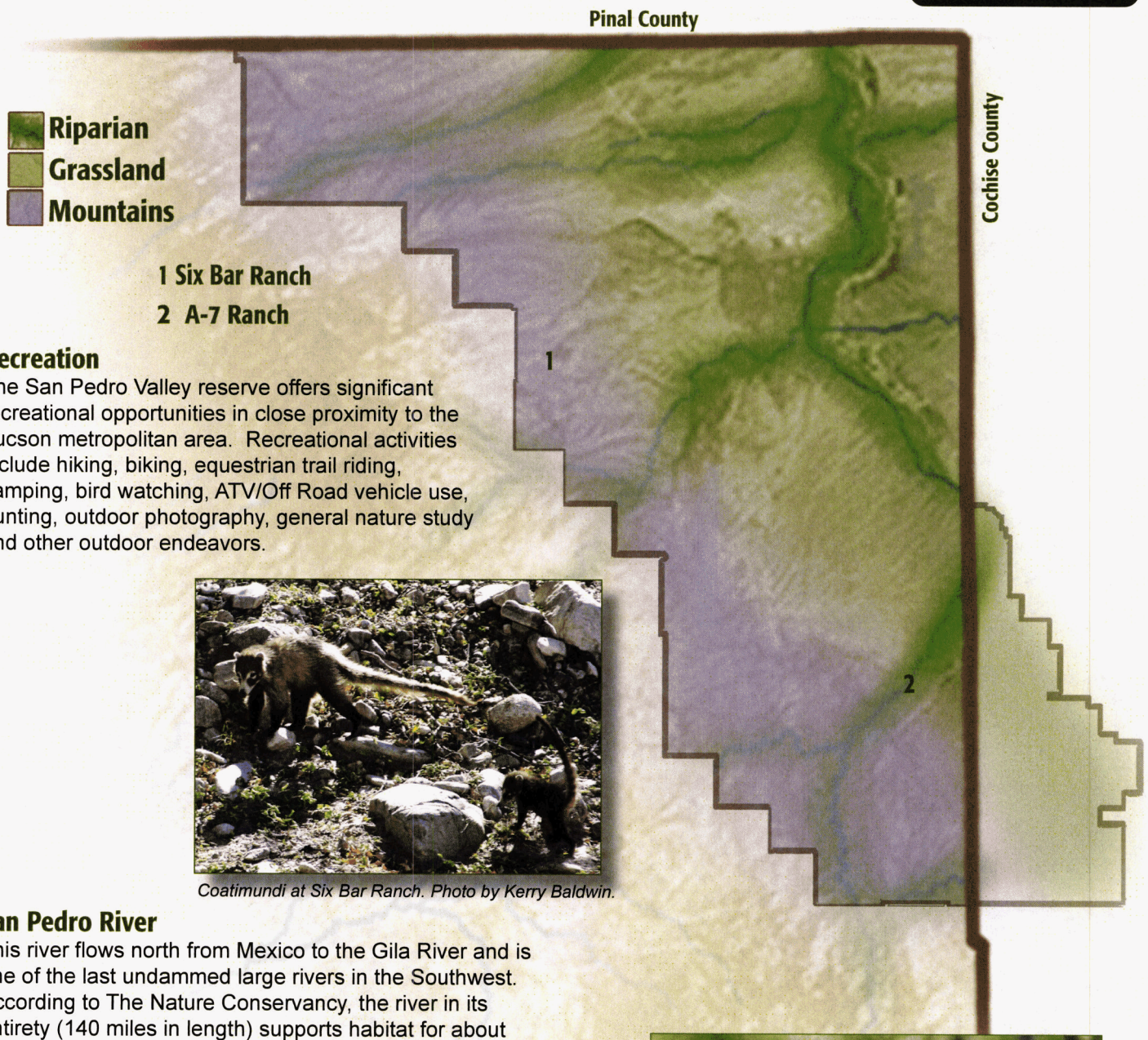


EXHIBIT
PENGAD 800-631-6989
MCV-5
ADMITTED

San Pedro Valley Reserve



Recreation

The San Pedro Valley reserve offers significant recreational opportunities in close proximity to the Tucson metropolitan area. Recreational activities include hiking, biking, equestrian trail riding, camping, bird watching, ATV/Off Road vehicle use, hunting, outdoor photography, general nature study and other outdoor endeavors.

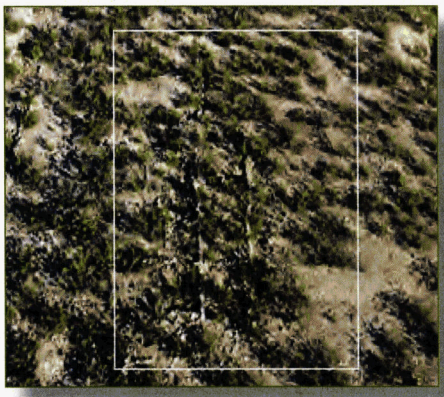
Coatimundi at Six Bar Ranch. Photo by Kerry Baldwin.

San Pedro River

This river flows north from Mexico to the Gila River and is one of the last undammed large rivers in the Southwest. According to The Nature Conservancy, the river in its entirety (140 miles in length) supports habitat for about 350 bird species and stopover habitat for up to 4 million birds migrating each year between North, Central and South America.

Photo by Henry Wallace, ALWT

Butterfy at Six Bar Ranch. Photo by Brian Powell



Reeve Ruin - Adapted from National Science Foundation online publication, "Archaeology from Reel to Real, a Special Report,: July 10, 2010

Cultural and Archaeological Resources

The San Pedro River Valley was an important historical crossroads of the Southwest from early prehistoric times to the historic era when the 1540 Coronado Expedition traveled through the San Pedro River corridor. Archaeological sites in the river valley represent the remains of human occupation from 13,000 years ago. The Lehner Mammoth Kill Site in the upper San Pedro River valley provides some of the first conclusive evidence of human hunting of mammoths in North America. This is also the site of the significant Reeve Ruin, located on the terrace overlooking the San Pedro River, dating back to A.D. 1200-1450

Bingham Cienega Natural Preserve. Photo by Priscilla Titus

Bingham Cienega Natural Preserve

In 1989, the Pima County Regional Flood Control District acquired 285 acres of land along the San Pedro River to preserve a spring-fed marsh known as Bingham Cienega. Because of the site's remote location and sensitive environment, the District entered into a long-term agreement with The Nature Conservancy to manage the property. Historically used for ranching and farming, the fallow fields began to be restored by Conservancy volunteers and marsh wetlands, mesquite bosques and riparian forests began to reclaim the land. The Conservancy has also restored sacaton and other native floodplain vegetation to the area.

Edgar Canyon in Six Bar Ranch with the Catalina Mountains in the background. Photo by Brian Powell.

The San Pedro Valley Reserve is located in the northeastern corner of Pima County, east of the Catalina Mountains, and encompasses a segment of the San Pedro River, one of the last free-flowing rivers in the Southwest. The river and its tributaries support riparian vegetation and intermittent stream flow providing habitat for species such as the Southwest willow flycatcher and the Giant spotted whiptail lizard. The upland semi-desert grasslands and woodlands provide habitat for species such as the Lesser Long-nosed bat and Desert box turtle. Archaeological findings suggest that the river valley has been occupied by humans for nearly 13,000 years. More recently its history has been dominated by ranching and agricultural efforts in support of ranching. Overtime, the ranches in this area have grown larger in an attempt to maintain profitability and weather the less than optimum range conditions due to continued drought and changing climate patterns. Free range grazing in this location is often supplemented with irrigated pastures adjacent to the river. Both Pima County and the Nature Conservancy have been active in purchasing and managing land in this reserve, conserving wildlife, river habitat, and archeological sites.

DOCKET NO. L-00000YY-15-0318-00171-MCV_6

EXHIBIT
MCV-6
ADMITTED
PENGAD 800-631-6989

PIMA PROSPERS
comprehensive plan initiative

Comprehensive Plan

Comprehensive Plan Update
Pima Prospers

Planning and Zoning Commission Public Hearing Draft

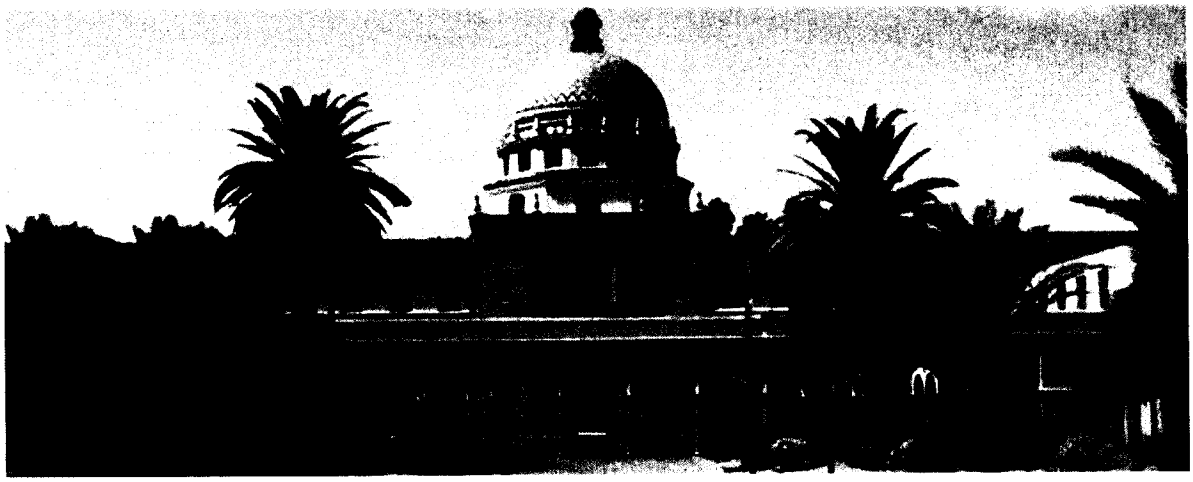
Prepared for:
The Pima County Planning and Zoning Commission
March 25, 2015

File Number: C07-13-10

PIMA County The Planning Center ESI Corporation Kaneen PSOMAS

Policy Volume

Table of Contents



Section	Page
Table of Contents	i
Chapter 1: Introduction and Overview	1.1
1.1 Introduction	1.1
1.2 Looking Back...Looking Forward...	1.2
1.3 What has Changed and Will be Changing?	1.3
1.4 What do We Mean by "Pima Prospers"?	1.6
1.5 The County's Role in the Region	1.7
1.6 Our Expected Population	1.7
1.7 Hearing the Public	1.8
1.8 Vision	1.9
1.9 Themes and Principles	1.10
1.10 Game Changers	1.13
1.11 Thank You to All Participants	1.14

Table of Contents (continued)

Section	Page
Chapter 2: Comprehensive Plan Structure	2.1
2.1 Pima Prospers Comprehensive Plan Structure	2.1
2.2 Jurisdictions and Planning Areas	2.3
2.3 Using this Document	2.10
Chapter 3: Use of Land	3.1
3.1 Land Use Element	3.2
3.2 Focused Development Investment Areas	3.11
3.3 Open Space Element	3.19
3.4 Environmental Element	3.23
3.5 Housing and Community Design Element	3.38
3.6 Cultural Resources Element	3.50
Chapter 4: Physical Infrastructure Connectivity	4.1
4.1 Transportation Element	4.2
4.2 Water Resources Element	4.6
4.3 Energy Element	4.16
4.4 Wastewater Treatment Element	4.20
4.5 Environmental: Air Quality and Solid Waste Element	4.21
4.6 Communication Element	4.23
4.7 Public Buildings and Facilities Element	4.26
4.8 Trails Element	4.31
4.9 Flood Control and Drainage Element	4.36
4.10 Countywide Infrastructure Concurrency Element	4.41
Chapter 5: Human Infrastructure Connectivity	5.1
5.1 Health Services Element	5.2
5.2 Public Safety and Emergency Services Element	5.12
5.3 Parks and Recreation Element	5.15
5.4 Workforce Training/Education Element	5.21
5.5 Arts and Entertainment Element	5.24
5.6 Library Services Element	5.26
5.7 Animal Care Element	5.29
5.8 Food Access Element	5.31

Table of Contents (continued)

Section	Page
Chapter 6: Economic Development	6.1
6.1 Business Retention, Expansion and Attraction	6.2
6.2 Tourism as an Economic Engine	6.18
6.3 Positive Climate for Business	6.21
6.4 Our People as an Economic Driver	6.23
6.5 Repair and Restore our Streets and Highways	6.26
6.6 Arts Districts as Tools for Economic Development	6.27
6.7 Construction as a Stimulus of our Economy	6.30
Chapter 7: Cost of Development	7.1
7.1 Introduction	7.1
7.2 Cost of Development Goals and Policies	7.2
7.3 Available Mechanisms to Fund and Finance Development	7.8
7.4 Cost of Development Community Indicators	7.10
7.5 Existing Methods of Recovery	7.10
Chapter 8: Land Use Legend and Map	8.1
8.1 Preface and Map Interpretation	8.1
8.1 Land Use Legend	8.2
8.2 Land Use Maps	8.14
Chapter 9: Special Area and Rezoning Policies	9.1
Special Area Policies	9.1
Rezoning Policies	9.21
Chapter 10: Administration	10.1
10.1 Introduction	10.1
10.2 Comprehensive Plan Authority and Interpretation	10.2
10.3 Rezoning Process and Comprehensive Plan Compliance	10.4
10.4 Land Use Map and Legend Implementation and Interpretation	10.4
10.5 Map Interpretation	10.6
10.6 Plan Amendment Review Program	10.6
10.7 Comprehensive Plan Amendments	10.7
10.8 Implementing and Monitoring the Comprehensive Plan	10.9
10.9 Community Plans	10.10

10.10 Comprehensive Plan Update 10.11
10.11 Existing Zoning Plans 10.11
10.12 Existing Approved Entitlements with Approved Zoning or Development Agreements 10.11
10.13 Conservation Lands System Definitions 10.12

Table of Contents: Appendices

Appendices	Page
Appendix A: Background and Current Conditions	A.1
A1 Introduction, Overview, Background and History	A1.1
A2 Inventory, Demographics and Socio-Economic Analysis	A2.1
A3 Use of Land Distribution, Analysis, and Current Conditions	A3.1
A4 Physical Infrastructure Connectivity Background	A4.1
A5 Human Infrastructure Connectivity Background	A5.1
A6 Economic Development Background	A6.1
Appendix B: Implementation (Sample)	B.1
Appendix C: Public Participation Plan (Summary)	C.1
C1 Public Participation Overview	C1.1
C2 Public Participation Plan	C2.1
Appendix D: Fiscal Impact Analysis	D.1
Appendix E: Glossary of Terms	E.1

Table of Contents: Maps by Chapter

Exhibit Number	Page
Chapter 2: Comprehensive Plan Structure	
Exhibit 2.2.1 Planning Areas (East)	2.8
Exhibit 2.2.2 Planning Areas (West)	2.9
Chapter 3: Use of Land	
Exhibit 3.2.1 Focused Development Investment Areas	3.18
Exhibit 3.4.1 Conservation Land System (Eastern Pima County)	3.32
Exhibit 3.4.2 Conservation Land System (western Pima County)	3.33

Chapter 4: Physical Infrastructure Connectivity

Exhibit 4.9.1 Avra Valley Planning Area Regional Hydrology 4.43
Exhibit 4.9.2 Tucson Mountains Planning Area Regional Hydrology 4.44
Exhibit 4.9.3 Southwest Planning Area Regional Hydrology 4.45
Exhibit 4.9.4 Altar Valley Planning Area Regional Hydrology 4.46

Table of Contents: Maps by Chapter (Continued)

Exhibit Number	Page
Chapter 4: Physical Infrastructure Connectivity	
Exhibit 4.9.5 Upper Santa Cruz Planning Area Regional Hydrology	4.47
Exhibit 4.9.6 Mountain View Planning Area Regional Hydrology	4.48
Exhibit 4.9.7 Southeast Planning Area Regional Hydrology	4.49
Exhibit 4.9.8 Central Planning Area Regional Hydrology	4.50
Exhibit 4.9.9 Catalina Foothills Planning Area Regional Hydrology	4.51
Exhibit 4.9.10 Rincon Valley Planning Area Regional Hydrology	4.52
Exhibit 4.9.11 Tortolita Planning Area Regional Hydrology	4.53
Exhibit 4.9.12 San Pedro Planning Area Regional Hydrology	4.54
Exhibit 4.9.13 Ajo/Why Planning Area Regional Hydrology	4.55
Chapter 8: Land Use Legend and Map	
Exhibit 8.1.1 Avra Valley Planning Area Planned Land Use	8.14
Exhibit 8.1.2 Tucson Mountains Planning Area Planned Land Use	8.15
Exhibit 8.1.3 Southwest Planning Area Planned Land Use	8.16
Exhibit 8.1.4 Altar Valley Planning Area Planned Land Use	8.17
Exhibit 8.1.5 Upper Santa Cruz Planning Area Planned Land Use	8.18
Exhibit 8.1.6 Mountain View Planning Area Planned Land Use	8.19
Exhibit 8.1.7 Southeast Planning Area Planned Land Use	8.20
Exhibit 8.1.8 Central Planning Area Planned Land Use	8.21
Exhibit 8.1.9 Catalina Foothills Planning Area Planned Land Use	8.22
Exhibit 8.1.10 Rincon Valley Planning Area Planned Land Use	8.23
Exhibit 8.1.11 Tortolita Planning Area Planned Land Use	8.24
Exhibit 8.1.12 San Pedro Planning Area Planned Land Use	8.25
Exhibit 4.9.13 Ajo/Why Planning Area Planned Land Use	8.26

PIMA COUNTY'S 2015 COMPREHENSIVE PLAN: PIMA PROSPERS

PAGE 56 of the PDF ENVIRONMENTAL ELEMENT

Natural Resources, Pima County, Arizona

The Environmental Planning Element calls for analysis, policies and strategies to address anticipated effects of implementation of plan elements on natural resources. Policies and strategies under this plan element are designed to have countywide applicability. Conservation actions are to be encouraged, and protection of biological resources is considered an essential component of land-use planning.

The Maeveen Marie Behan Conservation Lands System (CLS) is designed to protect biodiversity and provide land use guidelines consistent with the conservation goal of the Sonoran Desert Conservation Plan (SDCP).

The CLS identifies areas important to the conservation of our natural resources heritage and embodies the biological goal of the SDCP which is to "ensure the long-term survival of the full spectrum of plants and animals that are indigenous to Pima County through maintaining or improving the habitat conditions and ecosystem functions necessary for their survival."

Exhibits 3.4.1 and 3.4.2 show the Conservation Lands System for eastern and western Pima County are located at the end of this section.

Goal 1: Conserve and protect natural resources

Policy 1: CLS category designations and conservation guidelines apply to land uses and activities undertaken by or under the jurisdiction of Pima County or Pima County Regional Flood Control District (Flood Control District) as follows:

a) Pima County and the Flood Control District will seek consistency with the CLS for federal and state land-use decision plans and processes;
b) Application of CLS designations or guidelines shall not alter, modify, decrease or limit existing and legal land uses, zoning, permitted activities, or management of lands;
c) When applied to development of land subject to county or Flood Control District authority, CLS designations and guidelines will be applied to:
    1. New rezoning and specific plan requests;
    2. Time extension requests for rezoning cases;
    3. Requests for modifications or waivers of rezoning or specific plan conditions, including substantial changes;
    4. Requests for Comprehensive Plan amendments;
    5. Type II and Type III conditional use permit requests; and
    6. Requests for waivers of subdivision platting requirement of a zoning plan.
d) Implementation of these policies shall achieve the level of conservation necessary to protect a site's conservation values, preserve landscape integrity, and provide for the movement of native fauna and pollination of native flora across and through the landscape; and
e) Projects subject to these designations and guidelines will be evaluated against the conservation guidelines for the CLS categories provided in conservation guideline policies, where applicable, to determine their appropriateness.

Conservation Guidelines

Policy 2: The Conservation Guideline for the associated CLS designation applies to the total acreage of the site that lies within the boundaries of that designation:
a) If a CLS designation applies to a portion of a site, Conservation Guidelines for that designation will apply only to that portion of the site affected by that category;
b) For purposes of this policy, site is defined as a single lot or combination of contiguous lots; and
c) Where more than one CLS categories overlap, the more protective Conservation Guideline will apply to the affected portion.

Policy 3: The following conservation guidelines apply to Important Riparian Areas:
a) Across the entirety of the CLS landscape, at least 95 percent of the total acreage of lands within this designation shall be conserved in a natural or undisturbed condition;

b) Every effort should be made to protect, restore and enhance the structure and functions of Important Riparian Areas, including their hydrological, geomorphological and biological functions;
c) Areas within an Important Riparian Area that have been previously degraded or otherwise compromised may be restored and/or enhanced;
d) Such restored and/or enhanced areas may contribute to achieving the 95 percent conservation guideline for Important Riparian Areas (IRA);
e) Restoration and/or enhancement of degraded IRA may become a condition or requirement of approval of a comprehensive plan amendment and/or rezoning; and
f) On-site mitigation is preferable, however mitigation may be provided on-site, off-site, or in combination.

Policy 4: The following conservation guidelines apply to Biological Core Management Areas:

a) Across the entirety of the CLS landscape, at least 80 percent of the total acreage of lands within this designation shall be conserved as undisturbed natural open space;
b) Land use and management focus on the preservation, restoration, and enhancement of native biological communities including, but not limited to, preserving the movement of native fauna and flora across and through the landscape and promoting landscape integrity; and
c) Projects subject to this policy and within this designation will yield four conserved acres (mitigation) for each acre to be developed:
    1. Mitigation acres may be provided on-site, off-site, or in combination;
    2. The preference is for the mitigation acres to be within Biological Core Management Area or Habitat Protection Priority Areas;
    3. For purposes of this policy, Habitat Protection Priority Areas are those areas referenced and mapped as part of the 2004 Conservation Bond Program or subsequent conservation bond programs;
    4. The 4:1 mitigation ratio will be calculated according to the extent of impacts to the total surface area of that portion of any parcel designated as Biological Core Management Areas;
    5. Development shall be configured in the least sensitive portion(s) of the property;
    6. On-site mitigation area(s) of undisturbed natural open space will be configured to maximize conservation values and preserve the movement of native fauna and pollination of native flora across and through the landscape; and
    7. A Transfer of Development Rights (TDR) may be used in order to secure mitigation lands.

Policy 5: The following conservation guidelines apply to Scientific Research Areas:

a) Scientific Research Areas should continue to be managed for the purpose of scientific research on the environment and natural resources;
b) Scientific research activities should minimize any long-lasting impacts that may affect adjacent or nearby CLS lands; and
c) Any land-use changes subject to Pima County jurisdiction should achieve the conservation goals of the underlying CLS category.

Policy 6: The following conservation guidelines apply to Multiple Use Management Areas:

a) Across the entirety of the CLS landscape at least 66 ⅔ percent of the total acreage of lands within this designation shall be conserved as undisturbed natural open space;
b) Land use and management goals within these areas focus on balancing land uses with conservation, restoration, and enhancement of native biological communities and must:
    1. Facilitate the movement of native fauna and pollination of native flora across and through the landscape;
    2. Maximize retention of on-site conservation values; and
    3. Promote landscape integrity.
c) Projects subject to this policy within this designation will yield two conserved (mitigation) acres for each acre developed:
    1. Mitigation acres may be provided on-site, off-site, or in combination;
    2. The preference is for mitigation acres to be within Multiple Use Management Areas, any more protective category of the CLS, or Habitat Protection Priority Areas;
    3. For purposes of this policy, Habitat Protection Priority Areas are those areas referenced and mapped as part of the 2004 Conservation Bond Program or any subsequent conservation bond program;
    4. The 2:1 mitigation ratio will be calculated according to the extent of impacts to the total surface area of that portion of any parcel designated as Multiple Use Management Areas;
    5. Development shall be configured in the least sensitive portion(s) of the property;
    6. On-site mitigation area(s) of undisturbed natural open space will maximize conservation values and facilitate the movement of native fauna and pollination of native flora across and through the landscape;
    7. Additional conservation exceeding 66⅔ percent will be encouraged through the use of development-related incentives and may utilize undisturbed natural open space on individual lots; and

8. A Transfer of Development Rights (TDR) may be used in order to secure lands utilized for mitigation, restoration, and/or enhancement purposes.

Policy 7: The following conservation guidelines apply to Agriculture In-Holdings within the Conservation Lands Systems:

a) Intensifying land uses of these areas will emphasize the use of native flora, facilitate the movement of native fauna and pollination of native flora across and through the landscape, and conserve on-site conservation values when they are present; and

b) Development within these areas will be configured in a manner that does not compromise the conservation values of adjacent and nearby CLS lands.

Policy 8: The following conservation guidelines apply to Special Species Management Areas:

a) Across the entirety of the CLS landscape, at least 80 percent of the total acreage of lands within this designation shall be conserved as undisturbed natural open space and will provide for the conservation, restoration, or enhancement of habitat for the affected Special Species;

b) Projects subject to this policy and within this designation will yield four conserved (mitigation) acres for each acre to be developed:

1. Mitigation acres may be provided on-site, off-site, or in combination;
2. The preference is for the mitigation acres to be within a designated Special Species Management Area;
3. The 4:1 mitigation ratio will be calculated according to the extent of impacts to the total surface area of that portion of any parcel designated as Special Species Management Area;
4. Development shall be configured in the least sensitive portion(s) of the property;
5. On-site area(s) of undisturbed natural open space will be configured to facilitate the movement of the relevant Special Species through the landscape and will include conservation values essential to survival of the relevant Special Species; and
6. A Transfer of Development Rights (TDR) may be used in order to secure mitigation lands.

c) Special Species and associated Conservation Guidelines may be added or deleted in the future based on the best available regional scientific information as developed by the Science Technical Advisory Team and added to or deleted from the Special Species Management Areas as shown on the CLS map; and

d) Additions and/or deletions to the list of Special Species or conservation guidelines for Special Species Management Areas will be processed as a comprehensive plan amendment.

Policy 9: The following conservation guidelines apply to Critical Landscape Connections:

a) Land-use changes in these broadly defined areas should protect existing biological linkages;
b) Where they occur, barriers to the movement of native fauna and pollination of native flora across and through the landscape should be removed and fragmented corridors of native biological communities should be restored;
c) Opportunities to remove barriers and restore corridor connectivity may arise as part of other, non-land use related activities (e.g., new construction for or upgrade of infrastructure services). Such opportunities should be pursued; and
d) High priority shall be given to identifying, preserving, and re-establishing the connection between native biological communities especially where natural connectivity is most constrained.

Policy 10: The Board of Supervisors has the sole authority to modify mitigation specified in any conservation guideline or otherwise determined the appropriate amount of mitigation necessary for a comprehensive plan amendment or rezoning to comply with the CLS, including increases, reductions, and exemptions:

a) Requests to modify or be exempt from providing mitigation will be deliberated on a case-by-case basis; and
b) Staff may review proposals and make recommendations for the modification of mitigation ratios, including exemption.

Conservation Lands System Mitigation Lands:

Policy 11: The following guidelines apply to lands being considered for off-site mitigation:

a) The location of off-site mitigation properties should be within the same general geographic region of the original project site;
b) Off-site mitigation property should provide the same or better resource values as the original project site including, but not limited to:
    1. Conservation Lands System (CLS) designations inclusive of 2004 Conservation Bond Habitat Protection Priority designations or subsequent conservation bond programs;
    2. Vegetation community type(s);
    3. Habitat values for applicable CLS Special Species (e.g., breeding, dispersal);
    4. Surface water or unique landforms such as rock outcrops;
    5. Contribution to landscape connectivity; and
    6. Demonstration that the resource and conservation values of the off-site mitigation property will be protected in perpetuity.

c) Off-site mitigation of IRA may include the purchase and transfer of water rights that directly impact and/or support groundwater dependent ecosystems.

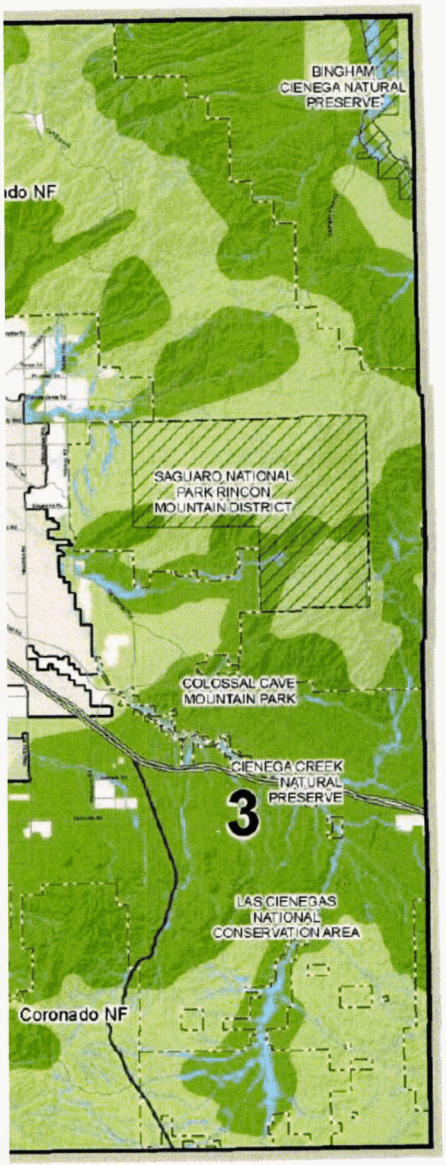
Policy 12: Lands that are to be reserved from development and which will provide CLS mitigation shall be conserved and managed, in perpetuity, for the benefit of the natural resources:

a) Various means may be utilized to protect conservation or mitigation lands including, but not limited to, the transfer of deeded property to Pima County, pending approval by the Board of Supervisors, or other conservation entities and the granting of conservation easements;

b) CLS mitigation lands shall be established as separate, natural open space parcel(s) from the development area; and

c) Residents, or associations of residents, of a development may not serve as the sole administrator or enforcement entity for the management and protection of those conservation or mitigation lands.

PAGE 65 of the PDF: EXCERPT of the MAP referencing eastern Pima County, showing the San Pedro area



PIMA PROSPERS
comprehensive plan initiative

Exhibit 3.4.1

Conservation Lands System
Eastern Pima County

- Important Riparian Areas
- Biological Core Management Areas
- Multiple Use Management Areas
- Agriculture Inholdings
- 5 Critical Landscape Connections
- Special Species Management Areas

Climate and Emerging Environmental Issues

Pima County has made sustainability, reduction of greenhouse gas emissions, and preparing for the impacts of climate change a high priority by leading by example.

Over time, climate change stands to adversely impact the natural environment of the rich and diversified Sonoran Desert, threatening (a) the resilience and vitality of our economy; (b) the health and safety of vulnerable populations; (c) our limited water supply with more frequent and persistent drought; (d) more intense flooding; and (e) the overall well-being of our community and surrounding natural areas through increased frequency and intensity of extreme heat, cold, drought and wildland fires.

Proper planning and execution of that planning is necessary on a local, regional and statewide basis to both prepare adaptation strategies and to address ways we can make modifications that improve public health, reduce the stress on the environment and benefit the economy.

The County has taken a number of steps in collaboration with other organizations and agencies to plan for – and mitigate – the negative effects of climate change and increase the resilience of the human and natural dimensions of the environment to climate-induced changes. Work has included:

- Sonoran Desert Conservation Plan (2001)
- Pima County Drought Response Plan and Water Wasting Ordinance (2007,2014)
- Pima County Sustainability Resolution (2007)
- Regional Optimization Master Plan (2007)
- PAG Regional Greenhouse Gas Inventory (2008, 2010, 2012, 2014)
- Travel Reduction Ordinance
- LEED Silver Building Standards for County Facilities
- 2011-2015 Action Plan for Water Sustainability (2010)
- Community Wildfire Protection Plan (2013)
- Planning for Change in Southern Arizona forum (2013)
- Pima County Sustainability Action Plan for County Operations (2008, 2014)
- Multi-Jurisdictional Hazard Mitigation Plan (2012)

Goal 2: Minimize the negative impacts of climate change on Pima County and increase the resiliency of the human, economic, and natural environment

Policy 1: Support climate adaptation strategies that benefit the public health, economy, and the environment by:

a) Developing drought response preparedness plans and other emergency management plans;
b) Improving stormwater management strategies to minimize runoff and flooding in urban areas by considering incorporation of Low Impact Development (LID) principles, and making beneficial use of stormwater;
c) Adopting strategies to reduce loss of life and property from flooding and erosion; and
d) Retaining natural open space.

Policy 2: Pursue adaptive, flexible, cost effective, multi-pronged preparedness strategies such as diversification of water supplies, water conservation, improved demand management and increased reliance on water harvesting.

Policy 3: Reduce greenhouse gas emissions and heat island effects by:
a) Establishing targets and monitoring progress;
b) Reducing barriers to the production of renewable energy;
c) Continuing to increase energy efficiency including energy efficiency standards in both County-owned and privately owned buildings;
d) Developing strategies and providing incentives to reduce single-occupancy Vehicle Miles Traveled (VMT);
e) Promoting, designing and constructing multi-modal (alternative modes) transportation and transit systems.

Policy 4: Ensure the viability of the natural environment in context of climate change by:
a) Preserving watershed and ecological function, connectivity, and resiliency;
b) Identifying and protecting areas that have served as ecological refugia for species during time of past climatic variability (e.g., riparian areas, talus, limestone);
c) Ensuring the availability of an adequate water supply for the natural environment in the context of climate change including using best management practices to establish and maintain water for wildlife and their habitats;
d) Protecting the carbon dioxide (CO_2) sequestration functions of the natural environment including maintaining a balance between preserving natural, grassland and riparian areas that can absorb excess carbon from the atmosphere and developed areas by implementing the Maeveen Marie Behan Conservation Lands System.
e) Creating consistency in regulatory requirements, policies, and practices for the restoration and re-vegetation of construction activities impacting undisturbed desert areas.

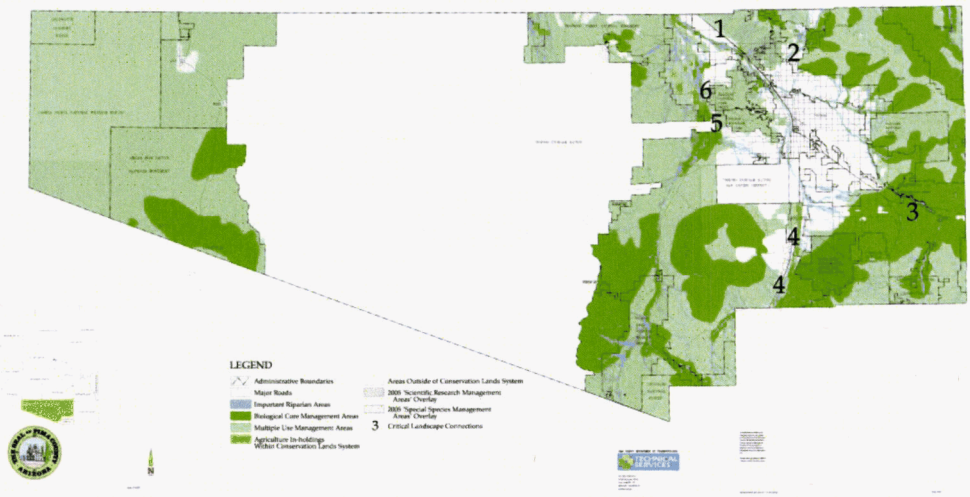
Policy 5: Enter a regional conversation on carbon footprint reduction (see carbon footprint illustration of page 4.25 of the Physical Infrastructure Connectivity chapter).

Policy 6: Support and strengthen Pima County based policies and programs to control and eradicate buffelgrass and other invasive species to reduce the threat of wildfire and loss of native species.

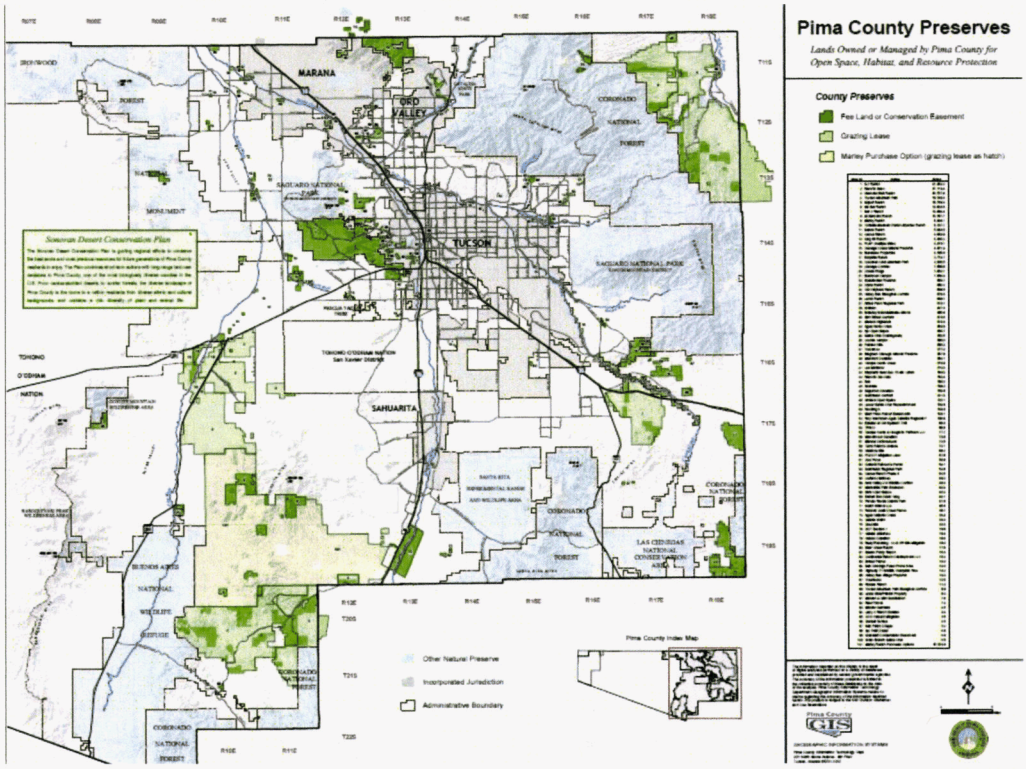
Policy 7: Support the establishment of an integrated and adaptive drought management strategies plan for the County that:

DOCKET NO. L-00000YY-15-0318-00171-MCV_EXHIBIT 6A

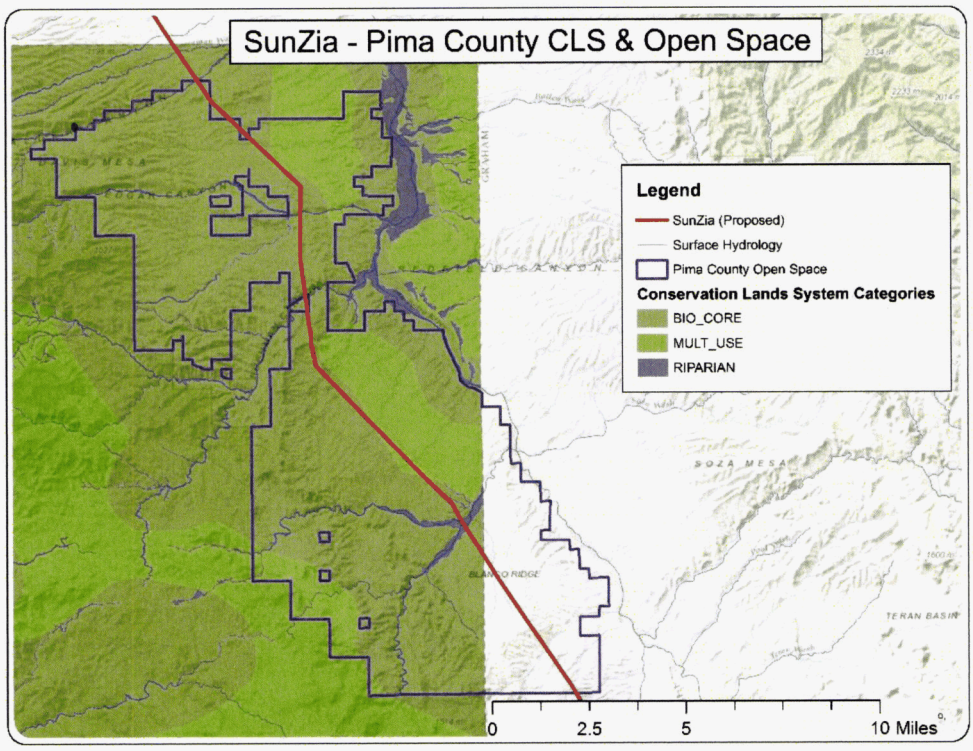
PIMA COUNTY CONSERVATION LANDS SYSTEM
Adopted June 21, 2005



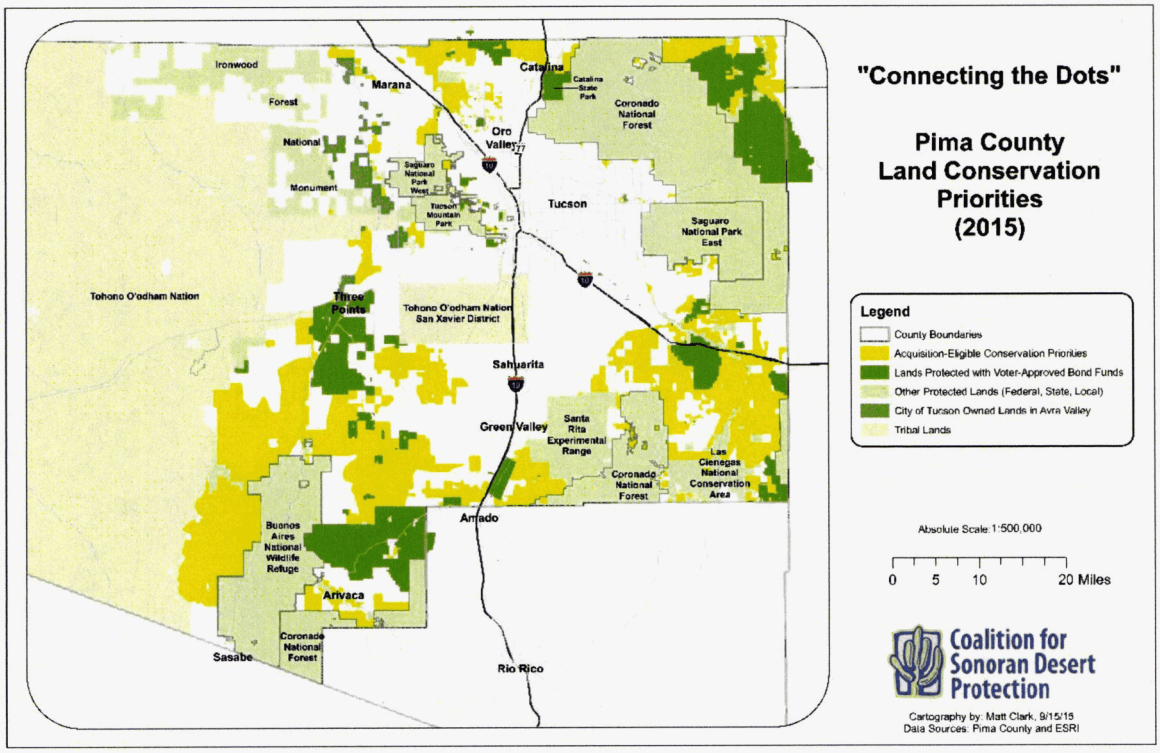
DOCKET NO. L-00000YY-15-0318-00171-MCV_EXHIBIT 6B



DOCKET NO. L-00000YY-15-0318-00171-MCV_6C



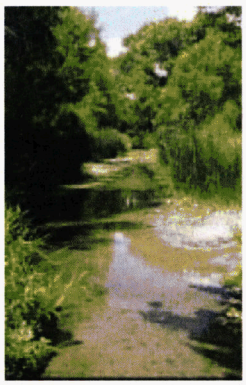
DOCKET NO. L-00000YY-15-0318-00171-MCV_Exhibit 6E



DOCKET NO. L-00000YY-15-0318-00171-MCV_7

The Upper San Pedro Partnership

by Doug Duncan and Lynn Slagle



Upper San Pedro River
Photo by William G. Kepner/EPA

People have lived in the desert Southwest for thousands of years. To survive in this arid land, early settlers had to develop special skills and adapt to a desert-based way of life. Today, communities throughout the region face a similar challenge: learning how to grow sustainably while conserving water and functioning ecosystems.

This part of the country has an old saying: "Whiskey's for drinkin' and water's for fighting." There are no easy answers for managing water resources in the arid Southwest, but cooperative approaches have made fighting unnecessary. In southeastern Arizona, 21 government agencies and private organizations have banded together as a group to ensure that the region will continue to have an adequate ground water supply for area residents and the natural resources of the San Pedro River. They call this group the Upper San Pedro Partnership.

The purpose of the Partnership is to cooperate in identifying, prioritizing, and implementing policies and projects to assist in meeting water needs in the Sierra Vista Subwatershed of the Upper San Pedro River Basin.

The Challenge

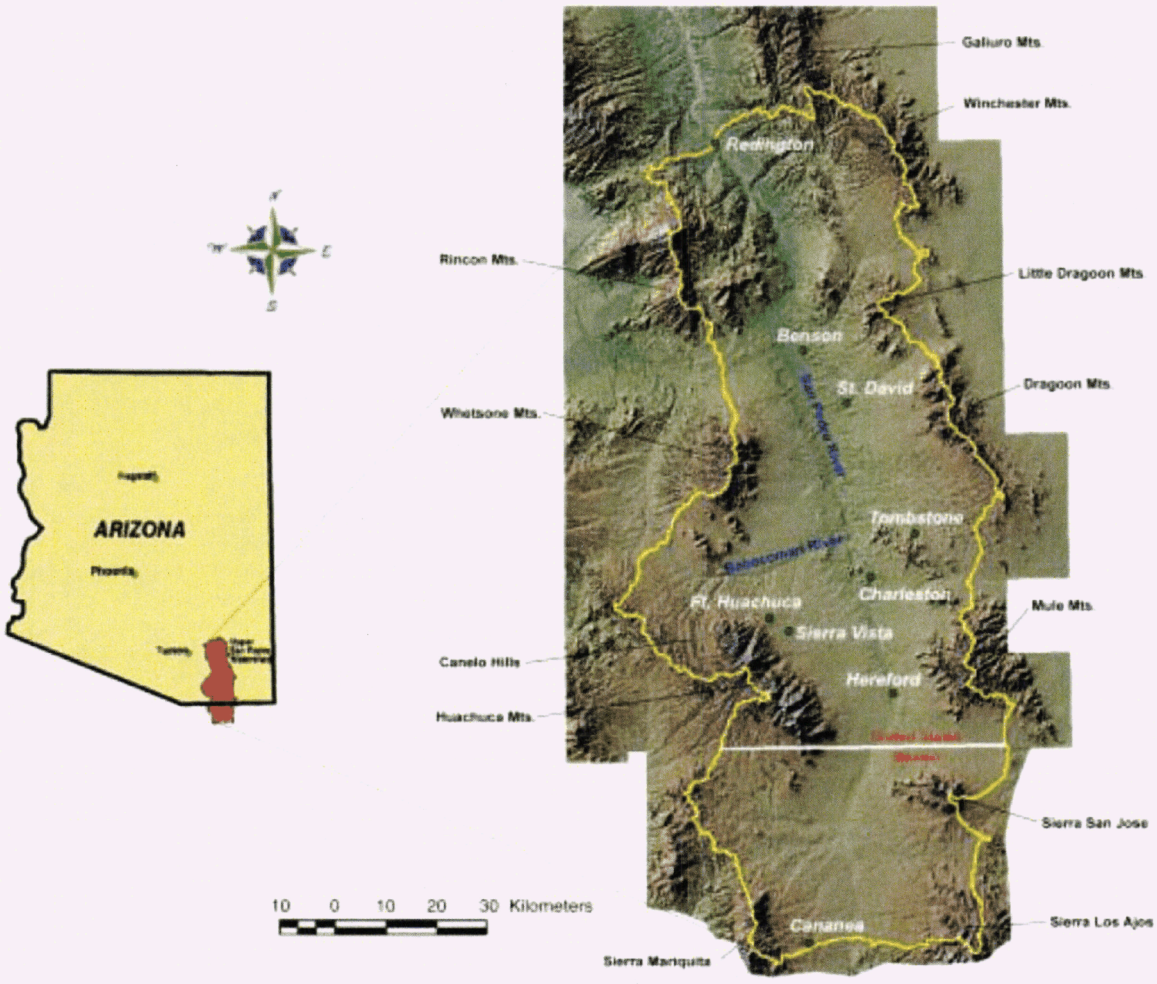
The San Pedro is considered one of the most significant perennial undammed desert rivers in the United States. It provides important habitat for almost 400 species of migratory birds, 80 species of mammals, and 40 species of reptiles and amphibians. Many of these animals rely on the riparian vegetation of the Bureau of Land Management's San Pedro Riparian National Conservation Area (SPRNCA), which Congress designated in 1988. This area includes marshland, cottonwood-willow forest, mesquite forest, and various shrub lands. The water stored in the aquifer supports this vegetation and the perennial flow of surface water.

The Upper San Pedro River Basin and the San Pedro River are home to several listed species and provide suitable or potential habitat for several more. The river provides most of the occupied habitat for the endangered Huachuca water-umbel (*Lilaeopsis schaffneriana* var. *recurva*). This small, cryptic, semi-aquatic plant has 33 miles (53 km) of designated critical habitat along the San Pedro River. The San Pedro River also contains critical habitat for two threatened fish species, the spikedace (*Meda fulgida*) and loach minnow (*Tiaroga cobitis*), and potential habitat for a host of other native fishes.

The Upper San Pedro Basin uplands provide significant habitat for the threatened Mexican spotted owl (*Strix occidentalis lucida*) and the nectar-feeding lesser long-nosed bat (*Leptonycteris curosoae yerbabuenae*). This endangered bat occurs seasonally in protected roosts on Fort Huachuca and the Coronado National Memorial. The watershed also provides potentially

EXCERPY PAGE 2 of the PDF

Upper San Pedro Watershed



EXCERPT PAGE 4 of the PDF

Doug Duncan is a fisheries biologist in the Service's Tucson, Arizona, Ecological Services Office (520-670-6114 ext. 236; doug_duncan@fws.gov). Lynn Slagle is the outreach coordinator for the Upper San Pedro Partnership (lsm@theriver.com). Additional information is available from the Partnership's web site: http://www.usppartnership.com/.

EXHIBIT
MCV-8
ADMITTED
PENGAD 800-631-6989

Six Bar Ranch

Fee lands: 3,292 acres
State grazing lease: 9,000 acres
Conservation easement: 40 acres
Cost: $11,525,322
Acquired: August 23, 2006
Fund: 2004 Bond Funds
Partner: Arizona Land & Water Trust

Background

The 12,000 acre Six-Bar Ranch is located along the eastern flank of the Catalina Mountains, adjacent to the Coronado National Forest and northwest of the County's A-7 Ranch. It is visible from Catalina Highway at the San Pedro overlook and can be accessed via several trails from the top of the Catalina Mountains. The Ranch contains a major tributary to the San Pedro River – Edgar Canyon. The property expands upon other conserved lands in the area, including the Coronado National Forest, The Nature Conservancy's Buehman Canyon Preserve, and the County's A-7 Ranch, Bingham-Cienega Preserve and Oracle Ridge Properties. A 24,000-acre Forest Service grazing permit is associated with this property. The ranch is a rugged complex of canyons and drainages off the east slopes of the Catalina Mountains down towards the San Pedro Valley.

Lowland leopard frog. Photo by Bill Singleton

Historical and Cultural Resources

Archaeological sites in the Six-Bar Ranch area suggest a long period of prehistoric human occupation associated with the San Pedro River Valley villages sites. In addition, a cultural resources survey dated July 2006 identified a historic ranch house and related outbuildings along the southeastern bank of Edgar Canyon – the major tributary to the San Pedro River. This complex is located on a 40-acre conservation easement held by the County, and is used today. Records show that this is likely the O.R. Parker House depicted on the General Land Office map for this area, filed in 1924. The Parker family was involved in the original development of Redington Pass road, and at one time owned some, if not all, of the land associated with the County's A-7 Ranch, southeast of the Six-Bar Ranch.

Biological Resources

The Ranch is located in the lower San Pedro River Valley and is composed of rugged uplands along the eastern flanks of the Catalina Mountains, alternating with narrow, incised valleys formed by generally east trending tributary washes draining into the San Pedro River. The property contains important stands of cottonwoods, sycamore, hackberry and ash trees along the Edgar Canyon drainage, along with intermittent streams and springs, and limestone outcrops. The uplands contain dense stands of saguaros in many places. The property contributes to the conservation of several Priority Vulnerable Species, including Lowland leopard frog, Lesser long-nosed bat, Mexican long-tongued bat, Western red bat, and the Giant spotted whiptail. Fish and frogs have been reported in Edgar Canyon. All of the ranch lies within the Biological Core of the Conservation Lands System and contains portions of Important Riparian Areas. The location of the property between the Catalina and Galiuro Mountains provides for a corridor of open lands for wildlife movement back and forth between the mountain ranges.

Edgar Canyon on Six Bar Ranch. Photo by Brian Powell.

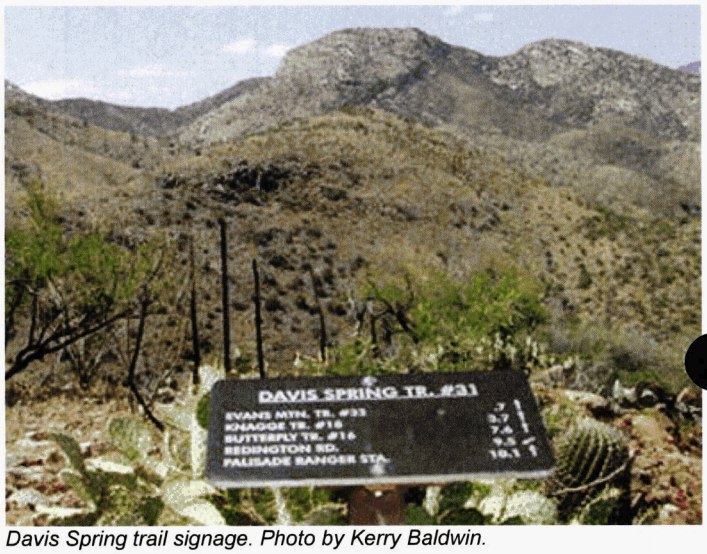
Management

The Six Bar Ranch is a working ranch landscape. The ranch is currently stocked at a light rate, about 20% of allowed use, to reflect ongoing drought conditions. The County maintains a Ranch Management Agreement over all aspects of use of the ranch by an independent operator. The rugged ranch has few roads and is generally accessible only by horseback or on foot. The ranch is being monitored twice annually to establish some baseline data on the overall range condition and trend in vegetative community diversity and productivity. Existing waters are being modified to be more wildlife friendly. Public recreation access on the major road into Edgar Canyon and Davis Mesa is being managed under an agreement with the Arizona Game and Fish Department. All visitors are required to check in and out at an information kiosk as the road passes through private and enters County lands.

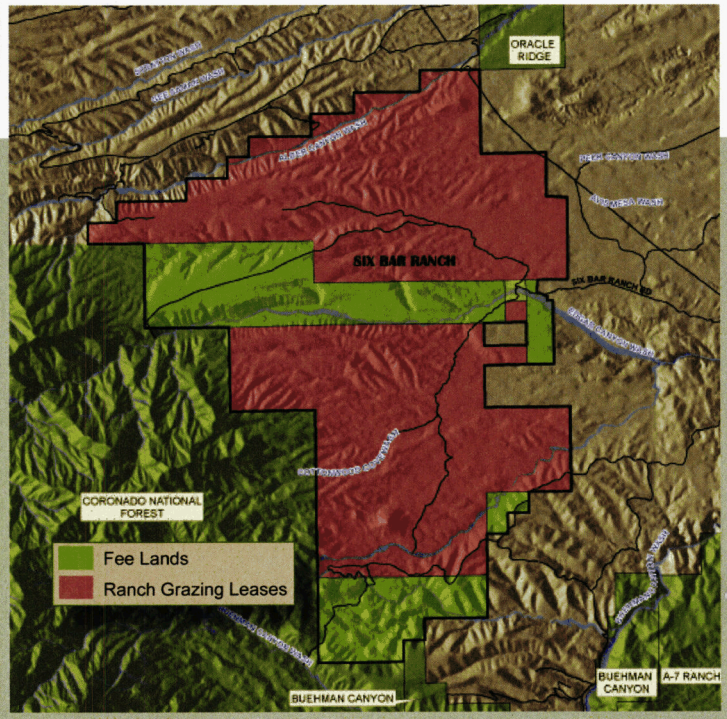
Stream in Edgar Canyon. Photo by Locana de Souza.

Recreation

The fee lands along Edgar Canyon contain an existing trailhead for the Davis Spring Trail, which leads up the eastern slopes of the Catalinas to the Palisades Ranger Station from Davis Mesa. The ranch is a popular area for hunting both small game like quail and big game like deer and javelina. Other recreational activities like ATV/OHV riding, wildlife viewing and biking are popular uses of the ranch. This ranch is more remote and has limited access points so it does not get as much use as many of the other ranch properties.



Davis Spring trail signage. Photo by Kerry Baldwin.



Ongoing Property Improvements

- Most of the ongoing activities on the ranch are related to establishing representative long-term monitoring data points and gathering information about the ranch ecosystem.
- Waters are being maintained for wildlife and livestock with escape ramps being installed to prevent wildlife drowning incidents in open troughs and tanks.
- Challenges exist in protecting the historic ranch buildings because of changes in the dynamics of flood water flows in Edgar Canyon due to the buildings being built on the active flood plain of the stream channel.
- Other routine activities include monitoring of recreational use and users.

DOCKET NO. L-00000YY-15-0318-00171-MCV_9

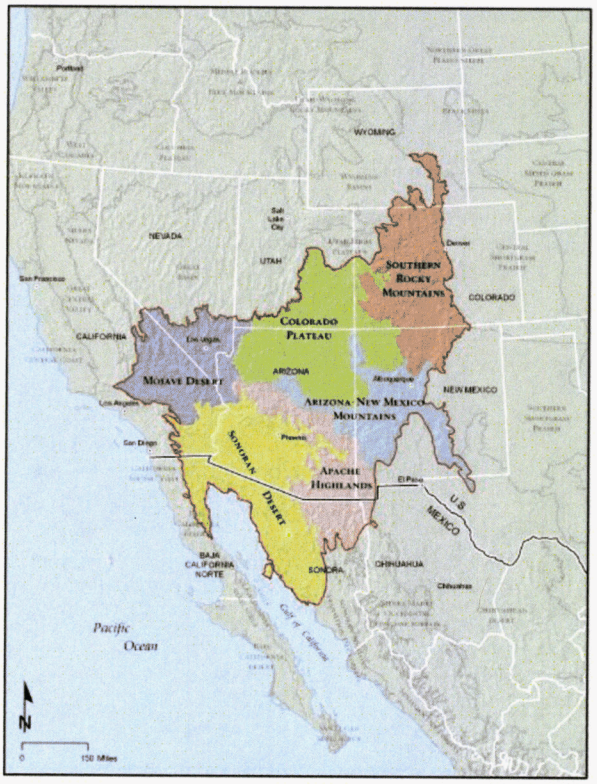
EXHIBIT
mcv-9
ADMITTED
PENGAD 800-631-6989

Ecoregion-Based Conservation Assessments of the Southwestern United States and Northwestern Mexico

A Geodatabase for Six Ecoregions, Including the Apache Highlands, Arizona-New Mexico Mountains, Colorado Plateau, Mojave Desert, Sonoran Desert, and Southern Rocky Mountains

Rob Marshall, Michael List, and Carolyn Enquist

May 2006



The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

TABLE OF CONTENTS

EXECUTIVE SUMMARY i

ACKNOWLEDGMENTS iii

INTRODUCTION 1

ECOREGIONAL ASSESSMENT OVERVIEW 2
- Ecoregions 2
- Ecoregional assessment approach 2
- The role of partner agencies, institutions, and tribes 5
- Ecoregional assessment components 5
  - Conservation targets 6
  - Conservation goals 7
  - Viability assessment 7
  - Identification of conservation areas 9
- The conservation area network 11

USE OF ECOREGIONAL ASSESSMENT DATA 14
- Land management status and the network of conservation areas 14
- Cooperative land management focused on ecosystem health 15
- State wildlife conservation plans 16
- National Fish Habitat Initiative 17

THE SIX-ECOREGION GEODATABASE 19
- Development of the geodatabase 19
  - Data content and attributes 19
  - Data standardization 20
  - Reconciling spatial overlap of conservation areas at ecoregional boundaries 20
  - Database schema and conventions 23
- Geodatabase function 24
  - Generating conservation target lists per conservation area 24
  - Generating conservation area lists for particular conservation targets 24
  - Generating comparison data for the 568 conservation areas 24

LITERATURE CITED 25

APPENDICES 27

Appendix 1. Reference list for conservation areas in which boundaries were evaluated for modification in the six-ecoregion geodatabase 27

LIST OF TABLES

Table 1. Comparison of Attributes and Summary Statistics for Six Ecoregional Assessments in the Southwestern United States and Northwestern Mexico 3

Table 2. The Number of Fine Filter Conservation Targets by Taxonomic Group for Six Ecoregions of the Southwestern United States and Northwestern Mexico 7

Table 3. The Number of Fine Filter Conservation Targets by Level of Rarity for Six Ecoregions of the Southwestern United states and Northwestern Mexico 8

Table 4. Example Conservation Goals for Conservation Targets in Six Ecoregional Assessments for the Southwestern United States and Northwestern Mexico 8

Table 5. Example Data Records for Eleven Standardized Attributes in the Six-Ecoregion Geodatabase 22

LIST OF FIGURES

Figure 1. Six Ecoregions of the Southwestern United States and Northwestern Mexico 4

Figure 2. Fine Filter Species Occurrence Data for the Huachuca Mountains Grassland Valley Complex Conservation Area 9

Figure 3. Ecological Systems Data for the Huachuca Mountains Grassland Valley Complex Conservation Area 10

Figure 4. Apache Highlands Cost Surface for the Huachuca Mountains Grassland Valley Complex and Environs 10

Figure 5. Conservation Areas Delineated for the Six Ecoregions 12

Figure 6. Frequency Distribution for the Size of Conservation Areas in the Six-Ecoregion Study Area 13

Figure 7. Management Status for Conservation Areas Identified in the Six-Ecoregion Study area 14

Figure 8. The Conservation Area Network Identified in the Six-Ecoregion Study Area as a Function of the Total Area Managed by Major Land Managers 15

Figure 9. Historical Fire Frequency for the Primary Vegetation Types in Southeastern Arizona 16

Figure 10. The Conservation Area Network by the Number of Terrestrial ESA-Listed Species and Non-Listed Rare Species 17

Figure 11. The Conservation Area Network by the Number of Aquatic and Riparian ESA-Listed Species and Non-Listed Rare Species 18

Figure 12. Six-Ecoregion Geodatabase Schema 23

EXECUTIVE SUMMARY

In 1995 The Nature Conservancy developed a new conservation framework – ecoregional assessments – to guide development of a blueprint for regional-scale conservation efforts. Ecoregions are large areas of land and water – on the scale of tens of millions of acres – characterized by distinct plant and animal communities, similar landforms, and environmental conditions such as climate. The framework's foundation was a systematic and comprehensive scientific analysis intended to serve as a guide for prioritizing the organization's work, engaging collaborators, and providing a context for understanding how individual projects fit into a larger conservation vision. Agency, university, institutional, and tribal resource professionals played a major role in the development of the assessments. Conservation assessments were completed for the southwestern U.S. and northwestern Mexico between 1999 and 2004.

Ecoregions are based on ecological rather than political boundaries. As a result they often bisect federal, state, private, and tribal jurisdictional boundaries, complicating the use of assessment data by public land managers and others. The six assessments covering the southwestern U.S. and northwestern Mexico were completed independent of one another; the methodology used did not ensure that data could be aggregated by simply combining the six assessments. Without additional data standardization and reconciliation, the utility of ecoregional assessments would be limited to the boundaries of each respective ecoregion. To solve this problem and to create a cross-ecoregional dataset that would facilitate analyses at multiple scales, we aggregated and standardized data from the six assessments into a single spatial dataset, referred to as the "six-ecoregion geodatabase."

A primary goal in compiling the six-ecoregion geodatabase was to facilitate conservation-related analyses and problem-solving at multiple scales and across jurisdictional and political boundaries. Several additional goals included:

- Enable review and analysis with a single dataset of conservation priorities across a large multi-state region.
- Introduce conservation priorities for a large region that shares similar challenges of habitat loss and fragmentation and increasing pressures on limited water resources from rapid urban and ex-urban growth, and, likely, climate-induced changes in the distribution of habitat for the region's biological diversity.
- Enable land managers, planners, policy-makers, and conservationists to evaluate, visualize, plan, and implement conservation actions across jurisdictional and political boundaries.

The six assessments compiled in this study evaluated 238 million acres across 11 states and two countries. Overall, more than 1300 species and 350 native plant communities and ecological systems were analyzed as part of the assessment process. The end result was a network of lands comprising 100 million acres (42% of the study area) where conservation should play a significant role if we are to maintain the region's biological diversity. The median size class of the areas comprising the network is from 50,000 to 250,000 acres. The comprehensive datasets and systematic analyses used to identify the network represent a new, synthetic data source for agencies, institutions, and organizations engaged in land-use planning and conservation land management.

Sixty-five percent of the network occurs on federal lands with Bureau of Land Management (BLM) and U.S. Forest Service (USFS) lands comprising 47% of the total network. Private lands, the next largest category, comprise 19% of the network. Underscoring the importance of the federal estate for conservation management, the U.S. Forest Service, Department of Defense, and Bureau of Land Management each has between 44% and 51% of their holdings within the network; the U.S. Fish and

Wildlife Service and National Park Service have 84% and 78%, respectively, of their holdings within the network. Moreover, 54% of the individual areas that make up the network have at least three major land managers responsible for on-the-ground management, affirming the fact that ecosystems don't stop at jurisdictional boundaries.

Conservation assessments purporting to identify priorities, typically, are identifying a set of tradeoffs. Identifying tradeoffs explicitly is one of the purposes of ecoregional assessments. In rapidly-growing areas, such as the southwestern U.S., conservation options are foreclosed on a daily basis and resources are inadequate to protect all important lands and waters. The assessment work represents the first attempt for this region at a systematic, comprehensive analysis and identification of conservation priorities at a scale commensurate with the scope and magnitude of change caused by human activities. The comprehensive, systematic, and explicit nature of the assessments can better enable decision-makers and other leaders in institutions and agencies to plan, fund, and implement conservation-related activities in a manner that enhances biological diversity while carrying out unrelated activities in a manner that minimizes further losses of biological diversity.

There are several important applications of ecoregional data. The network represents an important geography on federal, state, and private lands for which land-use allocations may be evaluated for their compatibility with the conservation values present. The broad diversity of systems and species used to represent the region's biological diversity provide a starting point for evaluations of the extent to which natural disturbance regimes – important for perpetuating habitat – are operating on the landscape. Furthermore, reducing stressors and threats in this geography will increase the likelihood that the region' ecological systems and species remain viable, an important component of management focused on maintaining "healthy ecosystems." Action to promote natural disturbance processes at appropriate scale and minimize known stressors and threats throughout the network should, over time, limit the need for additional listings under the Endangered Species Act.

Many federal, state, county, and municipal agencies are completing land-use, land management, wildlife conservation, or habitat conservation plans. These efforts typically encourage or require collaboration and planning across jurisdictional boundaries to leverage limited funding and increase overall effectiveness. Ecoregional data are well-suited for these purposes and have been integrated into numerous planning efforts throughout the U.S. Among the unique aspects of ecoregional assessments is the integration of aquatic/riparian- and terrestrial-based data into unified geographies that lend themselve to "watershed" or "ecosystem-based" management. With the proliferation of planning efforts underway, such as the National Fish Habitat Initiative, State Comprehensive Wildlife Conservation Plans, federal land management plans etc., ensuring integration of the terrestrial and aquatic realms into a cohesive and effective set of management strategies will be paramount. The prospect of achieving large-scale system-level restoration and management presents a unique challenge for all planning efforts because funding fo such work remains limited. If large-scale, cooperative conservation planning is the new prerequisite for capturing federal, state, and private conservation funds, then a first step for emerging efforts might be to critically evaluate the opportunities that can be leveraged with contemporary, cross-boundary ecoregiona assessments that unify terrestrial and aquatic conservation priorities before additional investments are made in new priority-setting exercises.

native grasslands would maximize viability for grassland species. Note that despite the lack of fine filter data for the Mexico portion, 47% of the conservation area lies on the Mexico side of the border. This is largely the result of the extensive grassland that occurs in the Mexico portion. This graphic illustrates how good coarse filter data, combined with conservation goals at a meaningful scale, can compensate for gaps in fine filter data in the delineation of conservation areas.

Figure 4 illustrates one type of viability assessment used in the ecoregional assessment process – a "cost" surface or suitability index. The graphic illustrates the effect of "cost" on the delineation of conservation areas. Increasing cost is depicted by increasingly dark shades of red. Cost is an additive but unit-free value represented by the extent of human infrastructure, such as mines and other industrial development, agriculture, urban development, and roads (see Marshall et al. 2004). The algorithm that delineated conservation areas was programmed to avoid high cost areas where conservation may be incompatible and or prohibitively costly. The Huachuca Mountains conservation area is delineated in green: the graphic illustrates how higher cost areas were largely avoided, such as the major highway corridor that borders the western boundary. Some high cost areas, such as the east side of the Huachuca Mountains adjacent to the city of Sierra Vista, were included, however. This is due to the high number of endemic species occurring in this mountain range. The inclusion of "high cost" areas indicates there are limited or no other alternatives in the ecoregion in which to protect those conservation targets. Cost analyses were used in the Apache Highlands, Colorado Plateau and Southern Rocky Mountain ecoregional assessments (**Table 1**).

The conservation area network

Carried out across an entire ecoregion, the process of identifying conservation areas described in **Figures 2 – 4** yields the primary end product of the ecoregional assessment process, a network of "conservation areas." The term "conservation area" is shorthand for the locations identified that capture the most important places to protect the 366 ecological systems and 1374 species analyzed over the six-ecoregion study area. The term does not convey special status to those areas; rather, the network of conservation areas is a blueprint for where enhanced attention to conservation management would contribute to a larger regional conservation vision. The purpose of this project was to aggregate and standardize conservation area data across the six-ecoregion study area.

The aggregation and standardization process resulted in a network of 568 conservation areas comprising nearly 100 million acres, or 42% of the six-ecoregion study area. **Figure 5** depicts this network as a series of irregularly shaped polygons in green. Conservation areas range in size from just over 100 acres to approximately 5.7 million acres. **Figure 6** provides a frequency distribution for the size of conservation areas. The vast majority of conservation areas (82%) are less than 250,000 acres in size; the median for all conservation areas was 50,000 acres. There are at least five factors that account for the size, shape, and distribution of the conservation area network, including:

1. The distribution of species and ecological systems is not uniform across the southwestern U.S. and northwestern Mexico. The considerable range in elevation (sea level to 14,000 feet) and complex topography in the six-ecoregion study area yields a non-uniform distribution of systems and species.
2. Habitat and other life-history requirements of target systems and species differ. For example, the San Fransciso groundsel (*Senecio franciscanus*) is restricted to alpine areas on the San Francisco Peaks in the Arizona – New Mexico Mountains ecoregion, whereas the endangered Sonoran pronghorn (*Antilocapra americana sonoriensis*) roams across nearly 6 million acres along the Arizona – Sonora borderlands in the Sonoran Desert ecoregion. The net result is that the size and shape of conservation areas is, in part, a function of the spatial occurrence of the conservation targets selected and the requirements of those targets as expressed by conservation goals.

3. Species-level target data are not uniformly sampled across the landscape. Species-level datasets often contain taxonomic and geographic sampling biases. These biases are inherent in any analysis using species-level data. However, coarse-filter conservation targets may help overcome this bias as hypothesized in **Figures 2-4**.
4. The advent of computerized conservation area selection algorithms enabled assessment teams to program boundary modifier values that affect perimeter to interior ratios and the degree to which conservation areas were "connected." Assessments, such as the Apache Highlands used higher values for the boundary modifier which yielded large, "connected" conservation areas.
5. Conservation area selection algorithms are programmed to identify an "efficient" network where conservation goals are met with a minimum amount of area. Thus, if a conservation target is found in two locations, but one location includes two additional conservation targets, the algorithm will select the area with the additional conservation targets (assuming viability and other factors are equal).

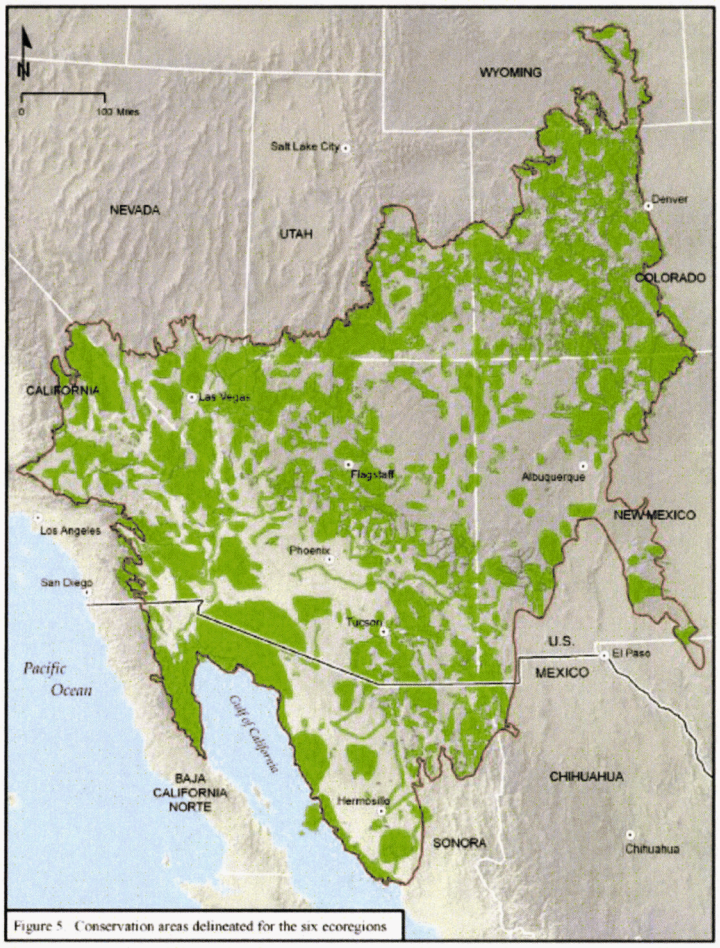


Figure 5 Conservation areas delineated for the six ecoregions

Enlargement of Figure 5 Page 20 of the PDF

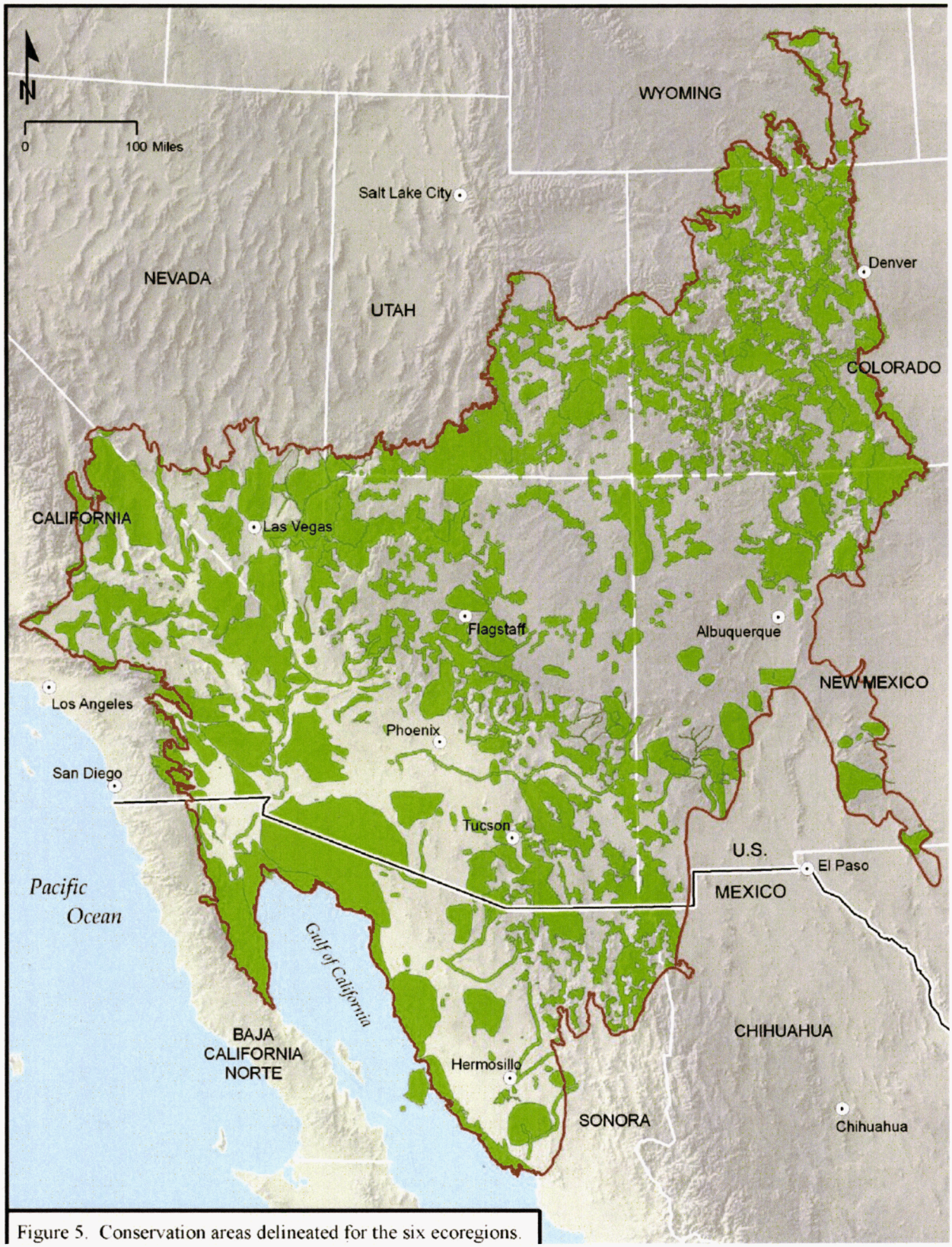
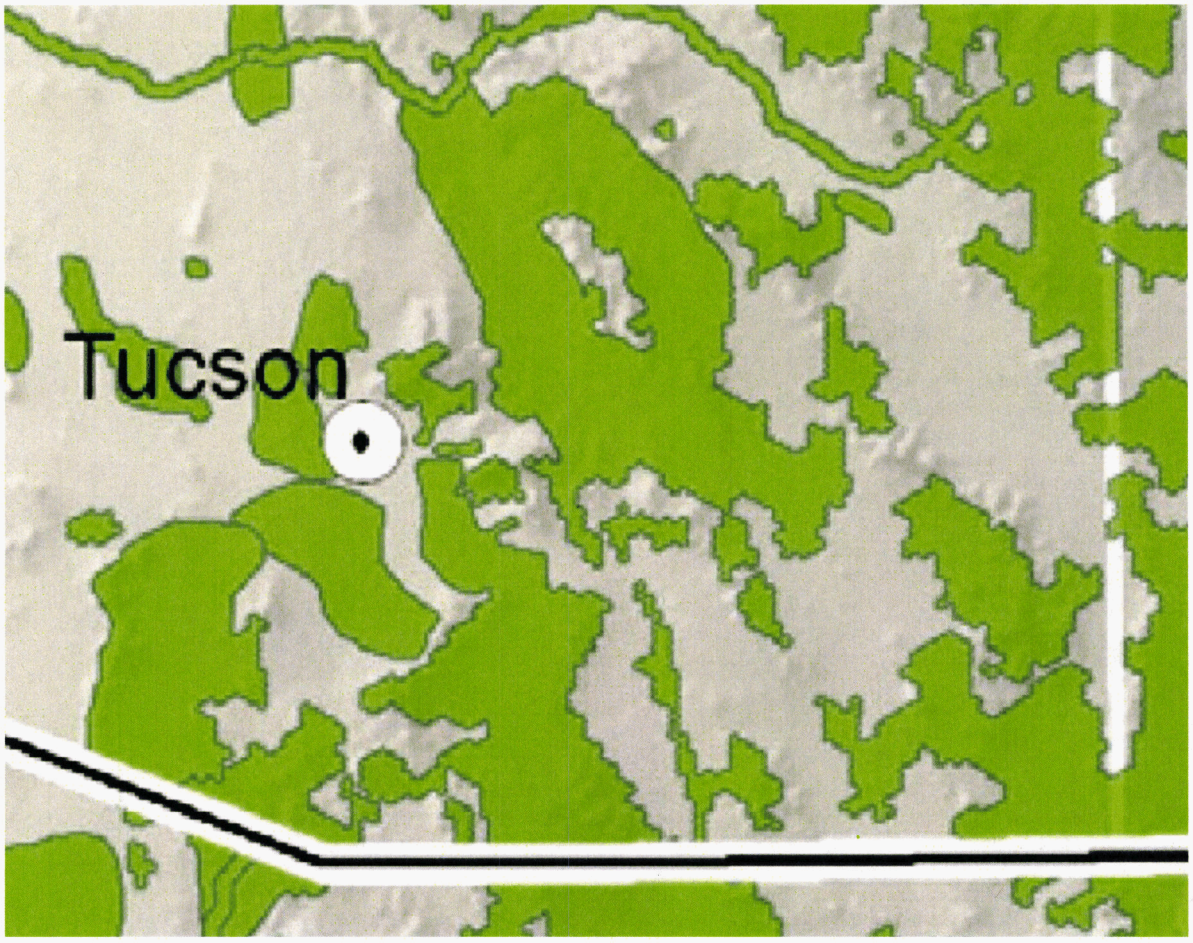


Figure 5. Conservation areas delineated for the six ecoregions.

ENLARGEMENT of Figure 5 Page 20 of the PDF



EXCERPT PAGE 24 of the PDF

State wildlife conservation plans

In 2001 Congress created the State Wildlife Grants program as the nation's core program for keeping wildlife from becoming endangered. Federal funding to states is predicated on the completion of State Wildlife Conservation Plans. These plans, also referred to as State Wildlife Action Plans, define a vision of conservation success for the nation's wildlife. Among the eight elements state plans address is a requirement for states to coordinate implementation of conservation measures with federal, state, and local agencies and Tribes. This requirement provides an opportunity for states to play a leadership role in focusing state and federal funding on geographies and approaches that will enable states to meet the vision intended by Congress. Many states have integrated ecoregional assessment data, in whole or part, into their plans. And some groups, such as the Huachuca Area Fire Partners described above, have already begun collaborative efforts that focus on enhancing ecosystem health at conservation areas identified through the ecoregional assessment process.

However, there is a considerable need to expand the number of outcome-focused collaborations working to improve ecosystem health at a meaningful scale. As an example, **Figure 10** ranks the network of conservation areas based on the number of terrestrial species with status under the Endangered Species Act or that are non-listed but rare. Sixty-two percent of the conservation areas (over 350 areas) support rare or endangered terrestrial species and their habitat. Eighty-two conservation areas support habitat for between 5 and 20 rare or endangered species, comprising approximately 47.8 million acres. Maintaining healthy ecosystems for these species as well as limiting the need for additional listings under the ESA presents a significant challenge in an era of decreasing budgets. Collaborative, cross-boundary projects

focused on ecosystem condition provide one avenue to meet this challenge. Consider that 54% of the conservation areas in the U.S. portion of **Figure 10** are managed by at least three major land managers. More than 100 conservation areas are managed by USFS and BLM and 84 are managed by USFS, BLM and a state agency. These data affirm the well-known fact that ecosystems don't stop at jurisdictional boundaries. Given the median size for conservation areas is from 50,000 to 250,000 acres, these data also underscore that the conservation and land management community will have to increase the scale of conservation management, a significant challenge in an era of limited funding. Under the auspices of State Wildlife Conservation Plans, and armed with regional datasets, states have an opportunity to play a leadership role in convening, implementing, and learning how to manage ecosystems for the benefit of biodiversity.

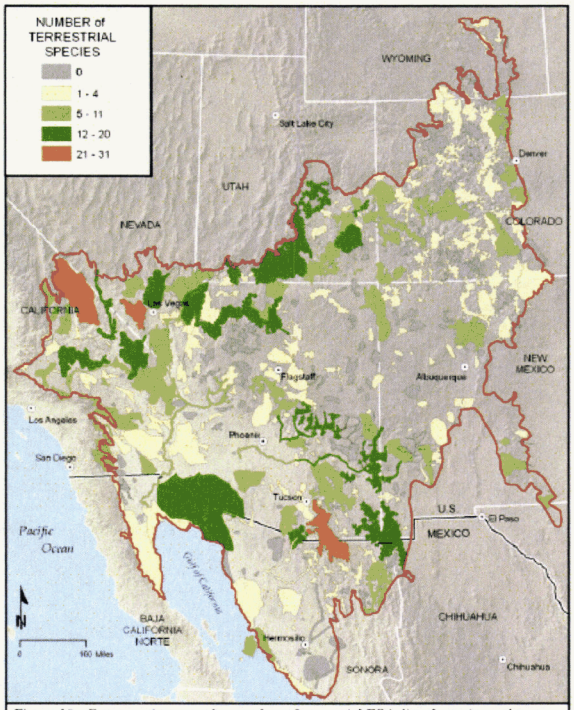


Figure 10. Conservation areas by number of terrestrial ESA-listed species and non-listed rare species.

National Fish Habitat Initiative

The International Association of Fish and Wildlife Agencies, in conjunction with the U.S. Fish & Wildlife Service and National Marine Fisheries Service, is leading a nation-wide effort to address the loss and degradation of aquatic habitats that supports the nation's fish biodiversity – the National Fish Habitat Initiative (NFHI). Noting significant gains made in the enhancement of aquatic habitat with the advent of environmental regulations introduced in the 1970s, NFHI's Action Plan cautions that "these efforts have not kept pace with impacts resulting from population growth and land-use changes" (NFHI 2006). The Plan includes a number of ambitious goals, including: preparation of a *Status of Fish Habitats in the United States* by 2010; protection of all healthy and intact fish habitats by 2015; and improvement in the condition of 90% of priority habitats and species targeted by Fish Habitat Partnerships by 2020. Among the Initiative's strategies is support to foster new partnerships and communicate the status and needs of aquatic habitats. A science and data strategy notes the need to "utilize an integrated landscape approach that includes the upstream/downstream linkages of large scale habitat condition factors" (NFHI 2006).

The Plan's ambitious goals and strategies will require biological and ecological assessments and data syntheses to support effective use of funds and successful outcomes. The six-ecoregion geodatabase provides one source of contemporary assessment information that can be used to quickly identify high priority aquatic systems and species. Native aquatic- and riparian-dependent species were a major focal point of ecoregional assessment for the southwestern U.S. Of the 1374 fine-filter conservation targets analyzed in the six-ecoregion study area, 39% were aquatic- or riparian-obligate species. Each conservation target was assigned a conservation goal and is represented in one or more conservation areas throughout the network. Moreover, conservation areas typically capture several or more aquatic systems

Enlargement of Figure 10

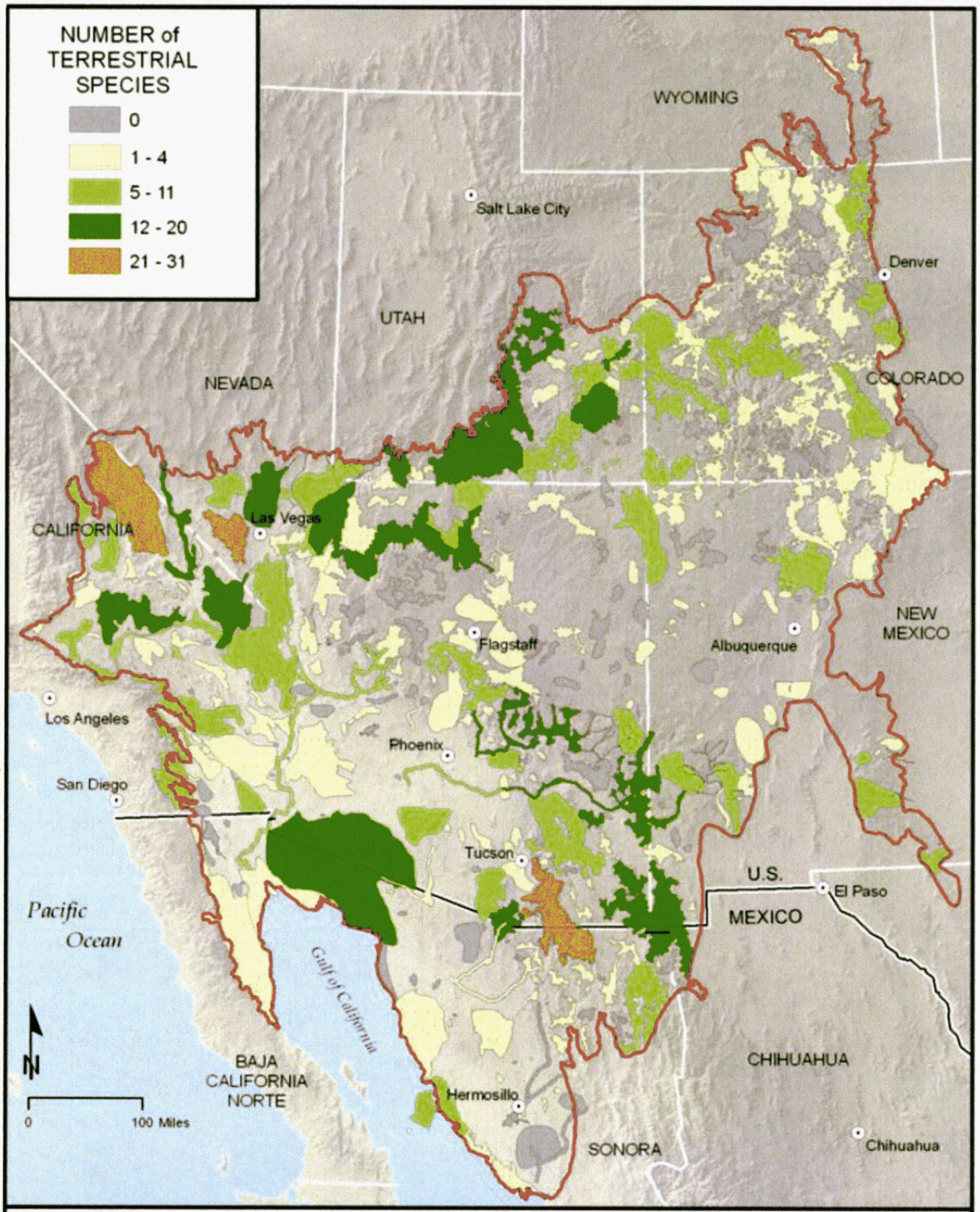
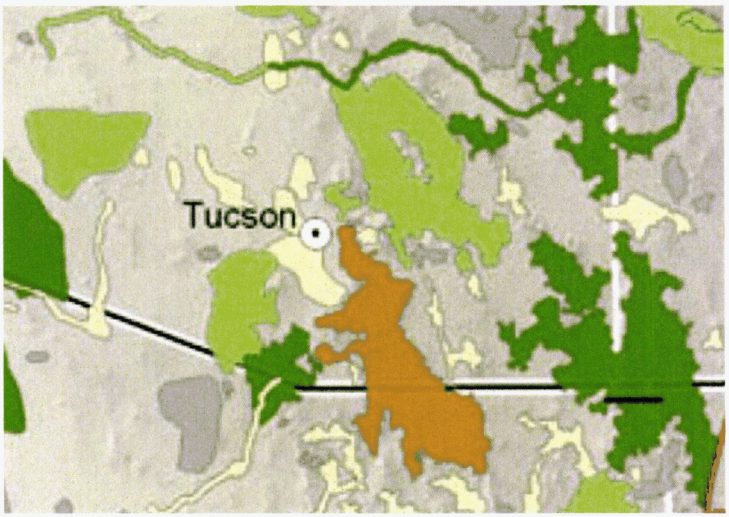


Figure 10. Conservation areas by number of terrestrial ESA-listed species and non-listed rare species.

Enlargement of Figure 10



and species (**Figure 11**) and, thus, form a good starting point for evaluating the conservation activities needed to maintain the viability of those systems and species.

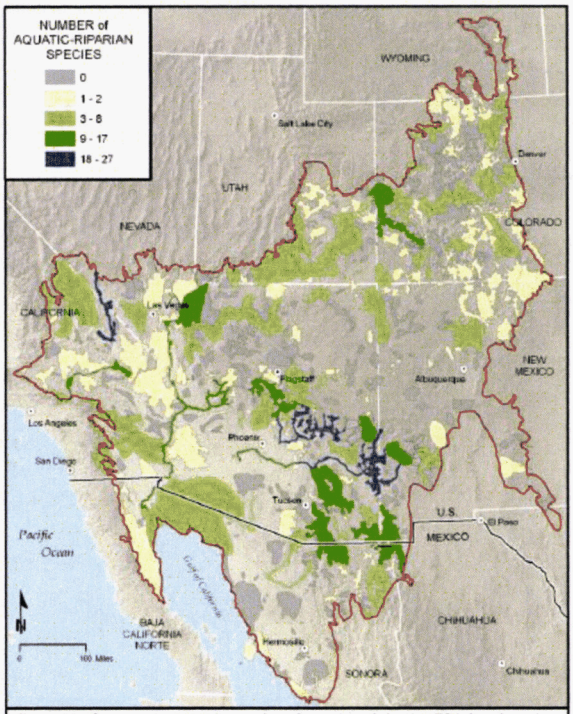


Figure 11. Conservation areas by number of aquatic and riparian ESA-listed species and non-listed rare species.

In **Figure 11** conservation areas are ranked by the number of aquatic and riparian species that are rare or have status under the ESA. This analysis demonstrates the importance of aquatic habitat throughout the arid Southwest; it is also a sobering illustration of the state of imperilment of our aquatic systems with several large conservation areas harboring nearly 30 rare and endangered aquatic and riparian species. Although NFHI's goals extend to introduced sport fisheries, ecoregional assessment data provide highly synthesized data for those efforts that wish to pursue native fish conservation. Moreover, ecoregional assessment data also facilitate NFHI's intent to "utilize an integrated landscape approach," because locations identified to capture aquatic systems and species are imbedded within their larger terrestrial conservation areas providing NFHI efforts an opportunity to evaluate system-level management actions that might benefit terrestrial as well as aquatic and riparian systems and species. For example, Gori and Backer (2005) found a ten-fold increase in populations of Gila chub (*Gila intermedia*), proposed for listing under the ESA, over the course of a 12-year period where grazing rest and prescribed burning were used to improve watershed conditions on a 50,000-acre watershed jointly managed by BLM and TNC in southeastern Arizona. The study also documented significant improvement in aquatic habitats, such as increasing pool depth, number of pools per km, and extent of bank cover. These changes occurred during a period of decreasing stream flows indicating that the habitat improvements likely resulted from structural changes in the stream channel rather than increases in stream flow.

The National Fish Habitat Initiative's caution about the causes of current aquatic habitat loss and degradation – impacts from population growth and land-use changes – are the same issues facing conservation efforts within the terrestrial domain. Thus, the prospect of unifying aquatic- and terrestrial-based conservation efforts around a shared geography with shared priorities and the gamut of strategies, including large-scale system-level restoration and management, presents a unique challenge for efforts like NFHI and State Wildlife Conservation Plans. If large-scale, cooperative conservation planning is the new prerequisite for capturing federal, state, and private conservation funds then a first step for existing and emerging efforts might be to critically evaluate the opportunities that can be leveraged with contemporary, cross-boundary assessments that unify terrestrial and aquatic conservation priorities before additional investments are made in new priority-setting exercises.

Enlargement of Figure 11

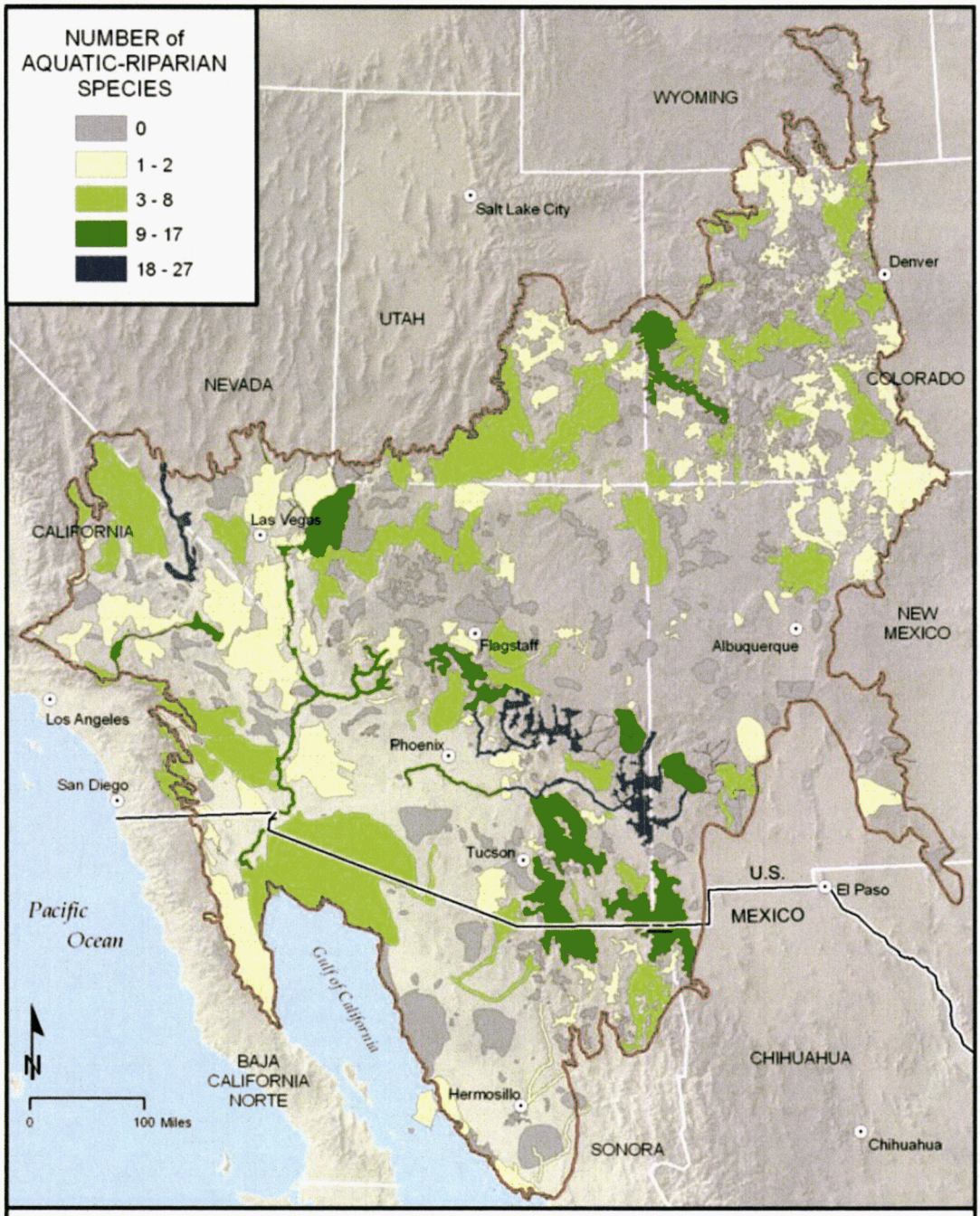
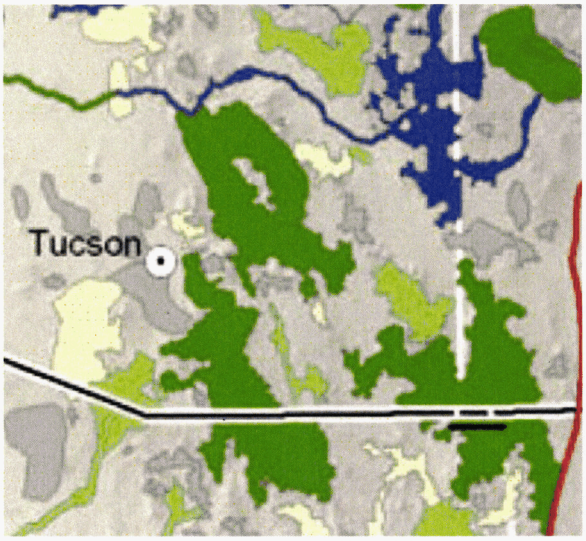
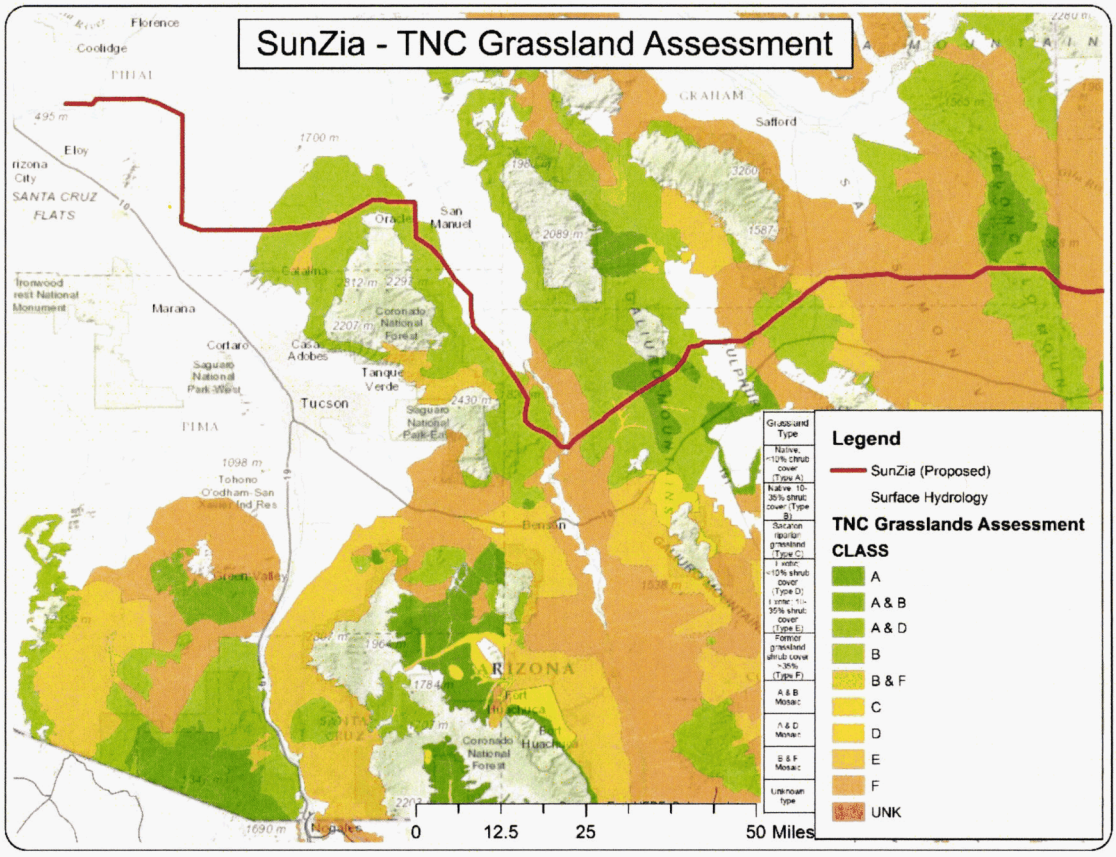


Figure 11. Conservation areas by number of aquatic and riparian ESA-listed species and non-listed rare species.

Enlargement of Figure 11

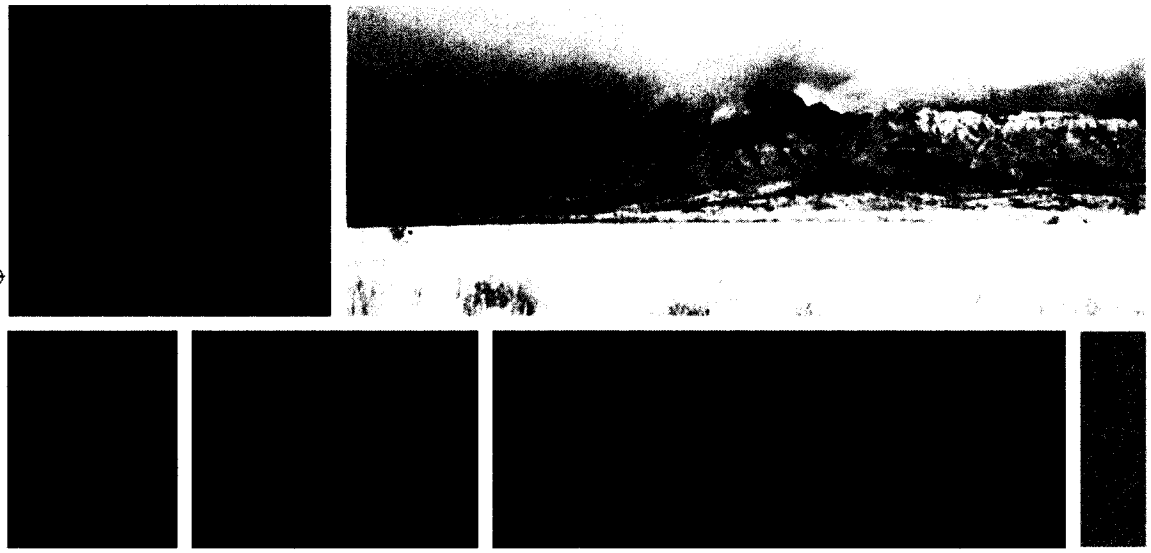


DOCKET NO. L-00000YY-15-0318-00171-MCV_EXHIBIT 9A



PENGAD 800-631-6989
EXHIBIT
mcv-10
ADMITTED

DOCKET NO. L-00000YY-15-0318-00171-MCV_10



National Fish and Wildlife Foundation

Draft Business Plan for the Sky Island Grasslands

March 24, 2009

Summary

The Sky Islands are a unique region of more than 40 isolated mountain ridges surrounded by a sea of dry grasslands that straddles the Mexico/Arizona/New Mexico border. It is one of America's great hotspots for wildlife diversity, hosting more twice as many mammal species as Yellowstone National Park and supporting the nation's highest diversity of reptiles, bees and ants.

Of the 13 million acres of grassland which once dominated this 30 million acre landscape, at least 2 million acres still have exceptional wildlife values and another 4 to 7 million acres of grassland could be restored. These grasslands are centered around 10 valley landscapes, each of which contain more than 100,000 acres of grassland habitat of exceptional value, and most of which support embedded wetlands. Within these landscapes we are targeting jaguar, bison, pronghorn, black-tailed prairie dog, Chiricahua leopard frogs, pronghorn and grassland sparrows as wildlife whose population response to conservation investments will be the best indicators of success.

PAGE 6

Contents

What Is a Business Plan? i

Summary iii

Conservation Need 1

Conservation Outcomes. 3

Logic Framework 5

Implementation Plan 6

Funding Needs 18

Evaluating Success 19

Ancillary Benefits 25

Acknowledgements 26

Priority Map of Biological Features 27

EXCERPT PAGE 8 of the PDF

Conservation Need

The Sky Islands is a region on the U.S./Mexico boundary that is a world renowned Biodiversity Hotspot, linking the North American continent's temperate and tropical latitudes. The region also bridges the lowest point in the Continental Divide, melding two of the largest deserts (Sonoran and Chihuahuan) in the western Hemisphere with short-grass prairie and semi-desert grasslands, which are interspersed with towering mountains of pine-oak, mixed conifer, and spruce-fir forests. This landscape still supports a community of ranchers and others whose livelihoods are still largely a land-based economy.

The Sky Island region is defined as much by the grassland sea as by the mountains that rise from it. These grasslands include semi-desert and Plains grasslands, as well as sacaton grassland bottomlands and many variations on the three types. Built on the alluvial fans of rock worn off mountainsides and come to rest as valley soils, these grasslands serve as the stage for extraordinary plant life; one

...

In the face of climate change, this region provides unique opportunities for wildlife to follow the conditions they depend on — upwards in elevation along the steep gradients created by the Sky Island's many mountain ranges, or northwards through valleys or along mountain chains. The north-south orientation of the region's topography is already credited with promoting mixing of floras and faunas, and will continue to facilitate wildlife movement. This region is already at the northern frontier of many species' ranges, making it the anchor point for their journeys further north. These factors make preserving both corridors across latitudes and continuity across valleys even more important as conditions continue to shift.

...

EXCERPT PAGE 9 of the PDF

Pronghorn are indicators for ecological and landscape integrity. These wide-ranging grassland specialists require sight lines unbroken by shrubs and movement corridors unfragmented by human development. Because of this, they are among the first species to decline when shrubs take over grasslands, and among the first to disappear as roads, fences, and homes block the paths they use to wander in search of fresh food.

Grassland bird populations have shown a steeper, more consistent, and more geographically widespread decline than any other guild of North American bird species. Breeding Bird Survey data collected from 1966 to 1993 indicate that approximately 70% of the grassland bird species surveyed had negative population trends. The grasslands of the southwestern US and northern Mexico are the primary over-wintering grounds for most North American grassland bird species and are therefore, continentally important to their survival.

EXCERPT PAGE 10 of the PDF

This plan will be focused around a core set of large grassland landscapes in Arizona, New Mexico and Mexico which have extensive high quality and restorable grasslands and support many of the most important grassland biodiversity values. Together these areas create important north-south corridors that connect grassland habitats as well as the 'Sky Island' mountain ranges among the grasslands.

EXCERPT PAGE 16 of the PDF

permanent, but the indirect effects to surrounding natural habitat due to fragmentation of wildlife movement corridors, disruption of watershed function, and introduction of exotic species can have far-reaching impacts. For some valleys it is already too late; unfragmented, valley-wide grassland habitat has already been lost. However, there are several valleys where protection of sustainable, ecologically functional grassland ecosystems is still possible. To achieve our long-term goals for grass land conservation, protection of natural grassland habitat from fragmentation is the foundation upon which all other conservation strategies depend.

EXCERPT PAGE 17 of the PDF

The criteria used to establish land protection priorities often include presence of important water rights or vulnerable aquifers. For example, in the Upper San Pedro Basin ground water modeling that identifies core groundwater recharge zones is used to guide land protection. For these reasons, water protection is an integral part of all land protection goals. Nevertheless, explicit policy and planning work to protect water resources is sometimes needed in addition to land protection.

In recognition of the importance of protecting natural habitat, the residents of Pima County passed an Open Space Bond for $174 million for purchase of conservation easements and other land protection. Conservation goals — largely focused on grassland and riparian target species — guided the spending of these public monies, which is now protecting ranch land in some of the area's most important grassland valleys. Additional grassland purchases are being negotiated, and a second open space bond initiative is now being planned. Although both threats and land costs are highest in Pima

EXCERPT PAGE 18 of the PDF

acquisition of land, water, and easements has been funded by many stakeholders for a wide range of purposes, including Pima County to protect communities from flooding, reduce infrastructure costs for new growth, and mitigate for effects of other developments; the Department of Defense and

EXCERPTS PAGE 19 of the PDF

Wise land use planning can steer population and infrastructure growth towards areas where it will have the least impacts on natural infrastructure (community open-space lands, wildlife corridors, aquifer recharge zones, groundwater-dependent wetlands, etc.). Growth projections in Arizona show major overlap with high-value lands and waters. Engaging county planners and other policymakers to examine how alternative growth scenarios affect natural and human systems is already improving planning outcomes in Arizona. Similarly, using ecological flows and other methodologies can highlight tradeoffs between increased human water use and loss of wetland function and other ecosystem

services.

EXCERPT PAGE 23 of the PDF

The grasslands of the southwestern US and northern Mexico are the primary over-wintering grounds for most North American grassland bird species and are therefore, continentally important to their

DOCKET NO. L-00000YY-15-0318-00171-MCV_10A

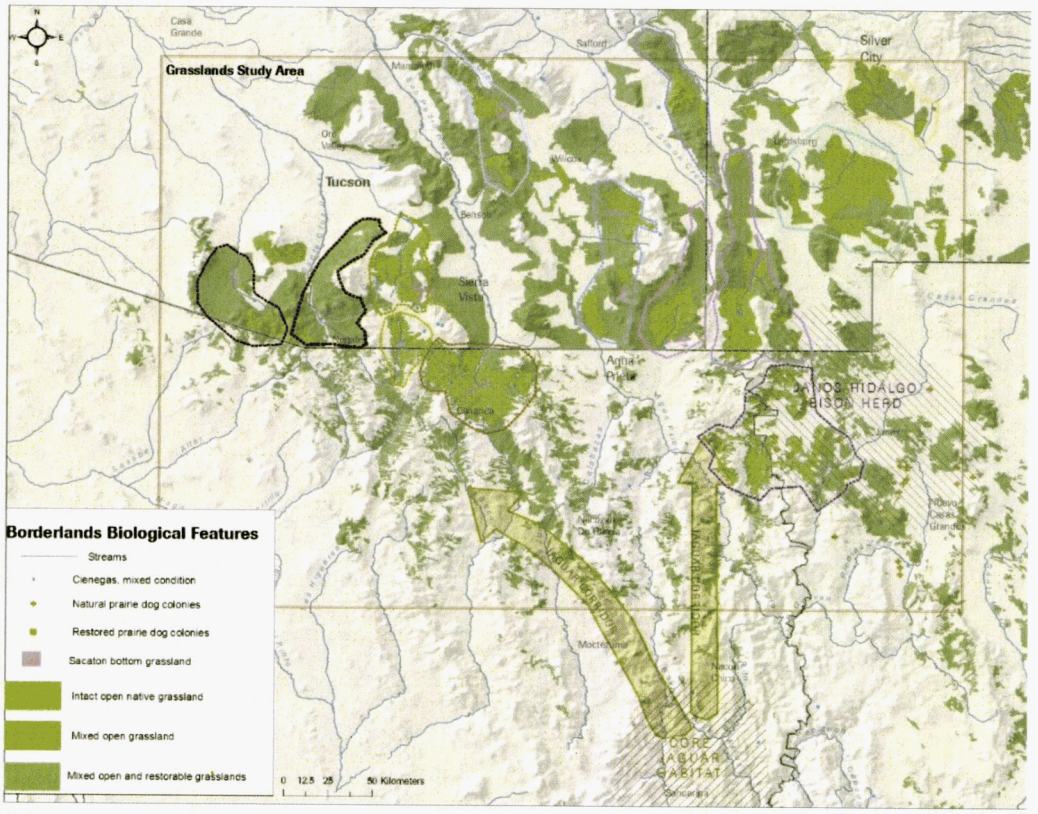


EXHIBIT
PENGAD 800-631-6989
MCV-11
ADMITTED

MAPPING BIODIVERSITY METRICS REPRESENTING ECOSYSTEM SERVICES AT THE LANDSCAPE SCALE IN THE AMERICAN SOUTHWEST

Kenneth G. Boykin[1], William G. Kepner[2], David F. Bradford[2], Kevin J.Gergely[3], *and* Anne C. Neale[2]

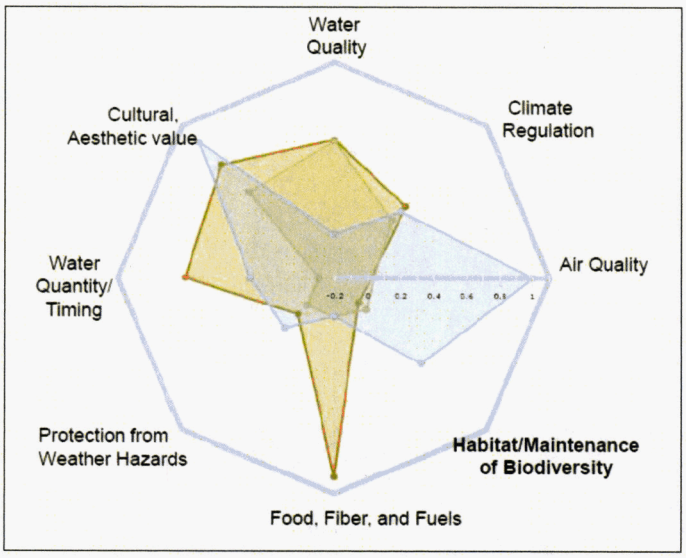
[1] New Mexico State University,

[2] U.S. Environmental Protection Agency

[3] U.S. Geological Survey, Gap Analysis Program

CASE Center for Applied Spatial Ecology
USGS science for the changing world
gap KEEPING COMMON SPECIES COMMON

EPA Atlas Vision/Implementation



- Contain series of clickable background maps
- Select ecosystem services from Table of Contents
- Allow "stacking" of multiple services
- Multiple metrics for each category
- Ancillary data
- Include potential and future scenarios
- Allow user to place their "area" in context of others

Page 3 of the PDF

Evaluation Factors for Selecting Indicators

- **Focus on Clients,**
  - *e.g.* FWS, BLM, USFS, & State departments of environment and natural resources (State & Tribal Wildlife Grants Program- $90M in FY10)
- **Include decision makers**
- include a **suite of indicators** to inform tradeoffs
- **Select scale** best needed to inform the decision
- select & evaluate within the **timeframe** needed to inform decision
- select indicators that can **easily be interpreted by non-scientists**

W. Munns, April 2010

Page 4 of the PDF

Scaling of Services

Objective

Develop and produce maps of an ecosystem service (e.g., habitat provisioning…a surrogate measure of biodiversity) based on current condition and available data for place-based, regional, and national scales of interest.

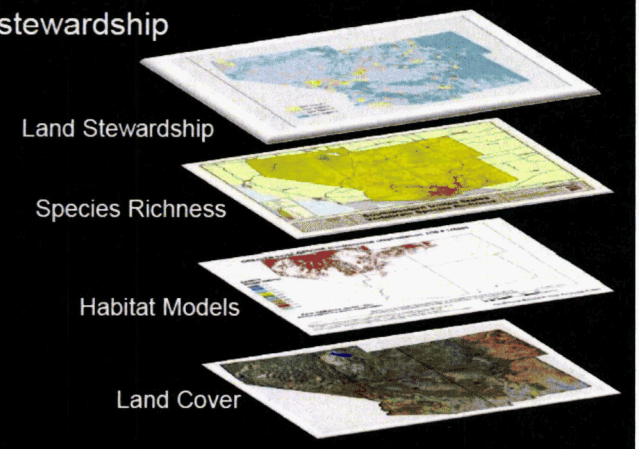
Page 5 of the PDF

Gap Analysis Products and Data Sources

(Southwest Regional Example)

Available Data

- Land cover dataset
- Terrestrial vertebrate models
- Land ownership/stewardship



Page 7 of the PDF

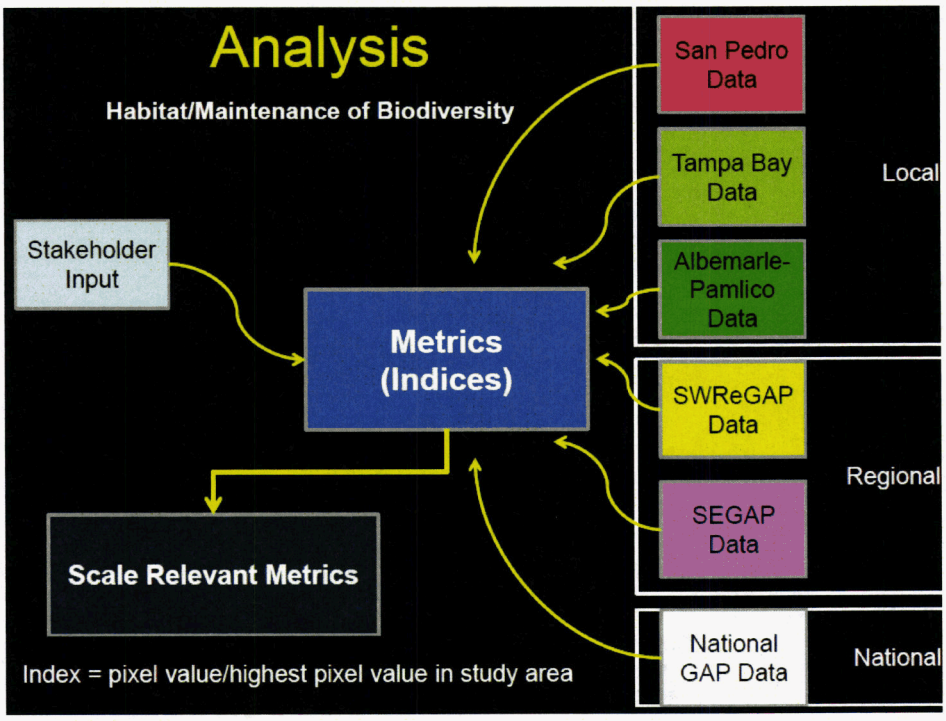
Metrics to Measure Biodiversity

Outcomes of joint EPA/USGS/FWS Workshop on Biodiversity/Habitat Metrics (Oct. 2009, Reston, VA)

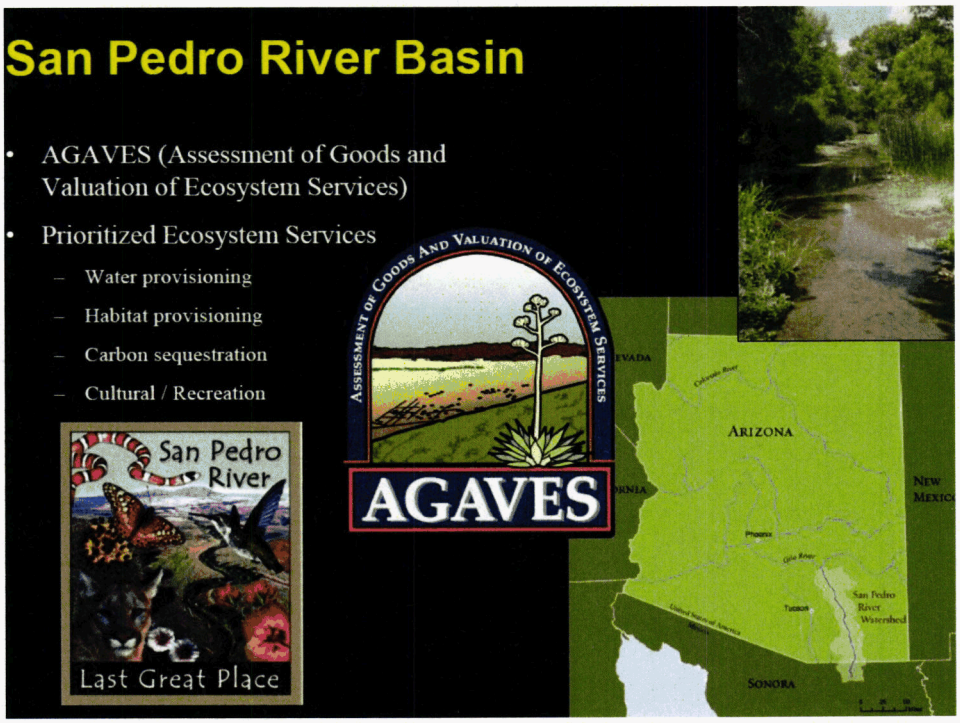
Category
Recreational Hunting
Wildlife –cultural, spiritual, intrinsic
Biodiversity for its intrinsic value, ecosystem resilience
Species Composition Intactness
Rarity/scarcity of ecological systems

Terrestrial Vertebrates	Species of Greatest Conservation Need	Harvestable Species	Ecological Systems (Land Cover)
All Species	All Species	Big Game	Richness/Diversity
Amphibians	Amphibians	Upland Game	
Birds	Birds	Furbearers	
Mammals	Mammals	Waterfowl	
Reptiles	Reptiles		
Bats			
T & E Species			

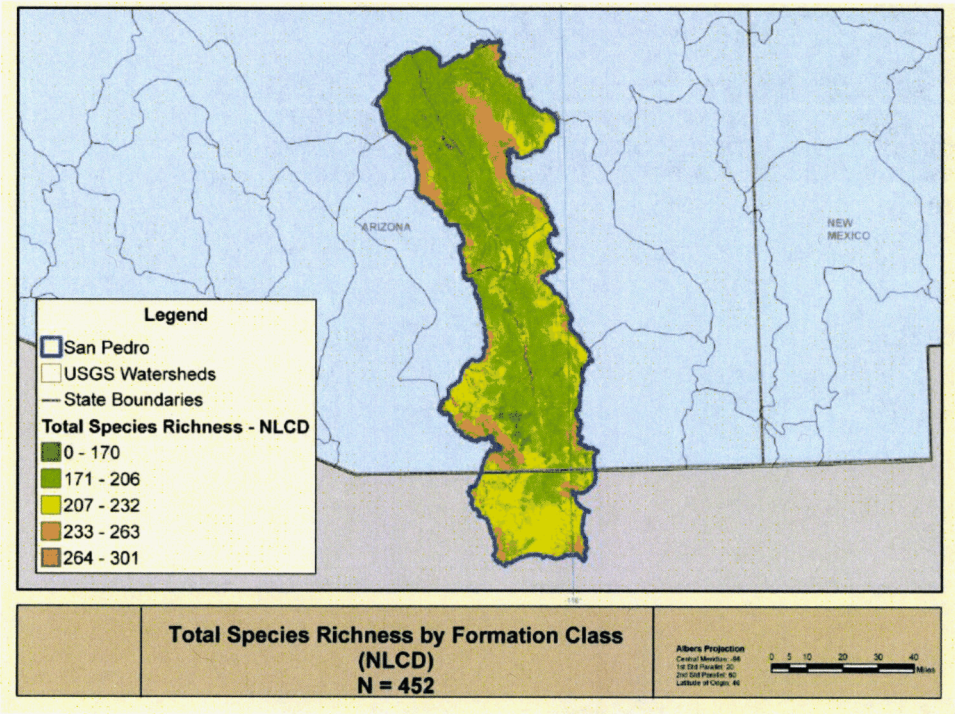
Page 8 of the PDF



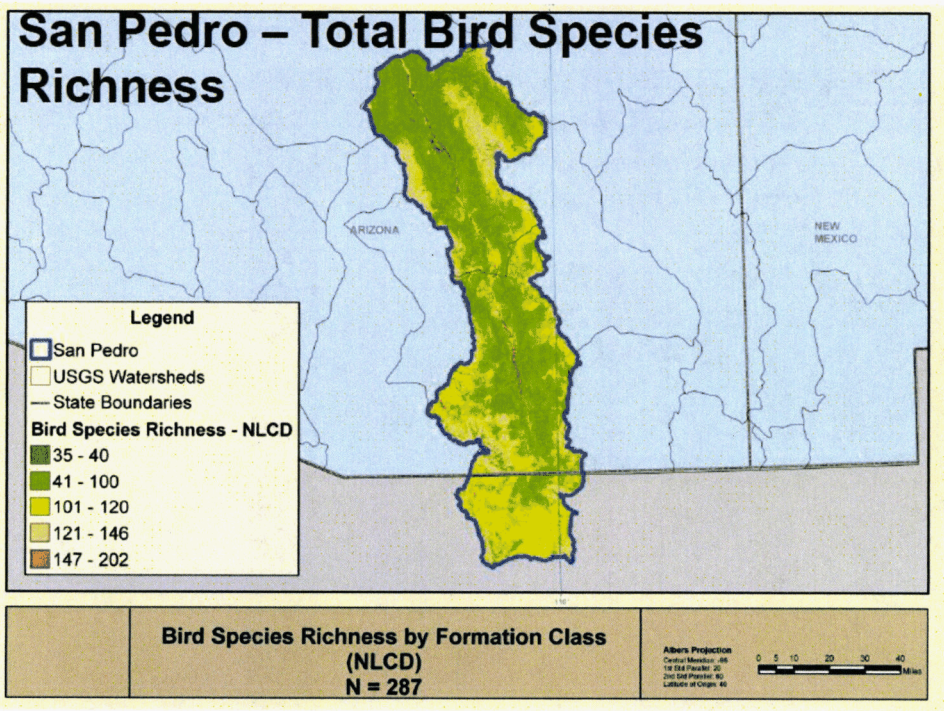
Page 9 of the PDF



Page 10 of the PDF



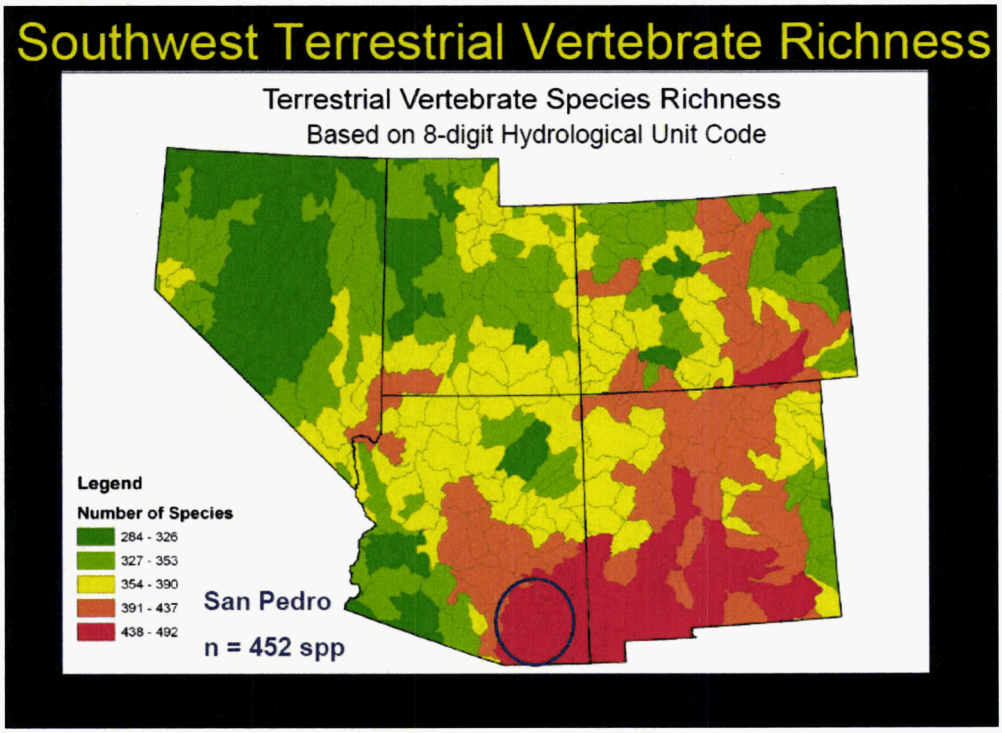
Page 12 of the PDF



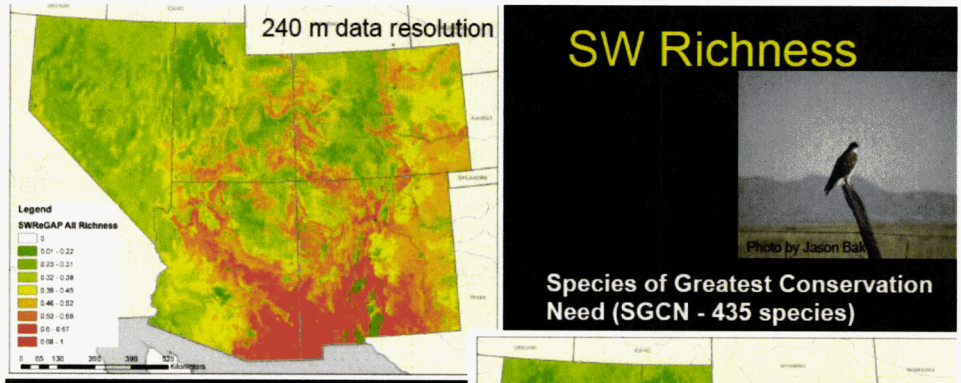
Page 13 of the PDF

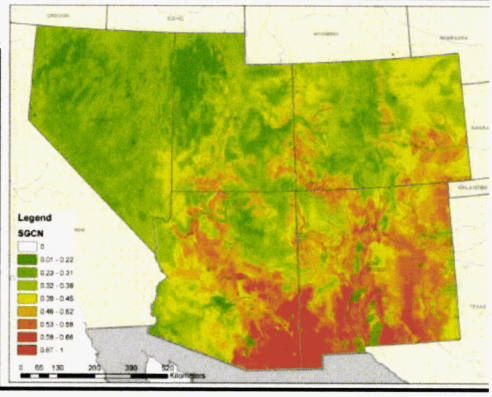
	Number of Species					
Formation (NLCD)	Total	Amphibians	Birds	Mammals	Reptiles	Areal Extent
Barren Lands	107	3	35	43	26	
Evergreen Forest	263	3	146	74	40	18.2%
Deciduous Forest	104	0	68	32	4	
Shrub/Scrub	206	6	96	76	45	49.4%
Grassland	232	5	102	80	45	27.8%
Woody Wetland	301	6	202	61	36	1.3%
Emergent Wetland	149	3	108	35	3	
Barren Lands	149	3	108	108	3	
Urban/Agriculture	170	1	131	33	7	
Water	94	2	79	12	1	
Total	452	16	287	88	61	

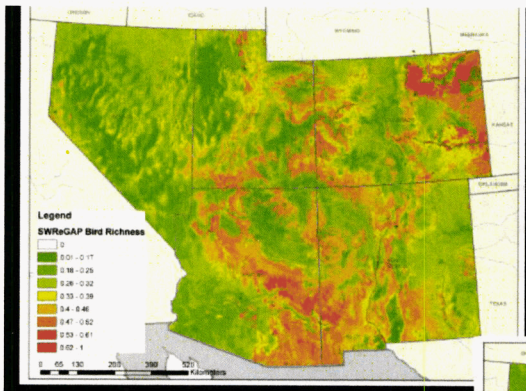
Page 14 of the PDF

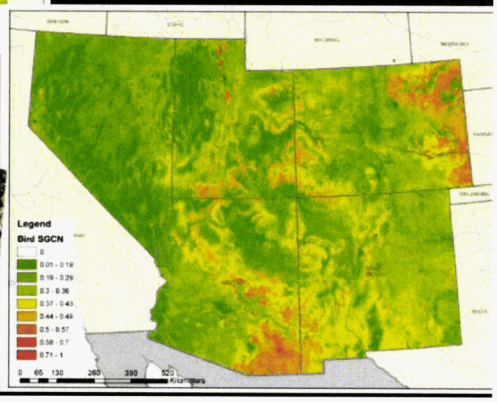


Page 15 of the PDF

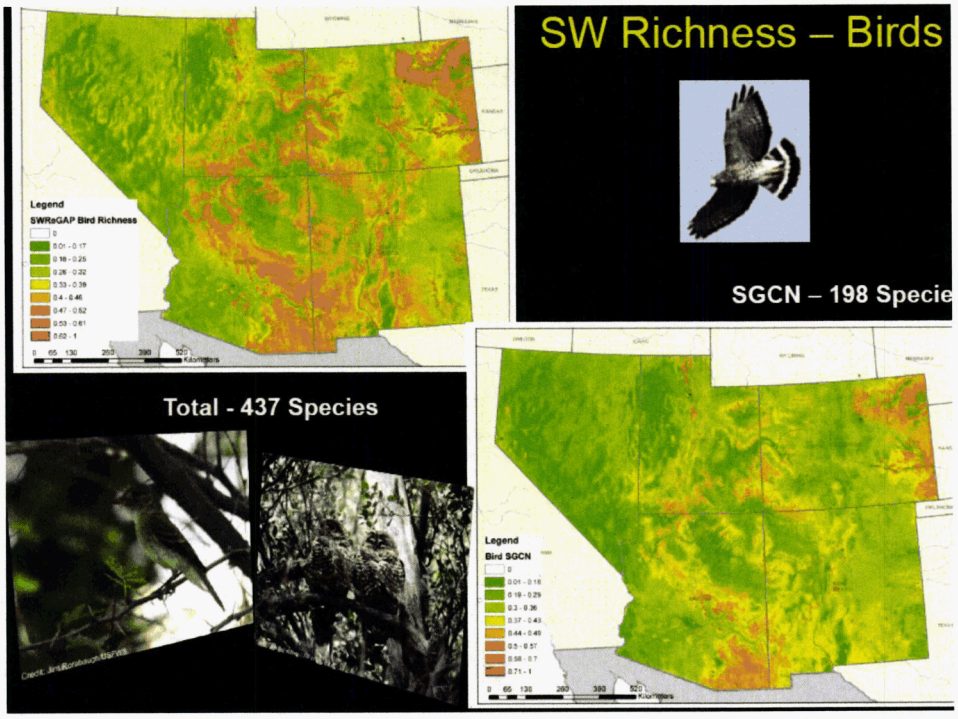




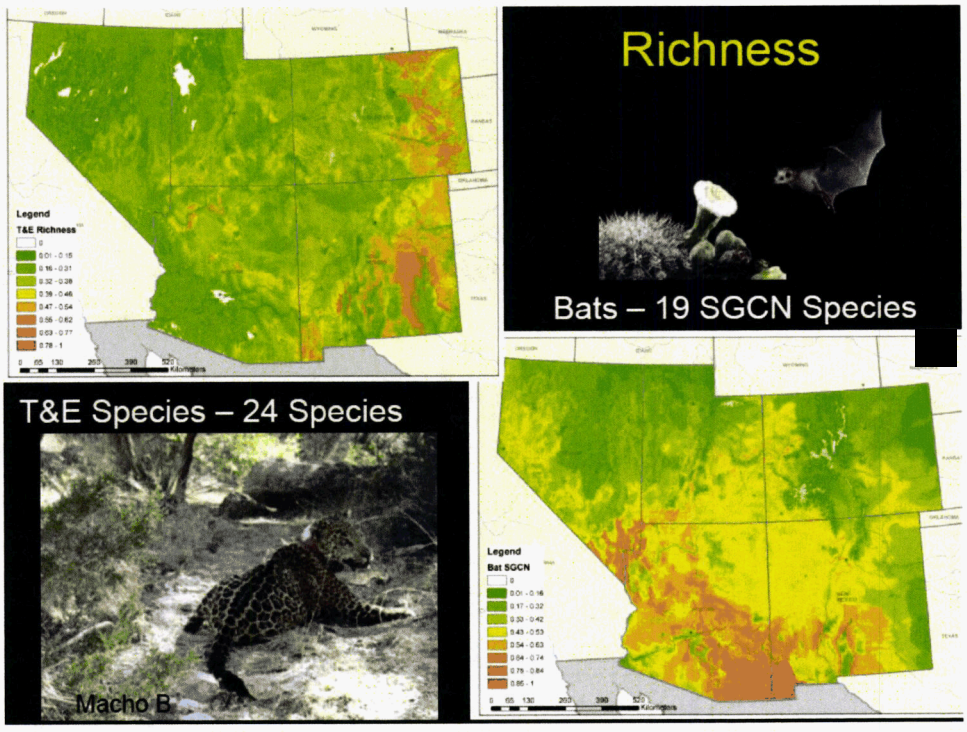




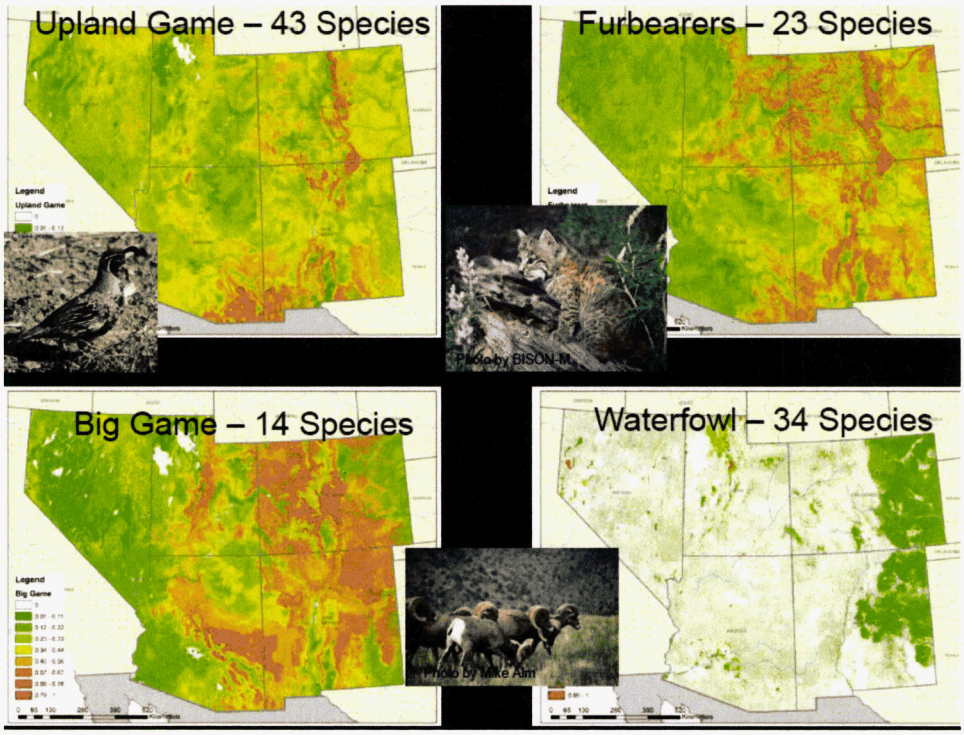
Page 16 of the PDF



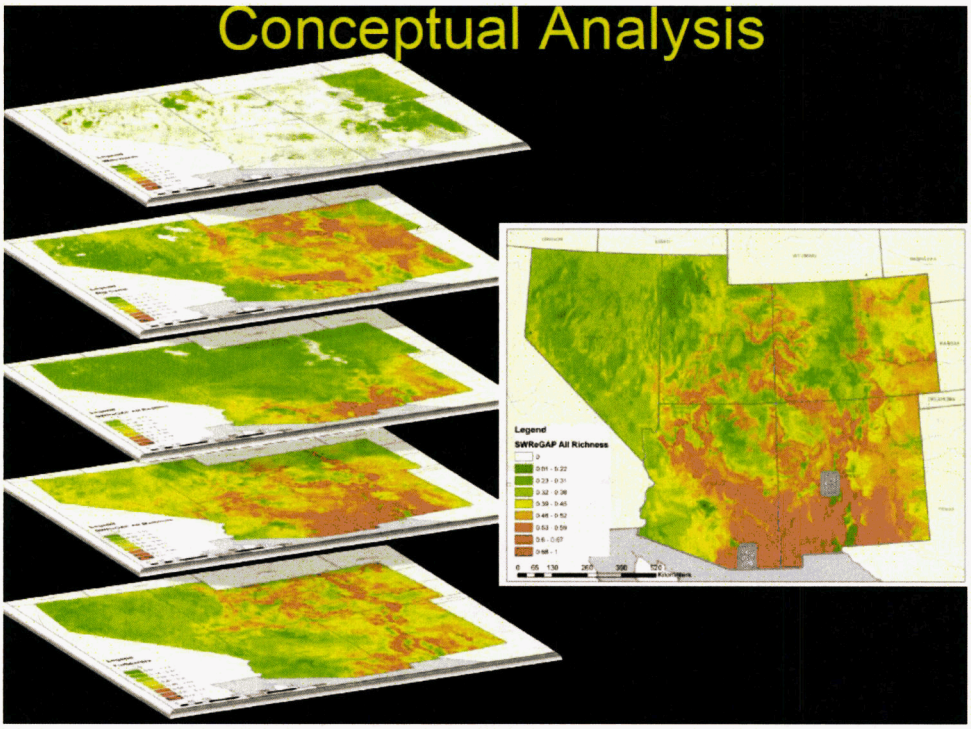
Page 17 of the PDF



Page 18 of the PDF

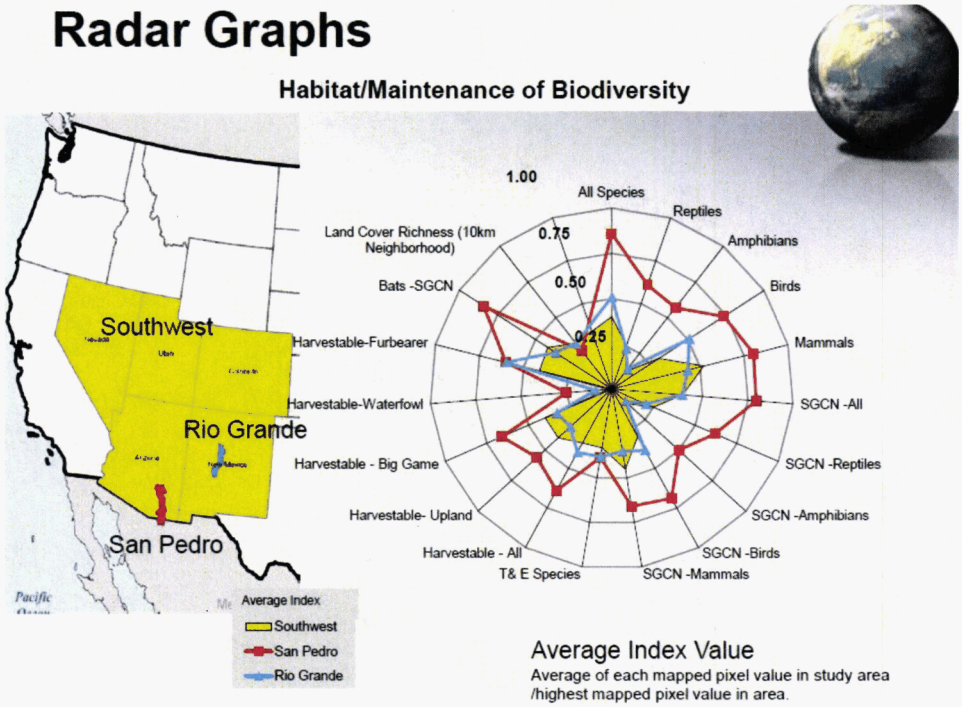


Page 20 of the PDF



Page 21 of the PDF

Radar Graphs

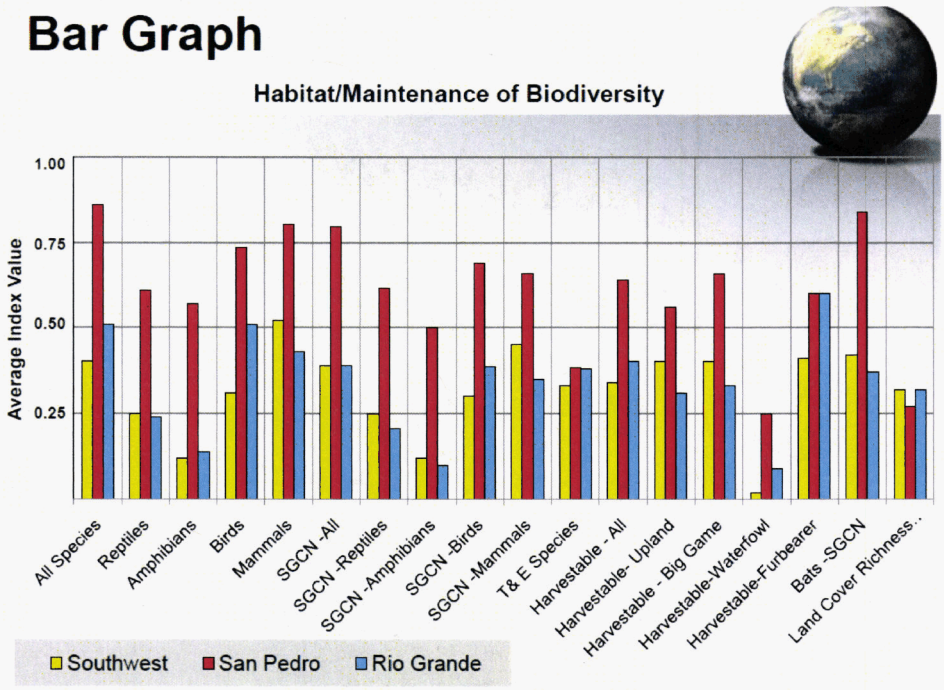


Average Index Value

Average of each mapped pixel value in study area /highest mapped pixel value in area.

Page 22 of the PDF

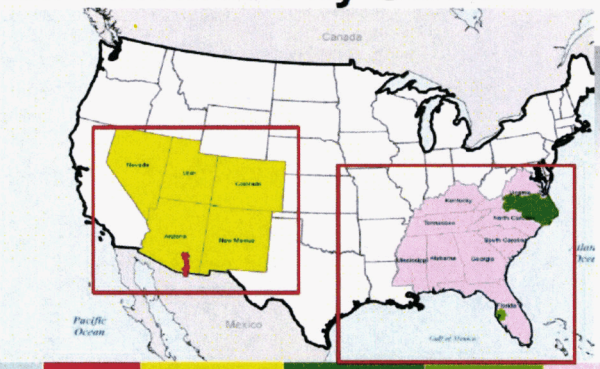
Bar Graph



Page 23 of the PDF

Page 24 of the PDF

Species Richness by Scale



* Preliminary Data

Taxon	San Pedro	Southwest	Albemarle Pamlico	Tampa Bay *	Southeast	Nation
Amphibians	16	37	40	9	124	310
Birds	287	435	155	192	259	719
Mammals	88	215	52	5	99	555
Reptiles	61	130	57	18	124	509
Total Species	452	817	304	224	606	2094

Page 25 of the PDF

General Conclusions

- Deductive modeling appears promising for mapping and quantifying metrics of habitat provisioning at multiple scales
  - Evaluating metrics (e.g., indices, species groups, keystone species, or guilds)
- First level effort and further work is underway
  - Application at national scale (USGS-GAP)
  - Ability to map wildlife as an Ecosystem Service (EPA)
- Provides reference conditions for alternative future scenarios (e.g. climate change, urbanization)
- Establish common sense *indicators of ES* for end-user and decision maker needs
  - Landscape Conservation Cooperatives
  - State Wildlife Action Plans
  - Local Initiatives (e.g. AGAVES)

Page 26 of the PDF

Contact Information

Kenneth G. Boykin
Center for Applied Spatial Ecology,
New Mexico State University,
New Mexico Cooperative Fish and Wildlife Research Unit
Las Cruces, NM
kboykin@nmsu.edu

William G. Kepner
David F. Bradford
Anne C. Neale
USEPA, Office of Research and Development
Las Vegas, NV and Research Park, NC
kepner.william@epa.gov
bradford.david@epa.gov

Kevin J. Gergely
USGS National Gap Analysis Program
Moscow ID

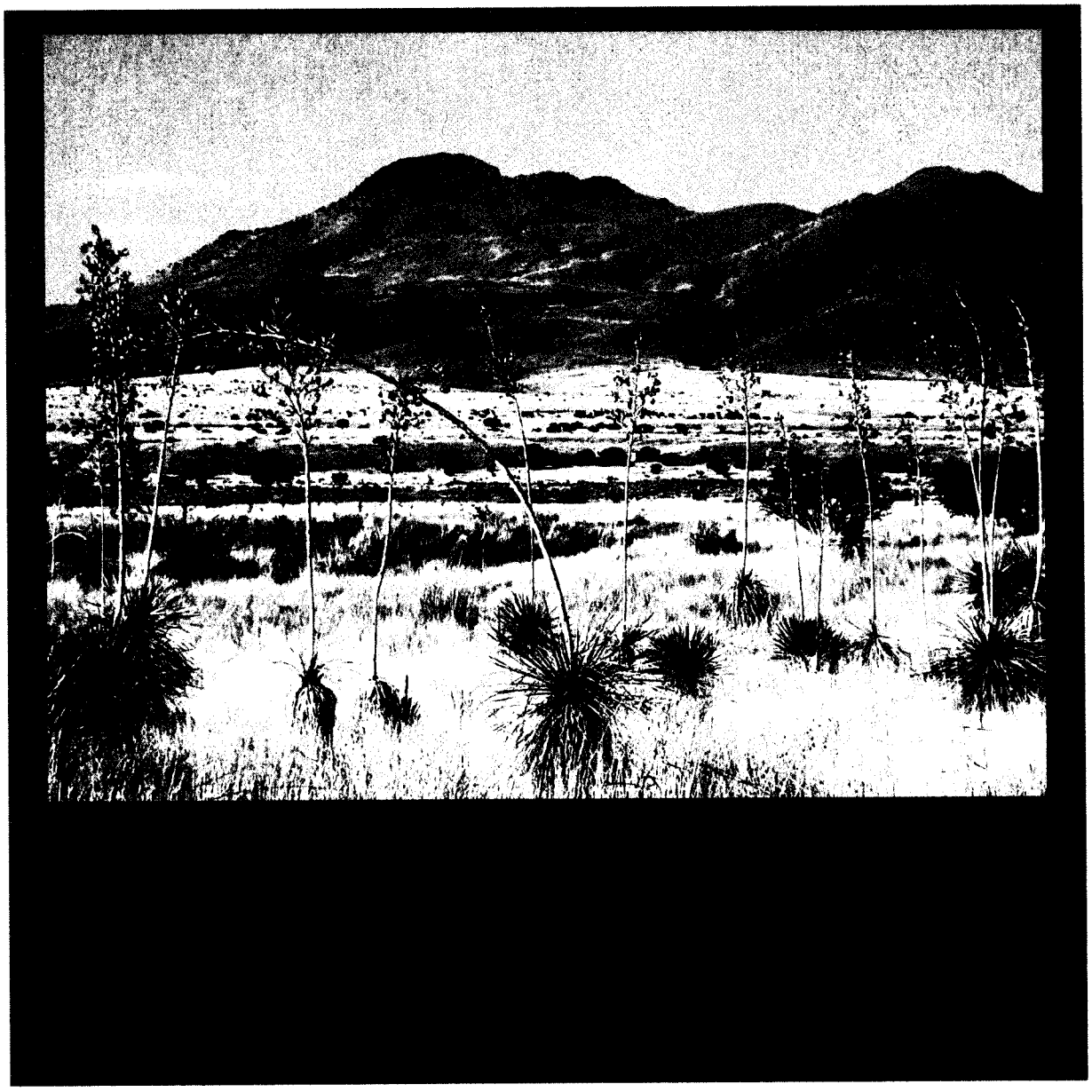
http://gapanalysis.nbii.gov
http://fws-nmcfwru.nmsu.edu/swregap/
http://www.epa.gov/nerlesd1/land-sci/gap.htm

DOCKET NO. L-00000YY-15-0318-00171-MCV_12

EXHIBIT
MCV-12
ADMITTED
PENGAD 800-631-6989

MADREAN ARCHIPELAGO RAPID ECOREGIONAL ASSESSMENT

EXECUTIVE SUMMARY



Contents

1 Executive Summary 4
1.1 Rapid Ecoregional Assessments: Purpose and Scope 4
1.2 Organization of the MAR REA Final Report 4
1.2.1 Common Terminology 4
1.3 The Assessment Region 5
1.4 Management Questions 6
1.5 Conservation Elements 7
1.6 Change Agents 8
1.7 REA Products and Results 10
1.7.1 Conservation Elements: Current Status 10
1.7.2 Current Ecological Integrity of the Ecoregion 13
1.7.3 Conservation Elements Future Risk 16
1.7.4 Recent and Future Climate Trends 17
1.7.4.1 Overall Climate Trends and Evaluation of Conservation Elements 19
1.7.4.2 Bioclimatic Envelope Modeling 19
1.8 Limitations and Applications 20
1.8.1 Conservation Element Distributions 21
1.8.2 Change Agent Distributions 21
1.8.2.1 Development, Invasive Species, and Fire 21
1.8.2.2 Climate Change Data 22
1.8.3 Modeling Methods 23
1.8.3.1 Conservation Element Status and Ecological Integrity Assessments 23
1.8.3.2 Climate Change: Bioclimatic Envelope Modeling 23
1.9 Potential Applications and Decision Support 23

Tables

Table 1-1. Ecological system conservation elements (CEs) selected for the Madrean Archipelago REA. 7
Table 1-2. Species conservation elements (CEs) selected for the Madrean Archipelago REA. 8

Figures

Figure 1-1. Map of the Madrean Archipelago REA assessment area. 6
Figure 1-2. Example of a development change agent. 9
Figure 1-3. Example of a KEA indicator scenario. 10
Figure 1-4. Current overall ecological status scores for the nectivorous bat assemblage 12
Figure 1-5. Overall ecological status scores for the North American Warm Desert Riparian Woodland, Shrubland, Mesquite Bosque and Stream CE (left) and graphs of frequency distribution (right). 13
Figure 1-6. Distribution (left) and integrity assessment results (right) of the Terrestrial Desert Scrub life zone in the Madrean Archipelago ecoregional assessment area. 14
Figure 1-7. Historical vs. current area of select terrestrial ecological systems for the entire MAR ecoregion. 15
Figure 1-8. Future ecological status scores for Apacherian-Chihuahuan Semi-Desert Grassland and Steppe. 17
Figure 1-9. Recent monthly trends in precipitation over last 30 years, compared to 20th century baseline. 18
Figure 1-10. Climate Change Exposure Index (CCEI), observed values. 19
Figure 1-11. Summary of modeled expansion, contraction, and stability for the geographic distribution of suitable climate conditions for Madrean Encinal. 20

1 Executive Summary

This executive summary describes the breadth of the entire Madrean Archipelago (MAR) Rapid Ecoregional Assessment (REA) and illustrates examples from all of the products. It does not summarize methods but instead focuses on products, key findings, and limitations. Because of the breadth and number of assessments, this summary is necessarily longer than a typical executive summary and is intended to give a brief but fairly complete picture of the MAR REA results.

1.1 Rapid Ecoregional Assessments: Purpose and Scope

Working with agency partners, the BLM is conducting rapid ecoregional assessments (REAs) covering approximately 800 million acres of public and non-public lands in 14 ecoregions and combinations of ecoregions in the American West. The goal of the REAs is to characterize the status of ecological resources and their potential to change from a landscape viewpoint. REAs are intended to serve BLM's developing Ecoregional Direction that links REAs and the BLM's Resource Management Plans and other on-the-ground decision-making processes. Ecoregional Direction establishes a regional roadmap for reviewing and updating Resource Management Plans; developing multi-year work for identified priority conservation, restoration, and development areas; establishing Best Management Practices for authorized use; designing regional adaptation and mitigation strategies; and developing conservation land acquisitions. While REAs produce information designed to be integrated into specific management processes, they are not decision documents and stop short of integrating the findings into management actions.

1.2 Organization of the MAR REA Final Report

This report for the Madrean Archipelago Rapid Ecoregional Assessment (MAR REA) conveys the objectives, methods, and results of the MAR REA. The report is arranged as the main report and a series of nine appendices:

A. Methods for Selecting and Evaluating Feasibility for Conservation Elements, Change Agents, and Assessments
B. Assessment Methods: Approaches and Rationales
C. Technical Methods: GIS Documentation
D. Terrestrial Ecological Systems: Conceptual Models and Ecological Status
E. Aquatic Ecological Systems: Conceptual Models and Ecological Status
F. Species: Conceptual Models and Ecological Status
G. Ecoregional Conceptual Model and Ecological Integrity Assessment
H. Mesquite Scrub Expansion: Restoration Opportunities
I. Climate Change: Assessment Methodology and Results

1.2.1 Common Terminology

Following are key terms and abbreviations used throughout the report; a complete listing of terms and abbreviations is found in the glossary and acronym list in Appendix E.

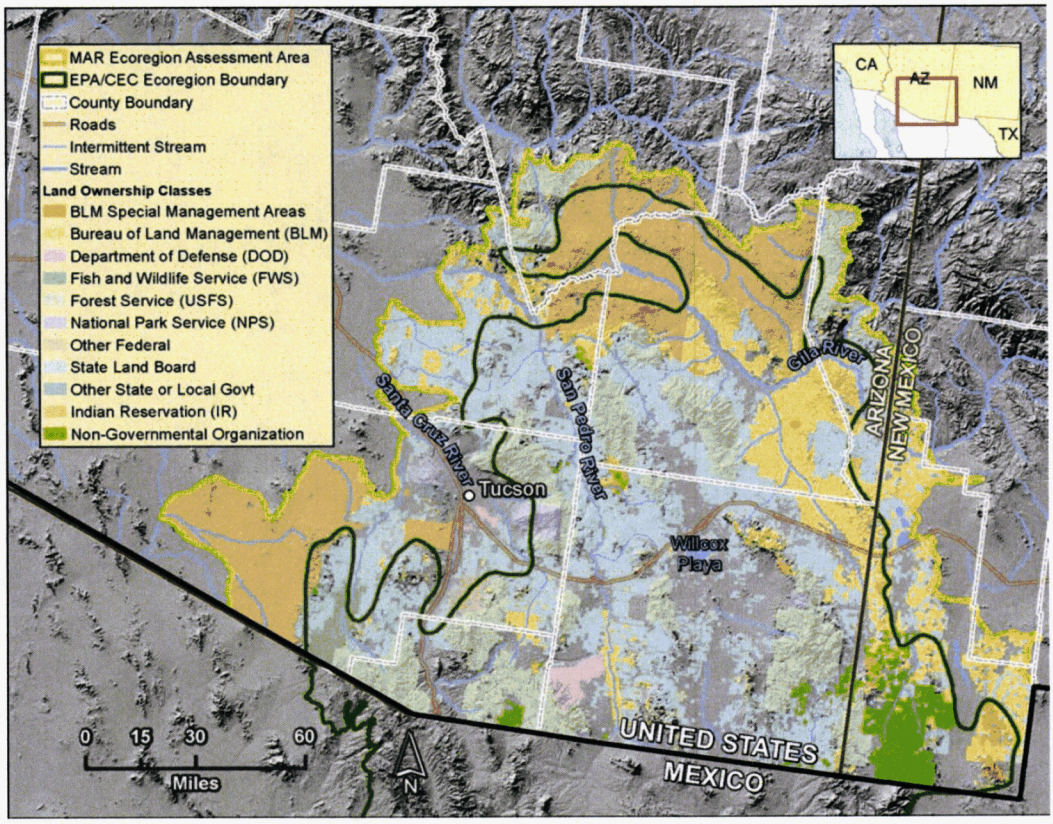
- **AMT**: **Assessment Management Team**. This is the team of BLM staff and participating partners in the region that provided review and guidance for the contractor throughout the REA.

- **CA**: **Change Agent**. These are the features or processes that can negatively impact **conservation elements** (and in some cases can have neutral or beneficial effects on certain CEs). Development, invasive species, fire, and climate change effects are the four primary change agents addressed in this REA.
- **CE**: **Conservation Element**. These are the natural resource features assessed in the REA and include terrestrial and aquatic ecological systems, species, and species assemblages.
- **CE conceptual model**: Conceptual models are the descriptive text and accompanying graphics that characterize the ecology and biology of the CEs, including descriptions of how change agents are expected to affect the **ecological status** or **condition** of CEs.
- **CE response model:** The set of numeric values that characterize the way a CE responds to direct exposure to a **CA** (site intensity value) and (optionally) within a specified distance from the CA.
- **Condition**: used interchangeably with **Status** (see below)
- **Ecological status (**or **Status):** formal term in BLM **REA**s to describe the **condition** or integrity of areas of distribution of a **CE** based on presumed effects of change agents on the CE.
- **EIA**: ecological integrity assessment used to indicate the overall integrity or condition of the ecoregion as a whole.
- **Indicator**: Biophysical attributes that are used either directly or indirectly to measure the status of the **KEA**s, and therefore of the CEs.
- **KEA**: **Key Ecological Attribute**. A KEA is a characteristic of a species' or ecosystem's biology, ecology, or physical environment that is critical to the resource's persistence in the face of both natural and human-caused disturbance. The combined **status** or **condition** of KEAs for a CE together determine the overall **ecological status** of the CE.
- **KEA indicator scenario (**or **Scenario)**: The aggregation of **CA** distribution maps used to assess the **indicators** associated with each of the **KEAs** for each of the CEs. The scenarios are input into the **LCM**.
- **Landscape Condition Model** (**LCM**): the geospatial modeling tool used to calculate the **ecological status** of CEs and conduct other related assessments (e.g., ecological integrity of the ecoregion). The **CE response models**, **KEA indicator scenarios**, and **CE** distribution maps are the key inputs that are run through the **LCM**.
- **MAR**: **Madrean Archipelago Ecoregion**, specifically referring to the U.S. portion assessed in this REA.
- **MQ**: **Management Question**. These are questions developed by BLM and gathered during the REA that are important for guiding natural resource management and land use decisions. The **ecological status** assessments of CEs and other assessments conducted in the REA provide information and analysis results to help address the management questions.
- **REA**: **Rapid Ecoregional Assessment**
- **Status:** See **Ecological Status** above.

1.3 The Assessment Region

The U.S. portion of the Madrean Archipelago ecoregion, including its intersecting 5th-level watersheds, was assessed in this REA. The REA assessment area encompasses approximately 6.4 million hectares (15.7 million acres). Within the assessment region, total BLM ownership is 1,009,375 ha (2,494,222 ac) or about 16% of the area and 38,382 ha (94,846 ac) is in BLM special management or 0.6% of the MAR.

Figure 1-1. Map of the Madrean Archipelago REA assessment area. The area assessed for this REA is the U.S. portion of the Madrean Archipelago plus its intersecting 5th-level watersheds, shown in the yellow outline and by the border between the U.S. and Mexico. The Madrean Archipelago ecoregion is shown by the solid green line and extends into Mexico beyond the map extent.



1.4 Management Questions

In this REA, natural resources management questions (MQs) and issues were identified by various agencies participating in the REA process. These MQs were iteratively reviewed and distilled into a discrete set of potential assessments and evaluated for appropriatness for an REA and feasibility. Relevant available datasets needed to answer the MQs were identified and evaluated, and proposed analytical steps were summarized for conducting the identified assessments. Based on management needs, data availability and suitability, and technical feasibility of the proposed analyses, the pool of potential assessments was narrowed to the following:

- Ecological Status of CEs (current)
- Ecoregional Ecological Integrity (current)
- Climate Space Trends (recent)
- Climate Space Trends (future)
- CE Distributions Intersected with Future Climate

- Bioclimate Envelope Models
- 2025 Risk Assessment (for three case study CEs)
- Mesquite Scrub Expansion: Restoration Opportunities
- Soil Erosion Potential

1.5 Conservation Elements

Conservation elements (CEs) are one of the core components of the REA. They are the natural resources – ecosystems and species (inclusive of species assemblages) -- that are the focus of the assessment. Ecological system and species CEs were selected through an iterative review process based on the following criteria and considerations:

- Regional significance
    - Relevant to more than one BLM field office or other agency's local management jurisdiction (ecosystems and species)
    - Dominant in the ecoregion (ecosystems)
    - Broadly represent a cross-section of the region's diversity (ecosystems and species)
    - Endemism (ecosystems and species)
- Nexus with identified management issues (ecosystems and species)
- Representation by associated ecological system CE (i.e., species that would add to, rather than being duplicative of, ecosystem CEs)

This resulted in the identification of 18 CEs that were the focus of the assessments in this REA (see Table 1-1 and Table 1-2). In addition, a significant portion of the ecoregion (~19%) is occupied by Apacharian-Chihuahuan Mesquite Upland Scrub, an ecological system that has greatly expanded primarily through mesquite expansion into grassland areas. This system is treated separately from the other 18 conservation elements (via the Mesquite Scrub Expansion assessment listed above) because managers desired information about restoration opportunities rather than a generalized status assessment of this ecosystem type.

Table 1-1. Ecological system conservation elements (CEs) selected for the Madrean Archipelago REA. The ecological systems are organized in this table according to the four major system divisions or groupings (valley upland system, montane upland system, connected stream and wetland, and isolated wetland) from the ecoregion conceptual model. Apacharian-Chihuahuan Mesquite Upland Scrub is a non-natural ecological system that has greatly expanded primarily through mesquite expansion into grassland areas.

Valley Upland System Division	**56.0%**
Apacherian-Chihuahuan Mesquite Upland Scrub	19.5%
Chihuahuan Creosotebush Desert Scrub	13.2%
Apacherian-Chihuahuan Semi-Desert Grassland and Steppe	18.2%
Madrean Encinal	5.1%
Montane Upland System Division	**13.4%**
Madrean Pinyon-Juniper Woodland	5.8%
Montane Conifer-Oak Forest and Woodland	2.8%

Mogollon Chaparral	4.8%
Isolated Wetland System Division	**<1%**
North American Warm Desert Playa and Ephemeral Lake	<1%
Connected Stream and Wetland System Division	**4.3%**
North American Warm Desert Riparian Woodland and Shrubland, Mesquite Bosque and Stream	3.3%
North American Arid West Emergent Marsh/Ciénega and Pond	1.0%
North American Warm Desert Lower Montane Riparian Woodland and Shrubland and Stream	<1%

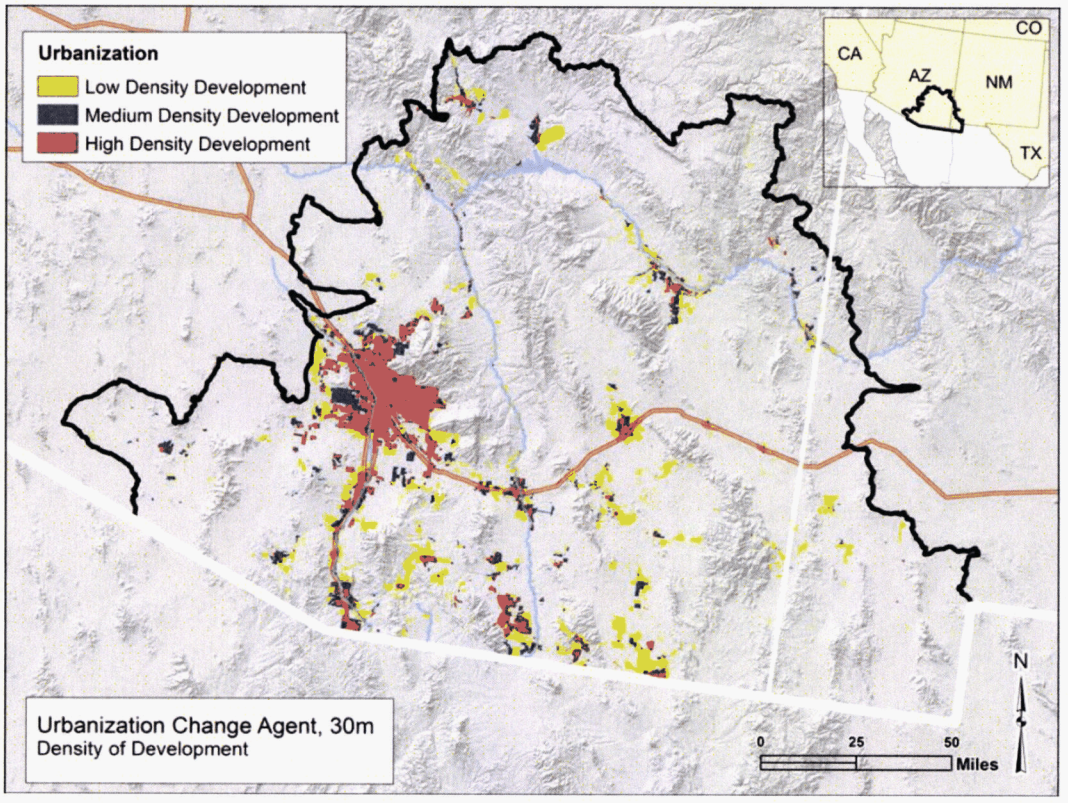
Table 1-2. Species conservation elements (CEs) selected for the Madrean Archipelago REA. Includes current state or federal endangered listing status.

Mammal	Pronghorn (*Antilocapra americana*)	None
Mammal	Coues white-tailed deer (*Odocoileus virginianus couesi*)	None
Mammal	Desert bighorn sheep, all subspecies (*Ovis canadensis*)	None
Mammal	Nectar-feeding bats	See conceptual model
Mammal	Black-tailed prairie dog (*Cynomys ludovicianus*)	None
Bird	Grassland bird assemblage	See conceptual model
Reptile	Ornate box turtle (*Terrapene ornata luteola*)	None
Amphibian	Chiricahua leopard frog (*Lithobates chiricahuensis*)	Federally Threatened, Arizona Threatened

1.6 Change Agents

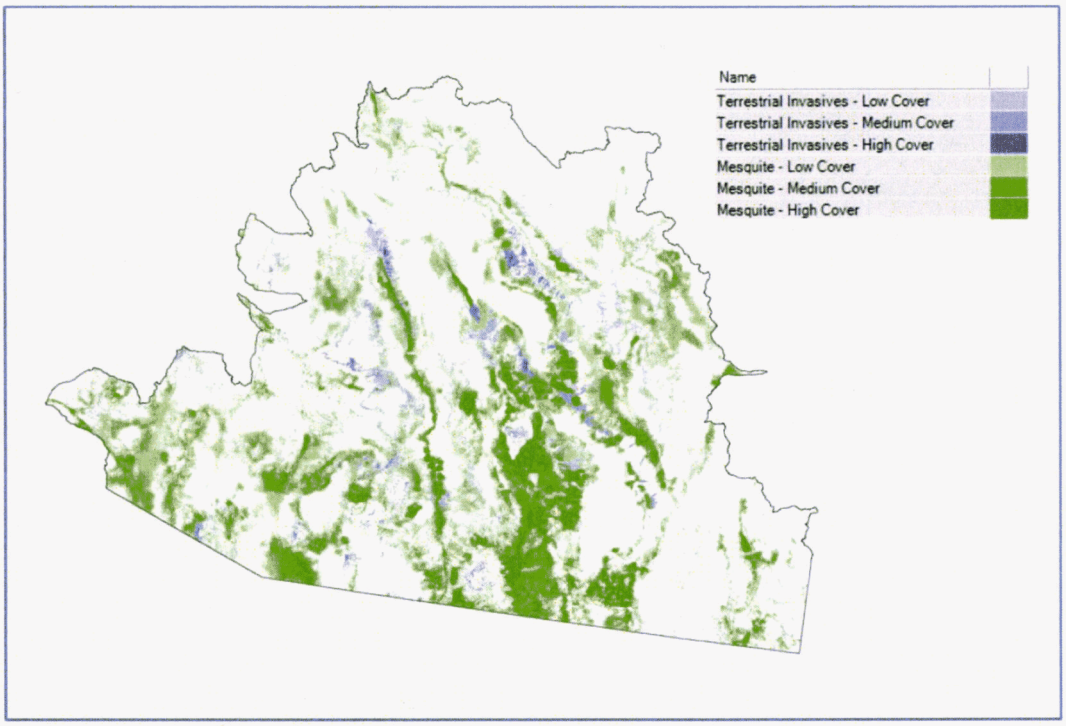
Change agents (CAs) are those anthropogenically-driven or -influenced land uses, activities, or phenomena that can affect the ecological status or condition of conservation elements. They are drawn from the standard REA change agent categories of development, climate change (described in greater detail below), invasive species, and wildland fire (fire). Development is a particularly broad category that includes any direct human use, activity, or infrastructure on the landscape, such as agriculture, border patrol activities, roads, urban development, or energy development, among many others. The invasive species CA includes invasive non-native species, managed non-native species (e.g., sport fish, game animals), and native woody increasers (such as mesquite). Figure 1-2 provides an example of a development CA; all individual CA maps can be viewed on the BLM REA GIS portal.

Figure 1-2. Example of a development change agent. The urbanization change agent comes from a model of urban density ICLUS SERGoM generated by EPA.



There were no direct assessments made of change agents in isolation (i.e., without interactions with CEs, other than climate change trends). Instead, change agents were incorporated into a series of "KEA indicator scenarios" (scenarios) that represent indicators of conservation element Key Ecological Attributes (see example Figure 1-3). These scenarios were used to model the current status of the conservation elements, the 2025 future landscape condition (development-caused) status of three case study conservation elements, and model the current ecological integrity of the ecoregion as a whole (see sections below). Additionally, more speculative modeled urban development for the 2025 timeframe is graphically overlaid on the case study conservation elements and solar potential maps are presented alone to indicate where future risks to conservation elements may occur (see section 1.7.3).

Figure 1-3. Example of a KEA indicator scenario. The invasive species indicator scenario is comprised of invasive species change agents represented at different levels of density that could be associated to different levels of impact to the KEA indicator.



The climate change assessment addresses climate exposure across the MAR by analyzing recent and future climate trends and their estimated influence on conservation elements (CEs). The recent and future climate trend analysis examines spatial and temporal patterns of change in a range of climate variables. Multiple trend detection statistics were employed to quantify the distribution and magnitude of recent climate change, as well as future changes projected by a suite of six global climate models run under the A2 greenhouse gas emissions scenario. Additionally, bioclimatic envelope modeling explores how projected future climate change may affect the distribution of suitable climate conditions for several ecological communities of the MAR. This approach estimates suitable climate conditions for a given CE and projects where those suitable conditions are likely to occur in the mid-century future.

1.7 REA Products and Results

1.7.1 Conservation Elements: Current Status

Current ecological status was assessed for five terrestrial upland CEs, four aquatic CEs, five species and two species assemblage CEs. Each indicator for each key ecological attribute was assessed individually for each CE; the indicators were then combined to calculate the overall ecological status for each CE. The individual indicators and overall ecological status were assessed at 30 m resolution and then the overall status was averaged across reporting units to show broader patterns of overall ecological status

for each CE (see example of both resolution products for the nectivorous bat assemblage CE, Figure 1-4). Additionally, a frequency graph of status by reporting unit is provided for each CE that illustrates the proportion of the CE area in which range of status values (e.g., in Figure 1-5, the bulk of the CE's distribution is in relatively low status).

Generally across the three groups of CEs, similar patterns were observed in the assessment results. First, while development activities can have major, local-scale impacts; most development occurs in, and hence has impacts upon, lower elevation areas including valleys, floodplains, or in the foothill zones. Therefore, it is generally a minor driver of the status results for the CEs found at higher elevations. Effects of development on CE distributions close to heavily populated or developed areas are evident in the ecoregion-wide maps. Effects of the many small roads and highways, which are pervasive throughout the area, are difficult to visually discern in the maps. Their impacts on status locally are evident when zoomed into specific areas and these smaller, pervasive impacts do contribute to ecoregional status results.

Secondly, altered fire regimes are affecting most areas of the ecoregion. All of the terrestrial upland ecosystems have significant portions of their distribution in either moderate or severe departure categories from historical fire regimes. Most of the species also have poor ecological status across much of their distribution due to the fire regime indicator.

Third, invasive species, both in the upland and aquatic realms, are a significant problem at middle to lower elevations of the ecoregion. The data for the invasives indicators was generally of poor to moderate quality, but the patterns are similar across all three groups of CEs. Lower elevations (i.e. not in the mountain ranges) are impacted by invasives, while the higher montane elevations are much less affected. These results are not unanticipated; invasion by mesquite (*Prosopis* spp.), exotic grasses and forbs, tamarisk (*Tamarix* spp.) or Russian olive (*Elaeagnus angustifolia*) and exotic aquatic animal species, is well documented for this ecoregion and known to be a growing issue.

Lastly, water use is one of the greatest stressors affecting aquatic CEs in the Madrean Archipelago ecoregion, especially at lower elevations. While the water use data used in this assessment are spatially coarse, the effects of high water usage can be severe and cause stress to the plants and animals dependent upon aquatic ecosystems and their associated riparian or wetland vegetation. The abbreviation "AMA" designates a basin identified as an "Active Management Area" for groundwater resources under Arizona water law. The areas of high rates of water use are all basins in Arizona with either dense municipal development (Tucson "AMA") or large areas of intensive irrigation (Pinal "AMA," Douglas and Willcox basins). Figure 1-5 illustrates the 30 m overall ecological status for one of the aquatic CEs, as well as its ecological status averaged across the watershed reporting units.

Figure 1-4. Current overall ecological status scores for the nectivorous bat assemblage for each 30m pixel (top) and 4km grid cells (reporting units, bottom). LCM = landscape condition model. Yellow scores (equivalent to 0) indicate high impacts from the CAs and correspondingly lower ecological status, dark blue (equivalent to 1) indicate little to no impact from the CAs and correspondingly higher ecological status. In the second map, the score for each 4km cell is an average of the overall ecological status scores of the 30m pixels within the 4km cell that were were scored for the CE.

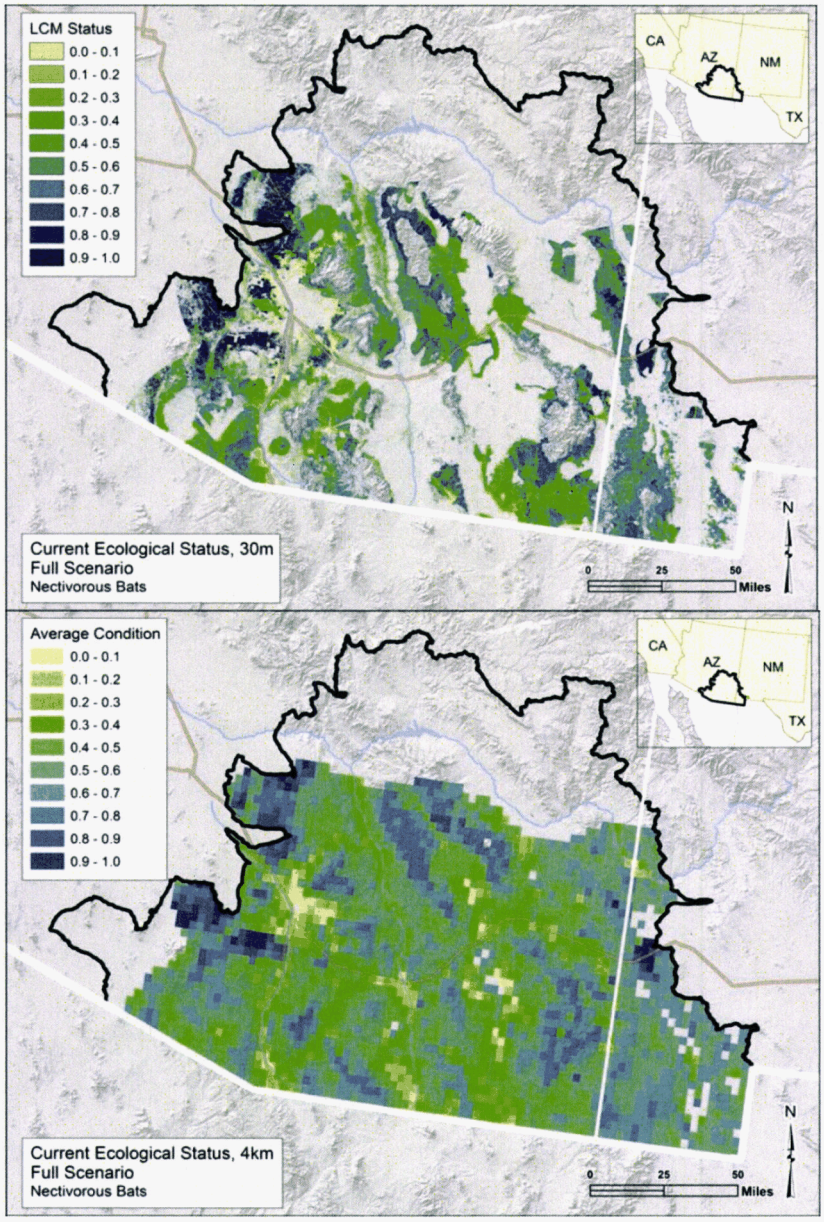
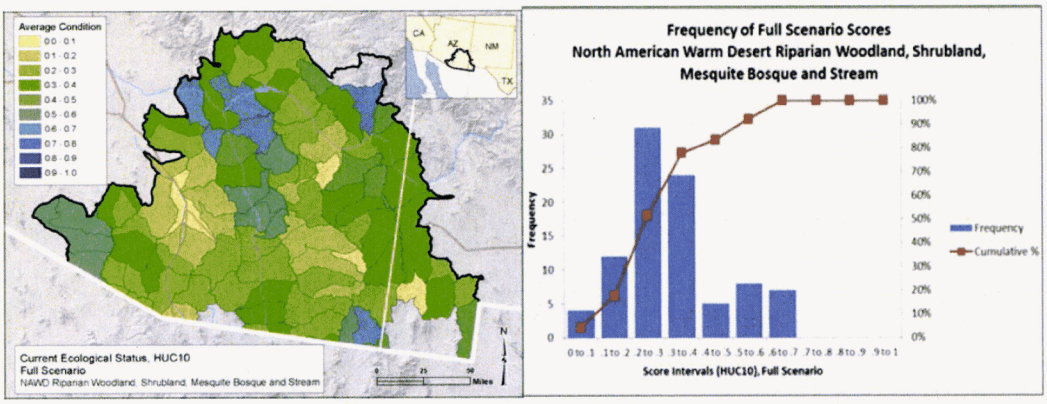


Figure 1-5. Overall ecological status scores for the North American Warm Desert Riparian Woodland, Shrubland, Mesquite Bosque and Stream CE (left) and graphs of frequency distribution (right). Ecological status scores were averaged across 5th-level watersheds for the CE. A companion graph indicates the frequency distribution of ecological status scores for the CE. The x-axis represents the 0.1 increment scoring intervals, while the y-axis shows the number of watersheds in each interval (left) and the cumulative percentage of the grid cells for each interval (right).

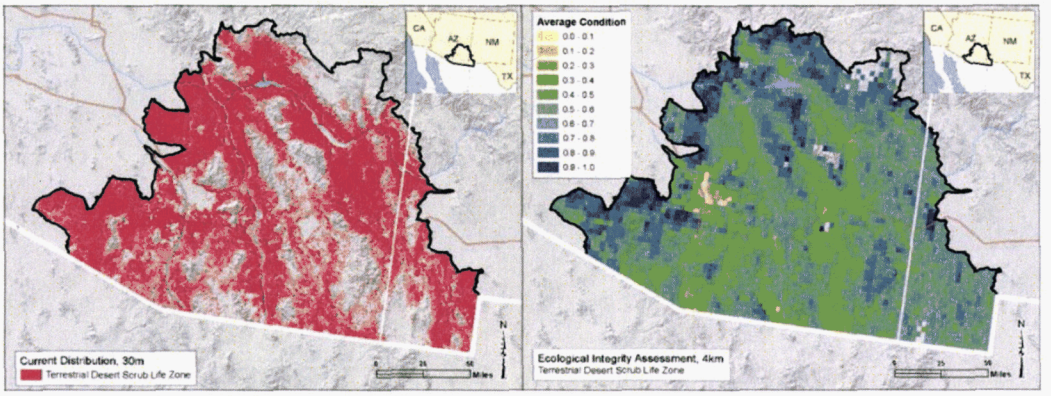


1.7.2 Current Ecological Integrity of the Ecoregion

Ecological integrity assessment characterizes the overall status or condition of the ecoregion. For the MAR, integrity was assessed for five life zones that incorporated the CEs but provided ecoregion-wide coverage: two for the aquatic realm (montane and lowland) and three for the uplands (montane, valley and desert). An additional analysis calculated the change in extent of distribution for upland ecological systems from historical distribution to current.

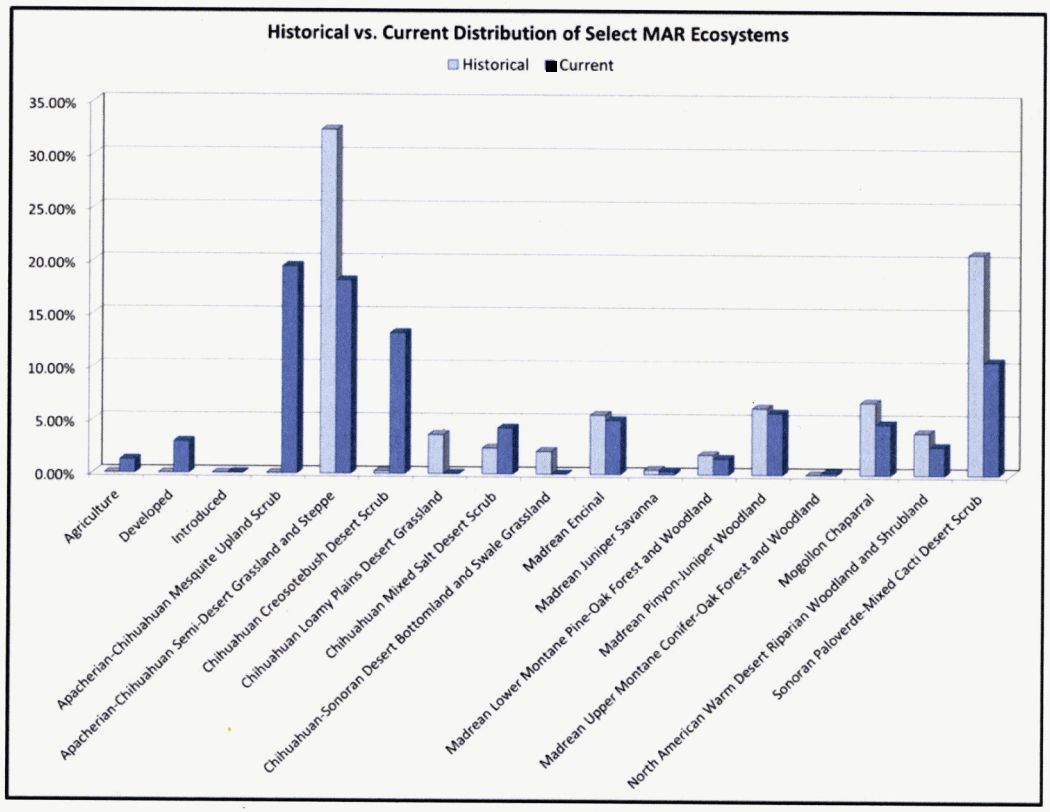
For the five life zones, the results for the ecological integrity assessment of the ecoregion show similar patterns to those for the CEs. In general, the higher elevation regions have better ecological integrity, a result of less development and fewer invasive species, although fire regime departure is significant in all of the upland life zones. The Desert Scrub life zone has poor to moderate ecological integrity for much of its distribution, a result of fire regime alterations and proximity to heavily developed areas (Figure 1-6). In contrast, much of the Montane Forest life zone has moderate to good ecological integrity (less development or invasives species). However, altered fire regimes are a real issue throughout much of the montane zone. The Valley Grassland life zone has low ecological integrity across much of its distribution. This life zone suffers from effects of all three indicators- extensive development impacts, invasive species including mesquite, and moderately to severely altered fire regimes. Only a few areas in the northern portions of the ecoregion have good integrity.

Figure 1-6. Distribution (left) and integrity assessment results (right) of the Terrestrial Desert Scrub life zone in the Madrean Archipelago ecoregional assessment area. The map on the left shows the combined distributions of 13 terrestrial ecological systems which comprise the distribution of this life zone. The map on the right illustrates integrity results for all three indicators: development, fire regime departure, and invasive species, which were combined into a single ecological integrity score for each 4km^2 grid cell. Yellow scores (equivalent to 0) indicate high impacts from the CAs, dark blue (equivalent to 1) indicate little to no impact from the CAs.



The results of the change in extent analysis from historical to current area of terrestrial ecological systems show major compositional changes have occurred that have resulted in type conversion (i.e. from one ecosystem to another) and resultant changes in extent (Figure 1-7). Mesquite Upland Scrub has expanded substantially (0% to 20%), as has Chihuahuan Creosotebush Desert Scrub (0.5% to 13%) with subsequent large declines in all of the grassland ecological systems (Apacherian-Chihuahuan Semi-desert Grassland and Steppe (32% to 18%), Chihuahuan Loamy Plains Desert Grassland (4% to nearly 0%), Chihuahuan Bottomland and Swale Grassland (2% to nearly 0%). In addition there has been a large decline in the extent of Sonoran Paloverde-Mixed Cacti Desert Scrub (21% to 11%), largely due to urban expansion from Tucson and surrounding areas and conversion to other desert scrub systems. There are only modest amounts of conversion from natural vegetation due to increases in post-European settlement (as a proportion of the ecoregion area) such as agriculture (to 1.3%) and development (to 3%).

Figure 1-7. Historical vs. current area of select terrestrial ecological systems for the entire MAR ecoregion. The y-axis presents the percent of the MAR study area of the mapped historical (light shade) or current (dark shade) extent of each ecological system or land cover type. Historical distribution was derived from the Landfire biophysical settings map and current distribution from the NatureServe terrestrial ecological systems map, which is based upon the land cover mapping of SW ReGAP.



The Aquatic Lowland life zone has reduced ecological integrity primarily because of water use and development whereas the Aquatic Montane life zone has much better integrity. For the Lowland life zone, areas surrounding, and waters within, the Gila River downstream from the San Simon River confluence, most of the San Pedro River, and most of the Santa Cruz River south of Tucson show high levels of impact from development, water use, and invasive species. The most altered watersheds are located in the areas of Safford, Willcox, and the Tucson metropolis, AZ. The least altered watersheds occur in the far west-southwestern corner of the ecoregion assessment area west and south of Sells, AZ (in the buffer area of the ecoregion); in the northern third of the lower San Pedro River basin; in the lower San Francisco River basin; and surrounding San Bernardino National Wildlife Refuge. Watersheds in the Aquatic Montane life zone occur in areas that are generally not impacted by significant groundwater withdrawal and surface water diversions, nor are they as heavily exposed to development.

1.7.3 Conservation Elements Future Risk

Inadequate data were available to conduct complete status assessments of the CEs for the 2025 timeframe equivalent to those done for the current (2014) assessments. However, a variety of data representing potential areas of development change agents for near future timeframes were available. Therefore, only the development indicator was assessed for the 2025 timeframe for each of the three case study CEs (see example Figure 1-8) to provide a limited picture of potential ecological status in 2025. In addition, the case study CE distribution maps were overlaid with a "risk map" of potential urban expansion areas to further inform areas and CEs at risk. Solar energy potential maps are provided but not overlaid on the CE distributions because of their broad distribution, but they can be overlaid with any CE via BLM's GIS portal found at http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas/dataportal.html.

Comparing the development indicator scores for the current timeframe to the 2025 development-based ecological status scores, the observable differences are subtle at the ecoregion scale and are primarily driven by urban expansion in the central and southwest portions of the ecoregional assessment area and around Tucson and the SunZia and Southline planned transmission corridors. For the aquatic ecosystem assessed, the impacts from proposed development appear negligible.

The extent of future development currently planned, modeled, or with fairly high potential for action by 2025 is relatively small compared to the ecoregion extent. Therefore, separate assessments would need to be conducted to characterize localized effects of individual projects. The SunZia and Southline electrical transmission corridors bisect the entire ecoregion and numerous occurrences for several CEs. No Solar Emphasis Zones were designated in the BLM Solar PEIS in the Madrean Archipelago Ecoregion, but there is some solar development on non-federal lands. There are extensive areas of federal lands delineated as variance areas where, through careful planning, facilities could be located on certain federal lands.

EXHIBIT
PENGAD 800-631-6989
MCV-13
ADMITTED

Economic Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

Tucson Audubon Society

TUCSON AUDUBON SOCIETY
conservation
education
recreation

Economic Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

© 2013 Tucson Audubon Society

300 E University Blvd, Suite 120
Tucson, AZ 85705
tucsonaudubon.org

Recommended citation / reference: Tucson Audubon Society: The Economic Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis. 2013. Southwick Associates / Arizona Game & Fish Department.

Analysis and report prepared by Southwick Associates, May 1, 2013

SOUTHWICK ASSOCIATES
FISH AND WILDLIFE ECONOMICS AND STATISTICS
BETTER INFORMATION. BETTER DECISIONS

Funded by a grant from Arizona Game & Fish Heritage Fund

Heritage Fund

INTRODUCTION

This report assesses the 2011 economic contributions of watchable wildlife recreation in Arizona, statewide, by county and by specific types of activity. Direct spending by both residents and non-residents for wildlife watching was analyzed, along with the multiplier effects of that spending. Only watchable wildlife activities that occurred within Arizona were considered.

This report updates an earlier study produced by Southwick Associates that estimated the economic contributions of wildlife watching in 2001.[1] This updated study is based on raw survey data from the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.[2] The national survey provides detailed state-level spending estimates. The statewide impacts in this report are allocated to individual counties according to county distributions in the 2001 study. The 2001 county estimates were based in part on a separate survey designed specifically to estimate county-level participation in wildlife watching. A detailed description of the methodology used to estimate the impacts in this report is provided in Appendix B.

STATEWIDE RESULTS

Wildlife-related recreation includes activities that occur around the home (residential) and away from home (nonresidential). In 2011, there were 732,343 watchable wildlife recreationists (residents and non-residents) who participated in non-residential (away from home) activities in Arizona. In addition, there were 1,221,654 residents participating in residential activities (around the home) in Arizona. Non-residential activities are those performed at least one mile from an individual's home. Conversely, residential activities are those performed within one mile of an individual's home. Overall, 1.6 million people participated in some form of residential or non-residential watchable wildlife recreation in Arizona in 2011.

Demographics

Only a small percentage of watchable wildlife recreationists in Arizona, both non-residential and residential, report they are non-white (Table 1). Participants are near fifty, are split fairly evenly between male and female, though more nonresidents are male. Resident participants are more likely to be married than nonresident participants. The average household income for residents participating in non-residential and residential activities is similar. Non-residents have, on average, a household income higher than resident participants. Both have incomes higher than the 2011 state average ($48,621, per U.S. Census Bureau). As with income levels, the education levels of residents who participate in residential and non-residential activities are similar, however non-residents have, on average, a higher level of education.

[1] Southwick Associates, "Economic Impact Analysis of Non-consumptive Wildlife-Related Recreation in Arizona", May 2003.
[2] U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau, 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Table 1. Demographic background of watchable wildlife recreationists in Arizona in 2011 (Participants 16 years old and older)

	Nonresidential Activity		Residential Activity
	Resident	Nonresident	
Average age	46.2	52.0	51.0
Gender (male)	53.8%	49.8%	44.5%
Marital Status (married)	56.7%	43.4%	56.8%
Average household Income	$62,364	$68,469	$58,721
Race			
White	91.9%	100.0%	90.7%
Black	2.7%	0.0%	1.0%
Other race	5.5%	0.0%	8.3%
Hispanic	11.1%	0.4%	19.1%
Education			
8 years or less	1.3%	0.0%	3.1%
9-11 years	0.0%	5.9%	3.1%
12 years	24.1%	20.0%	22.1%
1-3 years college	30.1%	24.6%	25.7%
4 years college or more	44.5%	49.6%	46.0%
Sample size	65	31	164

Participation

Watchable wildlife recreation includes a broad range of activities. To help describe the types of activities undertaken by residents and non-residents, and to better understand the types of wildlife they enjoy and the surroundings preferred, we present the following participation information. Participation information is divided into two subsections. The first subsection explores non-residential activities by residents and non-residents. The second subsection examines residential activities.

Non-Residential Participation

In 2011, there were 732,343 watchable wildlife recreationists (residents and non-residents) participating in non-residential activities in Arizona (Table 2). Of the total recreationists in Arizona, 443,111 were state residents and 289,232 were non-residents. The total number of watchable wildlife recreation days in Arizona was 11.9 million.

Table 2. Participation in Non-residential Watchable Wildlife Recreation by Site Visited and Wildlife Observed, Fed, or Photographed in Arizona in 2011 (Participants 16 years old and older, ranked)

	Resident	Nonresident	Total
Number of participants	443,111	289,232	732,343
Number of recreationists visiting:			
private land	106,473	193,431	299,904
public land	428,913	225,482	654,395
Number of recreationsts observing, feeding, photographing:			
birds	367,282	202,876	570,159
birds of prey	351,201	187,311	538,512
waterfowl	198,230	111,916	310,146
shorebirds	96,607	70,538	167,145
songbirds	272,038	125,088	397,126
other birds	206,745	168,141	374,887
mammals	304,485	165,620	470,105
large land mammals	232,326	161,664	393,990
small land mammals	209,487	137,946	347,433
fish	100,571	79,066	179,637
other wildlife	168,746	141,346	310,092

Note = a participant may be counted towards more than one category above

Residential Participation

In 2011, there were 1,221,654 residential watchable wildlife participants in Arizona (Table 3). This number represents Arizona residents participating in watchable wildlife recreation within one mile of their home. Compared to non-residential activity, there are nearly three times as many residents who participate in wildlife watching within one mile of their homes than those who travel away from home.

Table 3. Participation in Residential Watchable Wildlife Recreation in Arizona in 2011 (Participants 16 years old and older, ranked)

Number of participants	**1,221,654**	**(100.0%)**
observing wildlife	907,209	(74.3%)
photographing wildlife	533,627	(43.7%)
feeding birds & wildlife	796,116	(65.2%)
birds	772,679	(63.2%)
other wildlife	197,697	(16.2%)
visiting parks near home	226,818	(18.6%)
maintaining natural areas around home	94,558	(7.7%)
maintaining plantings around home	203,450	(16.7%)
Number of days		
observing wildlife	103,891,759	
photographing wildlife	8,504,168	

Note = a participant may enjoy more than one type of wildlife listed above

The primary residential watchable wildlife activity, measured in terms of number of participants in Table 3, was observing wildlife. Feeding wildlife was the second most popular residential watchable wildlife activity. This is in similar to the ranking of the non-residential activities, where observing wildlife was also the most popular activity away from home.

The number one type of wildlife observed by residential recreationists in Arizona was birds (Table 4). The second most prominent category to be observed by residents was mammals, with most of these being small mammals. These results do not necessarily imply that recreationists prefer to observe a certain wildlife type because the results reflect participants' preferences and the availability of wildlife types.

Table 4. Participation in Residential Watchable Wildlife Recreation by Wildlife Observed in Arizona in 2011 (Number of Participants 16 years old and older, ranked)

Number of recreationists		
birds	840,241	(68.8%)
mammals	565,885	(46.3%)
large mammals	213,858	(17.5%)
small mammals	520,203	(42.6%)
amphibians or reptiles	374,283	(30.6%)
insects or spiders	393,060	(32.2%)
fish & other wildlife	99,121	(8.1%)

Note = a participant may enjoy more than one type of wildlife listed above

Retail Sales

The expenditure figures in Table 5 describe the total statewide retail sales generated from 2011 watchable wildlife recreation within specific categories of goods and services. Regarding trip expenditures, residents spent the largest amount on private transportation ($90.5 million) followed by food, drink and refreshments ($78.2 million). Non-residents, on the other hand, spent the most on food, drink and refreshments ($63.9 million), followed private transportation ($47.1 million).

The largest equipment expenditures by Arizona residents were for pickups, campers or motor homes ($121.7 million), followed by cameras ($58.5 million) and plantings for wildlife ($56.6 million). Note that equipment expenditures are comprised of expenditures that may have been made for residential activities (i.e., those activities that are undertaken within one mile of home) and/or non-residential activities (i.e., those activities that are undertaken farther than one mile from home).

In total residents spent $665.0 million for watchable wildlife recreation. Non- residents spent $183.7 million, which represents new dollars brought into the state economy by out-of-state visitors[3].

[3] Total expenditures reported here differ from amounts reported by the US Fish and Wildlife Service due to the exclusion in this analysis of outlier values for selected expenditures.

Table 5. Expenditures Made by Residents and Non-Residents Participating in Watchable Wildlife Recreation Statewide in 2011 (Participants 16 Years Old and Older)

	Residents	Non-Residents	Total
Trip Expenditures			
Food	$78,153,917	$63,878,294	$142,032,210
Lodging	$23,123,662	$29,769,379	$52,893,041
Airfare	$13,168,740	$16,584,545	$29,753,285
Public transportation	$366,577	$8,916,201	$9,282,778
Private transportation	$90,461,935	$47,077,825	$137,539,760
Guide fees	$483,658	$336,805	$820,464
Public land access fees	$7,371,829	$2,822,598	$10,194,427
Private land access fees	$304,796	$1,879,837	$2,184,632
Equipment rental	$20,633	-	$20,633
Boat fuel	$225,771	-	$225,771
Other boat costs	$104,750	-	$104,750
Heating & cooking fuel	$846,387	$698,245	$1,544,632
Equipment Expenditures			
Binoculars, scopes	$9,413,959	$454,805	$9,868,765
Cameras	$58,499,953	$1,888,503	$60,388,457
Film and developing	$4,036,528	$287,634	$4,324,162
Commercially prepared bird food	$39,702,752	$681,994	$40,384,747
Other bird food	$11,943,461	$432,123	$12,375,583
Food for other wildlife	$1,916,346	-	$1,916,346
Nest boxes, feeders	$7,340,252	$173,686	$7,513,938
Other special equipment	$1,863,785	$335,911	$2,199,697
Tents, tarps	$2,042,435	$257,974	$2,300,408
Backpacking equipment	$3,495,475	$172,498	$3,667,973
Other camping equipment	$1,055,845	-	$1,055,845
Day packs, special clothing	$12,671,489	-	$12,671,489
Magazines and books	$5,949,804	$117,362	$6,067,166
Membership dues, contributions	$31,549,858	$1,836,419	$33,386,277
Other equipment	$2,599,378	-	$2,599,378
Off-road & 4WD vehicles	$23,055,325	-	$23,055,325
Pickups, campers, motor homes	$121,720,366	-	$121,720,366
Boats	$14,758,985	-	$14,758,985
Trailer, boat accessories	$7,741,403	-	$7,741,403
Cabin	-	-	$0
Other equipment	$5,467,590	-	$5,467,590
Land purchases	$27,035,758	-	$27,035,758
Land leases	-	$5,054,923	$5,054,923
Plantings	$56,539,744	-	$56,539,744
Total Trip and Equipment Expenditures	**$665,033,147**	**$183,657,562**	**$848,690,708**

Table 6 shows the average amount spent per day by recreationists on residential (within one mile of home) and non-residential (farther than one mile from home) activities, as well as the average amount spent annually per participant. Because the *National Survey* does not collect total days of participation broken down into residential and non-residential activities, the residential per day figure is estimated based on the number of days that the individual spent observing wildlife. The non-residential per day figure is estimated by totaling the travel expenses plus several equipment items that would be used away from home: binoculars, clothing, camping gear, backpacks and daypacks, film and developing, one-half of cameras and vehicles. The residential per day figure is estimated by totaling the remaining equipment items. Also, because purchased land may be used for visiting or as a homesite, 50% of its value was assigned to both the residential and non-residential activity estimates.

Table 6. Average Expenditures for Watchable Wildlife Recreationists in Arizona in 2011 (Participants 16 Years Old and Older)

	Residents	Non-Residents	Total
Avg. per Participant, Annually			
Residential activities	$157.09	NA	NA
Non-residential activities	$1,067.73	$613.88	$888.49
Avg. per Day, per Participant			
Non-residential activities	$61.47	$42.17	$54.65
Total Spent by Recreationists			
Residential activities	$191.9 million	$7.1 million	$198.0 million
Non-residential activities	$473.1 million	$177.6 million	$650.7 million
Total	$665.0 million	$183.7 million	$848.7 million

Total Economic Effect (Output)

Original expenditures made by watchable wildlife recreationists generate rounds of additional spending throughout the economy. This results in additional indirect and induced impacts that are commonly called the multiplier effect. Economic activity associated with both the direct spending and multiplier effects impacts is the total economic contribution resulting from the original expenditures. The economic figures in Table 7 show the total economic effect from 2011 watchable wildlife activities in Arizona to be $1.4 billion ($1.1 billion by residents and $314.6 million by non-residents).

Earnings

Total personal income (salaries and wages) supported by watchable wildlife recreation in Arizona was estimated at $463.6 million ($356.6 million by residents and $106.9 million by non-residents).

Table 7. Economic Impacts of Watchable Wildlife Recreation in Arizona in 2011 (Participants 16 Years Old and Older)

	Resident	Non-Resident	Total
Retail sales	$665.0 million	$183.7 million	$848.7 million
Salaries & wages	$356.6 million	$106.9 million	$463.6 million
Full & part-time jobs	9,894	2,998	12,892
Tax revenues:			
Federal taxes	$81.6 million	$24.2 million	$105.8 million
State and local taxes	$71.7 million	$22.2 million	$94.0 million
Total economic output	$1,123.6 million	$314.6 million	$1,438.2 million

Employment

During 2011, watchable wildlife recreation supported approximately 12,900 full and part-time jobs in Arizona (approximately 9,900 related to residents' spending and approximately 3,000 related to non-residents' spending). These are jobs that are associated with direct spending by wildlife watchers plus the jobs in industries that are indirectly affected by wildlife watching through the multiplier effect.

Tax Revenues

The economic activity related to wildlife watching by residents and non-residents generates sales tax revenues for the state and local governments. Total state and local tax revenues generated by watchable wildlife recreation are estimated at $71.7 million by residents and $22.2 million by non-residents. Total federal tax revenues generated by watchable wildlife recreation are estimated at $105.8 million.

COUNTY-SPECIFIC IMPACTS

Table 8 presents the total statewide impacts of watchable wildlife recreation generated by activity in each county for all forms of wildlife watching. Table 9 shows the economic impacts from residential activities (activities within one mile of home). These include impacts stimulated by expenditures made by county residents and residents from neighboring counties. By definition, residential impacts created by non-residents are rarely possible, because these people usually must travel more than one mile from home. Table 10 presents the economic impacts from non-residential activities (activities farther than one mile from home). These include only impacts of wildlife watching and impacts stimulated by county residents, residents from neighboring counties within the state, and from non-residents.

Table 8. Economic Contributions of All Watchable Wildlife Recreation in Arizona, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	Non-Residents	TOTAL
Apache	Retail Sales	$1,516,602	$10,192,062	$11,705,256	$25,731,350
	Total Multiplier Effect	$2,582,271	$17,256,020	$20,050,835	$44,061,142
	Salaries and Wages	$787,700	$5,497,478	$6,813,184	$14,004,624
	Full & Part-Time Jobs	26	150	191	419
	State & Local Tax Revenue	$165,367	$1,097,295	$1,417,057	$2,848,490
	Federal Tax Revenue	$198,526	$1,237,996	$1,543,713	$3,208,139
Cochise	Retail Sales	$7,357,921	$3,546,665	$3,227,150	$14,190,743
	Total Multiplier Effect	$12,470,790	$6,031,619	$5,528,034	$24,130,389
	Salaries and Wages	$3,830,269	$1,913,801	$1,878,401	$7,651,115
	Full & Part-Time Jobs	127	56	53	234
	State & Local Tax Revenue	$816,778	$359,172	$390,684	$1,570,931
	Federal Tax Revenue	$929,261	$408,610	$425,603	$1,769,276
Coconino	Retail Sales	$14,634,215	$14,715,256	$16,536,864	$48,192,790
	Total Multiplier Effect	$24,592,699	$24,925,679	$28,327,271	$82,007,844
	Salaries and Wages	$7,790,260	$7,937,568	$9,625,480	$26,255,976
	Full & Part-Time Jobs	207	218	270	747
	State & Local Tax Revenue	$1,541,970	$1,623,076	$2,001,980	$5,334,997
	Federal Tax Revenue	$1,754,246	$1,846,604	$2,180,916	$6,008,591
Gila	Retail Sales	$6,326,998	$2,695,908	$2,826,036	$11,940,372
	Total Multiplier Effect	$10,706,715	$4,572,961	$4,840,933	$20,282,515
	Salaries and Wages	$3,404,113	$1,454,388	$1,644,927	$6,537,975
	Full & Part-Time Jobs	94	41	46	183
	State & Local Tax Revenue	$686,208	$286,822	$342,124	$1,321,813
	Federal Tax Revenue	$781,074	$325,935	$372,703	$1,488,704
Graham	Retail Sales	$4,446,570	$1,447,610	$1,440,366	$7,283,288
	Total Multiplier Effect	$7,455,617	$2,457,967	$2,467,315	$12,292,101
	Salaries and Wages	$2,378,423	$781,026	$838,383	$3,977,764
	Full & Part-Time Jobs	61	22	24	105
	State & Local Tax Revenue	$475,759	$159,869	$174,373	$806,268
	Federal Tax Revenue	$541,824	$181,325	$189,958	$908,067

Table 8 (continued). Economic Contributions of All Watchable Wildlife Recreation in Arizona, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	Non-Residents	TOTAL
Greenlee	Retail Sales	sample size too small - data not available			
	Total Multiplier Effect	sample size too small - data not available			
	Salaries and Wages	sample size too small - data not available			
	Full & Part-Time Jobs	sample size too small - data not available			
	State & Local Tax Revenue	sample size too small - data not available			
	Federal Tax Revenue	sample size too small - data not available			
La Paz	Retail Sales	$195,651	$805,056	$765,765	$1,900,347
	Total Multiplier Effect	$267,605	$1,368,061	$1,311,737	$3,193,114
	Salaries and Wages	$56,066	$434,383	$445,722	$991,087
	Full & Part-Time Jobs	2	13	12	30
	State & Local Tax Revenue	$13,971	$93,945	$92,705	$210,371
	Federal Tax Revenue	$15,971	$106,804	$100,991	$236,932
Maricopa	Retail Sales	$269,590,809	$62,775,548	$57,815,213	$380,888,578
	Total Multiplier Effect	$454,501,909	$106,736,884	$99,036,135	$643,549,679
	Salaries and Wages	$144,276,858	$33,873,403	$33,652,037	$208,165,875
	Full & Part-Time Jobs	3934	982	943	5653
	State & Local Tax Revenue	$29,064,717	$6,777,655	$6,999,204	$42,164,798
	Federal Tax Revenue	$33,087,860	$7,689,759	$7,624,789	$47,488,506
Mohave	Retail Sales	$16,506,713	$7,753,748	$7,548,249	$32,040,791
	Total Multiplier Effect	$27,966,849	$13,170,746	$12,929,978	$54,473,740
	Salaries and Wages	$8,811,774	$4,183,517	$4,393,549	$17,480,101
	Full & Part-Time Jobs	259	120	123	505
	State Income Tax Revenues	$1,796,626	$819,621	$913,803	$3,546,952
	Federal Income Tax	$2,044,352	$932,134	$995,479	$3,994,788
Navajo	Retail Sales	$8,480,498	$7,460,158	$8,259,316	$25,255,072
	Total Multiplier Effect	$14,233,664	$12,640,452	$14,148,019	$42,928,305
	Salaries and Wages	$4,484,231	$4,024,202	$4,807,434	$13,730,682
	Full & Part-Time Jobs	116	111	135	387
	State & Local Tax Revenue	$881,628	$837,411	$999,886	$2,795,765
	Federal Tax Revenue	$1,003,084	$952,655	$1,089,256	$3,148,757

Table 8 (continued). Economic Contributions of All Watchable Wildlife Recreation in Arizona, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	Non-Residents	TOTAL
Pima	Retail Sales	$95,440,007	$40,537,825	$42,208,205	$179,459,718
	Total Multiplier Effect	$161,002,669	$68,771,763	$72,301,688	$304,368,133
	Salaries and Wages	$51,012,094	$21,869,589	$24,567,791	$97,947,943
	Full & Part-Time Jobs	1406	614	688	2736
	State & Local Tax Revenue	$10,252,806	$4,411,036	$5,109,794	$19,866,395
	Federal Tax Revenue	$11,666,952	$5,016,001	$5,566,505	$22,374,716
Pinal	Retail Sales	$23,141,009	$13,572,187	$14,677,151	$52,631,795
	Total Multiplier Effect	$39,067,381	$23,007,700	$25,141,624	$89,450,156
	Salaries and Wages	$12,384,663	$7,321,508	$8,543,012	$28,733,395
	Full & Part-Time Jobs	341	203	239	812
	State & Local Tax Revenue	$2,490,479	$1,468,670	$1,776,840	$5,826,399
	Federal Tax Revenue	$2,833,792	$1,670,505	$1,935,653	$6,562,038
Santa Cruz	Retail Sales	$958,583	$4,863,188	$5,469,746	$12,347,956
	Total Multiplier Effect	$1,662,908	$8,237,448	$9,369,549	$21,168,665
	Salaries and Wages	$518,639	$2,623,253	$3,183,731	$6,737,809
	Full & Part-Time Jobs	17	72	89	202
	State & Local Tax Revenue	$119,913	$507,906	$662,176	$1,366,933
	Federal Tax Revenue	$136,289	$577,977	$721,361	$1,539,521
Yavapai	Retail Sales	$26,400,590	$7,293,267	$7,147,134	$40,250,711
	Total Multiplier Effect	$44,442,211	$12,387,064	$12,242,877	$68,016,033
	Salaries and Wages	$14,165,765	$3,935,022	$4,160,075	$22,027,630
	Full & Part-Time Jobs	376	112	117	592
	State Income Tax Revenues	$2,834,296	$799,248	$865,244	$4,455,799
	Federal Income Tax	$3,226,544	$907,314	$942,579	$5,018,387
Yuma	Retail Sales	$9,255,619	$2,208,050	$1,695,621	$12,757,115
	Total Multiplier Effect	$15,626,569	$3,765,045	$2,904,560	$21,569,417
	Salaries and Wages	$4,886,749	$1,191,762	$986,956	$6,911,740
	Full & Part-Time Jobs	142	36	27	196
	State & Local Tax Revenue	$1,007,081	$229,161	$205,275	$1,412,227
	Federal Tax Revenue	$1,146,921	$259,542	$223,622	$1,590,534

Table 9. Economic Contributions of Residential Wildlife Watching Activities, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	TOTAL
Apache	Retail Sales	$437,646	$2,941,125	$3,378,771
	Total Multiplier Effect	$745,166	$4,979,573	$5,724,739
	Salaries and Wages	$227,307	$1,586,408	$1,813,715
	Full & Part-Time Jobs	8	43	51
	State & Local Tax Revenue	$47,720	$316,647	$364,367
	Federal Tax Revenue	$57,289	$357,249	$414,537
Cochise	Retail Sales	$2,123,277	$1,023,462	$3,146,738
	Total Multiplier Effect	$3,598,698	$1,740,545	$5,339,243
	Salaries and Wages	$1,105,301	$552,266	$1,657,567
	Full & Part-Time Jobs	37	16	53
	State & Local Tax Revenue	$235,698	$103,646	$339,344
	Federal Tax Revenue	$268,157	$117,913	$386,069
Coconino	Retail Sales	$4,222,998	$4,246,384	$8,469,382
	Total Multiplier Effect	$7,096,719	$7,192,807	$14,289,527
	Salaries and Wages	$2,248,037	$2,290,545	$4,538,582
	Full & Part-Time Jobs	60	63	122
	State & Local Tax Revenue	$444,967	$468,371	$913,338
	Federal Tax Revenue	$506,223	$532,875	$1,039,098
Gila	Retail Sales	$1,825,783	$777,959	$2,603,742
	Total Multiplier Effect	$3,089,639	$1,319,620	$4,409,259
	Salaries and Wages	$982,325	$419,693	$1,402,018
	Full & Part-Time Jobs	27	12	39
	State & Local Tax Revenue	$198,019	$82,768	$280,787
	Federal Tax Revenue	$225,395	$94,055	$319,450
Graham	Retail Sales	$1,283,147	$417,737	$1,700,885
	Total Multiplier Effect	$2,151,469	$709,296	$2,860,765
	Salaries and Wages	$686,342	$225,381	$911,723
	Full & Part-Time Jobs	18	6	24
	State & Local Tax Revenue	$137,290	$46,133	$183,423
	Federal Tax Revenue	$156,354	$52,325	$208,679

Table 9 (continued). Economic Contributions of Residential Wildlife Watching Activities, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	TOTAL
Greenlee	Retail Sales	sample size too small - data not available		
	Total Multiplier Effect	sample size too small - data not available		
	Salaries and Wages	sample size too small - data not available		
	Full & Part-Time Jobs	sample size too small - data not available		
	State & Local Tax Revenue	sample size too small - data not available		
	Federal Tax Revenue	sample size too small - data not available		
La Paz	Retail Sales	$56,459	$232,315	$288,774
	Total Multiplier Effect	$77,223	$394,782	$472,005
	Salaries and Wages	$16,179	$125,350	$141,529
	Full & Part-Time Jobs	1	4	4
	State & Local Tax Revenue	$4,032	$27,110	$31,141
	Federal Tax Revenue	$4,609	$30,821	$35,429
Maricopa	Retail Sales	$77,795,866	$18,115,151	$95,911,016
	Total Multiplier Effect	$131,155,693	$30,801,081	$161,956,774
	Salaries and Wages	$41,633,997	$9,774,854	$51,408,851
	Full & Part-Time Jobs	1,135	283	1,419
	State & Local Tax Revenue	$8,387,210	$1,955,829	$10,343,039
	Federal Tax Revenue	$9,548,169	$2,219,035	$11,767,205
Mohave	Retail Sales	$4,763,345	$2,237,501	$7,000,845
	Total Multiplier Effect	$8,070,398	$3,800,684	$11,871,083
	Salaries and Wages	$2,542,815	$1,207,238	$3,750,053
	Full & Part-Time Jobs	75	35	109
	State Income Tax Revenues	$518,453	$236,518	$754,971
	Federal Income Tax	$589,939	$268,986	$858,925
Navajo	Retail Sales	$2,447,219	$2,152,779	$4,599,998
	Total Multiplier Effect	$4,107,411	$3,647,657	$7,755,068
	Salaries and Wages	$1,294,015	$1,161,265	$2,455,280
	Full & Part-Time Jobs	33	32	66
	State & Local Tax Revenue	$254,412	$241,652	$496,064
	Federal Tax Revenue	$289,460	$274,908	$564,368

Table 9 (continued). Economic Contributions of Residential Wildlife Watching Activities, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	TOTAL
Pima	Retail Sales	$27,541,139	$11,698,007	$39,239,146
	Total Multiplier Effect	$46,460,567	$19,845,479	$66,306,047
	Salaries and Wages	$14,720,569	$6,310,911	$21,031,480
	Full & Part-Time Jobs	406	177	583
	State & Local Tax Revenue	$2,958,654	$1,272,893	$4,231,548
	Federal Tax Revenue	$3,366,734	$1,447,468	$4,814,203
Pinal	Retail Sales	$6,677,805	$3,916,528	$10,594,333
	Total Multiplier Effect	$11,273,681	$6,639,336	$17,913,017
	Salaries and Wages	$3,573,844	$2,112,769	$5,686,613
	Full & Part-Time Jobs	98	59	157
	State & Local Tax Revenue	$718,678	$423,814	$1,142,492
	Federal Tax Revenue	$817,748	$482,058	$1,299,806
Santa Cruz	Retail Sales	$276,619	$1,403,371	$1,679,990
	Total Multiplier Effect	$479,866	$2,377,082	$2,856,947
	Salaries and Wages	$149,664	$756,992	$906,656
	Full & Part-Time Jobs	5	21	26
	State & Local Tax Revenue	$34,603	$146,567	$181,170
	Federal Tax Revenue	$39,329	$166,787	$206,116
Yavapai	Retail Sales	$7,618,423	$2,104,619	$9,723,042
	Total Multiplier Effect	$12,824,696	$3,574,537	$16,399,234
	Salaries and Wages	$4,087,817	$1,135,530	$5,223,347
	Full & Part-Time Jobs	109	32	141
	State Income Tax Revenues	$817,893	$230,639	$1,048,532
	Federal Income Tax	$931,084	$261,824	$1,192,908
Yuma	Retail Sales	$2,670,895	$637,177	$3,308,073
	Total Multiplier Effect	$4,509,362	$1,086,480	$5,595,841
	Salaries and Wages	$1,410,170	$343,907	$1,754,077
	Full & Part-Time Jobs	41	10	51
	State & Local Tax Revenue	$290,613	$66,129	$356,742
	Federal Tax Revenue	$330,967	$74,896	$405,863

Table 10. Economic Contributions of Non-Residential Wildlife Watching Activities, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	Non-Residents	TOTAL
Apache	Retail Sales	$1,078,956	$7,250,937	$8,327,468	$16,657,361
	Total Multiplier Effect	$1,837,104	$12,276,448	$14,264,762	$28,378,314
	Salaries and Wages	$560,393	$3,911,070	$4,847,102	$9,318,566
	Full & Part-Time Jobs	19	107	136	261
	State & Local Tax Revenue	$117,647	$780,648	$1,008,137	$1,906,432
	Federal Tax Revenue	$141,237	$880,747	$1,098,244	$2,120,228
Cochise	Retail Sales	$5,234,645	$2,523,204	$2,295,891	$10,053,739
	Total Multiplier Effect	$8,872,092	$4,291,074	$3,932,808	$17,095,974
	Salaries and Wages	$2,724,968	$1,361,535	$1,336,351	$5,422,853
	Full & Part-Time Jobs	90	40	38	168
	State & Local Tax Revenue	$581,080	$255,526	$277,944	$1,114,550
	Federal Tax Revenue	$661,104	$290,697	$302,787	$1,254,588
Coconino	Retail Sales	$10,411,217	$10,468,872	$11,764,819	$32,644,908
	Total Multiplier Effect	$17,495,980	$17,732,872	$20,152,865	$55,381,717
	Salaries and Wages	$5,542,224	$5,647,023	$6,847,854	$18,037,100
	Full & Part-Time Jobs	147	155	192	494
	State & Local Tax Revenue	$1,097,003	$1,154,704	$1,424,268	$3,675,976
	Federal Tax Revenue	$1,248,023	$1,313,729	$1,551,569	$4,113,321
Gila	Retail Sales	$4,501,215	$1,917,950	$2,010,526	$8,429,691
	Total Multiplier Effect	$7,617,076	$3,253,341	$3,443,984	$14,314,401
	Salaries and Wages	$2,421,788	$1,034,695	$1,170,250	$4,626,733
	Full & Part-Time Jobs	67	29	33	128
	State & Local Tax Revenue	$488,189	$204,053	$243,398	$935,640
	Federal Tax Revenue	$555,679	$231,880	$265,152	$1,052,712
Graham	Retail Sales	$3,163,423	$1,029,873	$1,024,719	$5,218,015
	Total Multiplier Effect	$5,304,149	$1,748,671	$1,755,321	$8,808,141
	Salaries and Wages	$1,692,081	$555,645	$596,451	$2,844,177
	Full & Part-Time Jobs	43	16	17	76
	State & Local Tax Revenue	$338,469	$113,735	$124,054	$576,259
	Federal Tax Revenue	$385,470	$129,000	$135,142	$649,612

Table 10 (continued). Economic Contributions of Non-Residential Wildlife Watching Activities, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	TOTAL
Greenlee	Retail Sales	sample size too small - data not available		
	Total Multiplier Effect	sample size too small - data not available		
	Salaries and Wages	sample size too small - data not available		
	Full & Part-Time Jobs	sample size too small - data not available		
	State & Local Tax Revenue	sample size too small - data not available		
	Federal Tax Revenue	sample size too small - data not available		
La Paz	Retail Sales	$56,459	$232,315	$288,774
	Total Multiplier Effect	$77,223	$394,782	$472,005
	Salaries and Wages	$16,179	$125,350	$141,529
	Full & Part-Time Jobs	1	4	4
	State & Local Tax Revenue	$4,032	$27,110	$31,141
	Federal Tax Revenue	$4,609	$30,821	$35,429
Maricopa	Retail Sales	$77,795,866	$18,115,151	$95,911,016
	Total Multiplier Effect	$131,155,693	$30,801,081	$161,956,774
	Salaries and Wages	$41,633,997	$9,774,854	$51,408,851
	Full & Part-Time Jobs	1,135	283	1,419
	State & Local Tax Revenue	$8,387,210	$1,955,829	$10,343,039
	Federal Tax Revenue	$9,548,169	$2,219,035	$11,767,205
Mohave	Retail Sales	$4,763,345	$2,237,501	$7,000,845
	Total Multiplier Effect	$8,070,398	$3,800,684	$11,871,083
	Salaries and Wages	$2,542,815	$1,207,238	$3,750,053
	Full & Part-Time Jobs	75	35	109
	State Income Tax Revenues	$518,453	$236,518	$754,971
	Federal Income Tax	$589,939	$268,986	$858,925
Navajo	Retail Sales	$2,447,219	$2,152,779	$4,599,998
	Total Multiplier Effect	$4,107,411	$3,647,657	$7,755,068
	Salaries and Wages	$1,294,015	$1,161,265	$2,455,280
	Full & Part-Time Jobs	33	32	66
	State & Local Tax Revenue	$254,412	$241,652	$496,064
	Federal Tax Revenue	$289,460	$274,908	$564,368

Table 10 (continued). Economic Contributions of Non-Residential Wildlife Watching Activities, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	Non-Residents	TOTAL
Pima	Retail Sales	$67,898,868	$28,839,818	$30,028,176	$126,766,862
	Total Multiplier Effect	$114,542,101	$48,926,283	$51,437,577	$214,905,962
	Salaries and Wages	$36,291,526	$15,558,678	$17,478,259	$69,328,463
	Full & Part-Time Jobs	1,000	437	490	1,926
	State & Local Tax Revenue	$7,294,152	$3,138,143	$3,635,260	$14,067,555
	Federal Tax Revenue	$8,300,217	$3,568,533	$3,960,178	$15,828,928
Pinal	Retail Sales	$16,463,204	$9,655,659	$10,441,763	$36,560,625
	Total Multiplier Effect	$27,793,700	$16,368,364	$17,886,501	$62,048,565
	Salaries and Wages	$8,810,819	$5,208,739	$6,077,753	$20,097,311
	Full & Part-Time Jobs	243	144	170	557
	State & Local Tax Revenue	$1,771,801	$1,044,856	$1,264,097	$4,080,754
	Federal Tax Revenue	$2,016,044	$1,188,447	$1,377,081	$4,581,572
Santa Cruz	Retail Sales	$681,965	$3,459,817	$3,891,340	$8,033,122
	Total Multiplier Effect	$1,183,042	$5,860,366	$6,665,777	$13,709,185
	Salaries and Wages	$368,975	$1,866,260	$2,265,001	$4,500,236
	Full & Part-Time Jobs	12	51	63	127
	State & Local Tax Revenue	$85,310	$361,340	$471,092	$917,742
	Federal Tax Revenue	$96,960	$411,190	$513,198	$1,021,348
Yavapai	Retail Sales	$18,782,167	$5,188,648	$5,084,685	$29,055,499
	Total Multiplier Effect	$31,617,515	$8,812,527	$8,709,948	$49,139,990
	Salaries and Wages	$10,077,948	$2,799,492	$2,959,601	$15,837,041
	Full & Part-Time Jobs	268	80	83	430
	State Income Tax Revenues	$2,016,403	$568,609	$615,560	$3,200,572
	Federal Income Tax	$2,295,460	$645,490	$670,579	$3,611,528
Yuma	Retail Sales	$6,584,723	$1,570,873	$1,206,316	$9,361,912
	Total Multiplier Effect	$11,117,207	$2,678,565	$2,066,391	$15,862,164
	Salaries and Wages	$3,476,579	$847,855	$702,150	$5,026,584
	Full & Part-Time Jobs	101	25	19	146
	State & Local Tax Revenue	$716,467	$163,032	$146,039	$1,025,538
	Federal Tax Revenue	$815,954	$184,646	$159,091	$1,159,691

APPENDIX A
Definitions

Economic benefits can be estimated by two types of economic measures: economic impacts and economic values. An **economic impact** addresses the business and financial activity resulting from the use of a resource. **Economic value**, on the other hand, is a non-business measure that estimates the value people receive from an activity after subtracting for their costs and expenditures. This concept is also known as consumer surplus.

There are three types of economic impact: direct, indirect and induced. A **direct impact** is defined as the economic impact of the initial purchase made by the consumer (the original retail sale). **Indirect impacts** are the secondary effects generated from a direct impact, such as the retailer buying additional inventory, and the wholesaler and manufacturers buying additional materials. Indirect impacts affect not only the industry being studied, but also the industries that supply the first industry. An **induced impact** results from the salaries and wages paid by the directly and indirectly impacted industries. The employees of these industries spend their income on various goods and services. These expenditures are induced impacts, which, in turn, create a continual cycle of indirect and induced effects.

The direct, indirect and induced impact effects sum together to provide the overall economic impact of the activity under study. As the original retail purchase (direct impact) goes through round after round of indirect and induced effects, the economic impact of the original purchase is multiplied, benefiting many industries and individuals. Likewise, the reverse is true. If a particular item or industry is removed from the economy, the economic loss is greater than the original lost retail sale. Once the original retail purchase is made, each successive round of spending is smaller than the previous round. When the economic benefits are no longer measurable, the economic examination ends.

This study presents several important measures:

Retail Sales – these include the expenditures made by wildlife viewers for equipment, travel expenses and services related to their wildlife viewing activities over the course of the year. The initial retail sale is the *direct impact*.

Total Multiplier Effect – also known as the "total economic effect" or "output," this measure reports the sum of the direct, indirect and induced impacts resulting from the original retail sale. This figure explains the total activity in the economy generated by a retail sale. Another way to look at this figure is, if the activity in question were to disappear and participants did not spend their money elsewhere, the economy would contract by this amount.

Salaries and Wages – this figure reports the total salaries and wages paid in all sectors of the economy as a result of the activity under study. These are not just the paychecks of those employees directly serving recreationists or manufacturing their goods, it also includes portions of the paychecks of, for example, the truck driver who delivers food to the restaurants serving recreationists and the accountants who manage the books for companies down the supply chain, etc. This figure is based on the direct, indirect and induced effects, and is essentially a portion of the total economic effect figure reported in this study.

Jobs – much like Salaries and Wages, this figure reports the total jobs in all sectors of the economy as a result of the activity under study. These are not just the employees directly serving recreationists or manufacturing their goods, they also include, for example, the truck driver who delivers food to the restaurants serving recreationists and the accountants who manage the books for companies down the supply chain, etc. This figure is based on direct, indirect and induced effects.

Watchable wildlife recreation is defined here as the primary purpose of observing, photographing or feeding of fish or other wildlife. **Wildlife** is defined as animals that are living in natural or wild environments. Animals in museums, zoos and aquariums are not included. Domestic and farm animals also are not included as wildlife. Watchable wildlife recreation is divided into two types of activity: residential and non-residential. According to the 2011 USFWS Survey, **residential activities** are those activities that occur within one mile of one's home for the primary purpose of observing, photographing or feeding wildlife. In contrast, according to the Survey, **non-residential activities** are trips or outings that occur at least one mile from home for the primary purpose of observing, photographing or feeding wildlife. Given the definitions, residential activities are made by Arizona residents, whereas, non-residential activities are made by both Arizona residents and non-residents.

APPENDIX B
Methods

The county-level estimates provided in this report represent each county's contribution to total economic activity in Arizona as a result of spending by people who participate in wildlife watching. The economic contributions were estimated first at the statewide level, and the statewide economic contributions were then allocated to each county on the basis of estimated wildlife watching activity that occurs in each county.

The methods used to generate the economic impact estimates of watchable wildlife recreation activities in Arizona are separated into five stages. The stages entailed:

1) Tabulating the expenditures made by recreationists (16 years old and older) from raw data provided by the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (Survey);

2) Allocating the detailed expenditures to the appropriate sectors of the economy that were directly impacted by the spending;

3) Estimating the direct, indirect and induced effects of the spending by recreationists through the use of an input-output model of the Arizona economy and the IMPLAN economic modeling software;

4) Estimating federal and state/local tax revenues with the IMPLAN economic modeling software;

5) Allocating the expenditures and impacts to each county, for each type of activity.

1. Tabulating Expenditures

Wildlife watchers' expenditures were obtained from the 2011 National Survey of Fishing, Hunting and Wildlife-Associated Recreation (Survey). This Survey is conducted approximately every five years by the

U.S. Fish and Wildlife Service and U.S. Bureau of the Census. The Survey provides data required by natural resource management agencies, industry and private organizations at the local, state, and national levels to assist in optimally managing natural resources. The Survey is funded through excise taxes on hunting and fishing equipment through the Federal Aid in Sport Fish and Wildlife Restoration Acts.

Expenditures by wildlife watchers were categorized into resident and non-resident files. Both included information on travel-related categories such as food and lodging, and equipment expenditures such as guidebooks and binoculars. Together, the resident and non-resident files represent all expenditures made in Arizona in 2011.

2. Applying the Economic Model

To estimate the economic impacts, the data were analyzed with the IMPLAN input-output model. The IMPLAN model was developed by MIG, Inc. of Stillwater, Minnesota originally for use by the U.S. Forest Service. Input-output models describe how sales in one industry impact other industries. For example, once a consumer makes a purchase, the retailer buys more merchandise from wholesalers, who buy more from manufacturers, who, in turn, purchase new inputs and supplies. In addition, the salaries and wages paid by these businesses stimulate more benefits. Simply put, the first purchase creates numerous rounds of purchasing. Input-output analysis tracks how the various rounds of purchasing flow throughout an economy and generate economic benefits.

The relationships between industries are explained through multipliers. For example, an income multiplier of 1.29 for industry X would indicate that for every dollar of income generated by the industry under study, $0.29 would be paid to the employees of industries impacted by the indirect and induced effects. The IMPLAN model provides multipliers for all major industries in the U.S. and for each state. The IMPLAN model includes output, earnings and employment multipliers. The output multiplier measures the total economic effect created by the original retail sale. The earnings multiplier measures the total salaries and wages generated by the original retail sale. The employment multiplier estimates the number of jobs supported by the original retail sale. IMPLAN also estimates federal, state and local tax revenues.

To apply the IMPLAN model, wildlife watching expenditures are matched to the appropriate industry sector. The resulting estimates describe the salaries and wages, total economic effects, and jobs supported by the purchases made by wildlife watchers. This same process is repeated for all reported expenditures.

3. Estimating Tax Revenues

The IMPLAN model estimates detailed tax revenues at the state, local and federal levels. The summary estimates provided in this report represent the total taxes estimated by the IMPLAN model including all income, sales, property and other taxes and fees that accrue to the various local, state and federal taxing authorities.

APPENDIX C

Economic Impacts in Arizona, by Economic Sector

ECONOMIC SECTORS STIMULATED BY RESIDENT WILDLIFE WATCHING SPENDING

	Total Output (Sales)	Employment	Income
Ag, Forestry, Fish & Hunting	75,849,154	1,353	15,002,669
Mining	25,453,166	213	4,006,661
Utilities	11,937,582	20	2,456,890
Construction	7,468,583	56	2,914,889
Manufacturing	225,216,903	528	35,359,024
Wholesale Trade	91,255,211	555	41,254,431
Retail trade	163,673,074	2,475	77,587,725
Transportation & Warehousing	45,423,765	318	17,692,684
Information	29,208,711	110	6,276,495
Finance & insurance	67,791,634	369	18,720,422
Real estate & rental	110,811,017	465	9,302,987
Professional- scientific & tech svcs	32,546,147	298	17,723,935
Management of companies	9,274,207	60	4,517,757
Administrative & waste services	21,294,726	340	11,220,113
Educational svcs	5,962,271	91	3,467,879
Health & social services	43,388,094	445	24,532,831
Arts- entertainment & recreation	5,619,815	115	2,427,574
Accomodation & food services	80,276,963	1,228	28,013,176
Other services	48,405,737	677	21,819,877
Government & non NAICs	22,731,107	178	12,321,909
TOTAL	**1,123,587,867**	**9,894**	**356,619,928**

ECONOMIC SECTORS STIMULATED BY NONRESIDENT WILDLIFE WATCHING SPENDING

	Total Output (Sales)	Employment	Income
Ag, Forestry, Fish & Hunting	3,372,639	49	462,162
Mining	13,230,740	111	2,079,527
Utilities	3,888,657	7	808,940
Construction	2,906,580	22	1,129,831
Manufacturing	24,256,793	46	2,829,889
Wholesale Trade	26,937,459	164	12,177,820
Retail trade	28,004,880	388	12,884,384
Transportation & Warehousing	33,976,172	202	12,181,750
Information	7,285,665	27	1,545,708
Finance & insurance	18,369,969	101	5,181,190
Real estate & rental	30,783,641	116	2,444,444
Professional- scientific & tech svcs	10,227,836	95	5,654,969
Management of companies	2,731,776	18	1,330,734
Administrative & waste services	7,290,126	112	3,682,416
Educational svcs	1,661,209	25	967,560
Health & social services	13,003,474	133	7,353,102
Arts- entertainment & recreation	1,814,602	37	805,606
Accomodation & food services	67,863,268	971	23,469,975
Other services	9,013,278	308	5,327,525
Government & non NAICs	7,990,972	67	4,632,265
TOTAL	**314,609,736**	**2,998**	**106,949,797**

ECONOMIC SECTORS STIMULATED BY RESIDENT+NONRESIDENT WILDLIFE WATCHING SPENDING

	Total Output (Sales)	Employment	Income
Ag, Forestry, Fish & Hunting	79,221,793	1,402	15,464,831
Mining	38,683,906	324	6,086,188
Utilities	15,826,239	27	3,265,830
Construction	10,375,163	77	4,044,720
Manufacturing	249,473,696	574	38,188,913
Wholesale Trade	118,192,670	719	53,432,251
Retail trade	191,677,954	2,864	90,472,109
Transportation & Warehousing	79,399,937	521	29,874,434
Information	36,494,376	137	7,822,203
Finance & insurance	86,161,603	470	23,901,612
Real estate & rental	141,594,658	581	11,747,431
Professional- scientific & tech svcs	42,773,983	392	23,378,904
Management of companies	12,005,983	78	5,848,491
Administrative & waste services	28,584,852	452	14,902,529
Educational svcs	7,623,480	116	4,435,439
Health & social services	56,391,568	578	31,885,933
Arts- entertainment & recreation	7,434,417	152	3,233,180
Accomodation & food services	148,140,231	2,199	51,483,151
Other services	57,419,015	985	27,147,402
Government & non NAICs	30,722,079	245	16,954,174
TOTAL	**1,438,197,603**	**12,892**	**463,569,725**

DOCKET NO. L-00000YY-15-0318-00171-MCV_14

EXHIBIT
MCV-14
ADMITTED
PENGAD 800-631-6989

ELSEVIER

Biological Conservation 86 (1998) 67–76

BIOLOGICAL CONSERVATION

Biological and conservation aspects of bird mortality caused by electricity power lines: a review

Kjetil Bevanger *

Norwegian Institute for Nature Research, Division of Terrestrial Ecology, Tungasletta 2, N-7005 Trondheim, Norway

Received 19 July 1997; received in revised form 31 October 1997; accepted 9 November 1997

Abstract

Empirical data and theoretical considerations indicate that species with high wing loading and low aspect run a high risk of colliding with power lines. These birds are characterised by rapid flight, and the combination of heavy body and small wings restricts swift reactions to unexpected obstacles. When the number of reported collision victims is considered relative to the abundance and population size of the species concerned, some Galliformes, Gruiformes, Pelecaniformes and Ciconiiformes species seem to appear in disproportionately high numbers. In contrast, species frequently affected by electrocution particularly seems to involve Ciconiiformes, Falconiformes, Strigiformes and Passeriformes. An alarmingly large number of species with endangered and vulnerable status are identified among the victims, but there are insufficient data at present for judging the significance of mortality caused by power lines at the population level. © 1998 Elsevier Science Ltd. All rights reserved.

Keywords: Bird; Electrocution; Endangered species; Collision; Power line

1. Introduction

Steadily increasing environmental stress has made mortality factors important that were once considered insignificant. Healthy populations can normally compensate for additional mortality deriving from unusual causes but may be seriously affected when these act on a reduced population. Ecologists (e.g. Temple, 1986) have emphasised that the circumstances that ultimately cause a species to perish may be entirely unlike the incidents that first caused the population to become endangered. The annual death of birds world-wide through electrocution and collision with power lines and other types of overhead wires (Braaksma, 1966; Renssen et al., 1975; Gylstorff, 1979; Hoerschelman et al., 1988; Bevanger, 1994a, 1995a) is an example of a poorly understood mortality, although it was observed and commented on for more than one hundred years (Coues, 1876; Emerson, 1904). Reports mainly derive from South Africa, North America and Europe, where they were highlighted because of the economic impact of interruptions in energy supply, and the scientific and conservation concern for endangered, vulnerable and harvestable species (Brown and Lawson, 1989; Bevanger, 1994a,b, 1995a,b; Negro and Ferrer, 1995). Information from the rest of Africa, South America, Asia and Australia is scarce (for a literature review, see Avery et al., 1980; Herbert and Reese, 1995). As a majority of power lines are located in remote areas far away from public awareness of the bird collision or electrocution problems, reported losses must be considered a superficial measure of its occurrence (Thompson, 1978; Longridge, 1986; Faanes, 1987).

Much is known about how topographical, meteorological and technical factors can alter collision or electrocution hazards for birds (Bevanger, 1994a; Alonso et al., 1994; Brown and Drewien, 1995; APLIC, 1996). Less attention was paid to the biological and ecological characteristics of the victims, i.e. behaviour, physiology and morphology. No investigations seem to have been designed to test the influence of, for instance, biomechanics on collisions. A main question addressed in the present paper is whether existing data can reveal qualities of morphology and biomechanics that predict a species' susceptibility to collisions with power lines or electrocution accidents. The implications of this mortality for conservation are discussed in the light of principles of population dynamics.

* Tel.: 0047 73 80 14 00; fax: 0047 73 80 14 01;
e-mail: kjetil.bevanger@ninatrd.ninaniku.no

0006-3207/98/$19.00 © 1998 Elsevier Science Ltd. All rights reserved
PII: S0006-3207(97)00176-6

2. Predicting bird collisions with power lines

The causes of birds colliding with power lines is a complex problem (Bevanger, 1994a,b). Statistical testing of pooled data is inappropriate because the records are biased by several factors: the geographical location of the research, the abundance of the species, their behavioural patterns (e.g. the time different species spend in the air) and their nocturnal and/or crepuscular habits. It is, for instance, impractical to obtain relative figures, i.e. the number of collisions compared to the number of birds crossing overhead wires, for rare species or species with a ground-dwelling life style. Resident and migratory species have frequently been pooled and treated together. Investigations addressing this type of information (e.g. Meyer, 1978; James and Haak, 1979; Willdan Associates, 1982; Faanes, 1987; Hartman et al., 1992) have partly been designed as 'worst case studies' connected with key functional areas for birds and major flyways of migratory species.

Rayner (1988) applied principal component analysis to wing morphology and derived statistically independent measures of size and wing proportions. Of particular interest were the 'loading' and 'aspect' components, and a scatterplot of these for flying birds is informative (Fig. 1). The major bird groups fall into six main categories, determined by differences in aerodynamic performance: 'poor' flyers, water birds, diving birds, marine soarers, aerial predators and thermal soarers.

As Rayner (1988) emphasised, the species in the lower right-hand quadrant (the 'poor' flyers) are interesting as they have probably never experienced strong pressure to enhance their flight efficiency. Most of them belong to Gruiformes, Galliformes and Tinamiformes. It is interesting to relate Rayner's categories to the data derived from the literature on 'collision species' (Table 1).

Indeed, rails, coots and cranes are among the species most commonly and numerously recorded as collision victims in America and Europe (e.g. McKenna and Allard, 1976; Heijnis, 1980; Zerda and Rosselli, 1997). Moreover, 14 species of the Gruidae and Rallidae families world-wide were classified as endangered (Temple, 1986). Most of the 15 crane species are known to have dwindling populations with endangered status (Bylin, 1983) mainly as a result of destruction of wetland habitats.

Several gallinaceous species were known to suffer losses because of flying into overhead wires (Leopold, 1931; Borell, 1939; Paludan, 1963; Krapu, 1974; Rose and Baillie, 1992). Recent research in Norway has revealed that tetraonids are particularly exposed to collision hazards (Bevanger, 1988, 1995a,b), which is all the more striking considering their ground-dwelling behaviour.

The 47 species of Tinamiformes are endemic to the Neotropical Region (del Hoyo et al., 1992). Most of them look like gallinaceous birds, although their morphology reflects convergent evolution. Unfortunately, almost no research addressing the problem of bird collisions with power lines was carried out in Latin America, but these birds are known to 'fly into obstacles—branches, posts, wires and even houses' (del Hoyo et al., 1992, p. 113). If the theoretical considerations about high collision probability for the 'poor' flyer group are correct, Tinamiformes species should be particularly vulnerable to colliding with power lines. Several Tinamiformes species are ranked as vulnerable and endangered (del Hoyo et al., 1992).

'Water birds' and 'diving birds' (Fig. 1) also have high wing loading, and many species of Anseriformes are recorded as frequent collision victims (Table 1). The Charadriformes vary somewhat. Species belonging to the Scolopacidae family are found as collision victims in nearly every investigation related to birds and power lines. This is not surprising considering that most of the species are Neotropical and Palaeotropical migrants crossing vast distances—and many power lines—in huge numbers. The snipe *Gallinago gallinago*, however, figures in the high wing loading group and accounts for 21% (n = 602) among the 2833 Scolopacidae victims recorded (Table 1).

In the 'low loading' group, gulls are frequent collision victims, and are therefore an exception to the prediction based on wing morphology (Table 1). Studies in Washington and Oregon (Meyer, 1978; James and Haak, 1979; Beaulaurier, 1981) showed a significantly higher probability that Anatidae species would collide than Laridae species, ducks being 50–100 times more likely to collide than gulls. However, Laridae species spend much of their time in the air and are numerous; moreover, the investigations incorporated in Tables 1 and 2 mainly derive from wetland and coastal habitats where they are particularly common. It has also been suggested that birds such as gulls, with high aspect ratio and low loading, are susceptible to being blown into wires in strong winds, and also that birds in flocks, like gulls, may be in greater danger of colliding, particularly those that are far behind, as their view is obstructed by the birds in front (Scott et al., 1972; Renssen et al., 1975; Henderson et al., 1996).

As Rayner (1988) emphasised, there are significant variations within some groups (e.g. Anatidae) regarding wing load and aspect ratio, underlining the importance of making accurate analyses among species in the same family to predict the species-specific collision hazard. Moreover, reaction studies (James and Haak, 1979) have revealed significant variations in the reaction of ducks when approaching a power line, indicating differences in perceptional and reactional abilities as well as behaviour (e.g. descending or elevating flight course,

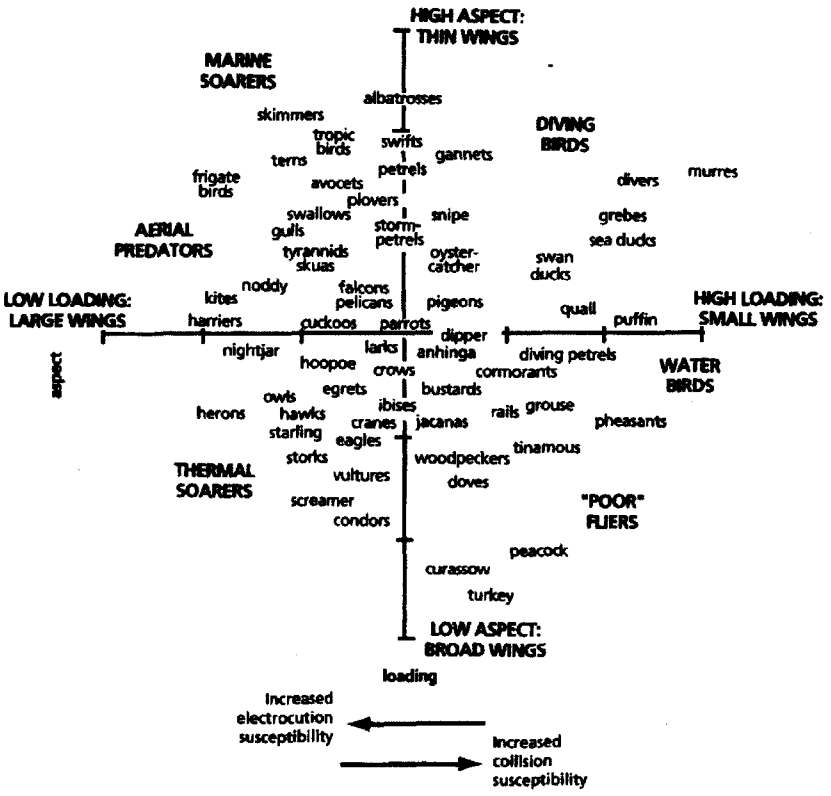


Fig. 1. Major bird groups arranged according to wing morphology expressed in principal-components form where statistically independent measures of size and wing proportions are derived. The figure is based on a scatterplot of the size-independent components of flying birds (after Rayner, 1988).

or flight interruption when attempting to cross the wires).

Aerial hunters like the European swift *Apus apus* and several raptor species possess excellent flying abilities (and binocular vision). However, they spend a major part of their life in the air and the probability of crossing power lines (and colliding) is higher compared to ground-dwelling species, which may explain why aerial predators are regularly recorded as collision victims, although in seemingly small numbers (Bevanger and Overskaug, in press).

It is difficult to predict the danger to 'thermal soarers' (Fig. 1), i.e. birds with large and broad wings and a decreased wing loading. Some species seem to be susceptible both to electrocution and collision. Herons and several other Ciconiiformes species and Gruiformes and Pelecaniformes species, suffer an alarmingly high mortality from power lines, but available data do not allow clear distinctions to be made between electrocution and collision accidents. However, electrocution accidents seem to be increasingly important among these groups, apparently being dependent on body size, hunting, perching or roosting behaviour.

Empirical evidence is amassing that species with high wing loading and low aspect, i.e. the 'poor' flyers, deserve to be classified in a high risk group as regards collisions with power lines. The 'poor' flyers are characterised by rapid flight, and the combination of heavy body and small wings obviously restricts swift reactions to unexpected obstacles.

An interrelationship between biomechanical factors and vision should certainly be considered. Unfortunately, there is a lack of detailed information about the sensory capacities of birds, although research into bird vision has revealed a great variety of adaptations among various groups (Sillman, 1973; Martin, 1985; Schmidt-Morand, 1992).

3. Characteristics of bird electrocution

Electrocution of birds is a simpler problem than collision. It may take place when a bird touches two phase conductors or one conductor and an earthed device simultaneously, especially when the feathers are wet.

Table 1
Birds recorded as victims of collisions with power lines in 16 investigations

Order	Family	Genera	Species	Individuals
Gaviformes	Gavidae (divers)	1	2	3
Podicipediformes	Podicipedidae (grebes)	4	7	303
Procellariiformes	Procellaridiidae (fulmars, petrels, shearwaters)	1	1	4
Pelecaniformes	Pelecanidae (pelicans)	1	2	4
	Sulidae (boobies, gannets)	1	1	1
	Phalacrocoracidae (cormorants, shags)	1	2	62
Ciconiiformes	Ardeidae (bitterns, herons)	4	6	79
	Ciconiidae (storks)	1	1	5
	Threskiornithidae (ibises, spoonbills)	2	3	13
	Phoenicopteridae (flamingoes)	1	1	8
Anseriformes	Anatidae (wildfowl)	14	37	2983
Falconiformes	Accipitridae (hawks, vultures, eagles)	3	4	7
	Falconidae (falcons and allies)	1	4	7
Galliformes	Phasianidae (partridges, quails, pheasants and allies)	7	9	321
Gruiformes	Rallidae/Gruidae (rails, coots, cranes)	6	9	1653
Charadriformes	Haematopodidae (oystercatchers)	1	1	54
	Recurvirostridae (stilts, avocets)	2	3	12
	Burhinidae (stone-curlews, stone-plovers)	1	1	1
	Charadriidae (plovers, lapwings)	3	7	520
	Scolopacidae (snipes, sandpipers and allies)	19	48	2833
	Laridae (gulls)	5	16	1447
Apodiformes	Apodidae (swifts)	1	1	6
Columbiformes	Columbidae (pigeons)	3	7	374
Cuculiformes	Cuculidae (cuckoos)	1	1	2
Strigiformes	Tytonidae (barn owls and allies)	1	1	1
	Strigidae (typical owls)	2	3	4
Passeriformes	Tyrannidae (tyrant flycatchers)	2	2	6
	Alaudidae (larks)	1	1	68
	Hirundinidae (swallows)	1	1	9
	Motacillidae (pipits, wagtails)	2	3	34
	Troglodytidae (wrens)	2	3	3
	Turdidae (chats, thrushes)	6	12	420
	Sylviidae (warblers and allies)	5	12	117
	Muscicapidae (flycatchers)	1	2	3
	Emberizidae (buntings and allies)	7	11	86
	Parulidae (wood-warblers)	3	4	7
	Icteridae (blackbirds, orioles and allies)	3	3	87
	Fringillidae (finches)	2	4	25
	Ploceidae (weavers and allies)	1	1	46
	Sturnidae (starlings)	4	6	590
	Corvidae (crows and allies)	2	2	18

References: Scott et al. (1972); McKenna and Allard (1976); Anderson (1978); Gylstorff (1979); Meyer (1978); Christensen (1980); Grosse et al., (1980); Heijnis (1980); Willdan Associates (1982); Longridge (1986); Rusz et al. (1986); Bevanger (1988); Thingstad (1989); Hartman et al. (1992); Bevanger (1993); Bevanger and Sandaker (1993).

Hence, body size and behaviour, such as perching and roosting on poles or wires, are the keys to understanding why and how birds become electrocuted.

Birds below the size of a jackdaw *Corvus monedula* have a reduced chance of becoming electrocuted because the conductors and earth wire or earthed devices are generally too far apart. However, irregular and unexpected electrocution accidents do take place because of the huge diversity in electrical installations and equipment (Kroodsma and Van Dyke, 1985; Negro and Ferrer, 1995). In Norway, pole-mounted transformers, pin insulators and a triangular conductor configuration were reported as the most dangerous electrocuting devices by the energy companies as a response to a questionnaire (Bevanger and Thingstad, 1988). Flocks of small birds (house sparrow *Passer domesticus*, starling *Sturnus vulgaris* and thrushes *Turdus* spp.) crossing a high tension power line (and when several roosting birds take off simultaneously) have also been observed to result in short circuits, as the current can pass through several individuals (reported by four energy companies in Norway; cf. Bevanger and Thingstad, 1988).

Species frequently affected by electrocution belong to Ciconiiformes, Falconiformes, Strigiformes and Passeriformes (Tables 2 and 3) (Bevanger, 1994b). Data on electrocution from Germany, Switzerland and Spain (Haas, 1980) show a majority of medium sized raptors

Page 5 of the PDF

Table 2
Birds recorded as collision or electrocution victims. The data have been separated into studies dealing with: (i) bird collisions with power lines; (ii) bird electrocution; and (iii) ringing recoveries reporting 'killed by electricity'. Category (iii) cannot be separated into collision or electrocution as recoveries of ringed birds are not normally specific regarding collision or electrocution mortality

Order	Number of birds		
	Collision	Electrocution	Ringing recoveries
Gaviformes	3	—	—
Podicipediformes	303	—	2
Procellariiformes	4	—	18
Pelecaniformes	67	—	45
Ciconiiformes	105	14	193
Anseriformes	2983	—	3091
Falconiformes	14	739	648
Galliformes	321	—	17
Gruiformes	1653	—	37
Charadriformes	4867	1	1150
Apodiformes	6	—	74
Columbiformes	374	12	20
Cuculiformes	2	—	3
Strigiformes	5	68	263
Caprimulgiformes	—	—	1
Coraciiformes	—	—	4
Piciformes	—	—	13
Passeriformes	1519	416	1258

References collision data: Scott et al. (1972); McKenna and Allard (1976); Anderson (1978); Meyer (1978); Gylstorff (1979); Christensen (1980); Grosse et al. (1980); Heijnis (1980); Willdan Associates (1982); Longridge (1986); Rusz et al. (1986); Bevanger (1988); Thingstad (1989); Hartman et al. (1992); Bevanger (1993); Bevanger and Sandaker (1993).

References electrocution data: Haas (1980); Ferrer et al. (1991).

References ringing recoveries: Stolt et al. (1986); Bevanger and Thingstad (1988); Rose and Baillie (1992).

and owls (and also corvids) figuring among the casualties. Unfortunately, few reports addressing electrocution mortality have included complete lists of the victim species and the numbers of casualties. Several species among the 'thermal soarers' (e.g. hawks, eagles, vultures, condors) are obviously susceptible to electrocution using utility structures for perching. However, records, even from biologists, frequently fail to distinguish between death caused by collision or electrocution.

Adult white storks *Ciconia ciconia* and eagle owls *Bubo bubo* seem to be surprisingly common among electrocution (and collision) victims of these species (Fiedler and Wissner, 1980; Stolt et al., 1986; Larsen and Stensrud, 1988; Grischtschenko and Gaber, 1990). These data seem to be among the most convincing indication of a population-regulating effect of mortality caused by utility structures. In their analyses of 1185 recoveries of 'Helgoland ringed' white storks, Riegel and Winkel (1971) found that, of 294 birds recovered in Germany with known causes of death, 226 were killed because of 'overhead wires'. Of these, 62.8% were 1-year-old subadults, 2.2% were 2- and 3-year-old birds and 35% were 4-year-old or older adults.

Benson (1980, 1982) concluded that subadult age classes of large raptors suffer higher losses because of electrocution than adults, as a result of inexperience in flight and different hunting methods. Young and juvenile birds are inexperienced flyers less adept at manoeuvring than adults, e.g. when landing and taking off (Nelson and Nelson, 1976, 1977) and may even overbalance while perching on a high-tension wire and become electrocuted (Leshem, 1985). Several authors have stressed that there is a high percentage of juveniles and subadults among collision victims because subadults normally constitute the majority of a population, particularly in autumn; subadults often have a more gregarious behaviour, and several investigations were carried out in periods when the proportion of young birds in the population is high and exposed. It was claimed that birds learn to avoid air obstacles through experience (Lee, 1978; Thompson, 1978). However, no hard data seem to exist. Birds injured in collisions and electrocution may recover (Benson, 1982), but most individuals only gain experience once, and habituation seems particularly irrelevant in the case of electrocution.

In South Africa, several hundred individuals of the vulnerable, endemic Cape vulture *Gyps coprotheres* were found electrocuted (Markus, 1972; Ledger and Annegarn, 1981; Mundy et al., 1992; Ledger et al., 1993), and numerous Egyptian vultures *Neophron percnopterus*—

Table 3
Birds recorded as electrocution victims (based on Haas, 1980)

Order	Family	No. of genera	No. of species	No. of individuals
Ciconiiformes	Ciconiidae (storks)	1	2	14
Falconiformes	Accipitridae (hawks, vultures, eagles)	9	13	430
	Falconidae (falcons and allies)	1	1	88
Charadriformes	Laridae (gulls)	1	1	1
Columbiformes	Columbidae (pigeons)	1	3	12
Strigiformes	Tytonidae (barn owls and allies)	1	1	14
	Strigidae (typical owls)	3	3	54
Passeriformes	Turdidae (chats, thrushes)	2	4	15
	Sturnidae (starlings)	1	1	18
	Lanidae (shrikes)	1	1	1
	Corvidae (crows and allies)	2	4	382

considered as endangered in South Africa—were found electrocuted in the Sudan (Nikolaus, 1984). During the last few years, numerous reports of electrocuted raptors have come from Spain and other parts of southern Europe, particular concern being expressed for the Spanish imperial eagle *Aquila adalberti* (Ferrer et al., 1991; Negro and Ferrer, 1995). In Norway, most of the owl and raptor species were recorded as either collision or electrocution victims (Bevanger and Overskaug, in press).

It is now hoped to save the California condor *Gymnogyps californianus* from becoming extinct through breeding in captivity (Wallace, 1992; Caughley, 1994). In 1992, three of eight released birds in the former distribution area of the species were found electrocuted (Mestel, 1993). While the initial population decline was supposed to have been caused by habitat loss, shooting, etc., it was stressed that toxic organochlorines were the main factor during the 1970s and 1980s. It is imperative to clearly determine the causes of decline in the population of a critically endangered species to enable appropriate management actions to be implemented. Particular attention should be paid to local populations and areas with a high density of overhead wires.

4. Conservation impacts of collision and electrocution mortality

No investigation was found that was specifically designed to judge effects of power lines on bird mortality at the population level, and the problem has mainly been addressed as one co-objective among empirical questions connected with collision extent, behavioural effects and mitigating measures (Meyer, 1978; Beaulaurier, 1981; Willdan Associates, 1982; Faanes, 1987; Hartman et al., 1992).

The impact of seemingly density-independent mortality factors, like hunting, predation and utility structures, is generally thought to be compensated for among the survivors. Although numerous birds and mammals generally show a type II survivorship curve (e.g. Begon et al., 1996), indicating that few individuals reach their physiological life span and that survival is highly age-dependent, it is well known that heavy hunting may change survivorship curves within a population, for example from a type I survivorship (i.e. mortality is massive towards the end of the greatest life span) towards a type II survivorship curve (Lowe, 1969). If a dwindling population is unable to respond with compensatory actions to the mortality caused by utility structures, this mortality is population regulatory and must be considered a significant problem for nature management authorities.

Species with dwindling populations are listed in Red Data Books (RDB) and it is reasonable that RDB species are a main target of concern regarding anthropogenically-induced mortality factors (e.g. Willard, 1978. There are numerous collision and electrocution victims among bird species recorded as vulnerable and endangered (Appendix A). It is not surprising that there are no good data for most rare species. Even in abundant species, like waders and gulls, observed collisions occur in only between 0.07 and 0.003% of total flights (Meyer, 1978). However, recoveries of rare species, ringed in small numbers, were made. For example only two ringed individuals of both corn crake *Crex crex* and water rail *Rallus aquaticus* were recovered in Norway during the period 1914–1981 (Bevanger and Thingstad, 1988), which constitute 3.3 and 6.1% of the total number of ringed birds, respectively. In both these species, one of the recoveries was a collision victim.

There are contrasting views regarding threat categories for birds and animals (e.g. Collar and Andrew, 1988; Mace and Lande, 1991; Bibby et al., 1992). Species recorded in a world-wide RDB list do not necessarily reflect local or regional (in some instances not national) situations. When the significance of collision and electrocution-induced mortality is being addressed particular attention should be paid to local populations. Unfortunately, some countries are still ignorant about the population status of potentially vulnerable and endangered species, and lack a conservation management action plan.

The indirect effects of utility structures are rarely focused upon. Clear-felled transmission-line corridors in forest areas vary in breadth from 30 m up to 60 m or more depending on the voltage, and may have far-reaching fragmenting and habitat-changing effects that might affect the fauna (e.g. Bevanger and Henriksen, 1996). Habitat fragmentation is identified as a main threat to biodiversity and is a focal point among conservation biologists, especially in tropical and neotropical areas (Bierregaard et al., 1992; Fiedler, 1993). There is no question that many more power lines will be built in the future, particularly in vulnerable, tropical and subtropical areas (Bevanger, 1994a). It was stressed that power-line corridors may be particularly damaging and create barriers to some groups of species (e.g. antbirds (Formicariidae), ovenbirds (Furnariidae), hummingbirds (Trochilidae) and tapaculos (Rhinocryptidae)) that are restricted to the understorey of mature forests (Zerda and Rosselli, 1997). Specialised mammals in the tropics, including primates, bats and rodents, are vulnerable to habitat fragmentation, as are amphibians and reptiles. Several of these creatures are also prone to electrocution (e.g. Quincy, 1993; Lawson and Wyndham, 1993; Zerda and Rosselli, 1997), although few studies have focused on this.

Conservation management authorities should not only focus on the lack of hard data rooted in population dynamics but use available documentation and indices

PAGE 7 of the PDF – end of the article, followed by references

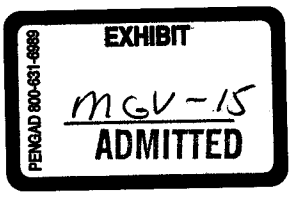
to carry out an early warning policy, like those deriving from analyses of morphology and biomechanics. Hopefully this can also convince energy companies to seriously consider financially adverse alternative routing, earth cabling and technical solutions for the construction of utility structures to reduce the adverse wildlife effects.

Appendix

Species regarded as rare, vulnerable or endangered (nationally or internationally) reported as collision and/or electrocution victims. The taxonomy follows Howard and Moore (1991)

Order	Family	Genus	Species	Source
Pelecaniformes	Pelecanidae	*Pelecanus*	Dalmatian pelican *P. crispus*	Crivelli et al., 1988
			White pelican *P. erythrorhynchos*	Ryder, 1981
			Brown pelican *P. occidentalis*	McNeil et al., 1985
Ciconiiformes	Ardeidae	*Botaurus*	Eurasian bittern *B. stellaris*	Andersen-Harild and Bloch, 1973; Gylstorff, 1979; Rose and Baillie, 1992
	Ciconiidae	*Ciconia*	White stork *C. ciconia*	Fiedler and Wissner, 1980; Haas, 1980; Oatley and Rammesmayer, 1988
	Phoenicopteridae	*Phoenicopterus*	Lesser flamingo *P. ruber*	Longridge, 1986
			Greater flamingo *P. minor*	Longridge, 1986
Anseriformes	Anatidae	*Cygnus*	Mute swan *C. olor*	Perrins and Sears, 1991; Rose and Baillie, 1992; Mathiasson, 1993
			Whooper swan *C. cygnus*	Folkestad, 1980; Rose and Baillie, 1992; Bevanger, unpubl.
			Tundra swan *C. columbianus bewickii*	Rose and Baillie, 1992
		Anser	Greylag goose *A. anser*	Rose and Baillie, 1992
Falconiformes	Cathartidae	*Gymnogyps*	California condor *G. californianus*	Snyder, 1986; Anon., 1993
	Pandionidae	*Pandion*	Osprey *P. haliaëtus*	Stolt et al., 1986; Bevanger and Thingstad, 1988; Muñoz-Pulido, 1990
	Accipitridae	*Pernis*	Western honey buzzard *P. apivorus*	Stolt et al., 1986
		Milvus	Red kite *M. milvus*	Haas, 1980; Ferrer et al., 1991; Rose and Baillie, 1992
		Haliaëtus	American bald eagle *H. leucocephalus*	Smith and Murphy, 1972; Meyer, 1980; Olendorff and Lehman, 1986
			White-tailed sea eagle *H. albicilla*	Bevanger and Thingstad, 1988
		Aegypius	Cinereous vulture *A. monachus*	Garzon, 1977
		Gyps	Griffon vulture *G. fulvus*	Mundy, 1983; Leshem, 1985; Ferrer et al., 1991
			Cape vulture *G. coprotheres*	Markus, 1972; Ledger, 1984; Ledger and Annegarn, 1981
			African white-backed vulture *G. africanus*	Drake and Mundy, 1981
		Neophron	Egyptian vulture *N. percnopterus*	Nikolaus, 1984
		Gypaetus	Lammergeier *G. barbatus*	Wuethrich, 1993
		Hieraaetus	Martial eagle *H. bellicosus*	Brooke, 1984; Maclean, 1985; Ledger, 1990
		Circus	Hen harrier *C. cyaneus*	Scott et al., 1972; Rose and Baillie, 1992
			Montague's harrier *C. pygargus*	Rose and Baillie, 1992
			Western marsh harrier *C. aeruginosus*	Rose and Baillie, 1992
		Accipiter	Northern goshawk *A. gentilis*	Stolt et al., 1986; Bevanger and Thingstad, 1988; Rose and Baillie, 1992
		Aquila	Spanish imperial eagle *A. heliaca adalberti*	Garzon, 1977; Haas, 1980; Ferrer and Court, 1988; Meyburg, 1989; Ferrer et al., 1991
			Golden eagle *A. chrysaëtos*	Olendorff et al., 1981; Bevanger and Thingstad, 1988; Rose and Baillie, 1992
	Falconidae	*Falco*	Gyr falcon *F. rusticolus*	Gudmundsson and Clausen, 1974
			Peregrine falcon *F. peregrinus*	Olsen and Olsen, 1980; Stolt et al., 1986; Rose and Baillie, 1992
Gruiformes	Gruidae	*Grus*	Common crane *G. grus*	Stolt et al., 1986
			Sandhill crane *G. canadensis*	Walkinshaw, 1956; Drewien, 1973; Brown et al., 1987; Windingstad, 1988
			Manchurian crane *G. japonensis*	Brown et al., 1987
			Whooping crane *G. americana*	Brown et al., 1987; Doughty, 1989; Howe, 1989
		Bugeranus	Wattled crane *B. carunculatus*	Johnson and Sinclair, 1984
	Rallidae	*Rallus*	Water rail *R. aquaticus*	Scott et al., 1972; Grosse et al., 1980; Bevanger and Thingstad, 1988
		Crex	Corn crake *C. crex*	Stolt et al., 1986; Bevanger and Thingstad, 1988
		Porzana	Spotted crake *P. porzana*	Grosse et al., 1980; Heijnis, 1980
	Otidae	*Ardeotis*	Kori bustard *A. kori*	Longridge, 1986
		Otis	Great bustard *O. tarda*	Cramp and Simmons, 1980; Cardoso, 1985
Strigiformes	Tytonidae	*Tyto*	Barn owl *T. alba*	Rose and Baillie, 1992
	Strigidae	*Bubo*	Northern eagle owl *B. bubo*	Glutz and Bauer, 1980; Förstel, 1983; Larsen and Stensrud, 1988
		Strix	Ural owl *S. uralensis*	Stolt et al., 1986
			Great grey owl *S. nebulosa*	Stolt et al., 1986

DOCKET NO. L-00000YY-15-0318-00171-MCV_15



Bird Strikes and Electrocutions at Power Lines, Communication Towers, and Wind Turbines: State of the Art and State of the Science – Next Steps Toward Mitigation[1]

Albert M. Manville, II[2]

Abstract

Migratory birds suffer considerable human-caused mortality from structures built to provide public services and amenities. Three such entities are increasing nationwide: communication towers, power lines, and wind turbines. Communication towers have been growing at an exponential rate over at least the past 6 years. The U.S. Fish and Wildlife Service is especially concerned about growing impacts to some 836 species of migratory birds currently protected under the Migratory Bird Treaty Act of 1918, as amended. While mortality estimates are often sketchy, and won't be verified until nationwide cumulative impact studies are conducted, current figures are troubling. Communication towers may kill from 4-50 million birds per year. Collisions with power transmission and distribution lines may kill anywhere from hundreds of thousands to 175 million birds annually, and power lines electrocute tens to hundreds of thousands more birds annually, but these utilities are poorly monitored for both strikes and electrocutions. More than 15,000 wind turbines may kill 40,000 or more birds annually nationwide, the majority in California. This paper will address the commonalities of bird impacts among these industries; those bird species that tend to be most affected; and research (completed, current, and proposed) intended to reduce bird collisions and electrocutions nationwide. The issues of structure location (siting), lighting, guy supports, lattice or tubular structures, bird behavior, and habitat modifications are reviewed. In addition, this paper reviews the respective roles and publications of the Avian Power Line Interaction Committee and the Wildlife Workgroup of the National Wind Coordinating Committee, the roles of the Service-chaired Communication Tower Working Group and Wind Turbine Siting Working Group, and the Fish and Wildlife Services' voluntary tower and turbine siting and placement guidelines. An update on recent Communication Tower Working Group research initiatives will also be discussed along with promising research findings and needs.

Key words: APLIC, avian impacts, avian mortality, BGEPA, bird strikes, collisions, communication towers, CTWG, electrocutions, ESA, MBTA, mitigation measures, NWCC, power lines, transmission and distribution lines, wind turbines.

Introduction

Acquiring reliable estimates of avian population mortality is difficult, even under controlled circumstances, and the threats to birds from human development continue to increase in the United States and elsewhere globally. As the U.S. human population grows – now the third largest in the world – human structures and the services needed to meet population demands continue to increase. Unfortunately, the impacts of these structures and services on birds, bats, and other species are generally unaccounted for, unknown, or only roughly estimated. This paper will address three of these structural impacts, those from power lines, communication towers, and wind turbines.

To better understand the impacts of human-caused mortality on landbirds – and recently on bats, attempts have been made not only to estimate these mortality factors, but also to assess the spring and fall populations of breeding landbirds in North America to determine rough mortality percentages. While bird hunting mortality has been documented back to at least Biblical times, mortality caused by structures was first documented in the United States in 1874 at lighthouses and lamps (Forest and Stream 1874) and in 1876 at telegraph wires (Coues 1876). The first U.S. Fish and Wildlife Service (USFWS or Service) attempt to estimate nationwide human-caused annual mortality was published by Banks (1979) where he estimated 196 million bird deaths caused by human activity. This estimate represented 1.9 percent of the then existing estimated bird population in North America. Of the 196 million estimated deaths, 61 percent were from hunting, 32 percent from collisions with structures, and 2 percent from pollution and poisoning. To assess the nationwide status of breeding bird populations, Aldrich et al. (1975) used the 1973 Breeding Bird Survey, which averaged 1.284 birds/km^2 (3,325 birds/mi^2), to

[1] A version of this paper was presented at the **Third International Partners in Flight Conference, March 20-24, 2002, Asilomar Conference Grounds, California.**

[2] Division of Migratory Bird Management, U.S. Fish and Wildlife Service, 4401 N. Fairfax Dr., Mail Stop MBSP 4107, Arlington, VA 22203. E-mail: Albert_Manville@fws.gov.

Page 2 of the PDF

estimate 9.975 billion breeding landbirds in the United States exclusive of Alaska and Hawaii. They concluded that the autumn landbird population was probably twice that figure – 20 billion. Banks (1979) used the figure of 10 billion breeding birds in the contiguous United States and assumed an average annual mortality of 10 billion birds. J. Trapp (unpubl. data), of the USFWS' Division of Migratory Bird Management, examined Breeding Bird Censuses for 1991 and 1992, extrapolated from these figures, and concluded that it was probably safe to talk about minimum breeding populations on the order of 10 billion birds, and minimum fall populations on the order of 20 billion birds in North America north of Mexico. While there are far more birds than people generally realize, population impacts can be sizable and most human-caused avian mortality factors are not systematically monitored or assessed.

The USFWS is currently responsible for the conservation and management of 836 species of migratory birds in the United States; these birds are killed by myriad non-hunting-related factors. These include collisions with communication towers, power lines, wind turbines, buildings and windows, smokestacks and monuments, automobiles, and aircraft; electrocutions at power lines; predation by domestic cats; poisoning from pesticides, oil and contaminant spills; drowning in oil and wastewater pits; entanglement, strangulation, and drowning in fishing gear; and loss or degradation of habitat.

Of the 836 migratory bird species managed by USFWS, at least 223 are in trouble. These include 92 listed on the Federal Endangered Species Act (ESA; 16 U.S.C. 1531 et seq.: 77 are endangered and 15 are threatened), and 131 on the USFWS's National List of Birds of Conservation Concern 2002 (USFWS 2003). Populations are declining precipitously for some of these species. To add yet another challenge to managing birds, we essentially lack data on the status of fully one-third of all North American bird populations. These challenges make management difficult. Recent extrapolations from various databases indicate that human-caused mortality could account for billions of bird deaths per year (Klem 1990, Corcoran 1999, Erickson et al. 2001, Manville 2001a, Manville 2001b). Based only on estimates of annual mortality from vehicles strikes (60- 80 million), building and window collisions (98- 980 million), smoke stack casualties (tens to hundreds of thousands), power line electrocutions (tens to hundreds of thousands), power line impacts (hundreds of thousands to perhaps 175 million), communication tower accidents (4-5 to 40-50 million), and wind turbine impacts (~ 34,000), Erickson et al. (2001) estimated from 100 million to well over one billion birds killed annually. The extent to which cumulative mortality from all human-caused factors affects bird populations, and measures that can be taken to reduce these events, are matters of considerable interest and concern to the Service and others (Manville 2001b).

Structural Review

The U.S. Power Grid

Since the U.S. power grid was first constructed in the late 1880s, power line expansion has increased tremendously. With a growing U.S. population, industrial expansion, and public demand for more electricity as exemplified by energy challenges in California in 2001, more power lines are being installed. The most recent nationwide estimates indicate that there are more than 804,500 km (500,000 mi) of bulk transmission lines in the U.S. (transmission lines in the U.S. carry ≥115,000 volts/115 kV, with conductors attached to either tall wood, concrete or steel towers; APLIC 1996, Harness 1997, Edison Electric Institute 2000). Much of the problem with bird collisions is associated with transmission lines. Distribution lines (those in the U.S. carrying ≤69,000 v/69kV) are constructed on 11- 15 m (36- 49 ft) wooden, steel, or concrete poles, typically configured with one, two, or three energized (phase) wires and one neutral (grounded) wire. Raptor electrocutions, especially in the western United States, are most frequently associated with distribution lines. Distribution lines have phase-to-phase and phase-to-ground wire clearances which place birds perching on the supporting poles at much greater risk of completing a circuit and suffering electrocution, often resulting in a power outage (Boeker and Nickerson 1975, Harness 1997). Because of rapid expansion, new development, and jurisdictional issues, no good accounting of the total amount of distribution line is available for the United States; it is certainly in the millions of kilometers. Williams (2000) cites the figure of 116,531,289 distribution poles in the United States but lists no figure for wire length.

Power Line Electrocutions

Birds have been subject to electrocutions and collisions in the United States since the first overhead telegraph wires were strung in the late 1860s, initially reported by Coues (1876) in rural Colorado. Electrification of the United States and development of the U.S. power grid began by the late 1880s and has rapidly expanded since. Not surprisingly, by 1922, eagle electrocutions were first reported at transmission lines, followed in 1933 by hawk electrocutions at distribution lines, and in 1940 by power outages on Idaho Power lines which subsequently were retrofitted with a deterrent device intended to discourage eagles from landing (R. Harness, EDM International, pers. comm.). By the early 1970s the electric utility industry had become

Page 3 of the PDF

acutely aware of bird electrocutions – especially to eagles, hawks, and owls. Reports of significant bird mortality during the winter of 1970-1971 in Colorado and Wyoming drew the attention of state and Federal law enforcement agents and the industry; nearly 1,200 eagle deaths were reported resulting from poisoning (N = 301), shooting from aircraft (N = 800+) and electrocution or shooting along a power line (N = 300+) (Olendorff et al. 1981; L. Suazo, USFWS, pers. comm.). M.W. Nelson's 1980 film "Silver Wires, Golden Wings" followed, which was one of the first public relations efforts designed to help prevent eagle electrocutions and to encourage use of nesting platforms on power poles (Lehman et al. 1999). Nelson filmed trained Golden Eagles (*Aquila chrysaetos*) during take-offs and landings on un-energized mock-up power poles to determine how electrocutions occurred and how they might be prevented. His and other research led to an update to the Suggested Practices document (Olendorff et al. 1981).

In an attempt to begin addressing both collision (specifically Whooping Cranes [*Grus americana*]) and electrocution problems, an ad hoc committee represented by several investor-owned electric utilities (IOUs), the National Audubon Society (NAS), and the Service was created in 1983. By 1989, a more formal relationship was established with the creation of the Avian Power Line Interaction Committee (APLIC) composed then of nine IOUs and the FWS (Lewis 1997) – with technical advice from staff of NAS, Clemson University, and the University of Idaho. APLIC was housed in the IOU trade association Edison Electric Institute (EEI), Washington, DC (Huckabee 1993). Following research and earlier publications in 1975 and 1981, Suggested Practices for Raptor Protection on Powerlines (APLIC 1996) became the first definitive work on raptor electrocutions. It was reprinted in 2000 in Spanish. That same year the instructional video, Raptors at Risk (North American Falconers' Association et al. 2000) was released to the public, documenting raptor electrocutions and illustrating inexpensive avoidance techniques. Copies can be obtained from R. Harness at EDM International, <rharness@edmlink.com>.

While the efforts of APLIC to reduce bird electrocutions and collisions have been key, many in the electric utility industry may still not be getting the message that human-caused bird deaths are unacceptable (Williams 2000). At present, APLIC is composed of 18 IOUs (out of 186-some IOUs within this country); one IOU trade association (EEI); some 960 cooperatives represented by the National Rural Electric Cooperative Association (NRECA; out of approximately 1,056 cooperatives housed under the U.S. Department of Agriculture [USDA]); one research organization (Electric Power Research Institute); and three Federal agencies (including USFWS, the Bonneville Power Administration, and the Western Area Power Administration) (L. Suazo, USFWS, pers. comm.; R. Loughery, Edison Electric Institute, pers. comm.; www.APLIC.org). To be a more effective arm of the overall industry, APLIC still needs to recruit additional utility membership. However, many of the cooperatives are small companies, and the $5,000 APLIC initiation fee and $2,500 annual dues are viewed by many as better spent on mitigation or for other purposes.

NRECA – somewhat like APLIC – is the not-for-profit national service organization representing most of the USDA cooperatives which provide electricity to more than 30 million consumer-owners primarily in sparsely population rural areas in 46 states. NRECA published a definitive manual for their industry, Animal Caused Outages (Southern Engineering Company 1996), which addresses wire configurations and situations unique to this segment of the industry. APLIC and NRECA are working to integrate guidance in Suggested Practices for Raptor Protection on Power Lines (APLIC 1996) that conforms to both types of utility structures and needs. USDA cooperatives, for example, now must construct distribution lines using non-conducting wooden braces and cross arms, and install ground wires that are raptor safe.

Prior to 1999, only two fines had been levied by law enforcement agents against electric utility companies for electrocuting birds protected under the Migratory Bird Treaty Act (MBTA; 16 U.S.C. 703-712) and the Bald and Golden Eagle Protection Act (BGEPA; 16 U.S.C. 668-668C), one in 1993 and the other in 1998. MBTA is a strict liability statute; the killing of any protected migratory bird is not technically allowed under law unless a permit is obtained, and the Service does not issue "incidental or accidental take" permits. The landscape changed in August 1999 with the District Court's decision against the Moon Lake Electric Association in western Colorado and eastern Utah. Beginning in 1997, agents of the Service's Office of Law Enforcement (LE) in the West investigated bird mortalities from electrocutions and strikes, and found to their dismay that the statistics rivaled those from the 1970s. As a result of this investigation, the Department of Justice prevailed in its first criminal prosecution of a utility under BGEPA and MBTA. Moon Lake pleaded guilty and agreed to pay $100,000 in fines and restitution, serve 3 year's probation, sign a memorandum of understanding (MOU) with the Service, implement an avian protection plan, and retrofit poles that were killing raptors. The message was a powerful one, sending shock waves through the electric utility, wind generation, and communication tower industries. In addition to fines as high as $500,000, company officers could be convicted of felonies, lose their right to vote, pay per-

Page 4 of the PDF

sonal fines as high as $250,000, and be jailed for up to two years (Williams 2000).

Following release of the Moon Lake MOU, LE was inundated with requests for other MOUs. In 2002, an historic MOU was signed with Xcel Energy and the USFWS Denver, Colorado, Regional Office in concurrence with the Department of Justice. The proactive agreement presently covers Colorado and Wyoming. The USFWS is currently finalizing the template for an avian protections plan (APP) with APLIC These voluntary, proactive agreements will call for the development of comprehensive APPs which are intended to reduce electrocutions and bird strikes by participating companies.

Looking specifically at the problem of electrocutions, eagles are the most commonly reported electrocuted birds, Golden Eagles reported 2.3 times more frequently than Bald Eagles (*Haliaeetus leucocephalus*) by Harness (1997) in the West, with juveniles more frequently reported killed than adults. Red-tailed Hawks (*Buteo jamaicensis*) and Great Horned Owls (*Bubo virginianus*) were the most commonly reported hawk and owl species by Harness (1997) and Harness and Wilson (2001). Power outages can result in damaged equipment, safety problems, brush and forest fires, and loss of service to customers. Nationwide, animals are the third leading identifiable cause of all power outages, with birds causing more outages than any other animal (Southern Engineering Company 1996). Of 4,300 eagle mortalities investigated by the Department of Interior from the early 1960s to 1995, electrocution was reported as the second greatest cause of mortality to Golden Eagles and the third greatest cause to Bald Eagles (LaRoe et al. 1995). Electrocution is now rated the fourth leading cause of death for Bald Eagles, following accidental trauma, poisoning, and shooting (Lehman 2001).

Where vegetation is low and terrain is flat, power poles are particularly attractive to raptors in the West since they provide structures from which to hunt and roost (Boeker 1972, Benson 1981). Eagles and buteos (soaring hawks) actively seek out poles, especially where prey is abundant and few other perches exist, increasing their range of vision, allowing greater attack speed when hunting, and advertising territorial ownership (Olendorff et al. 1981, Colson and Associates 1995). It was commonly believed in the 1980s that a very small percentage of distribution poles was actually electrocuting raptors. These were designated as "preferred poles," situated in good habitat or near high prey concentrations (Olendorff et al. 1981). Nelson and Nelson (1976) even estimated that 95 percent of electrocutions could be prevented by modifying 2 percent of the poles. Conventional wisdom indicates that these assessments were probably unrealistic due, in part, to lack of a nationwide reporting system and systematic natior wide studies, and observational and data-collectio biases (Lehman 2001).

Twelve North American raptor species are known nes ers on utility structures. In the East, Osprey (*Pandio haliaetus*) is frequently seen nesting on power pole (Blue 1996). Due to lack of staff and funding, very li tle of the U.S. power grid is assessed – if even infre quently – for bird electrocutions. The estimates of ter of thousands to hundreds of thousands or more birc killed each year are only very rough approximatior based on very limited data. True mortality could b much higher. Recent information suggests that rapt electrocutions may be under-reported, possibly large by several orders of magnitude (Lehman 2001).

Mitigation measures can vary in cost, depending o whether or not they are required for new constructio or are retrofitted. Sufficient phase-to-phase and phase to-ground wire spacing is critical for large-winge birds. This can be costly if wires have to be re-strun for wider separation. Three-phase transformers can b especially deadly where bare energized jumper wirc connect transformers, protective cutouts, and surge ai resters. These can be deadly to small and large raptor (Negro and Ferrer 1995). Jumper wires on all electrica equipment should be insulated, including at tap an dead-end locations. Existing transformers can be retrc fitted by replacing bare wire with either 600 v insulate jumpers or by sliding insulating material over bai jumpers; new jumpers should contain 600 v insulate jumpers and be insulated with bushing covers (Harnes 1997, Harness and Wilson 2001). Specifications ai provided by APLIC (1996) and Southern Engineerin Company (1996). With the use of cost-effective new c replacement steel distribution poles – steel has bee used on transmission towers for years – we see a ne electrocution challenge. The mitigation measures use on wooden poles are not effective on metal ones. In European study, insulating cross-arm braces on ste distribution poles proved most effective, while perc guards were less effective (Janss and Ferrer 1999 Harness and Wilson (2001) call for more research t attempt to qualify the relationships between rapt electrocutions and different types of electrical powc structures. The Service strongly agrees.

Power Line Collisions

Birds of a much greater variety strike power transmis sion and distribution lines. Coues (1876) was the fir to report over 100 dead birds, mostly Horned Lark (*Eremophila alpestris*), along a 4.8-km (3-mi) sectio of telegraph line, and even witnessed the deaths c three birds. Cohen (1896) reported 14 Red Phalarope (*Phalaropus fulicaria*) and a Ruddy Duck (*Oxyur jamaicensis*) verified by necropsies as telegraph wi

kills. Emerson (1904) reported shorebirds and a Black Rail (*Laterallus jamaicensis*) colliding with electrical wires over a salt marsh and evaporation ponds – representing the first reported power line strikes. Large, less maneuverable birds are more vulnerable to collisions with power lines, including Great Blue Herons (*Ardea herodias*), cranes (*Grus* spp.), swans (*Cygnus* spp.), and pelicans (*Pelicanus* spp.; Huckabee 1993). Line collisions resulted in 36 percent of the known mortality to fledged Greater Sandhill Cranes (*G. canadensis tabida*) in the Rocky Mountains (Drewien 1973), 44 percent mortality of fledged Trumpeter Swans (*C. buccinator*) in Wyoming (Lockman 1988), and 40 percent of the know mortality of endangered fledged Whooping Cranes in the Rocky Mountains (Lewis 1993). In a study near wetlands in North Dakota, Faanes (1987) found that waterbirds (based on 46 percent documented mortality), waterfowl (26 percent), shorebirds (8 percent), and passerines (5 percent) were most vulnerable to strikes with transmission lines. In habitats away from wetlands, raptors and passerines appear to be most susceptible to collisions with power lines. Collisions from many other species have also been reported (Erickson et al. 2001).

On Kaua'i, Hawaiian Islands, studies by Podolsky et al. (1998) and Ainley et al. (2001) documented rather unique lighting and power line impacts to Newell's Shearwaters (*Puffinus auricularis newelli*). During the first nocturnal flights of fledglings from nests to the ocean, a high percentage (≥2 to ≥10 percent) of fledglings were reported blinded by man-made lighting, disoriented, and killed while colliding with lights, utility poles, wires, buildings, and automobiles (Ainley et al. 2001). Contrary to recommendations by APLIC, wide spacing of power transmission lines appeared to increase collisions of summer nesting season adults and subadults during their nocturnal and crepuscular flights to and from bird colonies (Podolsky et al. 1998). It was hypothesized that the wide spacing increased the incidence of collisions as birds attempted to avoid hitting one line, only to hit another. In experimental areas, light shielding was shown to reduce attraction by as much as 40 percent while reducing light intensity also lowered deaths significantly (Ainley et al. 2001). Burying power lines was also recommended for particular hot spots.

Estimates of mortality from avian collisions with power lines have varied considerably and have frequently been based on extrapolations. Faanes (1987) estimated 124 avian fatalities/km/yr (200 fatalities/mi/yr) near prairie wetlands and lakes in North Dakota. Koops (1987) examined 4,666 km (2,900 mi) of bulk transmission line in the Netherlands, estimating 0.75 - 1 million birds killed there per year. U.S. mortality could range from hundreds of thousands up to perhaps 175 million birds per year, based on extrapolations by Erickson et al. (2001) and Koops (1987). Very little of the power grid, however, is currently being examined so these estimates are not particularly meaningful.

In an attempt to comprehensively address the collision problem, APLIC (1994) provided voluntary guidance to the industry on avoiding power line strikes. The document will be updated once research being conducted by the Electric Power Research Institute and others at the Audubon National Wildlife Refuge, North Dakota, is completed, and results of tests on a Bird Strike Indicator and Bird Activity Monitor can be published. Other research findings will also likely be included. For example, marker balls, bird diverters, and paint have been shown to reduce collisions, sometimes significantly. Strikes were reduced by 53 percent at a South Carolina transmission line outfitted with yellow marker balls (Savereno et al. 1996). In southwestern Colorado, polyvinyl chloride plastic dampers reduced collisions of cranes and waterfowl by 61 percent while yellow fiberglass square plates reduced mortality to the same species by 63 percent (Brown and Drewien 1995).

Communication Tower Collisions and Related Problems

Communication towers, whether monopole cellular telephone, or tall, lattice structured digital television (DTV) antennas, are an increasingly familiar sight in neighborhoods, near highways, and along ridge tops. For at least the past 6 years, the number of communication towers (including but not necessarily limited to radio, television, cellular, microwave, emergency broadcast, national defense, paging, and related) constructed across the landscape has been growing at an exponential rate. Based on the July 2002 statistics from the Federal Communication Commission's (FCC) Antenna Structure Registry Database (FCC 2002), more than 138,000 towers were listed with the Commission – of which some 106,000 were lighted. Revised published statistics (FCC 2003) may have indicated some double-counting of the 2002 numbers, since nearly 93,000 towers were reported registered in June 2003. Due to an under-reporting to the FCC of up to some 35 percent, the actual number of existing towers is likely higher (Manville 2001b).

While this is positive news for the communications industry, it is decidedly problematic for migrating birds. Towers today pose a likely significant impact on migratory birds, especially some 350 species of passerines. The earliest known report of a bird-tower kill in the United States took place in September 1948 at a 137-m (450-ft) radio tower in Baltimore, Maryland, although no details about the incident were available (Aronoff 1949). The first long-term study of the impact of a television tower on birds was begun in 1955 by the

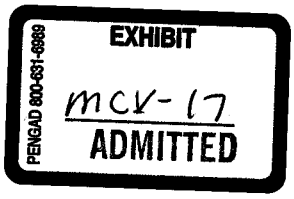
EXHIBIT
MCK-16
ADMITTED
PENGAD 800-631-6989

OUTSTANDING ARIZONA WATERS (OAWs)

A.A.C. R18-11-112(G)

1. West Fork of the Little Colorado River, from its headwaters at 33°55'02"/109°33'30" to Government Springs at 33°59'33"/109°27'54" (approximately 9.1 river miles);
2. Oak Creek, from its headwaters at 35°01'30"/111°44'12" to its confluence with the Verde River at 34°40'41"/111°56'30 (approximately 50.3 river miles);
3. West Fork of Oak Creek, from its headwaters at 35°02'44"/111°54'48" to its confluence with Oak Creek at 34°59'14"/111°44'46" (approximately 15.8 river miles);
4. Peeples Canyon Creek, from its headwaters at 34°23'57"/113°19'45" to its confluence with the Santa Maria River at 34°20'36"/113°15'12" (approximately 8.1 river miles);
5. Burro Creek, from its headwaters at 34°52'46.5"/113°05'13.5" to its confluence with Boulder Creek at 34°374.5"/113°18'36" (approximately 29.5 miles);
6. Francis Creek, from its headwaters at 34°54'38"/113°20'30" to its confluence with Burro Creek at 34°44'29"/113°14'37" (approximately 22.9 river miles);
7. Bonita Creek, from its boundary of the San Carlos Indian Reservation at 33°03'08"/109°33'41" to its confluence with the Gila River at 32°53'36"/109°28'43" (approximately 14.7 river miles);
8. Cienega Creek, from its confluence with Gardner Canyon and Spring Water Canyon at 31°47'38.5"/110°35'21.5" to the USGS gaging station at 32°02'09"/110°40'34" (approximately 28.3 river miles);
9. Aravaipa Creek, from its confluence with Stowe Gulch at 32°52'10"/110°22'03" to the downstream boundary of the Aravaipa Canyon Wilderness Area at 32°54'23"/110°33'42" (approximately 15.5 river miles);
10. Cave Creek, from its headwaters at 31°50'30"/109°17'04.5" to the Coronado National Forest boundary at 31°54'38"/109°08'40" (approximately 10.4 river miles);
11. South Fork of Cave Creek, from its headwaters at 31°50'20"/109°16'33" to its confluence with Cave Creek at 31°53'04"/109°10'30" (approximately 8.6 river miles);
12. Buehman Canyon Creek, from its headwaters at 32°52'0.5"/110°39'54.5" to its confluence with unnamed tributary at 32°24'31.5"/110°32'08" (approximately 9.8 river miles);
13. Lee Valley Creek, from its headwaters at 33°55'49"/109°31'34" to its confluence with Lee Valley Reservoir at 33°56'28"/109°30'15.5" (approximately 1.6 river miles);
14. Bear Wallow Creek, from its headwaters at 33°35'54"/109°26'54.5" to the boundary of the San Carlos Indian Reservation at 33°37'52"/109°29'44" (approximately 4.25 river miles);
15. North Fork of Bear Wallow Creek, from its headwaters at 33°34'47.5"/109°21'59.5" to its confluence with Bear Wallow Creek at 33°35'54"/109°26'54.5" (approximately 3.8 river miles);
16. South Fork of Bear Wallow Creek, from its headwaters at 33°34'38.5"/109°23'58" to its confluence with Bear Wallow Creek at 33°35'54"/109°26'54.5" (approximately 3.8 river miles);
17. Snake Creek, from its headwaters at 33°37'21.5"/109°26'11" to its confluence with the Black River at 33°40'31.5"/109°28'58.5" (approximately 6.2 river miles);
18. Hay Creek, from its headwaters at 33°51'00"/109°28'48" to its confluence with the West Fork of the Black River at 33°48'30"/109°25'19" (approximately 5.5 river miles);
19. Stinky Creek, from the White Mountain Apache Indian Reservation boundary at 33°52'36.5"/109°29'45" to its confluence with the West Fork of the Black River at 33°51'21.5"/109°27'09.5" (approximately 3.0 river miles);
20. KP Creek, from its headwaters at 33°34'03"/109°21'19" to its confluence with the Blue River at 33°31'44"/109°12'04.5" (approximately 12.7 river miles);
21. Davidson Canyon, from the unnamed spring at 31°59'00"/110°38'46" to its confluence with Cienega Creek; and
22. Fossil Creek, from its headwaters at the confluence of Sandrock and Calf Pen Canyons above Fossil Springs at 34°26'48.7"/111°32'25" to its confluence with the Verde River at 34°18'21.8"/111°40'31.6" (approximately 17.2 river miles).

DOCKET NO. L-00000YY-15-0318-00171-MCV_17



ARIZONA MISSING LINKAGES

Galiuro – Pinaleño – Dos Cabezas Linkage Design

Paul Beier, Emily Garding, Daniel Majka
2008

NORTHERN ARIZONA UNIVERSITY

Table of Contents

TABLE OF CONTENTS 1

LIST OF TABLES & FIGURES 2

TERMINOLOGY 4

EXECUTIVE SUMMARY 5

INTRODUCTION 9

- Nature Needs Room to Move 9
- A Statewide Vision 9
- Ecological Significance of the Galiuro-Pinaleño-Dos Cabezas Linkage 10
- Threats to Connectivity 11

LINKAGE DESIGN & RECOMMENDATIONS 14

- Two Linkages Provide Connectivity Across a Diverse Landscape 14
- Land Ownership, Land Cover, and Topographic Patterns within the Linkage Design 15
- Removing and Mitigating Barriers to Movement 15
- Impacts of Roads on Wildlife 20
  - *Mitigation for Roads* 20
  - *Existing Roads in the Linkage Design Area* 24
  - *Existing Crossing Structures in the Linkage Design* 25
  - *Recommendations for Highway Crossing Structures* 26
  - *Figure 13: Existing crossing structures in the Linkage Design Additional Road Crossing Structures Needed to Avoid Isolation of Reptile and Amphibian Populations Not Served by the Two Linkages* 29
  - *Additional Road Crossing Structures Needed to Avoid Isolation of Reptile and Amphibian Populations Not Served by the Two Linkages* 30
  - *Mitigation for Urban Barriers* 32

APPENDIX A: LINKAGE DESIGN METHODS 34

- Focal Species Selection 34
- Habitat Suitability Models 35
- Identifying Potential Breeding Patches & Potential Population Cores 36
- Identifying Biologically Best Corridors 37
- Patch Configuration Analysis 38
- Minimum Linkage Width 39
- Field Investigations 40

APPENDIX B: INDIVIDUAL SPECIES ANALYSES 41

BADGER (*TAXIDEA TAXUS*) 43

BLACK BEAR (*URSUS AMERICANUS*) 47

BOBCAT (*LYNX RUFUS*) 51

JAGUAR (*PANTHERA ONCA*) 55

JAVELINA (*TAYASSU TAJACU*) 59

KIT FOX (*VULPES MACROTIS*) 63

MEXICAN GRAY WOLF (*CANIS LUPUS BAILEYI*) 67

MOUNTAIN LION (*PUMA CONCOLOR*) 71

MULE DEER (*ODOCOILEUS HEMIONUS*) 75

PRONGHORN (*ANTILOCAPRA AMERICANA*) 79
APPENDIX C: FOCAL SPECIES NOT MODELED 83
APPENDIX D: CREATION OF LINKAGE DESIGN 85
APPENDIX E: DESCRIPTION OF LAND COVER CLASSES 86
APPENDIX F: LITERATURE CITED 89
APPENDIX G: DATABASE OF FIELD INVESTIGATIONS 96

List of Tables & Figures

List of Tables

TABLE 1: FOCAL SPECIES SELECTED FOR GALIURO - PINALEÑOS - DOS CABEZAS LINKAGE 6
TABLE 2: APPROXIMATE LAND COVER IN LINKAGE DESIGN. SEE TEXT FOR LAND COVER IN EACH OF THE FIVE STRANDS OF THE LINKAGE DESIGN 15
TABLE 3. CHARACTERISTICS WHICH MAKE SPECIES VULNERABLE TO THE THREE MAJOR DIRECT EFFECTS OF ROADS (FROM FORMAN ET AL. 2003). 20
TABLE 4: ROADS IN THE LINKAGE DESIGN 25
TABLE 5: HABITAT SUITABILITY SCORES AND FACTOR WEIGHTS FOR EACH SPECIES. SCORES RANGE FROM 1 (BEST) TO 10 (WORST). WITH 1-3 INDICATING OPTIMAL HABITAT, 4-5 SUBOPTIMAL BUT USABLE HABITAT, 6-7 OCCASIONALLY USED BUT NOT BREEDING HABITAT, AND 8-10 AVOIDED 41

List of Figures

FIGURE 1: THE GALIURO-PINALEÑO LINKAGE DESIGN CONTAINS TWO MAIN STRANDS, AND THE PINALEÑO-DOS CABEZAS LINKAGE DESIGN CONTAINS THREE MAIN STRANDS. MULTIPLE STRANDS SERVE SPECIES WITH DIVERSE HABITAT NEEDS. THE LINKAGE DESIGN ALSO CALLS FOR SMALL CULVERTS ON ROADS IN SULPHUR SPRINGS VALLEY (FIGURE 2) 7
FIGURE 2. THE LINKAGE DESIGN CALLS FOR SMALL CULVERTS EVERY 150 M ALONG GRAY-GREEN ROAD SEGMENTS (US-191, SR-186, SR-181) IN SULPHUR SPRINGS VALLEY TO PREVENT ISOLATION AND MINIMIZE MORTALITY TO REPTILE AND AMPHIBIAN POPULATIONS THERE. 8
FIGURE 3: LAND COVER IN THE LINKAGE PLANNING AREA 12
FIGURE 4: EXISTING CONSERVATION INVESTMENTS WITHIN THE LINKAGE PLANNING AREA 13
FIGURE 5: PROPERTY OWNERSHIP AND FIELD INVESTIGATION WAYPOINTS WITHIN LINKAGE DESIGN, THE ACCOMPANYING CD-ROM INCLUDES PHOTOGRAPHS TAKEN AT MOST WAYPOINTS 17
FIGURE 6: LAND COVER IN THE LINKAGE DESIGN. 18
FIGURE 7: TOPOGRAPHIC DIVERSITY ENCOMPASSED BY THE LINKAGE DESIGN: A) TOPOGRAPHIC POSITION, B) SLOPE, C) ASPECT 19
FIGURE 8: POTENTIAL ROAD MITIGATIONS (FROM TOP TO BOTTOM) INCLUDE: HIGHWAY OVERPASSES, BRIDGES, CULVERTS, AND DRAINAGE PIPES. FENCING (LOWER RIGHT) SHOULD BE USED TO GUIDE ANIMALS INTO CROSSING STRUCTURES. 22
FIGURE 9: AN 8X10' BOX CULVERT UNDER I-10 AT MILEPOST 351, WAYPOINT 59 26
FIGURE 10: A 3-BOX CULVERT UNDER US 191 AT MILEPOST 95, WAYPOINT 63 27
FIGURE 11: A 4-BOX CULVERT UNDER US 191 AT MILEPOST 96, WAYPOINT 64 27
FIGURE 12: A LARGE BRIDGE ALONG SR 266 NEAR THE JUNCTION WITH KLONDIKE RD, WAYPOINT 66 28
FIGURE 13: EXISTING CROSSING STRUCTURES IN THE LINKAGE DESIGN 29
FIGURE 14: PERCENT NATURAL VEGETATION DECLINES RAPIDLY AT HOUSING DENSITIES GREATER THAN 1 DWELLING UNIT PER 40 ACRES. 31
FIGURE 15: FOUR HABITAT FACTORS USED TO CREATE HABITAT SUITABILITY MODELS. INPUTS INCLUDED VEGETATION, ELEVATION, TOPOGRAPHIC POSITION, AND DISTANCE FROM ROADS 36
FIGURE 16: EXAMPLE MOVING WINDOW ANALYSIS WHICH CALCULATES THE AVERAGE HABITAT SUITABILITY SURROUNDING A PIXEL. A) ORIGINAL HABITAT SUITABILITY MODEL. B) 3X3-PIXEL MOVING WINDOW. C) 200M RADIUS MOVING WINDOW 37

FIGURE 17: TO GIVE OUR CORRIDORS MODELS "ROOM TO RUN," FOR THE PURPOSES OF BBC ANALYSES, WE MODIFIED THE WILDLAND BLOCKS USED IN OUR ANALYSES, SO THAT THE FACING EDGES WERE PARALLEL LINES ABOUT 15 KM APART. THIS FORCES THE MODELS TO IDENTIFY CORRIDORS WITH THE BEST HABITAT; WITHOUT THIS MODIFICATION, THE MODELS TEND TO IDENTIFY THE SHORTEST CORRIDORS REGARDLESS OF HABITAT QUALITY. 38
FIGURE 18: A) LANDSCAPE PERMEABILITY LAYER FOR ENTIRE LANDSCAPE, B) BIOLOGICALLY BEST CORRIDOR COMPOSED OF MOST PERMEABLE 10% OF LANDSCAPE 39
FIGURE 19: POTENTIAL HABITAT PATCHES AND CORES FOR BADGER IN THE GALIURO-PINALEÑO AREA 44
FIGURE 20: MODELED HABITAT SUITABILITY OF BADGER IN THE GALIURO-PINALEÑO AREA 45
FIGURE 21: POTENTIAL HABITAT PATCHES AND CORES FOR BADGER IN THE PINALEÑO-DOS CABEZAS AREA 45
FIGURE 22: MODELED HABITAT SUITABILITY FOR BADGER IN THE PINALEÑO-DOS CABEZAS AREA 46
FIGURE 23: POTENTIAL HABITAT PATCHES AND CORES FOR BLACK BEAR IN THE GALIURO-PINALEÑO AREA 48
FIGURE 24: MODELED HABITAT SUITABILITY OF BLACK BEAR IN THE GALIURO-PINALEÑO AREA 49
FIGURE 25: POTENTIAL HABITAT PATCHES AND CORES FOR BLACK BEAR IN THE PINALEÑO-DOS CABEZAS AREA 49
FIGURE 26: MODELED HABITAT SUITABILITY FOR BLACK BEAR IN THE PINALEÑO-DOS CABEZAS AREA 50
FIGURE 27: POTENTIAL HABITAT PATCHES AND CORES FOR BOBCAT IN THE GALIURO-PINALEÑO AREA 53
FIGURE 28: MODELED HABITAT SUITABILITY FOR BOBCAT IN THE GALIURO-PINALEÑO AREA 53
FIGURE 29: POTENTIAL HABITAT PATCHES AND CORES FOR BOBCAT IN THE PINALEÑO-DOS CABEZAS AREA 53
FIGURE 30: MODELED HABITAT SUITABILITY FOR BOBCAT IN THE PINALEÑO-DOS CABEZAS AREA 54
FIGURE 31: POTENTIAL HABITAT PATCHES AND CORES FOR JAGUAR IN THE GALIURO-PINALEÑO AREA 56
FIGURE 32: MODELED HABITAT SUITABILITY FOR JAGUAR IN THE GALIURO-PINALEÑO AREA 57
FIGURE 33: POTENTIAL HABITAT PATCHES AND CORES FOR JAGUAR IN THE PINALEÑO-DOS CABEZAS AREA 57
FIGURE 34: MODELED HABITAT SUITABILITY FOR JAGUAR IN THE PINALEÑO-DOS CABEZAS AREA 58
FIGURE 35: POTENTIAL HABITAT PATCHES AND CORES FOR JAVELINA IN THE GALIURO-PINALEÑO AREA 60
FIGURE 36: MODELED HABITAT SUITABILITY FOR JAVELINA IN THE GALIURO-PINALEÑO AREA 61
FIGURE 37: POTENTIAL HABITAT PATCHES AND CORES FOR JAVELINA IN THE PINALEÑO-DOS CABEZAS AREA 61
FIGURE 38: MODELED HABITAT SUITABILITY FOR JAVELINA IN THE PINALEÑO-DOS CABEZAS AREA 62
FIGURE 39: POTENTIAL HABITAT PATCHES AND CORES FOR KIT FOX IN THE GALIURO-PINALEÑO AREA 64
FIGURE 40: MODELED HABITAT SUITABILITY OF KIT FOX IN THE GALIURO-PINALEÑO AREA 65
FIGURE 41: POTENTIAL HABITAT PATCHES AND CORES FOR KIT FOX IN THE PINALEÑO-DOS CABEZAS AREA 65
FIGURE 42: MODELED HABITAT SUITABILITY FOR KIT FOX IN THE PINALEÑO-DOS CABEZAS AREA 66
FIGURE 43: POTENTIAL HABITAT PATCHES AND CORES FOR MEXICAN GRAY WOLF IN THE GALIURO-PINALEÑO AREA 68
FIGURE 44: MODELED HABITAT SUITABILITY FOR MEXICAN GRAY WOLF IN THE GALIURO-PINALEÑO AREA 69
FIGURE 45: POTENTIAL HABITAT PATCHES AND CORES FOR MEXICAN GRAY WOLF IN THE PINALEÑO-DOS CABEZAS AREA 69
FIGURE 46: MODELED HABITAT SUITABILITY FOR MEXICAN GRAY WOLF IN THE PINALEÑO-DOS CABEZAS AREA 70
FIGURE 47: POTENTIAL HABITAT PATCHES AND CORES FOR MOUNTAIN LION IN THE GALIURO-PINALEÑO AREA 72
FIGURE 48: MODELED HABITAT SUITABILITY FOR MOUNTAIN LION IN THE GALIURO-PINALEÑO AREA 73
FIGURE 49: POTENTIAL HABITAT PATCHES AND CORES FOR MOUNTAIN LION IN THE PINALEÑO-DOS CABEZAS AREA . 73
FIGURE 50: MODELED HABITAT SUITABILITY FOR MOUNTAIN LION IN THE PINALEÑO-DOS CABEZAS AREA 74
FIGURE 51: POTENTIAL HABITAT PATCHES AND CORES FOR MULE DEER IN THE GALIURO-PINALEÑO AREA 76
FIGURE 52: MODELED HABITAT SUITABILITY FOR MULE DEER IN THE GALIURO-PINALEÑO AREA 77
FIGURE 53: POTENTIAL HABITAT PATCHES AND CORES FOR MULE DEER IN THE PINALEÑO-DOS CABEZAS AREA 77
FIGURE 54: MODELED HABITAT SUITABILITY FOR MULE DEER IN THE PINALEÑO-DOS CABEZAS AREA 78
FIGURE 55: POTENTIAL HABITAT PATCHES AND CORES FOR PRONGHORN IN THE GALIURO-PINALEÑO AREA 80
FIGURE 56: MODELED HABITAT SUITABILITY FOR PRONGHORN IN THE GALIURO-PINALEÑO AREA 81
FIGURE 57: POTENTIAL HABITAT PATCHES AND CORES FOR PRONGHORN IN THE PINALEÑO-DOS CABEZAS AREA 81
FIGURE 58: MODELED HABITAT SUITABILITY FOR PRONGHORN IN THE PINALEÑO-DOS CABEZAS AREA 82
FIGURE 59: ADJUSTMENTS TO UNION OF BIOLOGICALLY BEST CORRIDORS TO CREATE THE LINKAGE DESIGN. 85

Executive Summary

Habitat loss and fragmentation are the leading threats to biodiversity, both globally and in Arizona. These threats can be mitigated by conserving well-connected networks of large wildland areas where natural ecological and evolutionary processes operate over large spatial and temporal scales. Large wildland blocks connected by corridors can maintain top-down regulation by large predators, natural patterns of gene flow, pollination, dispersal, energy flow, nutrient cycling, inter-specific competition, and mutualism. Corridors allow ecosystems to recover from natural disturbances such as fire or flood, and to respond to human-caused disturbance such as climate change and invasions by exotic species.

Arizona is fortunate to have vast conserved wildlands that are fundamentally one interconnected ecological system. In this report, we use a scientific approach to design a corridor (Linkage Design) that will conserve and enhance wildlife movement between three large wildland administered by the U.S. Forest Service and the Bureau of Land Management in southeastern Arizona. Interstate 10, other highways, urban development, and agriculture threaten to impede animal movement between the Galiuro and Pinaleño Mountains, and between the Pinaleño Mountains and the Dos Cabezas-Chiricahua Mountains. These wildlands represent a large public investment in biological diversity, and this Linkage Design is a reasonable science-based approach to maintain the value of that investment.

To begin the process of designing this linkage, we asked academic scientists, agency biologists, and conservation organizations to identify species sensitive to habitat loss and fragmentation. They identified 18 focal species, including 2 amphibians, 2 reptiles, 2 birds, and 12 mammals (Table 1). These focal species cover a broad range of habitat and movement requirements. Some require huge tracts of land to support viable populations (e.g. mountain lion, jaguar). Some species are habitat specialists (e.g. pronghorn), and others are reluctant or unable to cross barriers such as freeways (e.g. mule deer). Some species are rare and/or endangered while others like javelina are common but still need gene flow among populations. All the focal species are part of the natural heritage of this mosaic of Apache Highlands and Sonoran Desert. Together, these 18 species cover a wide array of habitats and movement needs in the region, so that the linkage design should cover connectivity needs for other species as well.

To identify potential routes between existing protected areas we used GIS methods to identify a biologically best corridor for each focal species to move between these wildland blocks. We also analyzed the size and configuration of suitable habitat patches to verify that the final Linkage Design (Figure 1, Figure 2) provides live-in or move-through habitat for each focal species. The resulting Linkage Design (Figure 1) is composed of two main linkages: the **Pinaleños-Galiuro Linkage** has two strands running 30-50 km, and the **Pinaleños-Dos Cabezas Linkage** has three strands 35-55 km in length. The 5 strands together provide habitat for movement and reproduction of wildlife between the Pinaleño Mountains and the Galiuros Mountains to the east and the Chiricahua Mountains to the south. The Linkage Design also includes recommendations to minimize the risk that publicly owned roads isolate reptile and amphibian populations conserved on private lands in Sulphur Springs Valley (Figure 2). We visited priority areas in the field to identify and evaluate barriers to wildlife movement, and we provide detailed mitigations for barriers to animal movement in the section titled *Linkage Design and Recommendations*.

This region provides significant ecological, educational, recreational, and spiritual values of protected wildlands. Our Linkage Design represents an opportunity to protect a functional landscape-level connection. The cost of implementing this vision will be substantial—but reasonable in relation to the benefits and the existing public investments in protected wild habitat. If implemented, our plan would not only permit movement of individuals and genes between the Galiuro, Pinaleño, and Dos Cabezas wildland blocks, but should also conserve large-scale ecosystem processes that are essential to the

continued integrity of existing conservation investments by the US Forest Service, Arizona State Parks, Bureau of Land Management, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and other conservancy lands.

Next Steps: This Linkage Design Plan is a science-based starting point for conservation actions. The plan can be used as a resource for regional land managers to understand their critical role in sustaining biodiversity and ecosystem processes. Relevant aspects of this plan can be folded into management plans of agencies managing public lands. Transportation agencies can use the plan to design new projects and find opportunities to upgrade existing structures. Regulatory agencies can use this information to help inform decisions regarding impacts on streams and other habitats. This report can also help motivate and inform construction of wildlife crossings, watershed planning, habitat restoration, conservation easements, zoning, and land acquisition. Implementing this plan will take decades, and collaboration among county planners, land management agencies, resource management agencies, land conservancies, and private landowners.

Public education and outreach is vital to the success of this effort – both to change land use activities that threaten wildlife movement and to generate appreciation for the importance of the corridor. Public education can encourage residents at the urban-wildland interface to become active stewards of the land and to generate a sense of place and ownership for local habitats and processes. Such voluntary cooperation is essential to preserving linkage function. The biological information, maps, figures, tables, and photographs in this plan are ready materials for interpretive programs.

Ultimately the fate of the plants and animals living on these lands will be determined by the size and distribution of protected lands and surrounding development and human activities. We hope this linkage conservation plan will be used to protect an interconnected system of natural space where our native biodiversity can thrive, at minimal cost to other human endeavors.

Table 1: Focal species selected for Galiuro - Pinaleños - Dos Cabezas Linkage

MAMMALS	AMPHIBIANS & REPTILES	BIRDS
Bats	Ornate Box Turtle	Western Burrowing Owl
*Badger	Plains Leopard Frog	Sandhill Crane
*Black Bear	Texas Horned Lizard	
Black-tailed Prairie Dog	Chiricahua Leopard Frog	
*Bobcat		
*Jaguar		
*Javelina		
*Kit Fox		
*Mountain Lion		
*Mule Deer		
*Pronghorn		
*Wolf		

* Species modeled in this report. The other species were not modeled because there were insufficient data to quantify habitat use in terms of available GIS data (e.g., species that select small rocks), because the species does not occur in both wildland blocks, or because the species probably can travel (e.g., by flying) across unsuitable habitat. Although we did not develop corridor models for ornate box turtleor plains leopard frog, we made special recommendations for roads in Sulphur Springs Valley to promote connectivity for these species.

Page 9 of the PDF Map Figure 1

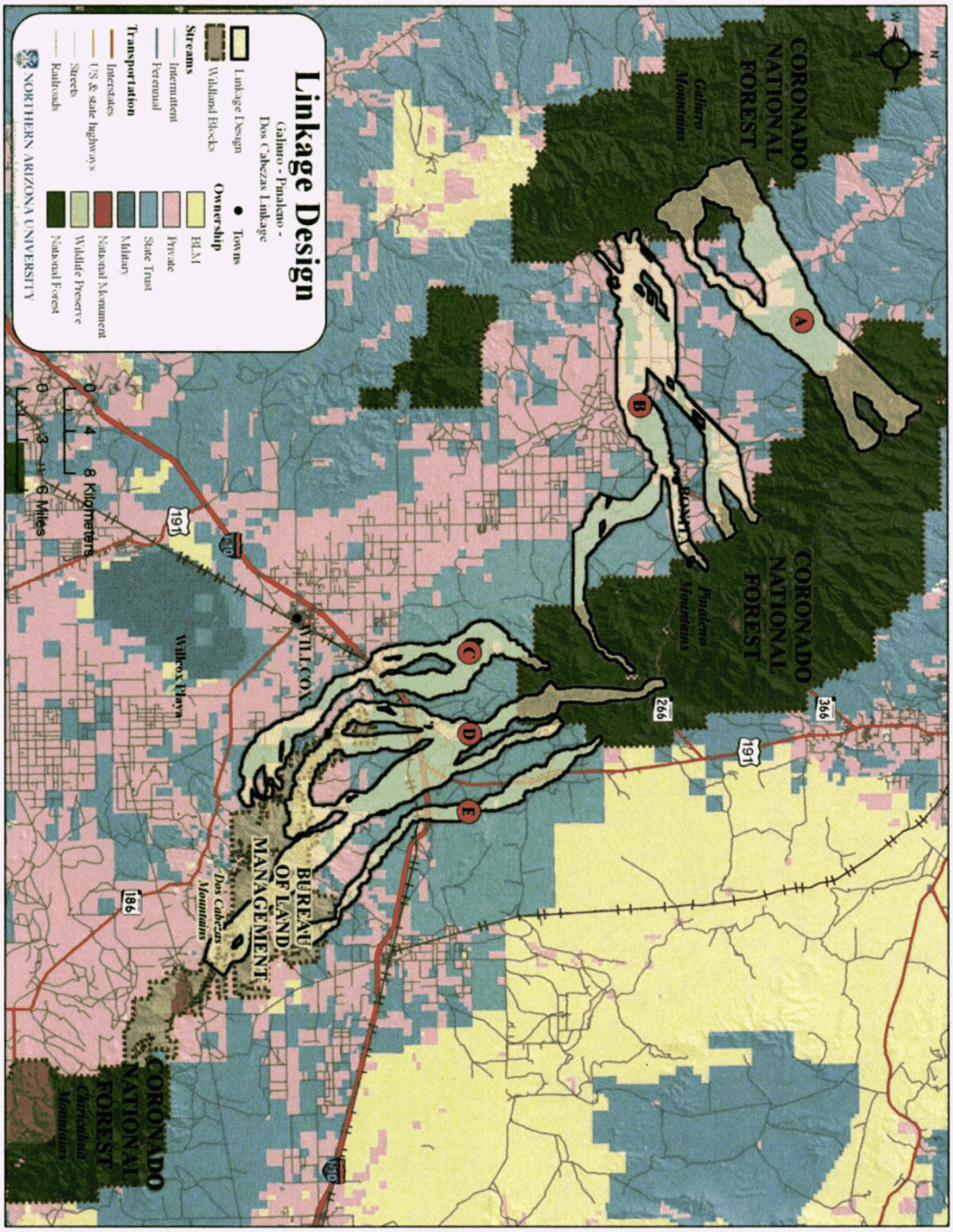


Figure 1: The Galiuro-Pinaleño Linkage Design contains two main strands, and the Pinaleño-Dos Cabezas Linkage Design contains three main strands. Multiple strands serve species with diverse habitat needs. The Linkage Design also calls for small culverts on roads in Sulphur Springs Valley (Figure 2).

Ecological Significance of the Galiuro-Pinaleño-Dos Cabezas Linkage

The Galiuro-Pinaleño-Dos Cabezas linkage planning area lies within Madrean Archipelago of southeastern Arizona. This ecoregion is a unique ecological zone lying south of the Rocky Mountains and north of the Sierra Madre Occidental. Natural communities here range from desert grasslands in the lowlands to coniferous forests in the higher elevations. The isolated mountain ranges separated by valleys are known as "sky islands." The linkage planning area includes three of these sky islands, separated by valleys, farmlands, highways, Interstate 10, and the town of Willcox.

The **Galiuro wildland block** consists of 152,778 protected acres of steep, rugged terrain administered mostly by the Coronado National Forest, with significant holdings by The Nature Conservancy and BLM in the southern Galiuro Mountains. This wildland block includes the Winchester Mountains, also managed by Coronado National Forest. Two wilderness areas (Figure 4) occur here: the 73,317-acre Galiuro Wilderness area in the Coronado National Forest, which reaches over 7,600 feet at Bassett Peak, and the contiguous 6,600-acre Redfield Canyon Wilderness managed by the Bureau of Land Management.

The **Pinaleño wildland block** consists of 198,144 protected acres of steep rocky slopes and rugged canyons. With elevations up to 10,700 feet on Mt Graham, this land supports coniferous forests and the endangered Mt Graham Red Squirrel, as well as oak and pine-oak forests and woodlands, and semi-desert grasslands.

The **Dos Cabezas wildland block** includes 245,900 acres in the BLM-administered Dos Cabezas Mountains and the adjacent Chiricahua Mountains which mostly within the Coronado National Forest. This block contains two wilderness areas, the 11,700-acre Dos Cabezas Mountains Wilderness, a rugged area with peaks above 7,000 feet, and the 87,700-acre Chiricahua Wilderness with 9,000-ft peaks and an extensive trail system. The Fort Bowie National Historic Site, managed by the National Park Service, protects Apache Pass, which links the Dos Cabezas Mountains in the north from the Chiricahua Mountains to the south. Another National Park unit is the Chiricahua National Monument, 12,000 acres of desert grassland and fantastic rock formations. This area is a unique ecological zone where the Sonoran Desert transitions to Chihuahuan Desert and the southern Rocky Mountains give way to the northern Sierra Madres. It contains several springs and streams important for wildlife.

The linkage planning area is dominated by semi-desert grasslands and desert scrub, with Sonoran desert and thornscrub vegetation to the west and Chihuahuan desert to the east. There are isolated patches of pine-oak woodlands. The broad grasslands of Sulphur Springs Valley separate the Gailuro Mountains from the Pinaleño Mountains and the Dos Cabezas. The Willcox Playa, a closed lake basin, lies in the south-central portion of the valley. The Willcox Playa Wildlife Area protects roughly 595 acres including 120 acres of deeded land, 320 acres of land patented from the Bureau of Land Management, a 115-acre perpetual right-of-way from the Arizona State Land Department, and a 40-acre donation from a private land owner. This playa is important wildlife habitat, especially for waterfowl and migratory birds. It attracts over 500 species of birds, including tens of thousands of Sandhill Cranes, and a similar number of tourists for an annual birding festival.

The Linkage Design incorporates and connects important habitat for threatened or endangered species such as jaguar and Mexican grey wolf. The linkage planning area is also home to far-ranging mammals such as mule deer, badger, and mountain lion. These animals move long distances to gain access to suitable foraging or breeding sites, and would benefit significantly from corridors that link large areas of habitat (Turner et al. 1995). Less-mobile species such as javelina also need corridors to maintain genetic diversity, allow populations to shift their range in response to climate change, and promote recolonization after fire or epidemics.

Threats to Connectivity

Major potential barriers in the linkage area include Interstate 10, habitat degradation, and urban and agricultural development. Willcox serves as the major trade and service center for agriculture and tourism within Cochise County. It is also an important cattle center. Human activities including grazing, water diversion, mining, and fire suppression have altered the natural landscape. These barriers could inhibit wildlife movement between the Galiuro, Pinaleño, and Dos Cabezas wildland blocks.

Providing connectivity is paramount in sustaining this unique area's diverse natural heritage. Recent and future human activities could sever natural connections and alter the functional integrity of this natural system. Creating linkages that overcome barriers to movement will ensure that wildlife in all wildland blocks and the potential linkage area will thrive there for generations to come.

Page 15 of the PDF Figure

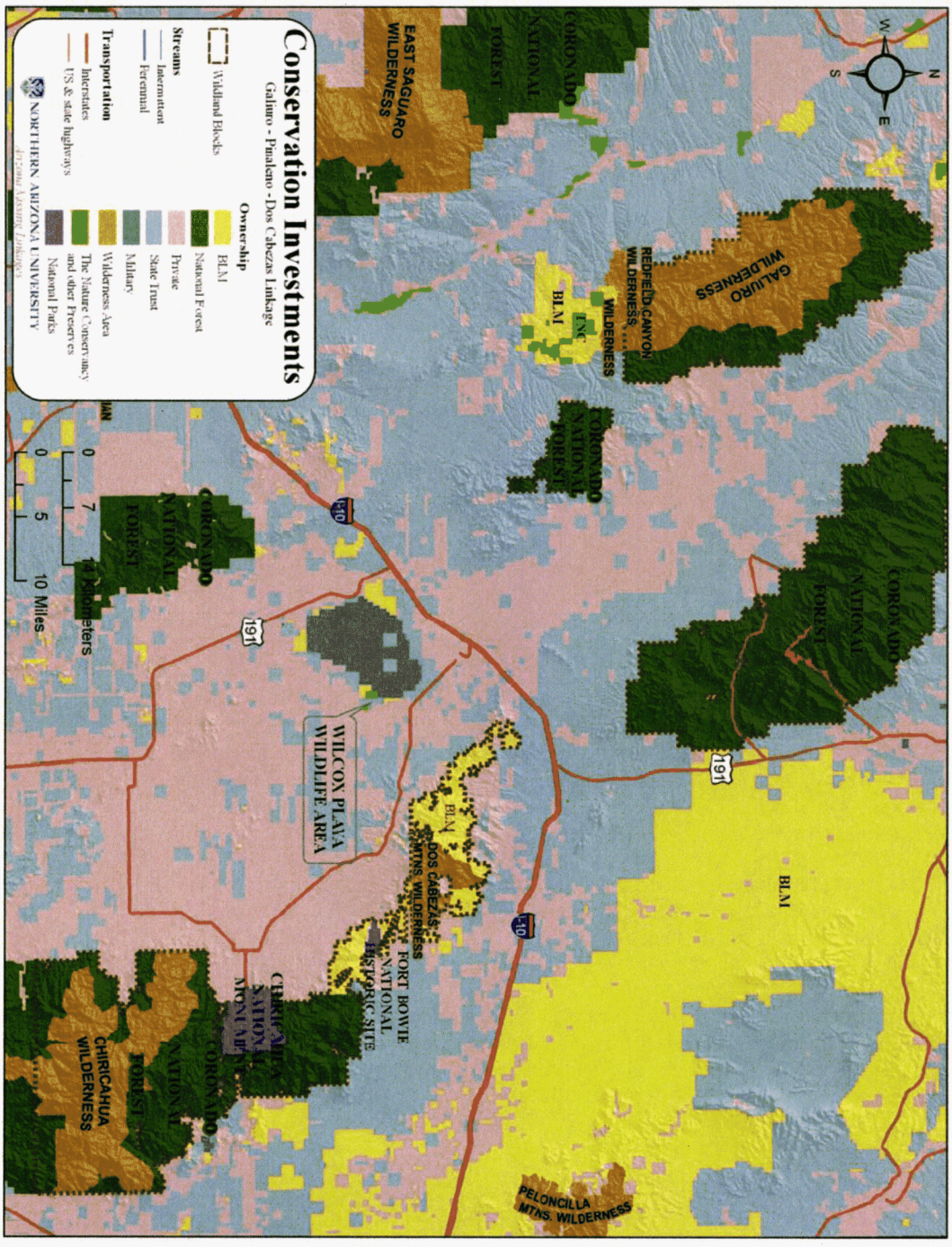


Figure 4: Existing conservation investments within the linkage planning area

Linkage Design & Recommendations

The Linkage Design[1] (Figure 1) is composed of two linkages, and a set of recommendations to minimize roadkill impacts on reptiles and amphibians conserved on private lands in Sulphur Springs Valley. In this section, we describe the linkage design, and recommend mitigations for barriers to animal movement. Methods for developing the Linkage Design are described in Appendix A.

Two Linkages Provide Connectivity Across a Diverse Landscape

The linkage design consists of two linkages, one connecting the Galiuro Mountains to the Pinaleño Mountains, and the other connecting the Pinaleños to the Dos Cabezas Mountains.

LINKAGE DESIGN GOALS

- Provide move-through habitat for diverse group of species
- Provide live-in habitat for species with dispersal distances too short to traverse linkage in one lifetime
- Provide adequate area for a metapopulation of corridor-dwelling species to move through the landscape over multiple generations
- Provide a buffer protecting aquatic habitats from pollutants
- Buffer against edge effects such as pets, lighting, noise, nest predation & parasitism, and invasive species
- Allow animals and plants to move in response to climate change

The **Pinaleños-Galiuro Linkage** has two strands. Strand A is made up of the best biological corridors for black bear, bobcat, jaguar, wolf, and mountain lion. About 31 km long, it encompasses much of the Black Hills and spans upper Aravaipa Canyon. The landcover in this strand is a mixture of Scrub-Shrub (42%), Evergreen Forest (42%), and Grassland-Herbaceous (13.5%). The rugged terrain has an average slope of 26% (Range: 0-85%, SD: 7.9). While 48% of the land was identified as steep slopes, almost 30% is composed of flat to gentle slopes.

Strand B provides habitat for badger, javelina, kit fox, mule deer, and pronghorn. It runs from the Galiuro Mountains across the Ash Creek Black Hills. East of there, it forks into 4 branches, each of which is important to different species. The longest branch stretches approximately 49 km. It is dominated by Grassland-Herbaceous vegetation (73%) and Scrub-Shrub (23%). Terrain is mostly gentle with an average slope of 3% (Range: 0-76%, SD: 5.1) and 96% of the strand is classified as flat to gentle slopes.

The **Pinaleños-Dos Cabezas Linkage** has three strands. About 36 km long, strand C provides habitat for badger and pronghorn. Its landcover is dominated by Grassland-Herbaceous (54%), and Scrub-Shrub (43%) vegetation. Average slope is 6% (Range: 0-79%, SD: 7.3) and 88% of the strand is classified as flat to gentle slopes, while 10% was classified as steep slopes.

Strand D provides habitat for black bear, bobcat, jaguar, javelina, wolf, mountain lion, and mule deer. This strand is made up of many branches, each of which provides habitat for different species. The longest branch stretches approximately 53 km. The dominant landcover types are Evergreen Forest (40%), Grassland-Herbaceous (23%), and Scrub-Shrub (36%). The variable topography has an average slope of 22% (Range: 0-98%, SD: 19.2). It has roughly as much flat to gentle slopes (41%) as steep slopes (40%).

[1] The reader will note that the strands of the linkage design extend well into each wildland block. As explained in Appendix A, for modeling purposes we had to redefine the wildland blocks such that the facing edges were parallel lines about 15 km apart.

The 35-km Strand E provides habitat for kit fox and is dominated by Scrub-Shrub (78%) and Grassland-Herbaceous (19%) vegetation. This strand has an average slope of 6% (Range: 0-85%. SD: 7.9) and 87% of the strand has a slope of less than or equal to 6%.

Special consideration for reptiles and amphibians in Sulphur Valley. Some of the reptiles and amphibians proposed as focal species find most of their habitat in the private and ASLD land in Sulphur Valley, rather than in the publicly-owned wildland blocks. This distribution precluded corridor modeling (which requires a clearly defined terminus at each end). However, to reduce the impact of roads on these species, we recommend regularly-spaced, soft-bottom culverts on paved roads throughout Sulphur Springs Valley (Figure 2).

Land Ownership, Land Cover, and Topographic Patterns within the Linkage Design

The Linkage Design encompasses 165,391acres (66,931 ha), of which 47% is state trust land, 28% privately owned, 17% in Coronado National Forest, and 8% managed by the Bureau of Land Management (Figure 5).The linkage design supports six natural vegetation communities (Figure 6), with developed land accounting for less than 1% of the linkage design. Natural vegetation is dominated by desert Scrub-Shrub associations and Grassland-Herbaceous vegetation.

The Linkage Design captured a range of topographic diversity, providing for the present ecological needs of species, as well as creating a buffer against a potential shift in ecological communities due to future climate change. Within the Linkage Design, 62% of the land is classified as gentle slopes, 26.5% is classified as steep slopes, with nearly equal parts canyon bottom (6%)or ridgetop (6%)(Figure 7). More land in the linkage had southern aspects than northern aspects (Figure 7).

Table 2: Approximate land cover in Linkage Design. See text for land cover in each of the five strands of the Linkage Design.

LAND COVER CATEGORY	ACRES	HECTARES	% OF TOTAL AREA
Evergreen Forest (< 0.1%)			
Pinyon-Juniper Woodland	44	18	< 0.1%
Scrub-Shrub (98%)			
Creosotebush-White Bursage Desert Scrub	12326	4988	13.7%
Desert Scrub (misc)	4739	1918	5.3%
Mesquite Upland Scrub	958	388	1.1%
Paloverde-Mixed Cacti Desert Scrub	69891	28284	77.9%
Woody Wetland (0.9%)			
Riparian Mesquite Bosque	540	219	0.6%
Riparian Woodland and Shrubland	288	116	0.3%
Barren Lands (0.1%)			
Non-specific Barren Lands	131	53	0.1%
Developed and Agriculture (0.9%)			
Open Space-Low Intensity Developed	662	268	0.7%
Medium-High Intensity Developed	152	61	0.2%

Removing and Mitigating Barriers to Movement

Although roads, rail lines, canals, agriculture, and urban areas occupy only a small fraction of the Linkage Design, their impacts threaten to block animal movement between the wildland blocks. In this section, we review the potential impacts of these features on ecological processes, identify specific barriers in the Linkage Design, and suggest appropriate mitigations. The complete database of our field investigations, including UTM coordinates and photographs, is provided in Appendix G and the Microsoft Access database on the CD-ROM accompanying this report.

While roads, canals, and fences impede animal movement, and the crossing structures we recommend are important, we remind the reader that crossing structures are only part of the overall linkage design. To restore and maintain connectivity between these wildland blocks, it is essential to consider the *entire* linkage design, including conserving the land in the linkage. Indeed, investment in a crossing structure would be futile if habitat between the crossing structure and either protected block is lost.

Page 20 of the PDF Figure 6

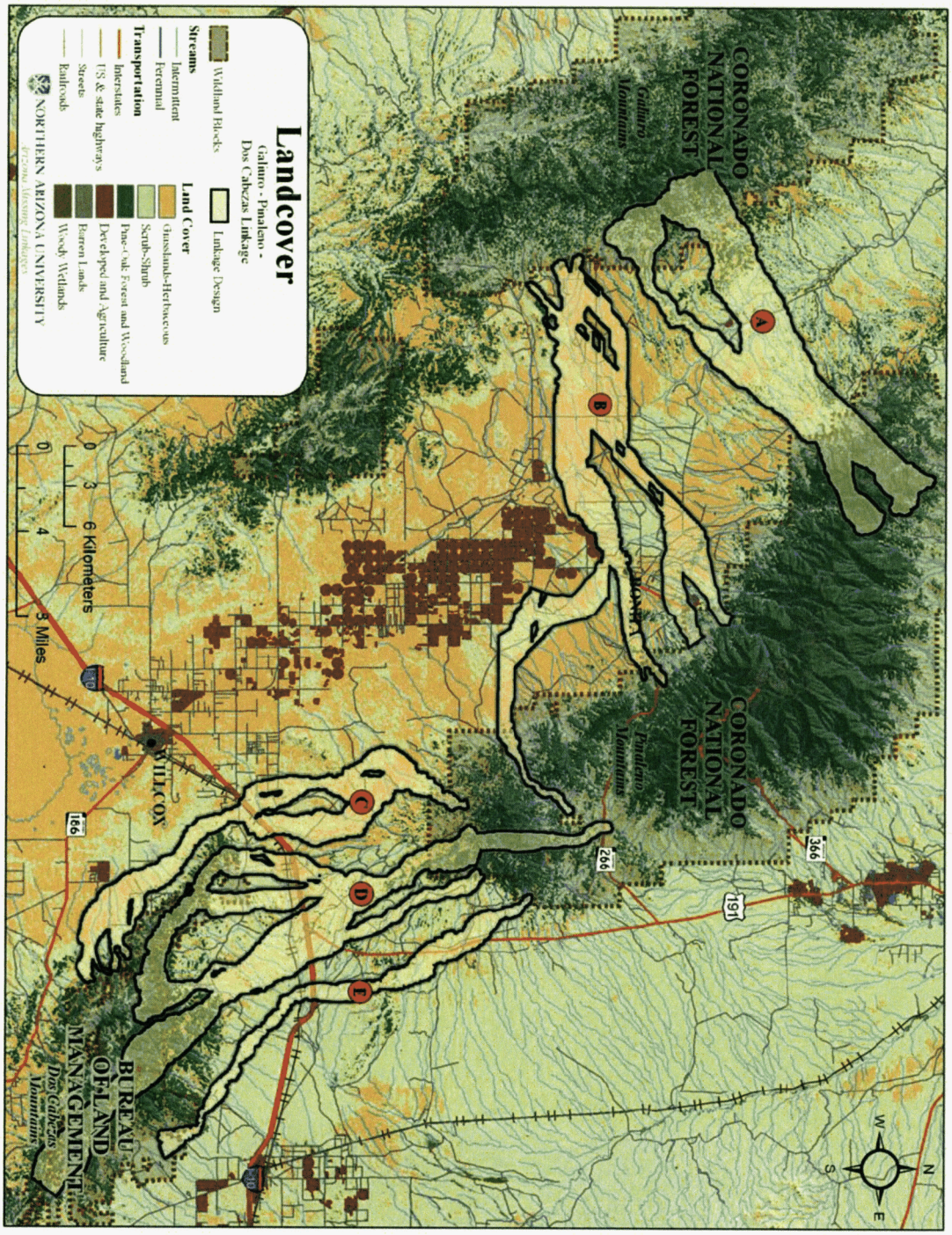


Figure 6: Land cover in the Linkage Design.

DOCKET NO. L-00000YY-15-0318-00171-MCV_18

EXHIBIT
MCV-18
ADMITTED
PENGAD 800-631-6989

Pinal County Open Space and Trails Master Plan

LOGAN SIMPSON DESIGN INC.

OCTOBER 2007

Pinal County Open Space and Trails Master Plan

TABLE OF CONTENTS

1.0 Project Overview **1**
1.1 Background and Purpose 1
1.2 Planning Process Overview 1

2.0 Inventory and Analysis **3**
2.1 Introduction 3
2.2 Data Collection 3
2.3 Existing Studies and Plans Overview 3
2.4 Adjacent Community Connections 6
2.5 Biological Resources Overview 6
2.6 Cultural Resources Overview 12
2.7 Slope Analysis 15
2.8 Existing Land Ownership, Development Patterns, and Infrastructure 15
2.9 Existing and Planned Parks, Open Space Areas, and Trails 17

3.0 Public Participation **22**
3.1 Introduction 22
3.2 Public Meetings – Values, Issues, and Needs 22
3.3 Public Meetings – Preliminary Master Plan 24
3.4 Stakeholder Taskforce Meetings 26

4.0 Conceptual Master Plan Alternatives **28**
4.1 Introduction 28
4.2 Conceptual Master Plan Alternatives 28
4.3 Preferred Conceptual Master Plan Alternative 32

5.0 Preliminary Master Plan **35**
5.1 Introduction 35
5.2 Open Space Categories 35
5.3 Preliminary Master Plan 37

6.0 Final Master Plan **39**
6.1 Introduction 39
6.2 Vision, Goals, and Objectives 39
6.3 Open Space and Trails Master Plan Elements 41
6.4 Land Ownership Considerations 45
6.5 Designation of Private, State Trust, and Bureau of Land Management Lands 46

7.0 Open Space and Trails Implementation Program **47**
7.1 Introduction 47
7.2 Open Space and Trails Implementation Techniques 47
7.3 Open Space and Trails Implementation Program 51

LIST OF FIGURES

Figure 1. Base Data Map 4
Figure 2. Regional Context Map 7
Figure 3. Biological Resources 10

Figure 4. Cultural Resources 14
Figure 5. Slope Analysis 16
Figure 6. Land Ownership 18
Figure 7. Utilities 19
Figure 8. Open Space and Trails Master Plan Concept A 29
Figure 9. Open Space and Trails Master Plan Concept B 30
Figure 10. Open Space and Trails Master Plan Concept C 31
Figure 11. Preferred Conceptual Master Plan Alternative 33
Figure 12. Preliminary Master Plan 36
Figure 13. Final Master Plan Map 42
Figure 14. Proposed Open Space and Regional Park Implementation 52
Figure 15. Proposed Trail Implementation 53
Figure A1. 2005 Pinal County Trails Plan 67
Figure A2. Bird Species Density 68
Figure A3. Mammal Species Density 69
Figure A4. Reptile Species Density 70
Figure A5. Desert Tortoise Habitat 71
Figure A6. Native Grassland Assessment 72
Figure A7. Nature Conservancy Conservation Areas 73
Figure A8. Springs and Riparian Areas 74
Figure A9. ADOT Corridor Studies 75
Figure A10. Central Arizona Association of Governments PAD Map 76

LIST OF TABLES

Table 1. Land Ownership 17
Table 2. Recreation Areas Within Pinal County 20
Table 3. Existing Pinal County Parks 20
Table 4. Pinal County Open Space and Trails Master Plan Implementation Program 2007-2032 54
Table A1. USFWS threatened, endangered, and candidate species potentially occurring in Pinal County 65
Table B1. NRHP Districts 78
Table D1. Stakeholder Taskforce List 98

LIST OF APPENDIXES

Appendix A – Biological and Environmental Resources Information 64
Appendix B – Cultural Resources Information 77
Appendix C – Public Involvement Information 79
Appendix D – Stakeholder Involvement Information 97
Appendix E – Data Collection Log 136

PAGE 16 of the PDF EXCERPT

The goal of this cultural resources overview is to use existing archaeological survey and site data in conjunction with a basic predictive model to evaluate potential impacts on NRHP-eligible resources for the proposed Pinal County trail system and open space design. Site and survey data from the AZSITE database, which is the repository for all archaeological survey and site data on state public lands were reviewed. In addition, the NRHP database was checked to identify historic districts and NRHP-listed sites within Pinal County. In general, agencies consider all known sites to be NRHP-eligible for planning purposes until their actual NRHP eligibility has been determined; therefore, all known sites were included

PAGE 17 of the PDF EXCERPT

in this analysis. Survey data analyzed for the County includes the total area of previous survey coverage, the number of known sites, and the available descriptive information on the type of sites present. Prehistoric and historic sites are not the only cultural resources that should be taken into consideration. Traditional cultural properties (TCPs) are places that have important cultural significance to Native American groups and other communities. Information on TCPs is often scarce, but the importance of these places should not be overlooked and should be taken into consideration whenever possible. An evaluation of TCPs should be undertaken by initiating consultation regarding sacred places with all interested Native American tribes.

PAGE 18 of the PDF EXCERPT of MAP illustrating Cultural Resources

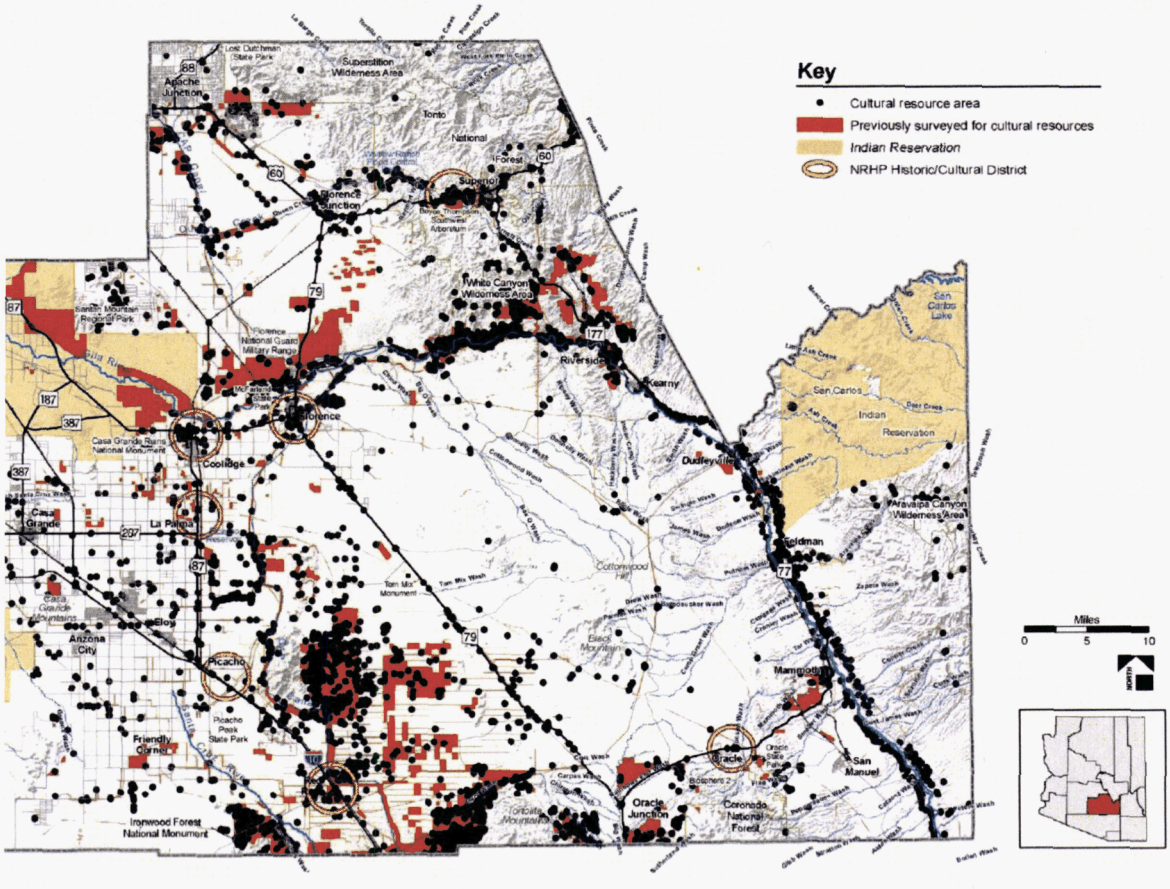


Figure 4. Cultural Resources

PAGE 19 of the PDF EXCERPT

also known as Snaketown, is located on the Gila River Indian Reservation. Both the Los Robles Archaeological District and the McClellan Wash Archaeological District are representative of Classic-period Hohokam settlements and continue to contribute significantly to the understanding of the prehistory of the area.

When considering prehistoric and historic archaeological sites in the planning process, avoidance is generally considered the prudent approach. Future projects may require a Class III cultural survey to determine the presence of NRHP-eligible sites and properties.

PAGE 21 of the PDF EXCERPT

Utilities and Infrastructure

Existing, certified, and proposed utility alignments were identified within the county for 500kv, 345kv, 230kv, 115kv transmission lines; gas pipelines; and the Arizona Corporation Commission (ACC) approved alignment of 500kv and 230kv transmission lines (see Figure 7, *Utilities*). Utility right-of-ways were not used as trail corridors, unless they occurred along a preestablished trail corridor within the *Pinal County 2005 Trails Plan* or other approved planning documents due to homeland security concerns. Future planning efforts should not exclude the use of utility corridors for trails where possible.

PAGE 23 of the PDF EXCERPT of Map illustrating existent Transmission Lines

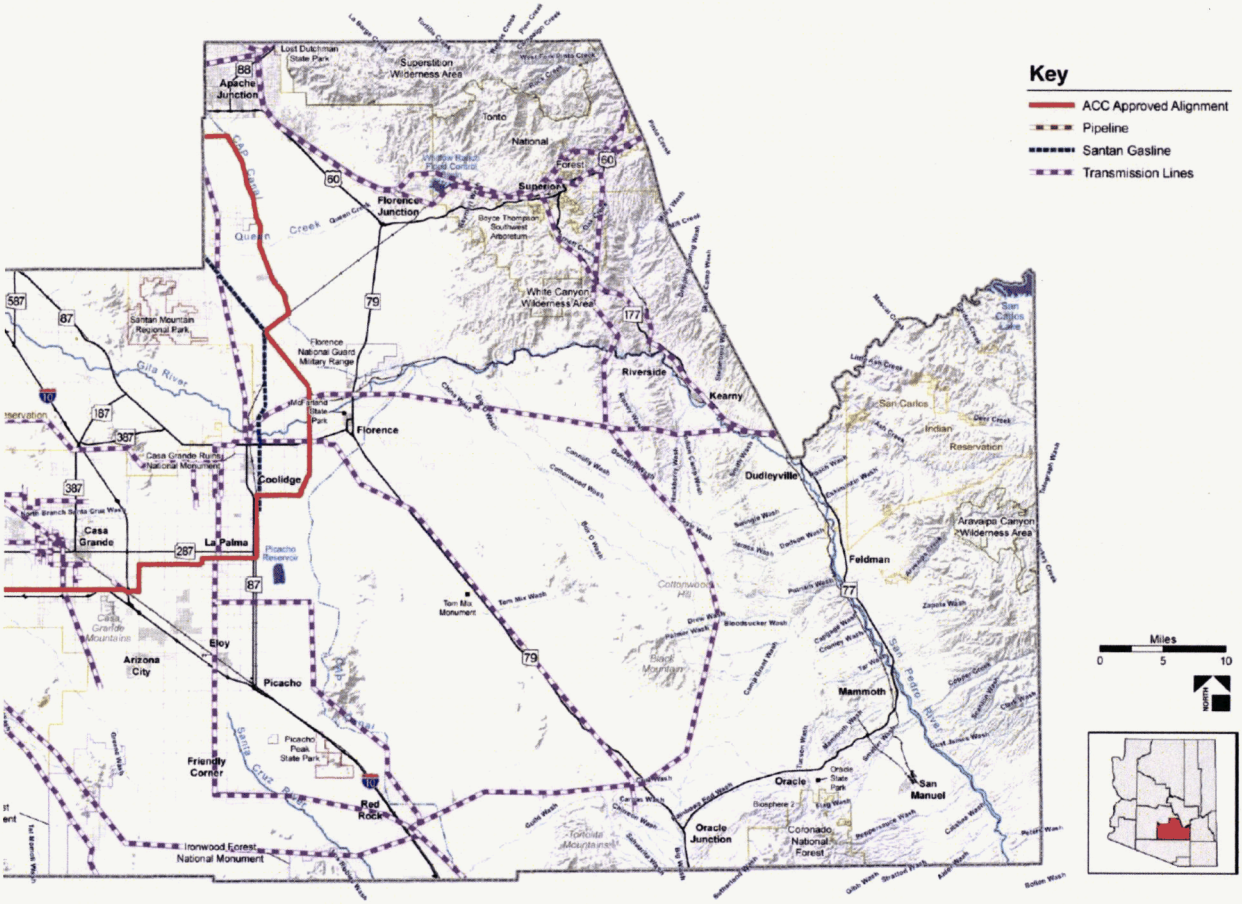


Figure 7. Utilities

Master Plan Report
Page 19

PAGE 25 of the PDF EXCERPT

Regional Trail Connections

As identified in the *Pinal County Trails Plan, 2005* (see Figure A1, in Appendix A *2005 Pinal County Trails Plan)* three primary regional trail corridors were identified. These three corridors, the Arizona Trail, the Central Arizona Project (CAP) canal corridor, and the Juan Bautista De Anza National Historic Trail, are described below. In addition, one multi-modal corridor was identified—the Great Western Trail (GWT).

PAGE 26 of the PDF EXCERPT

3.0 PUBLIC PARTICIPATION

An open solicitation of values, issues, and needs for county residents in reference to open space and trails was conducted. The values were based on the premise, if you were to move away from Pinal County for five years, what elements or aspects of the county would you like to stay the same? Likewise, issues and needs were solicited under the same premise, except residents were asked, what would you change? The following is a summary of the publics' values, issues, and needs.

Values

- Dark at night
- Value mountain views and open areas
- Foreground views (non-cluttered)
- Preserve viewsheds
- Wildlife corridors
- Habitat to sustain wildlife
- Riparian corridors preservation
- Undisturbed natural areas (no golf courses)
- Wilderness character of existing open space
- Natural wash corridors
- Geological resources
- Proximity to existing open space areas
- Historic areas
- National historic sites
- Open space corridors along roadways
- Abundant and easy access to trails
- Hiking and equestrian trails
- Close proximity to local equestrian trails

PAGE 32 of the PDF EXCERPT

4.0 Conceptual Master Plan Alternatives

4.1 Introduction

Three *Conceptual Master Plan Alternatives* were developed for the Plan and were based on two general premises: (1) conservation of critical resources including cultural and biological resources, viewsheds, physical characteristic of the land, and major riparian and river corridors and (2) overall connectivity including open space area and trail connectivity. Each conceptual alternative represented varying degrees of conservation and connectivity, with an overall relevancy to land ownership. The conceptual alternatives were developed to present variable scenarios, ideas, and pros and cons for the stakeholders

PAGE 36 of the PDF EXCERPT

4.3 Preferred Conceptual Master Plan Alternative

The majority of Stakeholder Taskforce Meeting attendees preferred Alternative C or a combination of Alternatives B and C. The *Preferred Conceptual Master Plan Alternative* (Figure 11, *Preferred Conceptual Master Plan Alternative*) was developed from the input and comments from the County and stakeholder taskforce members received during Stakeholder Taskforce Meetings No. 2 and No. 3 (see Appendix D for ...

Planning issues and concerns that needed to be addressed in development of the *Preferred Conceptual Master Plan Alternative* included the following:

...

- Remove of all trail alignments from the transmission line corridors due to increasing protection of these facilities based on homeland security concerns.

...

During the Stakeholder Taskforce Meeting No. 3, the following proposed Open Space System definition as presented with the *Preferred Conceptual Master Plan Alternative* for stakeholder comment.

> An open space system is a connected system of open space areas that maintain, as its primary purpose, the ecological health of the region/landscape and has as its natural consequence, the outcome of promoting human and biological health by allowing for passive and active recreational activities, solitude, natural landscapes, and wildlife movement. An open space system conserves elements of existing resources such as natural scenic beauty, view corridors, wildlife habitat, agricultural resources, and cultural heritage for the benefit of present and future generations.

PAGE 39 of the PDF EXCERPT

These categories were presented at the public meetings and reflect the communities' vision, goals, and objectives:

Developed Open Space Areas consist of developed areas that are designated for passive and active park and recreational activities. Developed open space areas should conserve the natural drainage patterns and maintain downstream flows. Drainageways provide natural stormwater management, areas for groundwater recharge, and natural biological movement corridors and can provide valuable natural linkages to adjacent areas. These developed areas can include parks, traditional park and recreational programming, and trails. Although developed open space areas could incorporate stormwater storage areas, these areas will not be substituted for traditional park development.

Transitional Open Space Areas consist of areas that abut or are adjacent to currently protected or planned open space areas such as state and national parks, national monuments, wilderness areas, and national forests, and areas identified within the Plan. Preserving the edge of these dedicated state and national lands will ensure equitable access to all. Every effort shall be made to extend the natural environment of the protected lands, and to provide a natural integration to surrounding protected landscapes. Facilities such as parks and stormwater storage areas within transitional open space areas allow for public access and the preservation of view corridors.

Continued on Page 40 of the PDF

PAGE 41 of the PDF EXCERPT

Heritage Open Space Areas are areas that have significant cultural value. They include working landscapes such as agricultural and ranching heritage, as well as cultural resources such as historic and prehistoric archaeological sites. Heritage areas can also be places of traditional cultural activities such as festivals or ceremonial/religious activities. It is important to recognize heritage areas as areas of diverse human activities that if irresponsibly disrupted could negatively impact social and environmental conditions. Careful consideration should be given to identifying heritage areas, as well as a development of prudent management approaches. The American Farmland Trust has identified areas within Pinal County as strategic prime ranchland at risk, which could be identified as heritage open space areas. Other examples could include prehistoric or historic archaeological sites or districts such as the Los Robles Archaeological District.

Conservation Open Space Areas are areas that have a demonstrated and important ecological function. Areas that have a high to medium habitat value, which includes substantial vegetation, important natural or geologic features, and biological movement corridors, should be preserved in an effort to maintain the ecological health of the region. Examples of high-quality habitat include areas designated as critical habitat, and large undisturbed expanses of land, such as mountain ranges, river corridors, perennial streams, and open desert areas. Medium-quality habitat may include washes nearer to developed areas, where land may be more fragmented but where water and food may be available.

PAGE 43 of the PDF EXCERPT

6.0 Final Master Plan

6.2 Vision, Goals, and Objectives

Vision

Pinal County's Open Space and Trails Master Plan promotes the quality of life of the region by providing areas of passive and active recreational opportunities, while conserving existing resources, such as natural scenic beauty, view corridors, wildlife habitat, agricultural resources designated at risk, and cultural heritage for the benefit of present and future generations. This Plan will encourage appropriate long-range growth planning opportunities, provide for a wide range of recreational activities for residents and visitors, preserve the county's rural and natural open space character, and contribute to the well-being of its communities.

6.3 Open Space and Trails Master Plan Elements

The *Final Master Plan* (see Figure 13, *Final Master Plan Map)* is based on the county's resource opportunities and constraints as identified in Section 2.0, *Inventory and Analysis*, and public, stakeholder, and County staff input identified in Section 3.0, *Public Participation*. The siting of specific proposed open space areas and trail corridors were identified based on the suitability of activities, surrounding land use, ecological factors, topography, viewsheds, and cultural resources.

PAGE 45 of the PDF EXCERPT

The proposed open space areas are based on protection and connectivity of the following items identified during the in-depth analysis of the county's natural and cultural resources discussed in Section 2.0, *Inventory and Analysis*.

Riparian and Mountainous Areas – Habitat fragmentation throughout Pinal County is a particular obstacle to threatened and endangered wildlife and a threat to overall biodiversity. To reduce the threat caused by habitat fragmentation, it is desirable to connect large contiguous areas of open space and allow for species mobility through wildlife movement corridors. As identified in Section 2.0, *Inventory and Analysis*, the highest levels of biodiversity, and the highest quality habitats are found within the riparian and mountainous areas of the county. Riparian corridors provide additional water availability and vegetative cover for wildlife, and protection of these corridors is of critical concern to overall species mobility. Riparian corridors also indicate the greatest concentrations of cultural resources. The Gila, San Pedro, and Santa Cruz Rivers were identified as the three most important riparian corridors throughout the County, and they deserve the highest priority for preservation. In addition, the mountainous areas that dominate the eastern portion of the county such as the Pinal, Superstition, Black, Dripping Springs, and Tortilla Mountains indicate a high level of biodiversity and high habitat values. Other mountainous areas such as the Tortolita and Picacho Mountains were also identified as having a high habitat value and a high level of biodiversity.

PAGE 46 of the PDF MAP – Final Master Plan Map Figure 13

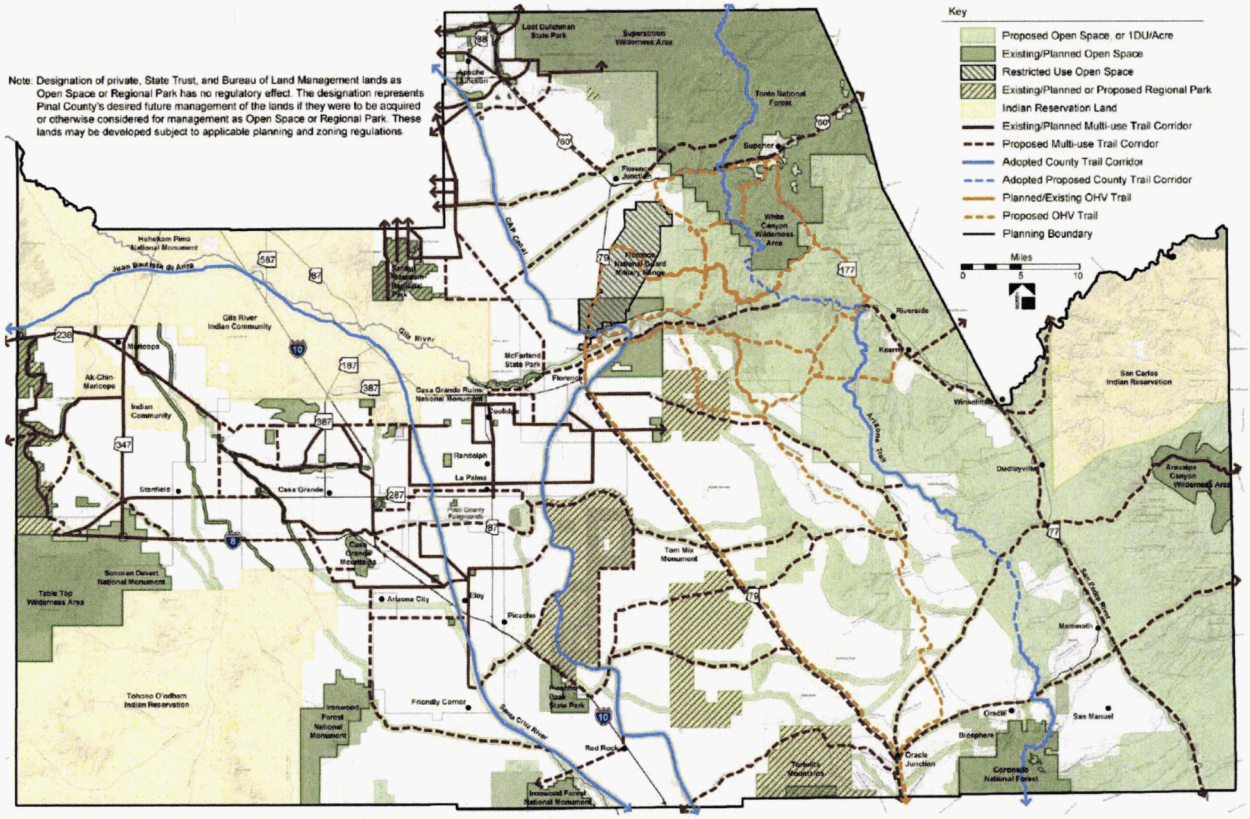


Figure 13.

PAGE 48 of the PDF EXCERPT

Proposed Trail Corridors

Providing equitable access to the county's resources through an interconnected multi-modal trail networl ensures a variety of passive and active recreation opportunities. The foundation of the trail system showr on the Final Master Plan Map relies on a skeletal framework of three regional trail corridors. The Juar Bautista de Anza National Historic Trail, the CAP Canal, and the Arizona Trail, which all provide regiona connectivity throughout Pinal County from Pima County to the south to Maricopa County to the north anc...

The following describes the five proposed regional parks, as shown on Figure 13, *Final Master Plan Map*.

- The regional park proposed along the east side of the city of Florence planning boundary may provide passive and active recreational opportunities that would help to support the growing needs of the users located within the surrounding municipalities.

PAGE 49 of the PDF EXCERPT

- The regional park proposed to the north of Picacho Peak State Park may provide more passive-oriented recreational opportunities that would conserve the natural resources located within this area while allowing users to experience the natural environment.
- The regional park located west of Highway 79 and east of the proposed regional park near Picacho Peak State Park may provide active and passive recreational opportunities to support the future needs of development that may occur in this area of the county.
- The regional park proposed on the western edge of the county was identified in the City of Maricopa's General Plan, and represents the desired future conditions for the city. The Plan identified additional areas surrounding the proposed regional park, and provided additional connectivity to the Table Top Wilderness area. This area may develop through cooperation with the City of Maricopa.
- The regional park located north of Florence Junction may provide passive and active recreational opportunities that would help to support the growing needs of the users located in the surrounding communities and municipalities.

The following describes the two existing/planned regional parks, as shown in Figure 13, *Final Master Plan Map*. These areas may continue to develop through cooperation with Maricopa and Pima Counties.

- The planned Tortolita Mountain Park located along the southern edge of the county may provide more passive-oriented recreational opportunities that would conserve existing natural resources.
- The existing San Tan Mountain Regional Park provides passive-oriented recreational opportunities, to support the growing needs of the expanding urban fringes of the Phoenix Metropolitan Area and the anticipated growth of the surrounding communities and municipalities.

PAGE 53 of the PDF Excerpt

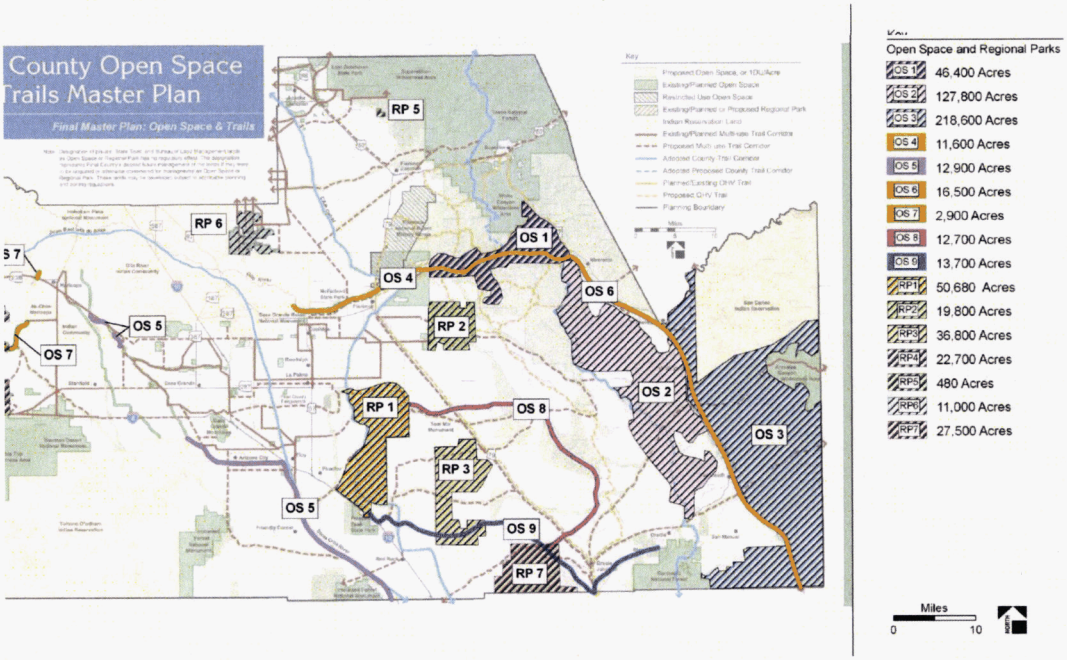
Influencing Land Management Decisions

While local governments do not have regulatory control over state and federal land management agencies, federal land management agencies protect open space on BLM and USFS lands through congressional designations of lands, through designations by the Secretaries of Interior (BLM) and Agriculture (USFS) and the heads of the agencies, and through approved land management plans completed using extensive public involvement processes. It is through these approved land management plans that the local governments can have considerable influence over landowners and managers that are not subject to local government regulation. For example, the Federal Land Management and Policy Act that governs the BLM's management of public land, provides for a significant role for local governments to influence federal land management policies. In a similar manner, Arizona cities and counties may have some input for land management decisions made by the Arizona State Land Department as it relates to the desired future land development patterns of their communities. As federal and state land management plans are undertaken, local governments should express their preferences so that they may be incorporated into the plans.

PAGE 55 of the PDF EXCERPT

The success of the implementation program strategy is dependent on the cooperation and coordinated efforts of the County, municipalities within the county, and affected state and federal agencies in order to secure the vision of a connected open space system that conserves the natural and cultural resources of the county. Each of the items indicated in Table 4 will require support and specialized expertise from county, municipal, state, and federal agency departments for which key responsibilities have been identified.

PAGE 56 of the PDF EXCERPT MAP Figure 14 Proposed Open Space and Regional Park Implementation



PAGE 57 of the PDF EXCERPT Map Figure 15 Multi-Use Trails

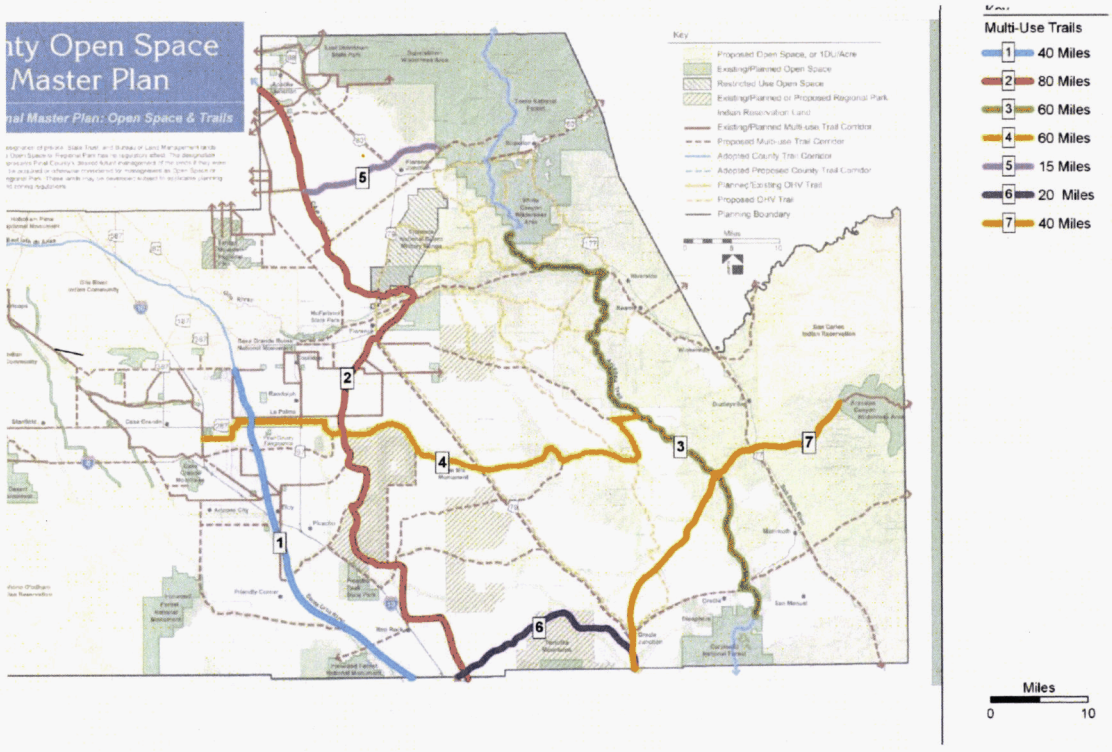
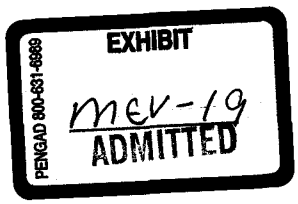


Figure 15. Proposed Trail Implementation

DOCKET NO. L-00000YY-15-0318-00171-MCV_19



ARIZONA MISSING LINKAGES

Ironwood–Picacho Linkage Design

Paul Beier, Daniel Majka, Todd Bayless

submitted June 2006
last revised May 24, 2007

NORTHERN ARIZONA UNIVERSITY

Table of Contents

TABLE OF CONTENTS I

LIST OF TABLES & FIGURES III

TERMINOLOGY V

EXECUTIVE SUMMARY VI

INTRODUCTION 1

- NATURE NEEDS ROOM TO MOVE 1
- A STATEWIDE VISION 1
- ECOLOGICAL SIGNIFICANCE OF THE IRONWOOD-PICACHO LINKAGE 2
- EXISTING CONSERVATION INVESTMENTS 3
- THREATS TO CONNECTIVITY 4

LINKAGE DESIGN & RECOMMENDATIONS 6

- TWO ROUTES PROVIDE CONNECTIVITY ACROSS A DIVERSE LANDSCAPE 6
- LAND OWNERSHIP, LAND COVER, AND TOPOGRAPHIC PATTERNS WITHIN THE LINKAGE DESIGN 6
- REMOVING AND MITIGATING BARRIERS TO MOVEMENT 11
- IMPACTS OF ROADS ON WILDLIFE 11
  - *Mitigation for Roads* 11
  - *Existing Roads and Rail Lines in the Linkage Design Area* 15
  - *Existing Crossing Structures on I-10* 16
  - *Recommendations for Interstate 10* 19
- IMPACTS OF CANALS ON WILDLIFE 21
  - *Canals in the Linkage Design Area* 21
  - *Mitigation for Canals* 21
- RECREATIONAL OFF-HIGHWAY VEHICLE USE AS A BARRIER TO MOVEMENT 24
  - *Mitigation for OHV Use* 24
- URBAN DEVELOPMENT AS BARRIERS TO MOVEMENT 26
  - *Urban Barriers in the Linkage Design Area* 26
  - *Mitigation for Urban Barriers* 27

APPENDIX A: LINKAGE DESIGN METHODS 28

- FOCAL SPECIES SELECTION 28
- HABITAT SUITABILITY MODELS 28
- IDENTIFYING POTENTIAL BREEDING PATCHES & POTENTIAL POPULATION CORES 30
- IDENTIFYING BIOLOGICALLY BEST CORRIDORS 31
- PATCH CONFIGURATION ANALYSIS 32
- MINIMUM LINKAGE WIDTH 33
- FIELD INVESTIGATIONS 34

APPENDIX B: INDIVIDUAL SPECIES ANALYSES 35

- BADGER (*TAXIDEA TAXUS*) 39
- BLACK-TAILED JACKRABBIT (*LEPUS CALIFORNICUS*) 42
- DESERT BIGHORN SHEEP (*OVIS CANADENSIS NELSONI*) 45
- JAVELINA (*TAYASSU TAJACU*) 49
- MULE DEER (*ODOCOILEUS HEMIONUS*) 52
- BLACK-TAILED RATTLESNAKE (*CROTALUS MOLOSSUS*) 55
- DESERT TORTOISE (*GOPHERUS AGASSIZII*) 58
- SONORAN DESERT TOAD (*BUFO ALVARIUS*) 62
- SONORAN WHIPSNAKE (*MASTICOPHIS BILINEATUS*) 65
- TUCSON SHOVEL-NOSED SNAKE (*CHIONACTIS OCCIPITALIS KLAUBERI*) 68

CACTUS FERRUGINOUS PYGMY-OWL (*GLAUCIDIUM BRASILIANUM CACTORUM*) 71
APPENDIX C: FOCAL SPECIES NOT MODELED **73**
APPENDIX D: CREATION OF LINKAGE DESIGN **75**
APPENDIX E: DESCRIPTION OF LAND COVER CLASSES **76**
APPENDIX F: LITERATURE CITED **80**
APPENDIX G: DATABASE OF FIELD INVESTIGATIONS **85**

List of Tables & Figures

List of Tables

TABLE 1: FOCAL SPECIES SELECTED FOR THE IRONWOOD-PICACHO LINKAGE. VII
TABLE 2: APPROXIMATE LAND COVER FOUND WITHIN LINKAGE DESIGN. 7
TABLE 3: MAJOR TRANSPORTATION ROUTES IN THE LINKAGE DESIGN. 15
TABLE 4: HABITAT SUITABILITY SCORES AND FACTOR WEIGHTS FOR EACH SPECIES. SCORES RANGE FROM 1 (BEST) TO 10 (WORST), WITH 1-3 INDICATING OPTIMAL HABITAT, 4-5 SUBOPTIMAL BUT USABLE HABITAT, 6-7 OCCASIONALLY USED BUT NOT BREEDING HABITAT, AND 8-10 AVOIDED. 36

List of Figures

FIGURE 1: THE LINKAGE DESIGN HAS 2 STRANDS: ONE CONNECTING THE IRONWOOD NATIONAL MONUMENT TO THE PICACHO MOUNTAINS, AND ONE CONNECTING IRONWOOD NATIONAL MONUMENT TO THE BLM LAND LABELED DURHAM-CORONADO PLAINS. VIII
FIGURE 2: LAND OWNERSHIP WITHIN THE LINKAGE PLANNING AREA. 4
FIGURE 3: LAND COVER WITHIN THE LINKAGE PLANNING AREA. 5
FIGURE 4: PROPERTY OWNERSHIP AND FIELD INVESTIGATION WAYPOINTS WITHIN LINKAGE DESIGN. THE ACCOMPANYING CD-ROM INCLUDES PHOTOGRAPHS TAKEN AT MOST WAYPOINTS (INDICATED BY STARS). 8
FIGURE 5: LAND COVER WITHIN LINKAGE DESIGN. 9
FIGURE 6: TOPOGRAPHIC DIVERSITY ENCOMPASSED BY LINKAGE DESIGN: A) TOPOGRAPHIC POSITION, B) SLOPE, C) ASPECT. 10
FIGURE 7: CHARACTERISTICS WHICH MAKE SPECIES VULNERABLE TO THE THREE MAJOR DIRECT EFFECTS OF ROADS (FROM FORMAN ET AL. 2003). 12
FIGURE 8: POTENTIAL ROAD MITIGATIONS (FROM TOP TO BOTTOM) INCLUDE: HIGHWAY OVERPASSES, BRIDGES, CULVERTS, AND DRAINAGE PIPES. FENCING (LOWER RIGHT) SHOULD BE USED TO GUIDE ANIMALS INTO CROSSING STRUCTURES. 13
FIGURE 9: FOUR 3 X 10 FT BOX CULVERTS UNDER I-10 (PHOTO AZIMUTH 280) AND A WOODEN RAILROAD CROSSING (PHOTO AZIMUTH 174) AT WAYPOINT 72. 17
FIGURE 10: A SMALL TWIN-SPAN CEMENT CULVERT (AZIMUTH: 280) AND A WOODEN RAILROAD CROSSING (AZIMUTH: 174) OCCUR AT WAYPOINT 73. 17
FIGURE 11: THREE SMALL CEMENT CULVERTS (AZIMUTH: 268) AND A WOODEN RAILROAD CROSSING (AZIMUTH: 54) OCCUR AT WAYPOINT 74, NEAR MILE POST 227. 17
FIGURE 12: TWO EXAMPLES OF TWIN-SPAN 4 X 6 FT CULVERTS FOUND IN THE IRONWOOD – PICACHO STRAND OF THE LINKAGE DESIGN (LEFT: WAYPOINT 88, RIGHT: WAYPOINT 89. AZIMUTH ON BOTH PHOTOS: 220). 18
FIGURE 13: THE ENTRANCE OF THIS SMALL BOX CULVERT NORTH OF PICACHO PEAK STATE PARK HAS BEEN BLOCKED WITH VEGETATION (WAYPOINT 90, AZIMUTH 24). 18
FIGURE 14: A SMALL TWIN-SPAN CEMENT CULVERT (AZIMUTH: 220) AND A WOODEN RAILROAD CROSSING (AZIMUTH: 22) OCCUR AT WAYPOINT 91. 19
FIGURE 15: A SMALL 4 X 6 FT CEMENT CULVERT FILLED WITH TUMBLEWEEDS (AZIMUTH: 228) OCCURS AT WAYPOINT 92. 19
FIGURE 16: CANALS IN THE LINKAGE DESIGN AREA. THE 4 BLACK LINES INDICATE BURIED SECTIONS OF THE CENTRAL ARIZONA PROJECT CANAL: A 1.3-KM STRETCH ON THE NORTHWEST SIDE OF THE PICACHO MOUNTAINS, A 70-M STRETCH AT MCCLELLAN WASH, A 2.5-KM STRETCH IN THE EASTERN STRAND OF THE LINKAGE DESIGN, AND A 2.5 KM STRETCH UNDER INTERSTATE 10. 22
FIGURE 17: AN IRRIGATION CANAL CONNECTED TO THE CAP CANAL INTERSECTS ALL PORTIONS OF THE IRONWOOD - PICACHO MTNS LINKAGE (WAYPOINT 98, AZIMUTH: 96). 23
FIGURE 18: THE ONLY LOCATIONS WHERE AN ANIMAL CAN SAFELY CROSS THE IRRIGATION CANAL ARE WHERE ROADS PASS OVER THE CANAL (WAYPOINT 99, AZIMUTH: 286). 23
FIGURE 19: AN OHV AREA ON STATE TRUST LAND NEAR PINAL AIR PARK AFFECTS CONNECTIVITY BETWEEN IRONWOOD FOREST NATIONAL MONUMENT AND THE DESERT BLM BLOCK TO THTE NORTHWEST. 24
FIGURE 20: OHV USE HAS ALTERED VEGETATION AND THREATENS CONNECTIVITY (WAYPOINT 102, AZIMUTH: 122). SEE FIGURE 19 TO LOCATE THIS SCENE WITHIN THE LINKAGE DESIGN. 25

FIGURE 21: THE SAGUARO POWER PLANT BORDERS THE SOUTHERN END OF THE IRONWOOD - PICACHO LINKAGE ADJACENT TO I-10 (WAYPOINT 72; AZIMUTH: 38).....26
FIGURE 22: THE PINAL AIR PARK BORDERS THE SOUTHERN END OF THE IRONWOOD - PICACHO LINKAGE 4 KM NORTHWEST OF IRONWOOD FOREST NATIONAL MONUMENT. ATV USE IN FOREGROUND (WAYPOINT 103; AZIMUTH: 178).....27
FIGURE 23: FOUR HABITAT FACTORS USED TO CREATE HABITAT SUITABILITY MODELS. INPUTS INCLUDED VEGETATION, ELEVATION, TOPOGRAPHIC POSITION, AND DISTANCE FROM ROADS.....29
FIGURE 24: EXAMPLE MOVING WINDOW ANALYSIS WHICH CALCULATES THE AVERAGE HABITAT SUITABILITY SURROUNDING A PIXEL. A) ORIGINAL HABITAT SUITABILITY MODEL. B) 3X3-PIXEL MOVING WINDOW. C) 200M RADIUS MOVING WINDOW.....31
FIGURE 25: A) LANDSCAPE PERMEABILITY LAYER FOR ENTIRE LANDSCAPE. B) BIOLOGICALLY BEST CORRIDOR COMPOSED OF MOST PERMEABLE 10% OF LANDSCAPE.....33
FIGURE 26: MODELED HABITAT SUITABILITY OF BADGER.....40
FIGURE 27: POTENTIAL HABITAT PATCHES AND CORES FOR BADGER.....41
FIGURE 28: MODELED HABITAT SUITABILITY OF BLACK-TAILED JACKRABBIT.....43
FIGURE 29: POTENTIAL HABITAT PATCHES AND CORES FOR BLACK-TAILED JACKRABBIT.....44
FIGURE 30: MODELED HABITAT SUITABILITY OF DESERT BIGHORN SHEEP.....47
FIGURE 31: POTENTIAL HABITAT PATCHES AND CORES FOR DESERT BIGHORN SHEEP.....48
FIGURE 32: MODELED HABITAT SUITABILITY OF JAVELINA.....50
FIGURE 33: POTENTIAL HABITAT PATCHES AND CORES FOR JAVELINA.....51
FIGURE 34: MODELED HABITAT SUITABILITY OF MULE DEER.....53
FIGURE 35: POTENTIAL HABITAT PATCHES AND CORES FOR MULE DEER.....54
FIGURE 36: MODELED HABITAT SUITABILITY OF BLACK-TAILED RATTLESNAKE.....56
FIGURE 37: POTENTIAL HABITAT PATCHES AND CORES FOR BLACK-TAILED RATTLESNAKE.....57
FIGURE 38: MODELED HABITAT SUITABILITY OF DESERT TORTOISE.....60
FIGURE 39: POTENTIAL HABITAT PATCHES AND CORES FOR DESERT TORTOISE.....61
FIGURE 40: MODELED HABITAT SUITABILITY OF SONORAN DESERT TOAD.....63
FIGURE 41: POTENTIAL HABITAT PATCHES AND CORES FOR SONORAN DESERT TOAD.....64
FIGURE 42: MODELED HABITAT SUITABILITY OF SONORAN WHIPSNAKE.....66
FIGURE 43: POTENTIAL HABITAT PATCHES AND CORES FOR SONORAN WHIPSNAKE.....67
FIGURE 44: MODELED HABITAT SUITABILITY OF TUCSON SHOVEL-NOSED SNAKE.....69
FIGURE 45: POTENTIAL HABITAT PATCHES AND CORES FOR TUCSSON SHOVEL-NOSED SNAKE.....70
FIGURE 46: PROPOSED CRITICAL HABITAT FOR CACTUS FERRUGINOUS PYGMY-OWL.....72
FIGURE 47: FIELD INVESTIGATION WAYPOINTS.....85

The Ironwood-Picacho region provides significant ecological, educational, recreational, and spiritual values of protected wildlands. Our Linkage Design represents an opportunity to protect a functional landscape-level connection. The cost of implementing this vision will be substantial—but reasonable in relation to the benefits and the existing public investments in protected wild habitat. If implemented, our plan would not only permit movement of individuals and genes between the Ironwood National Monument, Picacho Mountains, and desert BLM wildland blocks, but should also conserve large-scale ecosystem processes that are essential to the continued integrity of existing conservation investments by the US Forest Service, Arizona State Parks, Bureau of Land Management, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and other conservancy lands.

Next Steps: This Linkage Design Plan is a science-based starting point for conservation actions. The plan can be used as a resource for regional land managers to understand their critical role in sustaining biodiversity and ecosystem processes. Relevant aspects of this plan can be folded into management plans of agencies managing public lands. Transportation agencies can use the plan to design new projects and find opportunities to upgrade existing structures. Regulatory agencies can use this information to help inform decisions regarding impacts on streams and other habitats. This report can also help motivate and inform construction of wildlife crossings, watershed planning, habitat restoration, conservation easements, zoning, and land acquisition. Implementing this plan will take decades, and collaboration among county planners, land management agencies, resource management agencies, land conservancies, and private landowners.

Public education and outreach is vital to the success of this effort – both to change land use activities that threaten wildlife movement and to generate appreciation for the importance of the corridor. Public education can encourage residents at the urban-wildland interface to become active stewards of the land and to generate a sense of place and ownership for local habitats and processes. Such voluntary cooperation is essential to preserving linkage function. The biological information, maps, figures, tables, and photographs in this plan are ready materials for interpretive programs.

Ultimately the fate of the plants and animals living on these lands will be determined by the size and distribution of protected lands and surrounding development and human activities. We hope this linkage conservation plan will be used to protect an interconnected system of natural space where our native biodiversity can thrive, at minimal cost to other human endeavors.

Table 1: Focal species selected for the Ironwood-Picacho Linkage.

MAMMALS	AMPHIBIANS & REPTILES	BIRDS
*Badger *Bighorn Sheep *Black-tailed Jackrabbit *Javelina[1] *Mule Deer	*Sonoran Desert Toad *Black-tailed Rattlesnake Chuckwalla Desert Iguana *Desert Tortoise Lyre Snake *Sonoran Whipsnake Tiger Rattlesnake *Tucson Shovel-nosed Snake	Cactus Ferruginous Pygmy-Owl Roadrunner
		PLANTS
		Ironwood Tree Palo Verde
		INSECTS
		Bee species Hawkmoth

* Species modeled in this report. The other species were not modeled because there were insufficient data to quantify habitat use in terms of available GIS data (e.g., some snakes that select small rocks), or because the species probably can travel (e.g., by flying) across unsuitable habitat.

[1] During field work, we found a dead javelina (apparently road-killed) near the entrance to a culvert under I-10 in the potential linkage area.

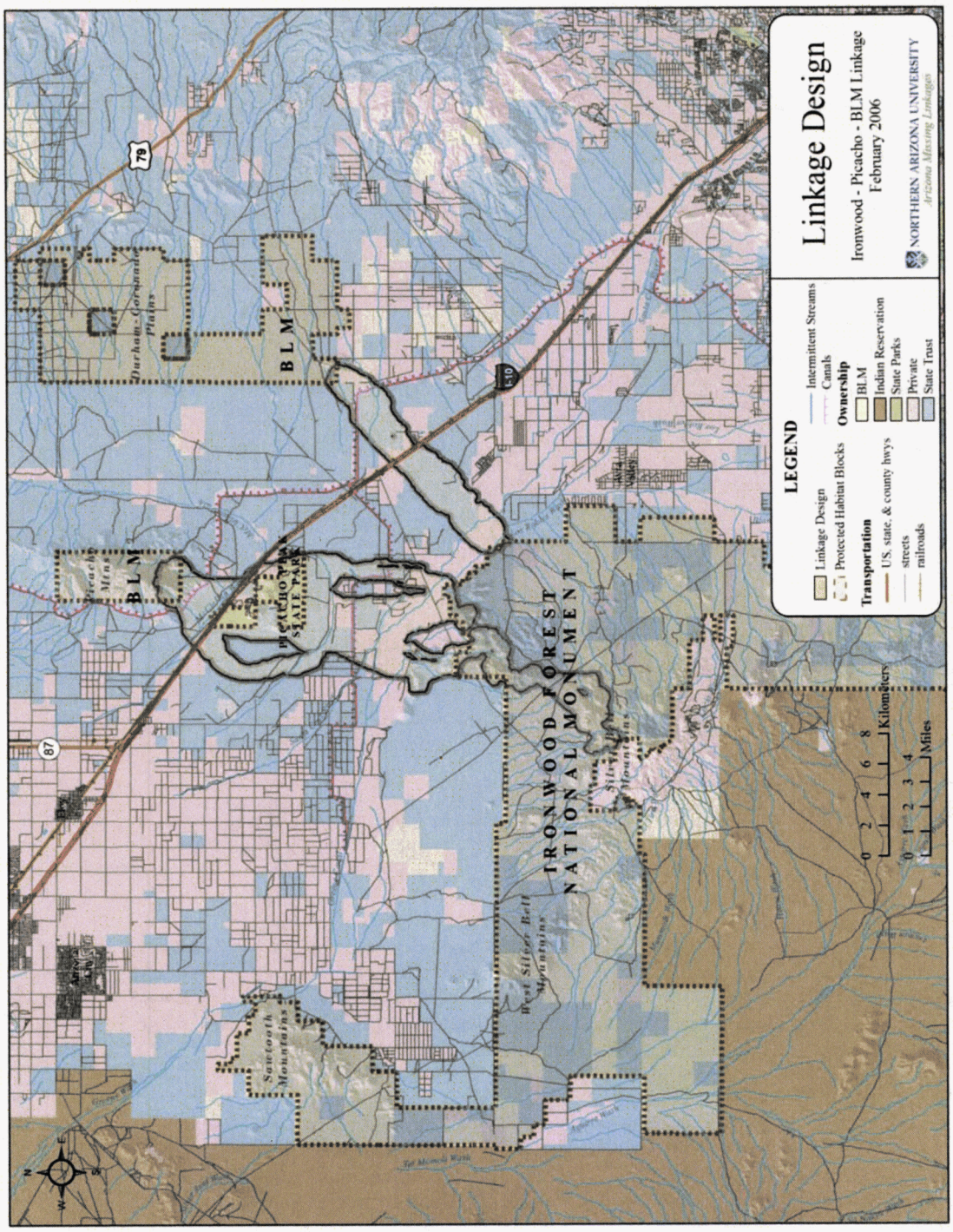


Figure 1: The Linkage Design has 2 strands: one connecting the Ironwood National Monument to the Picacho Mountains, and one connecting Ironwood National Monument to the BLM land labeled Durham-Coronado Plains.

Ecological Significance of the Ironwood-Picacho Linkage

The Ironwood-Picacho-BLM Linkage Planning area lies within the 55-million acre Sonoran Desert Ecoregion of southern Arizona, southeastern California, and northwestern Sonora, Mexico. This ecoregion is the most tropical of North America's warm deserts (Marshall et al. 2000). Bajadas sloping down from the mountains support forests of ancient saguaro cacti, paloverde, and ironwood; creosotebush and bursage desert shrub dominate the lower desert (The Nature Conservancy 2006). The Sonoran Desert Ecoregion is home to more than 200 threatened species, and its uniqueness lends to a high proportion of endemic plants, fish, and reptiles (Marshall et al. 2000; The Nature Conservancy 2006). More than 500 species of birds migrate through, breed, or permanently reside in the ecoregion, which are nearly two-thirds of all species that occur from northern Mexico to Canada (Marshall et al. 2000). The Sonoran Desert Ecoregion's rich biological diversity prompted Olson and Dinerstein (1998) to designate it as one of 233 of the earth's most biologically valuable ecoregions, whose conservation is critical for maintaining the earth's biodiversity.

Within the Sonoran Desert Ecoregion, the Linkage Planning Area includes three wildland blocks: Ironwood National Monument, the Picacho Mountains, and a block of Sonoran desert we call Durham-Coronado Plains[2]. All 3 areas are administered by the Bureau of Land Management (Figure 2).

The Ironwood Forest National Monument, the southern habitat block, encompasses several desert mountain ranges including the Silver Bell, Waterman and Sawtooth Mountains, which extend for 42 km (26 mi) (Bureau of Land Management 2005). These mountains support drainage systems such as Los Robles Wash, Blanco Wash, Cocio Wash, and the Santa Cruz River. Elevation ranges from 1,800 to 4,261 feet, providing a geologic and topographic variability that contributes to high biological diversity (Bureau of Land Management 2005).

The BLM land in the Picacho Mountains is one of the northern wildland blocks in the Ironwood-Picacho Linkage Planning Area. The Picacho Mountains extend for 20 km (12.5 mi) and range in elevation from 1,725 ft to 4,508 ft at Newman Peak. This mountain range supports the Brady and McClellan Washes, and provides important wildlife habitat. Mountain lions have been documented traveling between the Picacho Mountains and the Catalina Mountains (K. Nicholson & P. Krausman, University of Arizona, personal communication).

The Durham-Coronado Plain[2] is a 20 km (12.5 mi) stretch of protected Paloverde-mixed cacti desert communities. The Durham and Coronado Washes run through this habitat block, which ranges from 2000-2500 ft elevation. This area provides protected Sonoran desert for wildlife and plant species in the region.

The Linkage Planning Area ranges from 1700 feet elevation at the Santa Cruz River valley to 4,508 feet at Newman Peak in the Picacho Mountains. Paloverde-mixed cacti desert scrub, semi-desert grassland and steppe, and creosotebush-white bursage desert scrub communities dominate the landscape, with large areas of agricultural lands along the I-10 transportation corridor (Figure 3). Riparian areas in the Linkage Planning Area include the Santa Cruz River, and McClellan, Blanco, and Cocio Washes.

The varied habitat types in the Linkage Planning Area support many animal species. Species listed as threatened or endangered by the U.S. Fish and Wildlife Service include the desert tortoise, bighorn sheep, and the cactus ferruginous pygmy-owl (USFWS 2005). The Corridor Design incorporates and connects critical habitat needed for these species to achieve viable populations. The Ironwood-Picacho Linkage Planning Area is also home to far-ranging mammals such as mule deer, mountain lion, and badger. These

[2] This block of BLM land has no formal designation on most maps. We named it after Durham Wash and Coronado Wash, which are the 2 main drainages in the area

animals move long distances to gain access to suitable foraging or breeding sites, and would benefit significantly from corridors that link large areas of habitat (Turner et al. 1995). Less-mobile species and habitat specialists such as black-tailed jackrabbits, tiger rattlesnakes, and Sonoran desert toads also need corridors to maintain genetic diversity, allow populations to shift their range in response to climate change, and promote recolonization after fire or epidemics.

Existing Conservation Investments

The three wildland blocks are comprised of land federally protected by the Bureau of Land Management. The **southern habitat block** consists of Ironwood Forest National Monument, 129,000 protected acres of ancient legume and cactus forests (Bureau of Land Management 2005). This monument provides an outstanding example of the plant and animal diversity of the Sonoran desert (Bureau of Land Management 2005). The monument's Silver Bell Mountains alone claims more than 674 species, including 64 mammals and 57 birds (Bureau of Land Management 2005). The Ironwood Forest National Monument hosts one of the richest stands of ironwood trees in the Sonoran desert, and is home to many federally listed species, including the Nichols turk's head cactus, the lesser long-nosed bat, and the desert bighorn sheep (Bureau of Land Management 2005; Sierra Club 2006).

Adjacent to the southern habitat block's Ironwood Forest National Monument is a proposed conservation reserve that would protect 6,485 acres of State Trust land in the Sonoran desert (Sonoran Institute 2005). This reserve would help to link the Ironwood Forest National Monument with the Sawtooth Mountains to the north. Another proposed conservation reserve known as Sawtooth would add 3,395 acres of protected land in the southern habitat block's vicinity and encompass a stand of mature ironwood trees not protected within the monument's borders (Sonoran Institute 2005). Both of these proposed reserves would buffer the habitat block from urban development in the Marana and Tucson areas (Sonoran Institute 2005). The Tohono O'odham Nation also abuts the Monument. Although tribal sovereignty includes the right to develop reservation land, conserving this linkage gives the tribe the opportunity to maintain a wildlife corridor to the northeast of the reservation, which is now largely in a natural condition.

The **northwestern habitat block** consists of the Picacho Mountains, 6,400 protected acres owned by the Bureau of Land Management. This habitat block would be expanded by 18,705 acres through a proposed conservation reserve protecting surrounding State Trust Lands in the Picachos (Figure 2; Sonoran Institute 2005).

The Durham-Coronado Plain is 33,200 acres of BLM-protected Sonoran desert that comprise the **northeastern habitat block** in the Linkage Planning Area. This undeveloped tract of Sonoran desert provides desert species refuge from encroaching development in the area.

Picacho Peak State Park, a protected area in the Linkage Planning Area separate from the three wildland blocks, would both contribute to and benefit from a wildlife corridor in this area. This Arizona state park consists of 3,500 acres of Sonoran desert, including the iconic landmark of Picacho Peak, rising to 3,382 feet (Arizona State Parks 2005). The park attracts 60,000 visitors per year, bringing money into the local economy (Arizona Office of Tourism 2003). Adjacent to this state park is the proposed Picacho Peak State Park conservation reserve, which would protect 3,995 acres of additional lands. This conservation reserve would convert State Trust lands for conservation and connectivity between protected lands and buffer Picacho Peak State Park from urban development (Figure 2; Sonoran Institute 2005).

Connectivity between these three valuable and wildland blocks would help to provide the contiguous habitat necessary to sustain viable populations of sensitive and far ranging species in the Sonoran Desert of southern Arizona.

Linkage Design & Recommendations

The Linkage Design (Figure 4 & Figure 5) is composed of two strands which together provide habitat for movement and reproduction of wildlife between the Ironwood, Picacho, and desert BLM protected wildland blocks. In this section, we describe the land cover and ownership patterns in the linkage design, and recommend mitigations for barriers to animal movement. The methods used to develop the linkage design are detailed in Appendixes A through E.

Two Routes Provide Connectivity Across a Diverse Landscape

The linkage design consists of two distinct strands which connect Ironwood Forest National Monument to the Picacho Mountains and the Durham-Coronado Plain.

LINKAGE DESIGN GOALS

- Provide move-through habitat for diverse group of species
- Provide live-in habitat for species with dispersal distances too short to traverse linkage in one lifetime
- Provide adequate area for a metapopulation of corridor-dwelling species to move through the landscape over multiple generations
- Provide a buffer protecting aquatic habitats from pollutants
- Buffer against edge effects such as pets, lighting, noise, nest predation & parasitism, and invasive species
- Allow animals and plants to move in response to climate change

The western strand connects Ironwood Forest National Monument and the Picacho Mountain wildland blocks. It is approximately 18 km (11 miles) long, and varies in width from approximately 1.5 to 8 km (0.9 – 5 miles). This strand is primarily composed of paloverde-mixed cacti desert scrub and creosotebush-white bursage desert scrub, but also includes riparian woodland, shrubland, and agriculture. This linkage provides live-in and pass-through habitat for species dependent on desert vegetation and/or rugged topography, such as desert tortoise, black-tailed rattlesnake, desert bighorn sheep, javelina, black-tailed jackrabbit, mule deer, and Sonoran whipsnake. Important riparian areas encompassed by this linkage include portions of the Santa Cruz River and Los Robles Wash north of Ironwood Forest National Monument, and McClellan Wash north of Picacho Peak State Park. The Central Arizona Project canal and a smaller irrigation canal both pass through this linkage.

The eastern strand between Ironwood Forest National Monument and the BLM-administered Durham-Coronado Plain is approximately 15 km (9 miles) long and 2 km (1¼ miles) wide. This corridor crosses the Santa Cruz River and Los Robles Wash northeast or Ironwood, passes north of Pinal Air Park and Saguaro Power plant, and joins the BLM desert block near Desert Peak. This route is primarily composed of creosotebush-white bursage desert scrub and paloverde-mixed cacti desert scrub, but also includes riparian woodland and shrubland. This linkage provides live-in and pass-through habitat for species dependent on desert vegetation and/or flatter topography, such as Tucson shovel-nosed, badger, black-tailed jackrabbit, javelina, and Sonoran desert toad. The entire corridor is also within proposed critical habitat for the Cactus-Ferruginous Pygmy-Owl.

Land Ownership, Land Cover, and Topographic Patterns within the Linkage Design

The Linkage Design encompasses 43,400 acres (17,570 ha) of land, and is composed of 57% state trust land, 22% private land, 12% BLM land, 8% state parks land, and 1% Bureau of Reclamation land (Figure 4). Seven natural vegetation communities account for 95% of the land cover, barren lands account for 0.6%, and developed land accounts for approximately 4% of the land in the Linkage Design (Figure 5, Table 2). Natural vegetation is dominated by desert scrub-shrub associations, and has a similar

Impacts of Canals on Wildlife

Canals can have both positive and negative impacts on desert wildlife. Some species may use canals as a water source, but the steep banks make it impossible or dangerous for most animals to do so. Desert mule deer, bighorn sheep, and Sonoran pronghorn have drowned in canals (Rautenstrauch & Krausman 1989). Canals serve as significant barriers to movement by preventing species from moving to viable habitat on the other side of the canal, drowning species, and rerouting natural movement patterns.

Canals in the Linkage Design Area

Two main canals act as barriers to connectivity in the linkage zone (Figure 16). The Central Arizona Project's (CAP) Tucson Canal crosses through both strands of the linkage design. The CAP canal is approximately 12 meters (39 ft) wide, and is lined with eight-foot fences on both sides to keep large animals out. A smaller irrigation canal connects to the CAP canal, extending westward through the strand of the linkage design connecting Ironwood Forest National Monument to the Picacho Mountains (Figure 17). This canal parallels Baumgartner Rd. for 9 km (5.6 mi), and is approximately 5 meters (16 ft) wide.

There is only one location where wildlife can safely cross the CAP canal in the linkage design. About 1.4 km of a buried stretch of the CAP canal (out of the total 2.5 km length of the buried section) lies in the eastern strand of the linkage design (Figure 16). There are no crossing structures for animals in the western strand of the linkage design.

The only opportunities to cross the smaller irrigation canal are where the canal crosses under dirt roads (Figure 18).

Mitigation for Canals

To conserve connectivity, we have the following recommendations for all existing and future canals in this linkage zone:

1) **Ensure opportunities for wildlife to cross every canal in the linkage area**. This can be accomplished by several methods. The most permeable, yet most expensive method is to bury any canal within the linkage design below ground. The eastern strand contains a buried section of canal that effectively mitigates the effect of the canal in this strand. In the western strand, a significant section of the CAP canal should be buried, or crossing structures should be installed. For *wide canals*, such as the CAP, vegetated overpasses should be installed. While no studies have examined optimal crossing structures for canals, information can be gleaned from the literature on the determinants of success for road mitigation structures. For example, Van Wieren & Worm (2001) recommend wildlife overpasses over roads be at least 40-50 m wide for optimal wildlife usage. For *narrow canals*, such as the irrigation canal in the western strand of the linkage design, an affordable solution would be to cover the canal with metal plates, and cover these plates with an earthen substrate. The existing crossings at dirt roads (Figure 18) are helpful, but lack vegetation needed for some wildlife species to find them attractive. To ensure usability by an array of species, the grade of the entrance and exit to these crossing structures should provide a gentle approach to the canal.

2) **Install fencing on all areas of the canal which do not have crossing structures.** This fencing must completely seal the canal in order for it to effectively restrict wildlife use (Rautenstrauch & Krausman 1989), and be sufficiently high to prevent deer from jumping the fence (Peris & Morales 2004).

3) **Provide alternative water sources adjacent to crossing structures** (Rautenstrauch & Krausman 1989). To discourage use of the canals as a water supply by deer and other species, a small amount of water should be diverted to water catchments to allow wildlife to drink without risk of drowning.

EXCERPT Page 34 of the PDF Figure 16 The remainder of the page is related to deer escape structures.

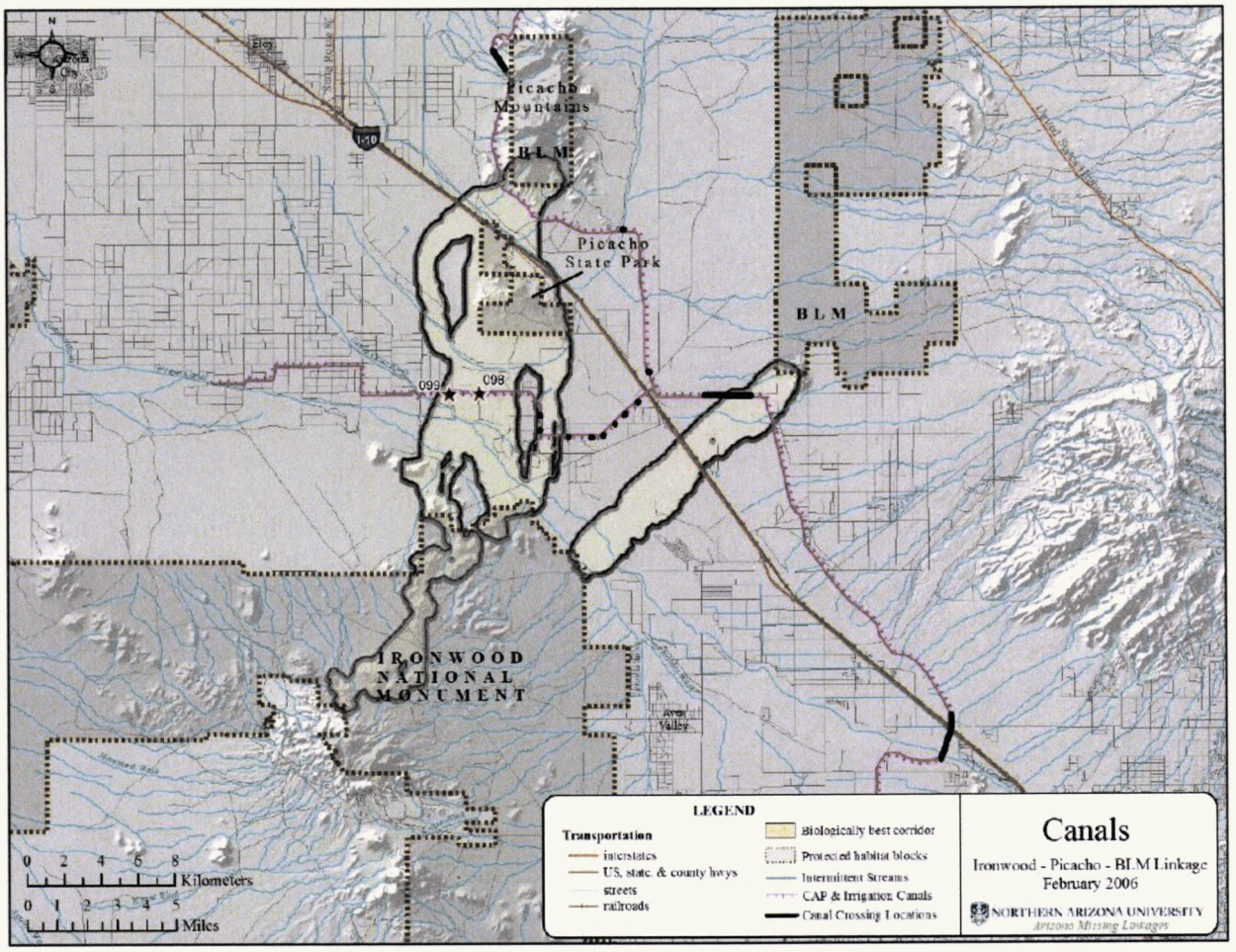


Figure 16: Canals in the Linkage Design area. The 4 black lines indicate buried sections of the Central Arizona Project canal: a 1.3-km stretch on the northwest side of the Picacho Mountains, a 70-m stretch at McClellan Wash, a 2.5-km stretch in the eastern strand of the linkage design, and a 2.5 km stretch under Interstate 10.

Urban Development as Barriers to Movement

While not a current major threat in the linkage area, urban and industrial development may become a greater threat in the future. Urban and industrial development, unlike roads, creates barriers to movement which cannot easily be removed, restored, or otherwise mitigated. Most large carnivores, small mammals, and reptiles cannot occupy these areas for a significant period of time, although several species of lizards or small mammals may occasionally occupy residential areas. While mapped urban areas only accounted for a marginal amount of the land cover in the linkage design, residential development may increase rapidly in the linkage area in the future.

Urban Barriers in the Linkage Design Area

While there are no current residential developments within the Linkage Design, there are several industrial developments. South of the Ironwood – desert BLM strand of the linkage, adjacent to I-10, is the Saguaro Power Plant (Figure 21). Several large tanks from the power plant are 200 m inside the border of this linkage.

Figure 21: The Saguaro Power Plant borders the southern end of the Ironwood - Picacho linkage adjacent to I-10 (waypoint 72; azimuth: 38).

The Pinal Air Park borders the southern end of the Ironwood – desert BLM linkage, approximately 4 km northwest of the Ironwood Forest National Monument boundary (Figure 22). In addition to storing aircraft, there is also a 1.2 mile racecourse for sports cars at the Air Park.

EXCERPT Page 39 of the PDF Complete Text. The rest of the page is a photo of Pinal Air Park Figure 22

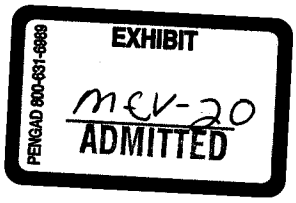
Mitigation for Urban Barriers

To conserve connectivity, we have the following recommendations for all future urban, residential, and industrial developments in this linkage zone:

1) Encourage conservation easements and land acquisition with willing land owners in the Linkage Design to protect important habitat.
2) Develop a public education campaign to inform those living and working within the linkage area about the local wildlife and the importance of maintaining ecological connectivity.
3) Encourage homeowners to focus outside lighting on their houses only, and never out into the linkage area.
4) Ensure that all domestic pets are kept indoors or in fenced areas outdoors.
5) Reduce vehicle traffic speeds in sensitive locations.
6) Discourage the conversion of natural areas within the Linkage Design into residential areas. Where development is permitted, encourage small building footprints on large (> 10-acre) parcels.
7) Encourage the use of wildlife-friendly fencing.
8) Discourage the killing of 'threat' species such as rattlesnakes.

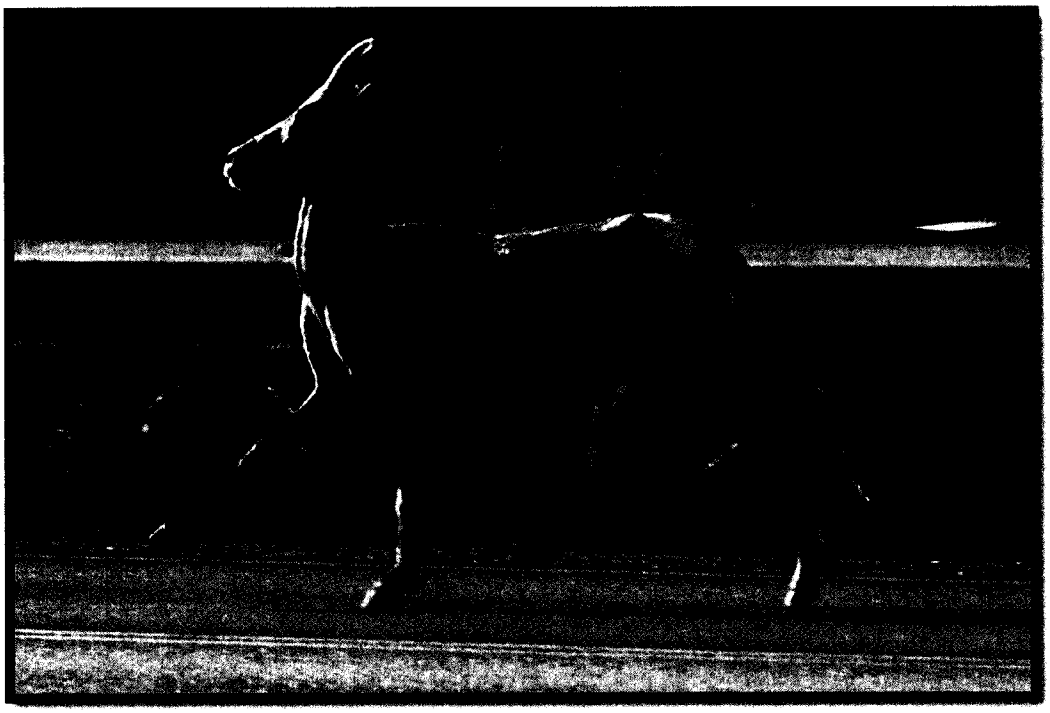
The next page is Appendix A: Linkage Design Methods

DOCKET NO. L-00000YY-15-0318-00171-MCV_20



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

TABLE OF CONTENTS

LIST OF FIGURES ii
RECOMMENDED CITATION iii
ACKNOWLEDGMENTS iii
DEFINITIONS iv
EXECUTIVE SUMMARY 1
BACKGROUND 2
METHODS 14
MAPS 19
PINAL COUNTY WILDLIFE LINKAGE DESCRIPTIONS 24
REFERENCES 35
APPENDIX I – TRANSPORTATION PLANNING STUDIES IN PINAL COUNTY 40
APPENDIX II – SAMPLE DATASHEET USED IN STAKEHOLDER WORKSHOPS 43

LIST OF FIGURES

Figure 1: ADWR check your water supply

Figure 2: Land ownership in Pinal County

Figure 3a/b: Satellite telemetry studies

Figure 4: Pinal County Multimodal Plan

Figures 5a/b: White-tailed deer movements along SR 260 and underpass near Kohl's Ranch

Figures 6a/b/c/d: Wildlife overpasses, underpasses, U.S. Highway ungulate-proof fencing and overpass allowing desert bighorn sheep to safely move

Figure 7: Pinal County Open Space and Trails Master Plan

Figures 8a/b: Statewide map of wildlife linkages and barriers and Ironwood-Picacho Linkage Design

Figure 9: Pinal County stakeholder-identified linkages – 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

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

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.

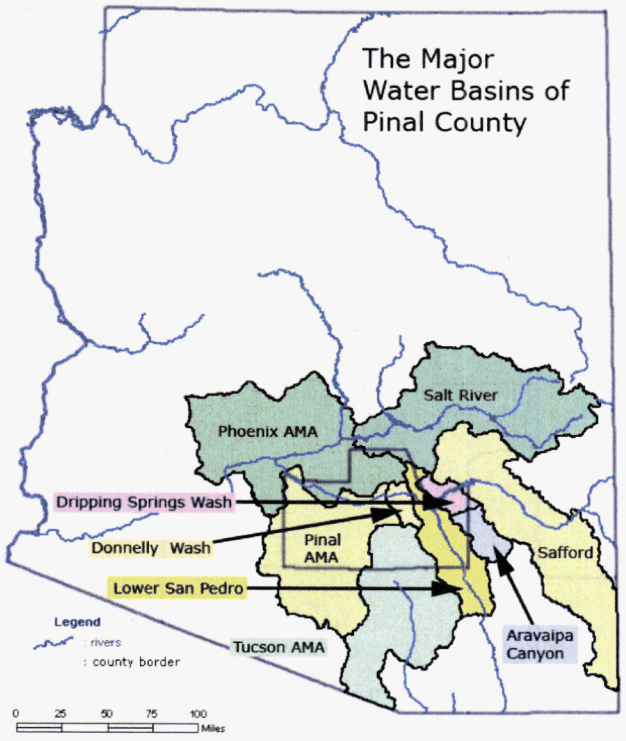


Figure 1: *ADWR check your water supply*

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.

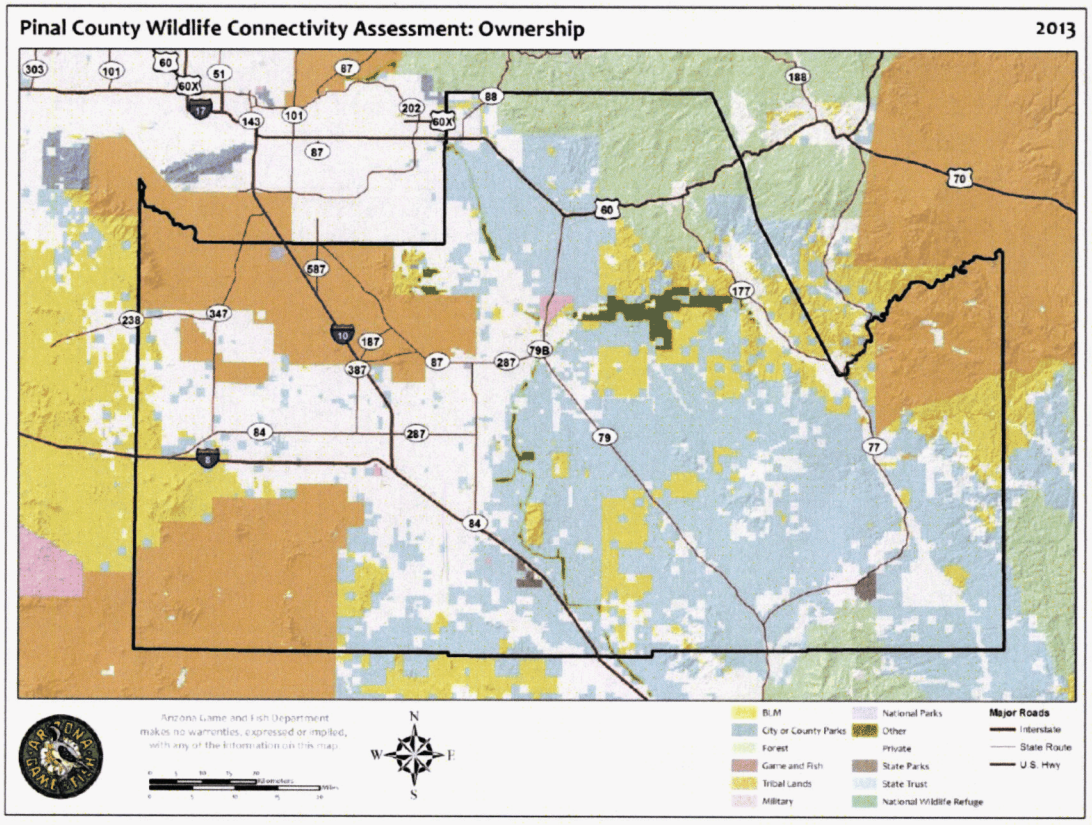


Figure 2 : *Land ownership in Pinal County*

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).

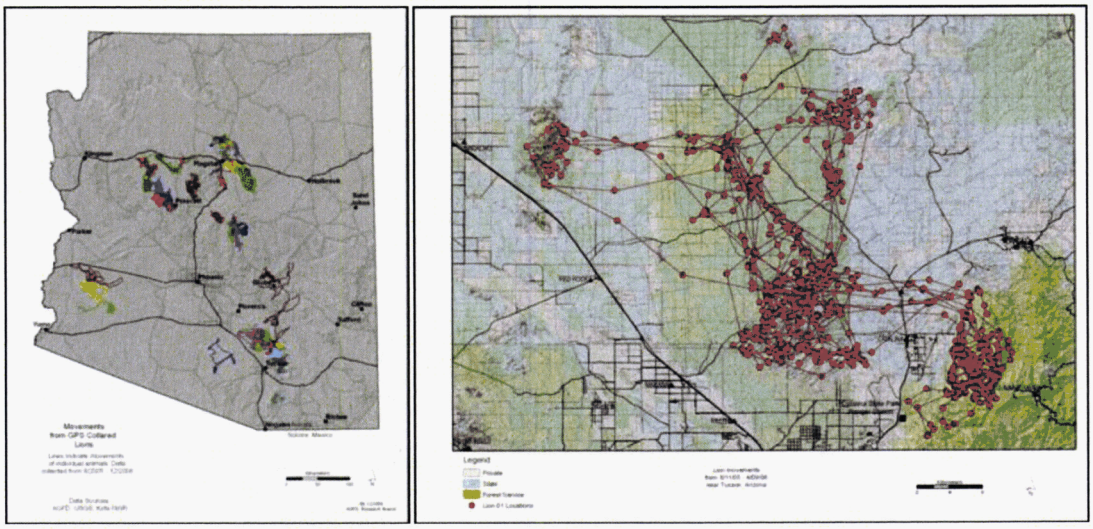


***Figure 3a and b: a**. A series of satellite telemetry studies conducted by the Arizona Game and Fish Department, the United States Geological Survey, the United States Fish and Wildlife Service, and the University of Arizona shows that highways act as barriers to lion movements across Arizona. Each 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 delineatedlow-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.

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.

Open space planning efforts substantively began in Pinal County in 2005 with the data gathering and development of the *Pinal County Open Space and Trails Master Plan* (Plan) as the foundation of the Open Space and Recreation Element of the *Pinal County Comprehensive Plan* (amended 2007 to include the Plan), and it identifies 399,300 acres of existing or planned open space, 802,400 acres of proposed open space, 25,900 acres of restricted use open space, and 168,700 acres of regional parks (*Figure 7*). The Plan reflects the vision of county residents and identifies goals and objectives for the attainments of open space, trails, and regional parks. The Plan includes an implementation program offering a variety of techniques from regulatory, acquisition, influencing land management decisions to land acquisition funding techniques. To aid the implementation of the Pinal Open Space Plan (adopted 2007), a committee was appointed by the Pinal County Board of Supervisors as the Pinal Partnership Parks, Trails, Open Space and Public Lands Committee. This committee has interest in incorporating wildlife linkages into the planning and implementation efforts within the county.

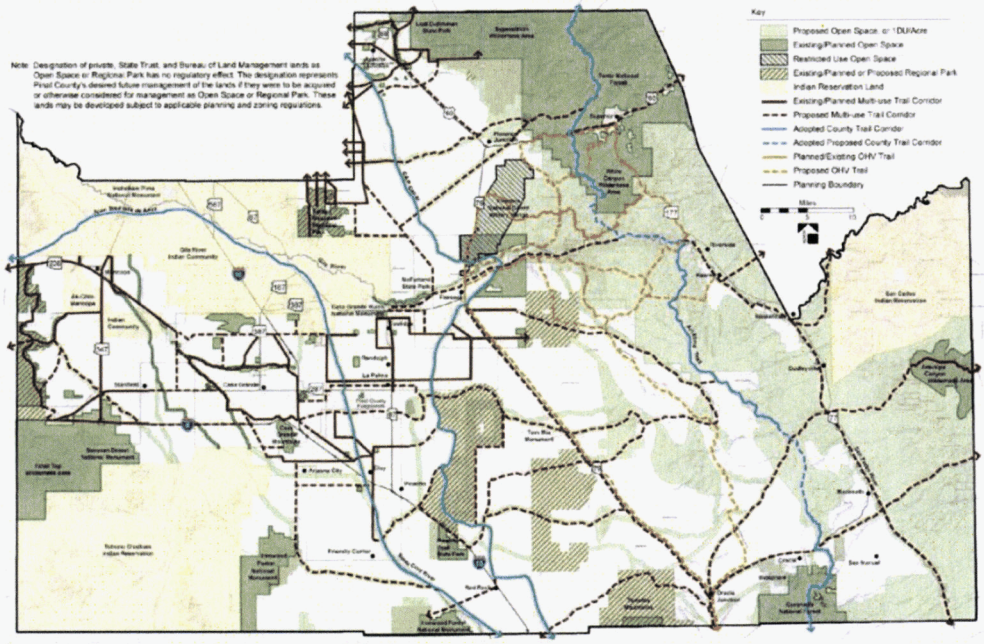


***Figure 7**: Pinal County Open Space and Trails Master Plan*

Page 18 of the PDF & Figures 8a & 8b

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.

a.

b.

***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*

Page 24 of the PDF & Figure 9

MAPS

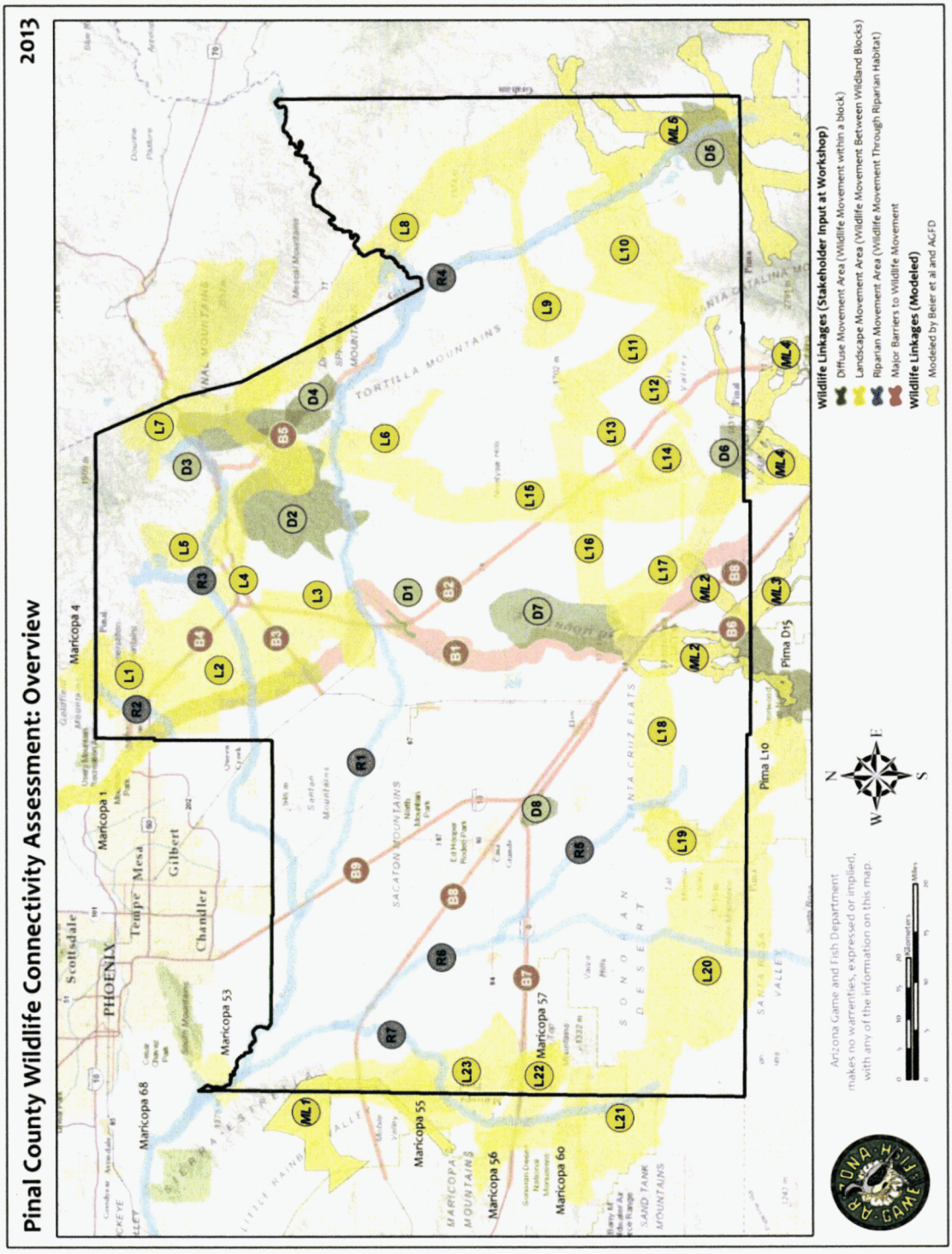


Figure 9: Pinal County stakeholder-identified linkages – County overview

Page 27 of the PDF & Figure 12

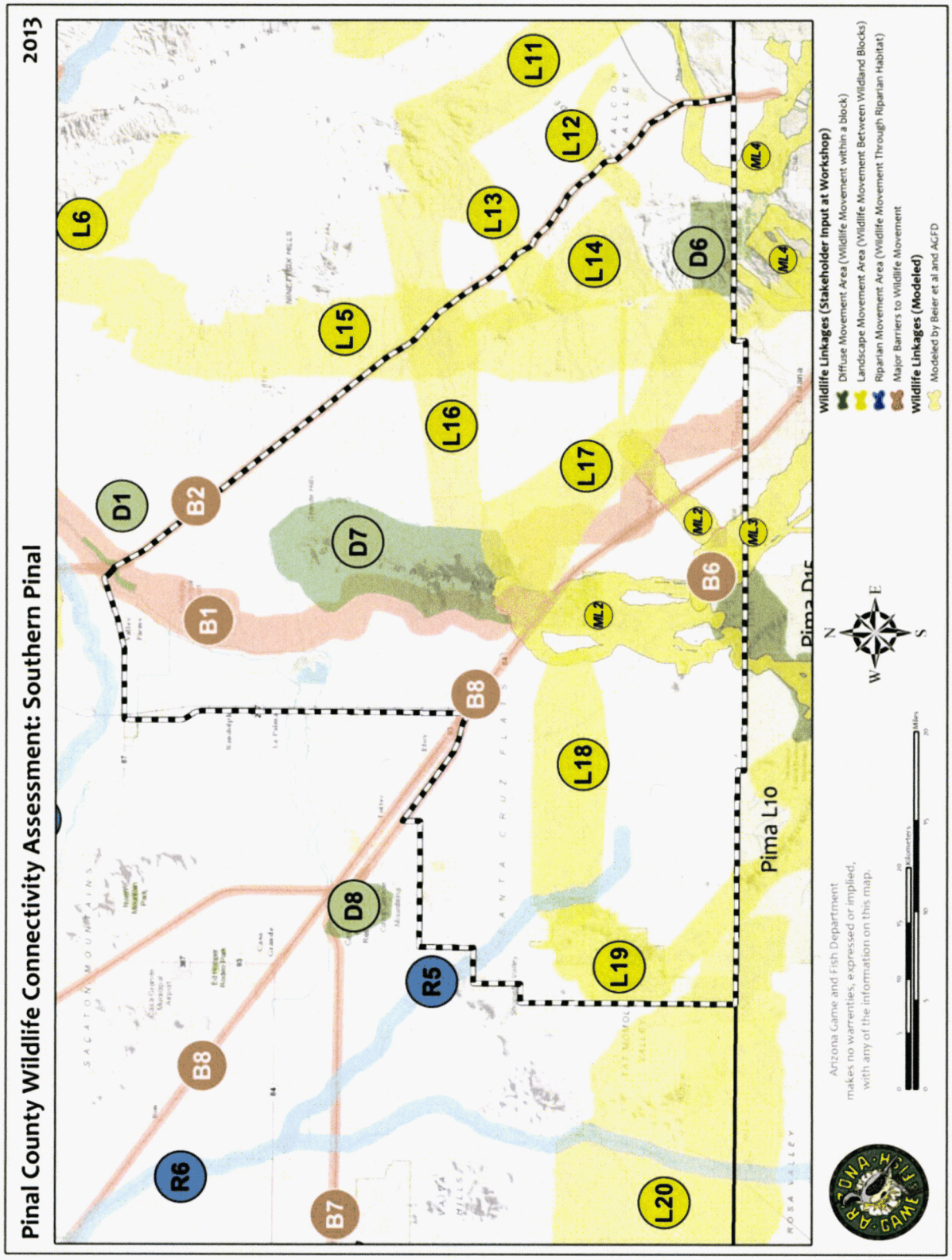


Figure 12: Pinal County stakeholder-identified linkages –Southern

Page 28 of the PDF & Figure 13

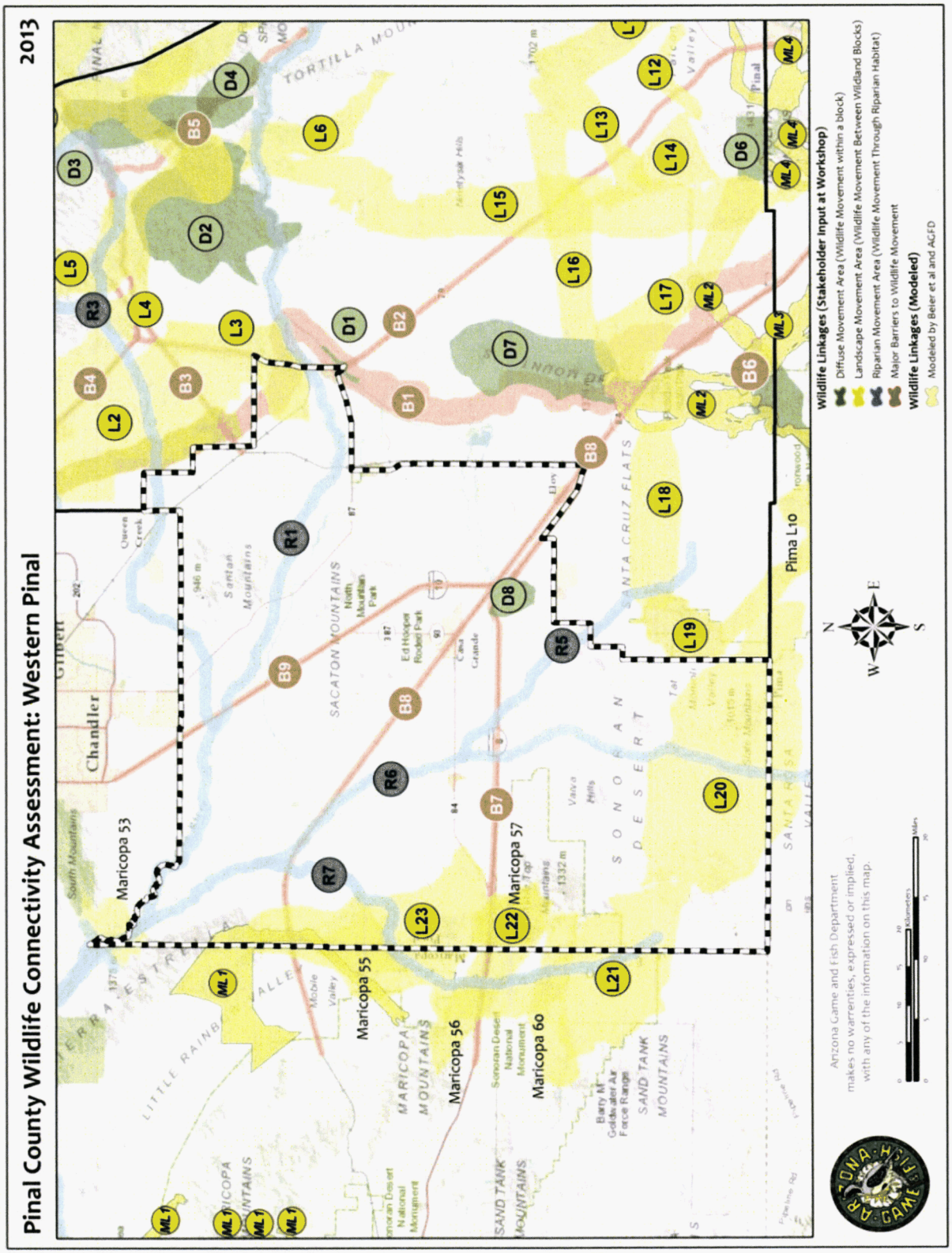


Figure 13: Pinal County stakeholder-identified linkages –Western

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:	• 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:	• 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:	• Mining
Future Threats/Opportunities:	None identified at workshop
Notes:	

D4. Ray Copper Mine

Species Identified:	Gila monster, Herpetofauna
Current Threats/Barriers:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• None identified at workshop
Future Threats/Opportunities:	Potential high and low residential development planned
Notes:	

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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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:	• 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

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)

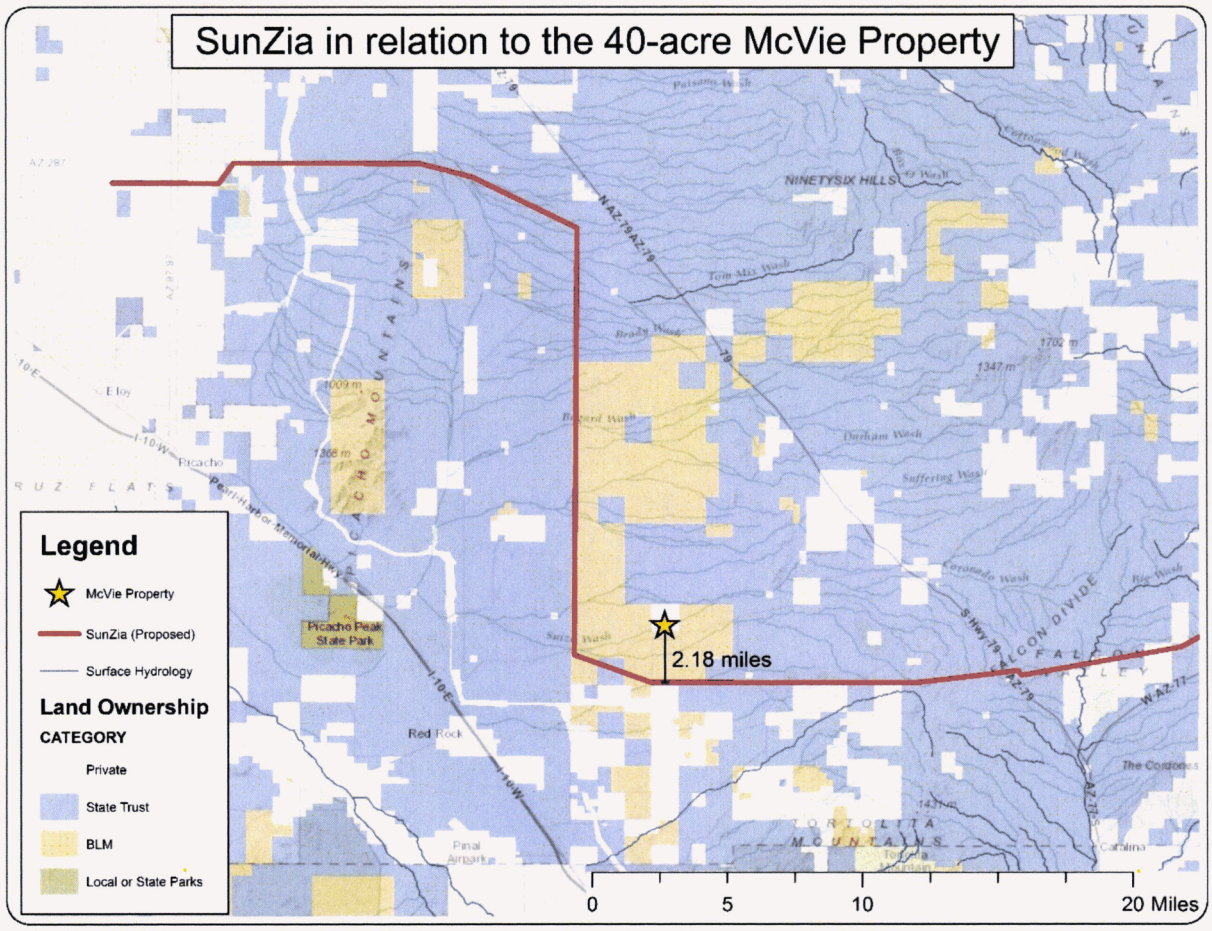
See Missing Linkage report at http://corridordesign.org/dl/linkages/reports/Tucson-Tortolita-SantaCatalina_LinkageDesign.pdf for complete list of modeled species, current and future threats and barriers, and additional recommendations on providing connectivity between these wildland blocks.

ML5. Santa Catalina/Rincons - 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.

DOCKET NO. L-00000YY-15-0318-001717-MCV_21

EXHIBIT
MCV-21
ADMITTED
PENGAD 800-631-6989



DOCKET NO. L-00000YY-15-0318-00171-MCV_22_Map of ~~McVie Property~~ Habitat Fragmentation

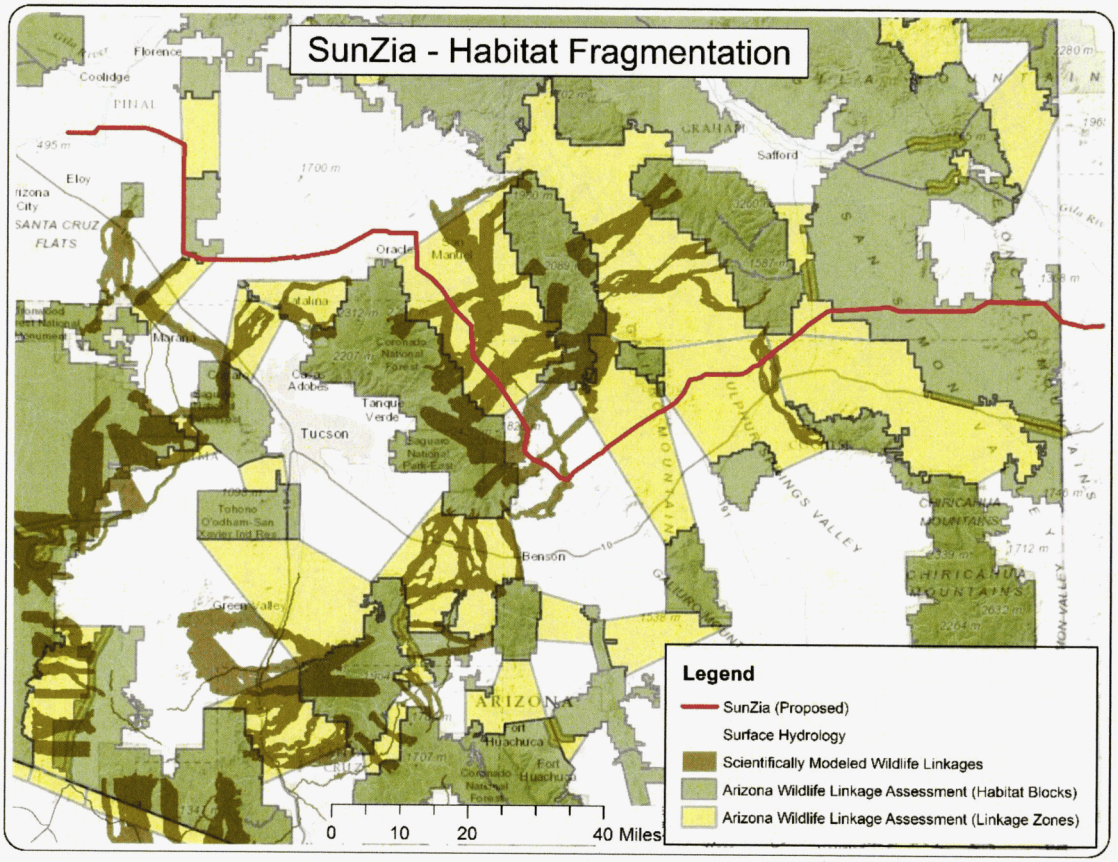


EXHIBIT
mcv-22
ADMITTED
PENGAD 800-631-6989

Arizona Wildlife Linkages Assessment Report, Arizona Department of Transportation Website:

http://www.azdot.gov/business/environmental-planning/programs/wildlife-linkages
(Accessed on 10/14/15)

From the webpage

"Biologists, engineers, planners and land managers from nine public agencies have worked together since 2004 to identify large blocks of protected habitat, the potential wildlife movement corridors through and between them, the factors that could possibly disrupt these linkage zones and opportunities for conservation.

Recognizing that habitat connectivity is a landscape issue involving multiple land jurisdictions, this workgroup has engaged in unprecedented cooperation and facilitated discussions and partnerships to help ensure a unified approach to wildlife linkage conservation and management.

This reinforces the commitment to and efficiency of wildlife connectivity measures undertaken by all stakeholders, using research and adaptive management in ongoing evaluations of those measures.

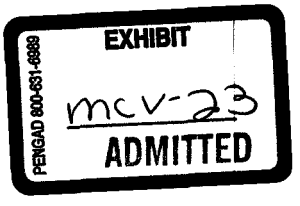
The assessment document (below) and map are the initial efforts to identify potential linkage zones that are important to Arizona's wildlife and natural ecosystems. This is only the first step in a continuing process of defining critical habitat connectivity areas.

This nonbinding document and map serve as an informational resource to planners and engineers, providing suggestions for the incorporation of these linkage zones into their management planning to address wildlife connectivity at an early stage of the process. If considerations for wildlife connectivity can be integrated into regional planning and projects early in the process, the linkage areas (or some portion of them) have the potential to be maintained or conserved during this time of growth and development."

Arizona's Wildlife Linkages Assessment Document

Due to the large file size of this study, it is divided up into the separate Adobe PDF segment.

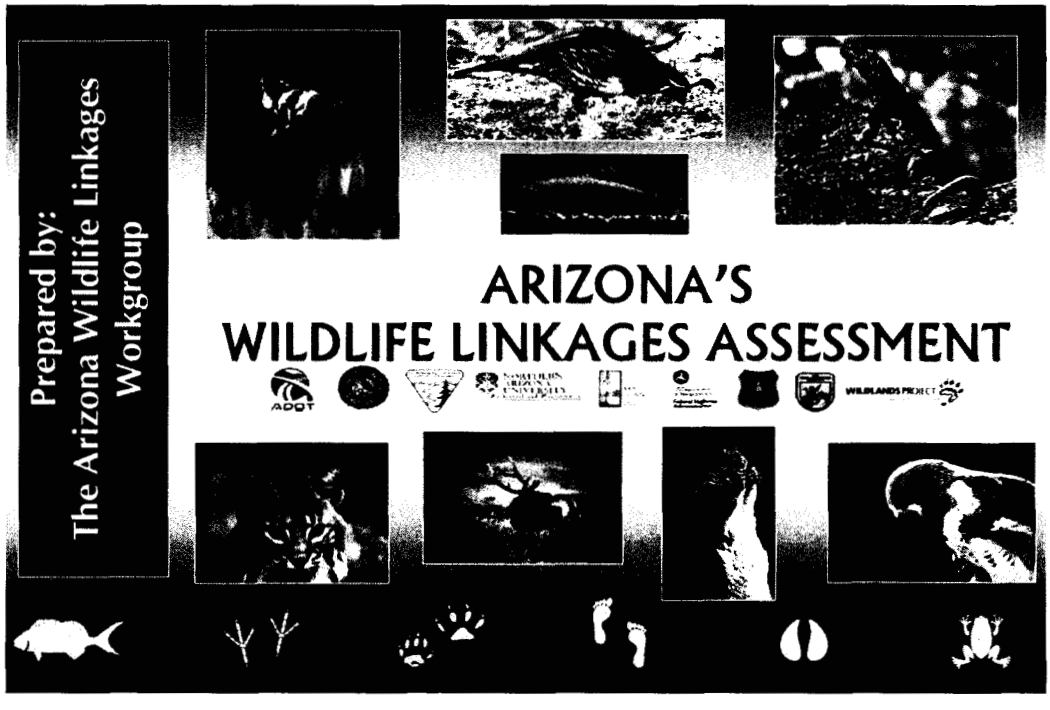
- **Arizona Wildlife Linkages Assessment (15435 KB)**
- **Section I Introduction (970 KB)**
- **Section II Arizona Wildlife Linkages Workgroup (223 KB)**
- **Section III Arizona Missing Linkages Workshop (14086 KB)**
- **Section IV Arizona Wildlife Linkages Mapping (103 KB)**



- Section V Arizona Wildlife Linkages Prioritization (923 KB)
- Section VI Arizonas Wildlife Linkages (200975 KB)
    - Figure 6 1 Arizona Wildlife Linkages (10162 KB)
    - Figure 6 2 Arizona Wildlife Linkages Across Habitat Blocks (9819 KB)
    - Figure 6 3 Arizona Fracture Zones (9499 KB)
    - Figure 6 4 Arizona Biotic Communities (10879 KB)
    - Figure 6 5 Landownership (11387 KB)
    - Figure 6 6 Tribal Nations (10814 KB)
    - Figure 6 7 USDA Forest Service (10851 KB)
    - Figure 6 8 Department of Defense (10756 KB)
    - Figure 6 9 Arizona Highway System with County Boundaries (10720 KB)
    - Figure 6 10 ADOT Engineering Districts (10582 KB)
    - Figure 6 11 ADOT Maintenance Districts (10947 KB)
    - Figure 6 12 ADOT Natural Resources Management Group (10363 KB)
    - Figure 6 13 Arizona Game and Fish Department (10651 KB)
    - Figure 6 14 Bureau of Land Management Districts (10518 KB)
    - Figure 6 15 Bureau of Land Management Field Offices (10514 KB)
    - Figure 6 16 Congressional Districts, 10690 KB
    - Figure 6 17 Council of Governments, 10632 KB
    - Figure 6 18 Federal Highway Administration Engineering Districts, 10472 KB
    - Figure 6 19 Legislative Districts, 10670 KB
- Section VII Potential Linkage Zones (9367 KB)
- Section VIII Riparian Habitat Linkage Zones (81776 KB)
    - Figure 8 2 Riparian Habitat Linkage Zones (11310 KB)

- Figure 8 3 Perennial Waters (12027 KB)
- Figure 8 6 Surface Water Basins (10823 KB)
- Figure 8 7 Unique Waters (9898 KB)
- Figure 8 8 Wild and Scenic Rivers (10760 KB)
- Figure 8 9 Impaired Waters (10506 KB)

- Section IX Future Directions (526 KB)
- Section X Connectivity Related Projects (1368 KB)
- Section XI Contributor Connectivity Efforts (213 KB)
- Section XII Sources for Connectivity Resolution (1424 KB)
- Appendix A Linkage Data Sheet (446 KB)
- Appendix B Workshop Participants (246 KB)
- References (521 KB)"



Page 11 of the PDF

EXECUTIVE SUMMARY

The phenomenal growth of Arizona's human population, economy, and infrastructure present challenges to maintaining natural ecosystems and wildlife populations that constitute an important part of Arizona's wealth. In particular, roads, urbanization, canals, railways, energy corridors, and activities of illegal migrants and border security operations not only destroy habitat, but create barriers that isolate wildlife populations and disrupt ecological functions such as gene flow, predator-prey interactions, and migration. Addressing each of these potential barriers one-at-a-time is expensive and inefficient. In each landscape, we must address all these factors concurrently to successfully maintain or restore linkages between habitats and conserve the wildlife and natural ecosystems that Arizona's residents and visitors rely on and benefit from.

Conspicuous evidence of habitat fragmentation is wildlife road kill – a far too common sight along many Arizona roadways. These often fatal encounters have far-reaching effects. Wildlife-vehicle collisions can result in human deaths and injuries, millions of dollars in property damage, loss of game and non-game animals, and sometimes expose the State to liability. Working together, federal, state, county and private stakeholders can minimize these social costs while enhancing opportunities for movement of wildlife between Arizona's habitat areas.

The Arizona Wildlife Linkages Workgroup (AWLW) has taken the first step in that process. The AWLW is a collaborative effort between public and private sector organizations formed to address habitat fragmentation through a comprehensive, systematic approach. Through this partnership and commitment, a statewide assessment was conducted to identify large blocks of protected habitat, the potential wildlife movement corridors between as well as through them, and the factors threatening to disrupt these linkage zones. After four successful workshops and many hours spent coordinating, meeting, mapping and writing, we present our initial findings, methodology and recommendations – a product that is intended to evolve and ultimately be used as a planning instrument.

The Arizona's Missing Linkages Workshop held in April 2004 and the follow-up workshops that ensued are the basis for this report and mapping tool. Attendance at the workshops was well represented with biologists, engineers, planners and land managers from state and federal agencies, universities, consulting firms and private sector conservation organizations. Individuals were divided into groups to address specific geographic regions. They used map transparencies and tailored questionnaires to assist in the identification of habitats, wildlife species, wildlife behavior and needs, *potential linkage zones* (see *Table 4-1*) as well as present and future threats or opportunities for conservation. One of the many products resulting from this process was a computerized geographic information system (GIS) projection graphically displaying the compiled information. There are over 150 potential linkage zones included in the Arizona's Wildlife Linkages Map.

The potential linkage zones represent areas that are important to Arizona's *wildlife and natural ecosystems*. If integrated into regional planning frameworks, these areas have the potential to be maintained or preserved during this time of prosperity, growth and development. As such, for each potential linkage zone, the AWLW built on information collected from the workshops to further define existing conditions, recording biotic communities, listing species that depend on particular linkages, identifying land ownership within those linkages, and detailing known and anticipated threats.

For further refinement, potential linkage zones were prioritized based on biological importance, threats - existing and anticipated - and opportunities for preservation and/or restoration purposes. Biological importance scores depended on the size and habitat quality of the *habitat blocks* (see *Table 4-1*) and on the ability of the potential linkage zones to support special status species, aquatic ecosystems, or seasonal migrations. Threat scores reflect the barrier effect of canals, roads, urbanization and railroads. Opportunity scores indicate ongoing and proposed conservation efforts in the areas, and whether impending major road projects provide an opportunity to increase the permeability of roads. As road construction programs are updated and development in the State progresses, this evaluation and resulting prioritization will need revision.

Our intention in this report is to provide a starting point for detailed consultation and coordination among the organizations and agencies that have a major role to play in maintaining habitat connectivity. To offer flexibility in the use of this report, all the maps within this document have been created at the same scale so that the transparency of the Arizona's Wildlife Linkages Map included in the front of this document may be used as an overlay. Furthermore, the report was drafted in a manner to allow each individual chapter to be used as a stand-alone tool. For that reason, terminology common throughout the entire document is defined in each section. All technical terms are also collectively defined in the glossary.

Important to taking the next step in preserving or restoring habitat connectivity is the physical design and construction of linkages. To help facilitate these applications, this report outlines the methodology used to create specific linkage designs within potential linkage zones. In the coming years, the AWLW intends to develop linkage designs for each potential linkage zone through a combination of GIS analysis and fieldwork. This analysis coupled with a feasibility study on linkage protection will further define the present potential linkage zones into smaller, more site-specific delineations and is intended to aid in conservation and planning efforts. Linkages ranking highest in our prioritization will be addressed first. Future assessments will identify additional potential linkage zones.

This report represents the results of the first statewide wildlife linkages assessment. We hope to elevate the current level of awareness of wildlife connectivity areas and issues in Arizona. The tools in this report will allow land managers to incorporate the identified wildlife linkage zones into their management planning processes to address habitat fragmentation due to highways and other human development. We expect to facilitate the integration of the potential linkage zones presented in this report and those identified in the future into early project planning efforts. We acknowledge that this is only the first step in a continuing process of defining critical habitat connectivity areas.

Now more than ever, decision makers have a responsibility to protect and maintain wildlife linkages to sustain Arizona's diverse wildlife species and wild landscapes. We firmly believe that government agencies and citizens working together with a comprehensive, landscape-scale approach can achieve these conservation goals while accommodating the growth of Arizona's population an expanding economy, and associated infrastructure.

- The Arizona Wildlife Linkages Workgroup

Page 13 of the PDF

TABLE OF CONTENTS

EXECUTIVE SUMMARY i
DISCLAIMER ii
TABLE OF CONTENTS iii
LIST OF FIGURES vii
LIST OF TABLES viii
LIST OF ACRONYMS ix
GLOSSARY x
ACKNOWLEDGEMENTS xi
SECTION I INTRODUCTION 1
The Challenge 1
Legal Environment 3
Providing Solutions 4
SECTION II ARIZONA'S WILDLIFE LINKAGES WORKGROUP 5
Forming Partnerships 5
AWLW Mission Statement 5
Primary Goals 5
Founding Individuals 6
SECTION III ARIZONA'S MISSING LINKAGES WORKSHOP 7
Breakout Sessions 7
Follow-up Workshops (November 2004) 9
Arizona's Missing Linkages Workshop Agenda (April 13 – 14, 2004) 10
SECTION IV ARIZONA'S WILDLIFE LINKAGES MAPPING 15
Layers 15
Mapping Generalities 16
Habitat Block Mapping Decision Rules 16
Potential Linkage Zone Mapping Decision Rules 16
SECTION V ARIZONA'S WILDLIFE LINKAGES PRIORITIZATION 17
Biological Value 17
Biological Value Weighting 19
Threat and Opportunity Value 19
Threat and Opportunity Value Weighting 20
Top Priority Linkages 20
SECTION VI ARIZONA'S WILDLIFE LINKAGES 21
Potential Linkage Zone Information 21
SECTION VII POTENTIAL LINKAGE ZONES 41
Linkage 1 Beaver Dam Slope – Virgin Slope 41
Linkage 2 Beaver Dam – Virgin Mountains 41
Linkage 3 Cedar Rim/Fredonia Pronghorn Crossing 42
Linkage 4 Kaibab – Paunsaugunt Plateau 43
Linkage 5 Kaibab Plateau – North Rim 43
Linkage 6 Paria Plateau – Kaibab Plateau 44
Linkage 7 Skeleton Mesa – Black Mesa 44
Linkage 8 Chinle Valley – Chuska Mountains 45
Linkage 9 Chuska Mountains – New Mexico 45
Linkage 10 Mount Tipton – Mount Perkins 46
Linkage 11 Grand Canyon – Prescott National Forest 47
Linkage 12 Coconino Plateau – Kaibab National Forest 47
Linkage 13 South Rim Grand Canyon 48
Linkage 14 Valle – Bellemont 49
Linkage 15 Garland – Arizona Divide 49
Linkage 16 Flagstaff 50
Linkage 17 Deadman Mesa – Gray Mountain 51
Linkage 18 Black Mountains – Cerbat Mountains 51
Linkage 19 Mount Perkins – Warm Springs 52
Linkage 20 Hualapai Mountains – Cerbat Mountains 53
Linkage 21 I-40 and US 93 – Kingman 53
Linkage 22 Big Black Mesa – Hell Canyon 54
Linkage 23 Oak Creek Canyon – Munds Park 55
Linkage 24 Cottonwood – Sedona 56
Linkage 25 State Route 179 56
Linkage 26 Northern I-17 Corridor 57
Linkage 27 Mogollon Rim – Navajo Nation 58
Linkage 28 North – South Petrified Forest 59
Linkage 29 Warm Springs – Hualapai Mountains 60
Linkage 30 Warm Springs – Aubrey Peak 60
Linkage 31 The Needles – Mohave Mountains 61
Linkage 32 Bill Williams – Aubrey Hills 62
Linkage 33 Hualapai Mountains – Bagdad 62

Page 14 of the PDF

Linkage 34 Tres Alamos Wilderness – Prescott National Forest ... 63
Linkage 35 East – West Prescott National Forest ... 64
Linkage 36 Yeager Canyon – Camp Verde ... 65
Linkage 37 North – South Black Hills ... 66
Linkage 38 Bradshaw Mountains – Agua Fria National Monument ... 67
Linkage 39 SR 260 West from I-17 to SR 87 ... 67
Linkage 40 East – West Mogollon Plateau ... 68
Linkage 41 SR 260 Payson – Heber ... 69
Linkage 42 Arpine – Cibecue ... 69
Linkage 43 Parker Valley – Cactus Plain ... 70
Linkage 44 Cactus Plain – Plomosa Mountains ... 71
Linkage 45 La Posa Plain ... 71
Linkage 46 Buckskin Mountains – Harcuvar Mountains ... 72
Linkage 47 Dome Rock Mountains ... 73
Linkage 48 Ranegras Plain ... 73
Linkage 49 Granite Wash – Little Harquahala Mountains ... 74
Linkage 50 Harcuvar Mountains – Harquahala Mountains ... 75
Linkage 51 Wickenburg ... 75
Linkage 52 Hassayampa River – Red Picacho ... 76
Linkage 53 North – South Mazatzal Mountains ... 77
Linkage 54 Sierra Ancha – Superstition Mountains ... 78
Linkage 55 East – West Sierra Ancha SR 288 ... 78
Linkage 56 Sevenmile – Sevenmile East US 60 ... 79
Linkage 57 Faught Ridge – Bald, SR 73 ... 80
Linkage 58 State Route 260 East ... 81
Linkage 59 Correo Crossing – Clifton US 191 ... 81
Linkage 60 Black Hills – Tolligate Canyon ... 83
Linkage 61 Black Hills – Peloncillo Mountains ... 83
Linkage 62 State Route 75 ... 83
Linkage 63 Trigo Mountains – Kofa Mountains ... 84
Linkage 64 Bighorn Belmont – Saddle Mountain ... 85
Linkage 65 White Tanks – Hassayampa River ... 85
Linkage 66 Superior – Miami, US 60 ... 86
Linkage 67 Gila River – El Capitan ... 87
Linkage 68 Saddle Mountain – Gila Bend Mountains ... 87
Linkage 69 Laguna Mountains – Muggins Mountains ... 88
Linkage 70 Arizona Service Highway (ASH) ... 89
Linkage 71 North – South Gila Mountains ... 89
Linkage 72 Sentinel Plain ... 90
Linkage 73 Gila Bend Mountains – North Maricopa Mountains ... 91
Linkage 74 North Maricopa Mountains – Sierra Estrella Mountains ... 92
Linkage 75 State Route 85 ... 92
Linkage 76 South Maricopa Mountains – Sand Tanks ... 93
Linkage 77 Quijotoa Valley ... 94
Linkage 78 State Route 79 ... 95
Linkage 79 Ironwood – Tortolita ... 95
Linkage 80 Saguaro – Tortolita ... 96
Linkage 81 Santa Catalina – Tortolita ... 97
Linkage 82 Santa Catalina – Galliuro ... 97
Linkage 83 Galliuro – Pinaleno ... 98
Linkage 84 Pinaleno – San Simon Valley ... 99
Linkage 85 Avra Valley ... 100
Linkage 86 Kitt Peak ... 100
Linkage 87 Tucson Mountains – San Xavier/San Robles Pass ... 101
Linkage 88 Galliuro – Winchester – Dragoon ... 102
Linkage 89 Wilcox Playa – Winchester – Pinaleno – Dos Cabezas ... 102
Linkage 90 Pinaleno – Dos Cabezas – San Simon Valley ... 103
Linkage 91 Baboquivari – San Luis Mountains ... 104
Linkage 92 San Xavier – Sierrita – Santa Rita ... 104
Linkage 93 Tumacacori – Santa Rita ... 105
Linkage 94 Rincons – Whetstone – Santa Rita ... 106
Linkage 95 Santa Rita – Empire Complex ... 106
Linkage 96 Patagonia – Santa Rita ... 107
Linkage 97 Whetstone – San Pedro River ... 108
Linkage 98 Las Cienegas – Huachuca ... 108
Linkage 99 Dragoon – San Pedro River ... 109
Linkage 100 Fort Huachuca – San Pedro River ... 110
Linkage 101 Chiricahuas– Peloncillos ... 110
Linkage 102 Western International Border ... 111
Linkage 103 Altar Valley – Mexico ... 112
Linkage 104 Tumacacori – Mexico ... 112
Linkage 105 Santa Cruz – Mexico ... 113
Linkage 106 Patagonia/Huachuca – Mexico ... 114
Linkage 107 San Pedro River – Mexico ... 114
Linkage 108 San Bernadino – Mexico ... 115
Linkage 109 Peloncillo – Mexico ... 116
Linkage 110 Beaver Dam Slope East – West ... 116
Linkage 111 Mohave Mountains – Castaneda Hills ... 117
Linkage 112 Gibraltar Mountain – Cactus Plain ... 118
Linkage 113 Poachie Range – Black Mountains ... 118
Linkage 114 Harcuvar Mountains – Black Mountains ... 119
Linkage 115 Cunningham Pass ... 120
Linkage 116 North – South Plumosa Mountains ... 120
Linkage 117 South Trigo Peaks – Trigo Mountains ... 121
Linkage 118 Indian Well – Livingston Hills ... 122
Linkage 119 Livingston Hills – Kofa Mountains ... 122
Linkage 120 Eagletail Mountains – Clanton Hills – Little Horn Mountains ... 123
Linkage 121 Harquahala Mountains – Little Harquahala Mountains ... 124
Linkage 122 Harquahala Mountains – Belmont Mountains – Big Horn Mountains ... 124
Linkage 123 Mohave Peak – Chocolate Mountains ... 125
Linkage 124 Kofa Mountains – Castle Dome ... 126
Linkage 125 Tank Mountains – Palomas Mountains ... 126
Linkage 126 Burnyan Peak – Painted Rock Mountains ... 127

Page 15 of the PDF

Linkage 127 Margies Peak – Sheep Mountain ... 128
Linkage 128 North Maricopa – South Maricopa Mountains ... 128
Linkage 129 Southern Colorado River ... 129
Linkage 130 Chocolate Mountains – Trigo Mountains – Laguna Mountains ... 130
Linkage 131 Castle Dome Mountains – Red Bluff Mountains – Muggins Mountains ... 131
Linkage 132 Tinajas Altas Mountains – Cabeza Prieta Mountains ... 131
Linkage 133 Copper Mountains – Cabeza Prieta Mountains ... 132
Linkage 134 Cabeza Prieta Mountains – Tule Mountains ... 133
Linkage 135 Sierra Pinta – Cabeza Prieta Mountains ... 133
Linkage 136 Mohawk Mountains/Bryan Mountains – North Sierra Pinta ... 134
Linkage 137 South Sierra Pinta – Papago Well ... 135
Linkage 138 Northern Mohawk Mountains ... 135
Linkage 139 Mohawk Mountains – Bryan Mountains ... 136
Linkage 140 Bryan Mountains – Antelope Hills ... 137
Linkage 141 Granite Mountains – Mohawk Mountains/Bryan Mountains ... 137
Linkage 142 Granite Mountains – Antelope Hills ... 138
Linkage 143 Aguila Mountains – Granite Mountains ... 139
Linkage 144 Crowler Mountains – Granite Mountains ... 139
Linkage 145 Bates Mountains/Cipriano Hills – Agua Dulce Mountains/Quitobaquito Hills ... 140
Linkage 146 Childs Mountains – Crowler Mountains ... 141
Linkage 147 Crowler Mountains – Bates Mountains ... 141
Linkage 148 Round Butte – Javelina Mountain ... 142
Linkage 149 Sand Tank Mountains – Sauceda Mountains ... 143
Linkage 150 Little Table Top – Vekol Mountains ... 143
Linkage 151 Gila/Salt River Corridor Granite Reef Dam – Gillespie Dam ... 144
Linkage 152 Central Arizona Project Canal ... 145

SECTION VIII RIPARIAN HABITAT/LINKAGE ZONES ... 147
Arizona Riparian Areas ... 147
Arizona Hydrological Classifications ... 150
Unique Waters ... 152
Wild and Scenic Rivers ... 152
Impaired Waters ... 162
Potential Impacts ... 162
Overview of Spatial and Temporal Impacts of Road or Other Construction Projects ... 162
Phase Descriptions ... 164
Ecological Components Consideration ... 164
General Recommendations ... 165

Section IX FUTURE DIRECTIONS ... 167
Additional Potential Linkage Zone Identification ... 167
Linkage Designs ... 167
Interactive Linkage Map Tool ... 168
Integrated Planning and Interagency Coordination ... 169
Outreach ... 169

Section X CONNECTIVITY RELATED PROJECTS ... 171
Wildlife Research ... 171
Road Kill Database ... 174

SECTION XI CONTRIBUTOR'S CONNECTIVITY EFFORTS ... 175
Arizona Department of Transportation ... 175
Arizona Game and Fish Department ... 175
Bureau of Land Management ... 176
Comprehensive Wildlife Conservation Strategy ... 176
The Federal Highway Administration ... 176
The Nature Conservancy ... 177
Northern Arizona University ... 177
The Sky Island Alliance ... 177
USDA Forest Service ... 177
The Wildlands Project ... 178

SECTION XII SOURCES FOR CONNECTIVITY RESOLUTION ... 179
Acres for America ... 179
Arizona Game and Fish Commission Heritage Fund ... 179
Arizona Growing Smarter Grant Program ... 180
Arizona Wildlife Conservation Fund ... 181
Arizona Partners in Amphibian and Reptile Conservation ... 181
Arizona Water Protection Fund ... 181
Bring Back the Natives ... 181
Candidate Conservation Agreements with Assurances ... 182
Conservation Innovation Grants ... 182
Conservation Reserve Program ... 182
Conservation Banking ... 182
Conservation Security Program ... 183
Cooperative Endangered Species Conservation Fund ... 183
Doris Duke Charitable Foundation ... 184
Environmental Quality Incentives Program ... 184
Farm and Ranch Land Protection Program ... 184
FishAmerica Foundation ... 184
Fish and Wildlife Habitat Improvement Grants ... 185
Five-Star Restoration Matching Grants Program ... 185
Grassland Reserve Program ... 185
Healthy Forests Reserve Program ... 186
Land and Water Conservation Fund ... 186
Landowner Incentive Program ... 186
Leonardo DiCaprio Foundation ... 186
Local, Regional and State Parks Heritage Fund ... 187
More Fish Partnership Fund ... 187
Multistate Conservation Grants Program ... 187
National Fish Passage Program ... 188
National Fish and Wildlife Foundation General Matching Grants Program ... 188
National Fish and Wildlife Foundation in Partnership with the NRCS ... 188
National Scenic Byways Grants Program ... 189
Native Plant Conservation Initiative ... 189
Neotropical Migratory Bird Conservation Act Grants Program ... 189

Page 16 of the PDF

North American Wetlands Conservation Act Grants Program ---- 189
North American Bat Conservation Fund ---- 189
Partners for Fish and Wildlife Program ---- 189
Private Stewardship Grant ---- 190
Pulling Together Initiative ---- 190
Resource Conservation and Development Program ---- 190
Riparian Trust Fund ---- 190
Rockefeller Brothers Fund ---- 191
Safe Harbor Agreements ---- 191
State Comprehensive Wildlife Conservation Support Program ---- 191
State Lake Improvement Fund Grant Program ---- 192
Sundna Foundation ---- 192
Transportation Enhancement Grants ---- 192
Tribal Landowner Incentive Program ---- 192
Tribal Wildlife Grants ---- 192
United States Golf Association Wildlife Links ---- 192
Wetlands Reserve Program ---- 193
Wilburforce Foundation ---- 193
Wildlife Habitat Incentives Program ---- 193
Wildlife Action Opportunities Fund ---- 193
Wildlife Habitat Policy Research Program ---- 193
Excerpts from the Highway Transportation Bill SAFETEA-LU ---- 194

APPENDIX A LINKAGE DATA SHEET ---- 197

APPENDIX B WORKSHOP PARTICIPANTS ---- 199

REFERENCES ---- 203

Page 17 of the PDF

LIST OF FIGURES

Figure 3-1. Arizona's Ecoregions ---- 8
Figure 3-2. Workshop Resource Maps ---- 7
Figure 3-3. Flowchart of Project Development ---- 9
Figure 3-4. Priority Conservation Areas Identified by The Nature Conservancy through Ecoregional Assessments ---- 12
Figure 4-1. Diagram of Refinement Progression ---- 16
Figure 5-1. Prioritization Graph ---- 17
Figure 5-2. Upper Right Quadrant of Prioritization ---- 20
Figure 6-1. Arizona's Wildlife Linkages ---- 22
Figure 6-2. Arizona's Wildlife Linkages Across Habitat Blocks ---- 23
Figure 6-3. Fracture Zones ---- 24
Figure 6-4. Arizona's Biotic Communities ---- 25
Figure 6-5. Landownership ---- 26
Figure 6-6. Tribal Nations ---- 27
Figure 6-7. USDA Forest Service ---- 28
Figure 6-8. Department of Defense ---- 29
Figure 6-9. Arizona Highway System ---- 30
Figure 6-10. ADOT Engineering Districts ---- 31
Figure 6-11. ADOT Maintenance Boundaries ---- 32
Figure 6-12. ADOT Natural Resources Management Section ---- 33
Figure 6-13. Arizona Game and Fish Department Regions ---- 34
Figure 6-14. Bureau of Land Management Districts ---- 35
Figure 6-15. Bureau of Land Management Field Offices ---- 36
Figure 6-16. Congressional Districts ---- 37
Figure 6-17. Council of Governments ---- 38
Figure 6-18. Federal Highway Administration Engineering Districts ---- 39
Figure 6-19. Legislative Districts ---- 40
Figure 8-1. Classification of Rivers and Streams ---- 147
Figure 8-2. Riparian Habitat/Linkage Zones ---- 148
Figure 8-3. Perennial Rivers, Stream and Selected Washes ---- 149
Figure 8-4. Major Pathways of Exchanges of Materials, Energy and Organisms in the Longitudinal, Lateral and Vertical Dimensions of a Riverine System (From Ward and Wiens 2001 and Wiens 2002) ---- 147
Figure 8-5. Hierarchical Classification of Stream Habitats (Wiens 2002) ---- 150
Figure 8-6. Arizona Department of Water Resources Surface Water Basins ---- 151
Figure 8-7. Unique Waters ---- 153
Figure 8-8. Wild and Scenic Rivers ---- 154
Figure 8-10. Impaired Waters ---- 163
Figure 8-11. Temporal and Spatial Extent of Ecological Impacts on Riparian Areas Due to Three Phases of Road Development (Angermeier et al. 2004) ---- 163

Page 18 of the PDF

LIST OF TABLES

Table 4-1. Important Terms 15
Table 5-1. HB1 Size of Habitat Blocks 17
Table 5-2. HB2 Habitat Quality of the Smaller Block 18
Table 5-3. HB3 Presence of Linkage Dependent Species 18
Table 5-4. L1 Facilitates Seasonal Migration 18
Table 5-5. L2 Riparian Area 18
Table 5-6. L3 Conservation Ownership 18
Table 5-7. L4 Special Status Species WITHIN the Linkage Zone 19
Table 5-8. L5 Other Linkages Depend on This One 19
Table 5-9. Weighting for Biological Values 19
Table 5-10. T1 – T5 Development Threats 19
Table 5-11. O1 Linkage to Other State or Mexico 19
Table 5-12. O2A ADOT 5-Year Plan 19
Table 5-13. O2B ADOT Long Range (20-Year) Plan 19
Table 5-14. O3 Active Conservation Efforts 20
Table 5-15. Weighting for Threats and Opportunities 20
Table 8-1. Arizona's Designated Unique Waters 152
Table 8-2. Arizona Waters Potential Candidates for Wild and Scenic Designations 155

Page 11 of the PDF Excerpt

This report represents the results of the first statewide wildlife linkages assessment. We hope to elevate the current level of awareness of wildlife connectivity areas and issues in Arizona. The tools in this report will allow land managers to incorporate the identified wildlife linkage zones into their management planning processes to address habitat fragmentation due to highways and other human development. We expect to facilitate the integration of the potential linkage zones presented in this report and those identified in the future into early project planning efforts. We acknowledge that this is only the first step in a continuing process of defining critical habitat connectivity areas.

Now more than ever, decision makers have a responsibility to protect and maintain wildlife linkages to sustain Arizona's diverse wildlife species and wild landscapes. We firmly believe that government agencies and citizens working together with a comprehensive, landscape-scale approach can achieve these conservation goals while accommodating the growth of Arizona's population, an expanding economy, and associated infrastructure.

- The Arizona Wildlife Linkages Workgroup

SECTION 1 AWLA Introduction

SECTION 1 INTRODUCTION

Why do people come to Arizona? Hiking in the desert? Birding in the southeast riparian galleries? The majesty of the Grand Canyon? The modern wonder of Hoover Dam? Is it the skiing in the high mountains? Rafting the Colorado River? Sunshine in all of those places?

Scenic vistas and wide, open spaces are a part of Arizona's allure.

The varied landscapes and climates that draw people from all over the world to Arizona are also responsible for the tremendous abundance of plant and animal diversity in this state. Ranking third in the nation for overall biodiversity, Arizona has 4,756 plant, invertebrate and vertebrate species of which 135 are endemic to this state (NatureServe 2002). All species that reside in and migrate through the state have habitat needs that include the basics for survival; food, shelter and water. Arizona supports nearly 900 vertebrate wildlife species in habitats of low deserts to alpine biotic communities ranging in elevation from only 70 feet to more than 12,500-feet above sea level (Swartz 2005). These spectacular wildlife resources help fuel our state's economy through tourism, hunting and fishing, as well as enhancing the quality of our own lives.

To protect the safe movement of people and plan for a future that includes wildlife, a blueprint is needed for Arizona's remaining wildlife habitats promoting the conservation or restoration of linkages in areas important for wildlife movement. This report is a preliminary statewide linkage assessment identifying important wildlife habitat connectivity areas, or linkage zones, as well as the associated threats. It is anticipated that this document will serve as a planning tool for all types and levels of planning including development, transportation, wildlife management and conservation.

To ensure the survival and persistence of Arizona's wildlife minimization of further fragmentation is required. Maintaining landscape connectivity can lessen the detrimental consequences caused by the built environment. The effects of economic growth do not have to be mutually exclusive from the preservation of our state's ecological resources. A comprehensive approach is needed to efficiently, effectively protect and maintain Arizona's natural areas. Cooperation of all those involved (federal, state and county agencies, special interest groups and private landowners) must be facilitated with early involvement.

The Challenge

As Arizona seeks economic growth, there is a pressing need to protect and enhance the environment. The Arizona Department of Economic Security projects that the state's population will increase by 54% from 4.7 million in 1998 to 7.4 million in 2020. The sixth largest state in land area, Arizona is rapidly losing its status as a state of wide-open spaces and low human impact. The unique natural areas that attract these new residents as well as visitors are being impacted and diminished at an unprecedented pace.

The most significant threats to Arizona's wildlife populations are habitat alteration, fragmentation, and loss. Some of the leading causes of these threats are development, transportation corridors and land conversion. Worldwide, 85% of endangered species are imperiled by habitat fragmentation (Shaffer et al. 2000).

On a local level, remnant populations of pronghorn antelope, bighorn sheep, desert tortoise, badger, and other species will be lost if habitat fragmentation continues unchecked. As connectivity between key habitat elements is lost, isolation deprives species of their daily, seasonal and lifetime needs. Loss of connectivity deprives animals of resources, prevents some animals from finding mates, reduces gene flow, prevents animals from re-colonizing areas where extirpations have occurred, and ultimately prevents animals from contributing to ecosystem functions such as pollination, seed dispersal, control of prey numbers, and resistance to invasive species. Maintaining biodiversity and ecosystem functions requires habitat connectivity (CERI 2001).

As a leading threat to habitat connectivity, transportation corridors cut through many large tracts of wildlife habitat, destroying and fragmenting their integrity. Upgrading the state's rural highways to support rapid growth and increased traffic creates new challenges. As two-lane roads are expanded to four-lane divided highways, heavily used wildlife corridors are further fragmented and highways become a serious impediment to wildlife movement. In some cases, wildlife alter their behavior to use culverts and bridge underpasses to reach portions of their habitats. For those species that cover smaller home ranges, including reptiles, access to previously utilized habitat is destroyed or cut off in perpetuity. These corridors can become either impassable to wildlife, or passable only at great risk to the traveling public and the wildlife crossing the highway.

Arizona's expanding human population requires land and infrastructure. Sprawl consumes substantial amounts of acreage leading to further fragmentation and elimination of habitat. Roads can provide access to previously undisturbed areas making these regions more vulnerable to commercial and residential development.

SECTION 1 AWLA Introduction Page 1 of the PDF Excerpt

The most significant threats to Arizona's wildlife populations are habitat alteration, fragmentation, and loss. Some of the leading causes of these threats are development, transportation corridors and land conversion. Worldwide, 85% of endangered species are imperiled by habitat fragmentation (Shaffer et al. 2000).

On a local level, remnant populations of pronghorn antelope, bighorn sheep, desert tortoise, badger, and other species will be lost if habitat fragmentation continues unchecked. As connectivity between key habitat elements is lost, isolation deprives species of their daily, seasonal and lifetime needs. Loss of connectivity deprives animals of resources, prevents some animals from finding mates, reduces gene flow, prevents animals from re-colonizing areas where extirpations have occurred, and ultimately prevents animals from contributing to ecosystem functions such as pollination, seed dispersal, control of prey numbers, and resistance to invasive species. Maintaining biodiversity and ecosystem functions requires habitat connectivity (CERI 2001).

As a leading threat to habitat connectivity, transportation corridors cut through many large tracts of wildlife habitat, destroying and fragmenting their integrity. Upgrading the state's rural highways to support rapid growth and increased traffic creates new challenges. As two-lane roads are expanded to four-lane divided highways, heavily used wildlife corridors are further fragmented and highways become a serious impediment to wildlife movement. In some cases, wildlife alter their behavior to use culverts and bridge underpasses to reach portions of their habitats. For those species that cover smaller home ranges, including reptiles, access to previously utilized habitat is destroyed or cut off in perpetuity. These corridors can become either impassable to wildlife, or passable only at great risk to the traveling public and the wildlife crossing the highway.

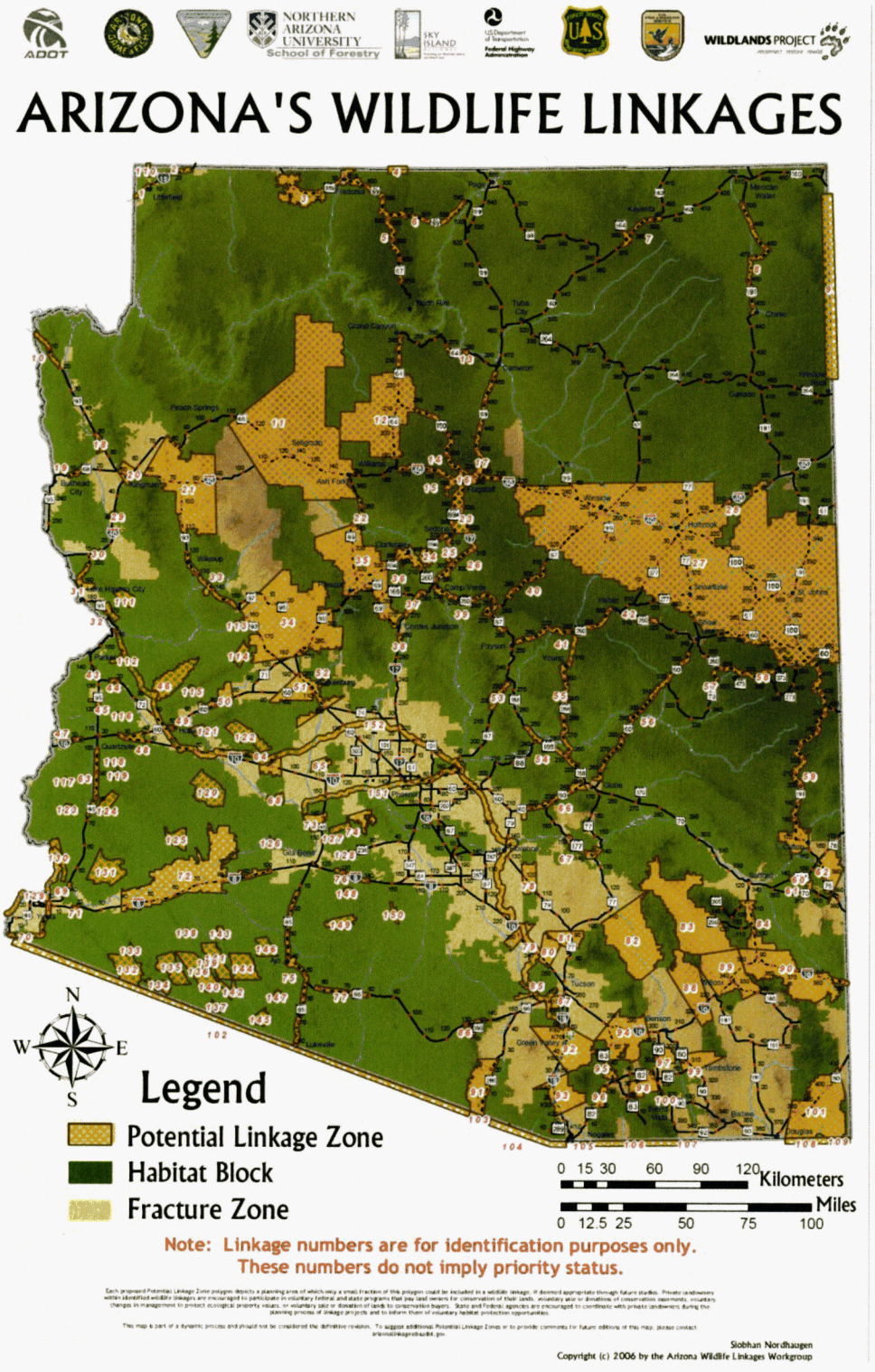
Arizona's expanding human population requires land and infrastructure. Sprawl consumes substantial amounts of acreage leading to further fragmentation and elimination of habitat. Roads can provide access to previously undisturbed areas making these regions more vulnerable to commercial and residential development

Page 2 of the AWLA Introduction PDF Excerpt

(Cerulean 2002). Likewise, urban expansion demands the ancillary structures of transmission lines, roads, canals and reservoirs. Along the international border, security measures pose additional barriers. Off road vehicle travel and the creation of wildcat roads also impact wildlife and habitat.

It is becoming increasingly obvious that manmade barriers such as highways and urban development are causing huge ecological problems with their concomitant costs. Increased pollution from roadsides into watersheds is an indirect result of proliferating roadways. The introduction and spread of non-native and invasive species is another associated concern. Disturbance and noise related to barriers including highways, border security and urbanization cause some species to abandon areas. And, of course, there is the direct mortality of wildlife on roadways, the size of which is unknown in aggregate, but estimated to be in the billions of vertebrates annually. Wildlife-vehicle collisions are a serious human safety concern. Nationally, it is estimated that over 200 human fatalities and nearly 30,000 injuries occur annually from these accidents with more than one billion dollars in related property damage (Meyer 2004).

Figure 6.1


ADOT
NORTHERN ARIZONA UNIVERSITY School of Forestry
SKY ISLAND
WILDLANDS PROJECT
ARIZONA'S WILDLIFE LINKAGES
N
W
E
S
Legend
Potential Linkage Zone
Habitat Block
Fracture Zone
0 15 30 60 90 120 Kilometers
0 12.5 25 50 75 100 Miles
Note: Linkage numbers are for identification purposes only.
These numbers do not imply priority status.
Each proposed Potential Linkage Zone polygon depicts a planning area of which only a small fraction of this polygon could be included in a wildlife linkage, if deemed appropriate through future studies. Private landowners within identified wildlife linkages are encouraged to participate in voluntary federal and state programs that pay land owners for conservation of their lands, voluntary sale or donations of conservation easements, voluntary changes in management to protect ecological property values, or voluntary sale or donation of lands to conservation buyers. State and Federal agencies are encouraged to coordinate with private landowners during the planning process of linkage projects and to inform them of voluntary habitat protection opportunities.
This map is part of a dynamic process and should not be considered the definitive revision. To suggest additional Potential Linkage Zones or to provide comments for future editions of this map, please contact
Siobhan Nordhaugen
Copyright (c) 2006 by the Arizona Wildlife Linkages Workgroup

Enlargement Wildlife Linkages

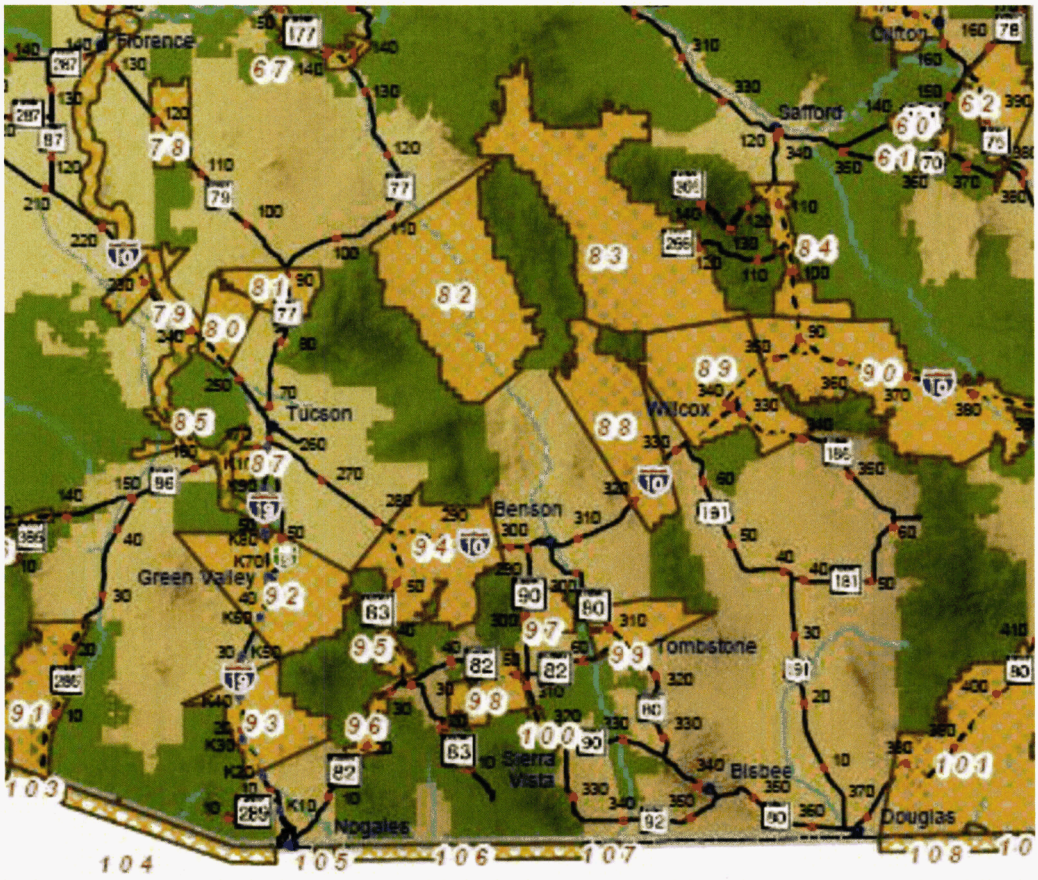
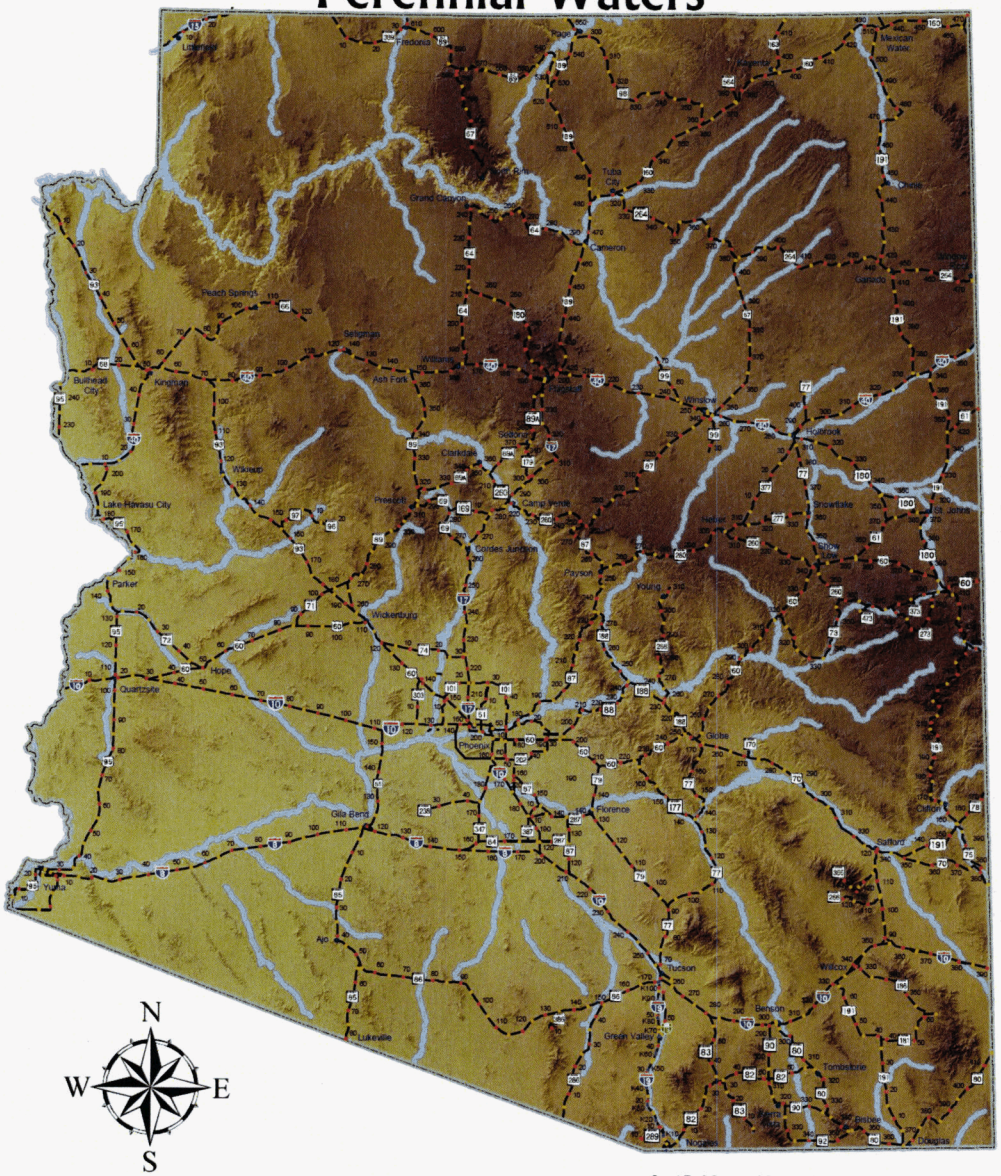


Figure 8.2

RIPARIAN HABITAT/LINKAGE ZONES

Perennial Waters



0 15 30 60 90 120 Kilometers

0 12.5 25 50 75 100 Miles

Legend

Riparian Habitat/Linkage Zone

Figure 8-2. Riparian Habitat/Linkage Zones

Siobhan Nordhaugen 2006
ADOT Statewide Natural Resources Management Group

Enlargement Riparian Linkages

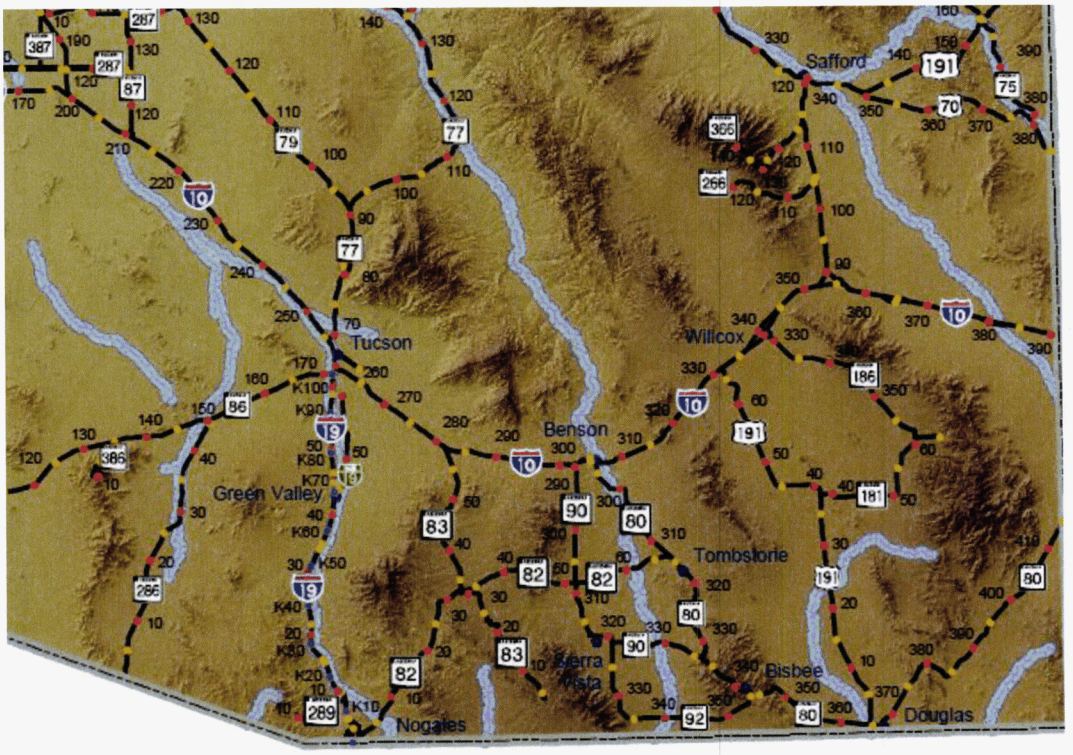


Figure 8.7

UNIQUE WATERS

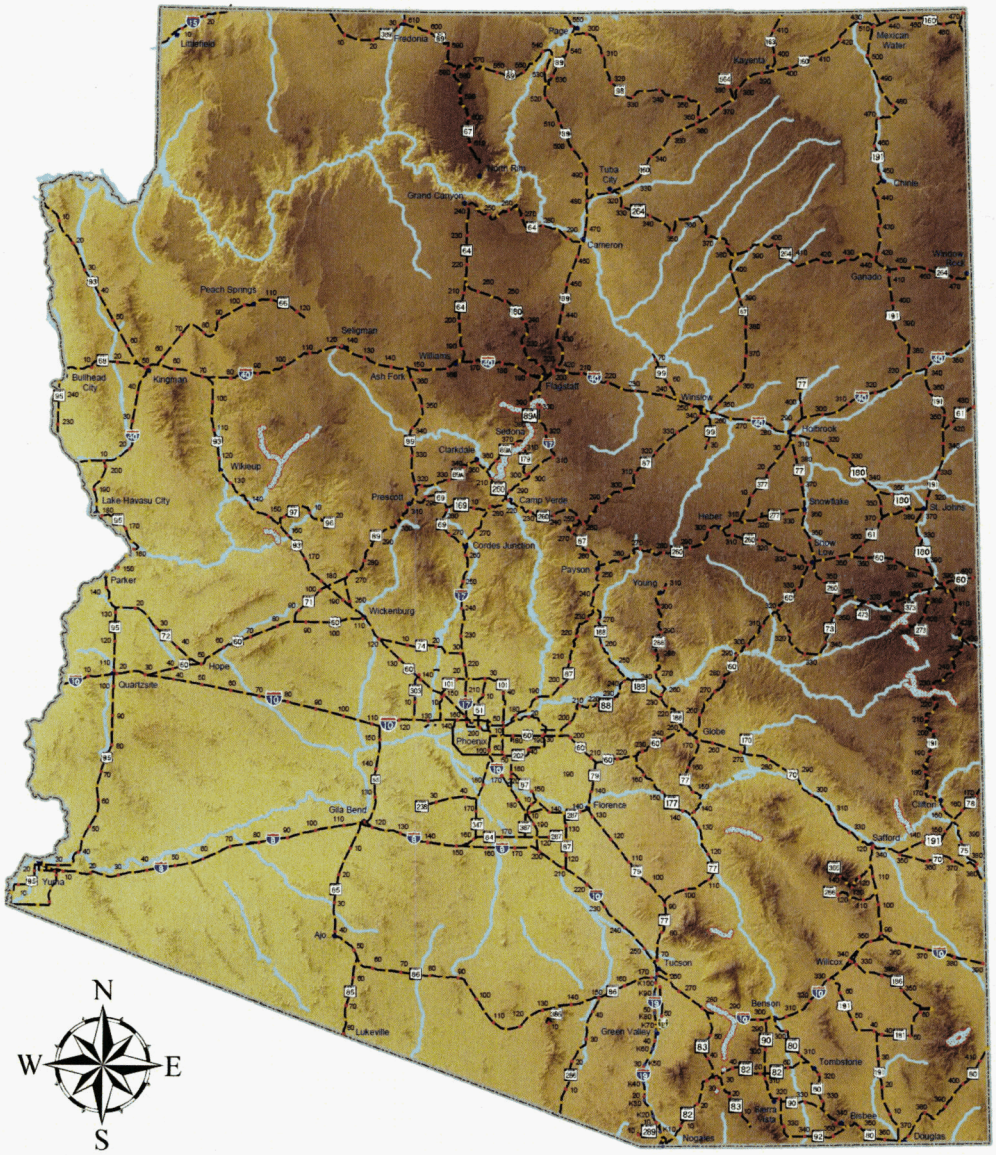
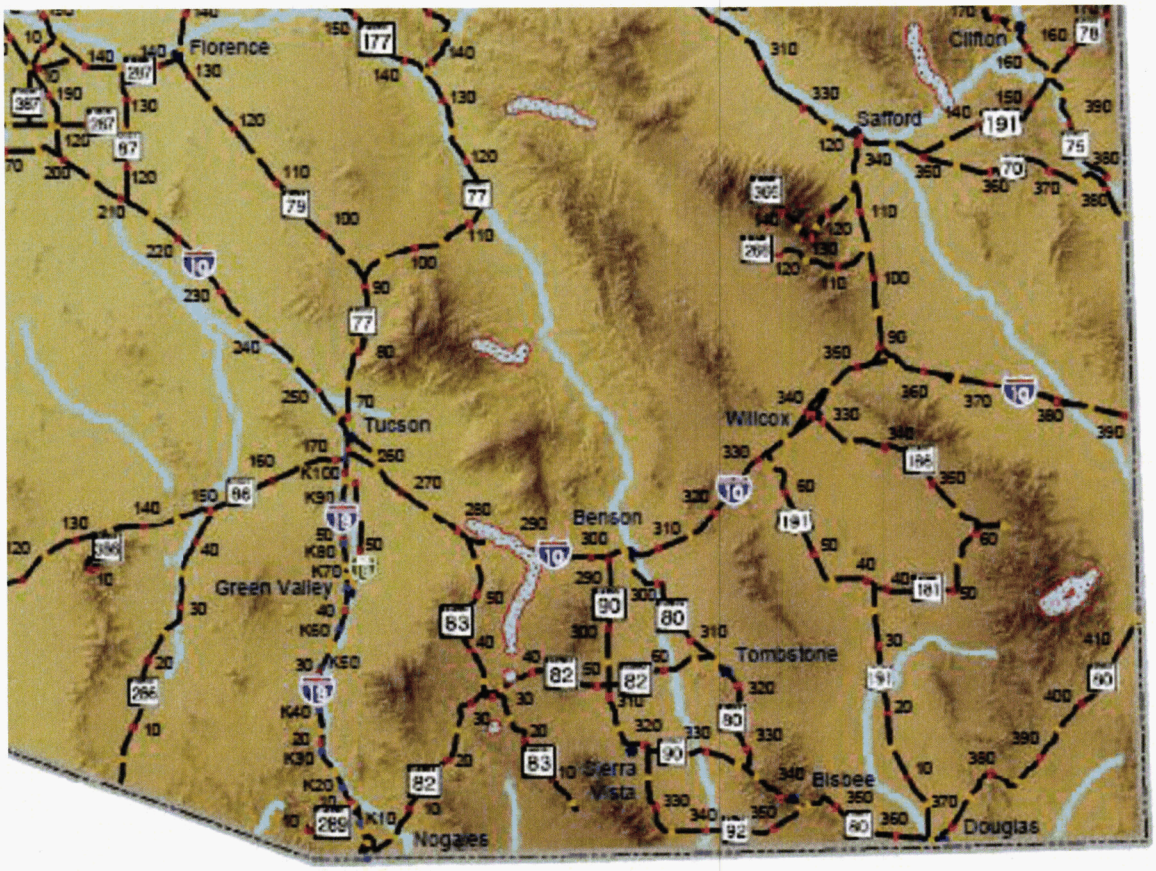


Figure 8-7. Unique Waters

Siobhan Nordhaugen 2006
ADOT Statewide Natural Resources Management Group

Enlargement Unique Waters outlined in red (ADEQs Outstanding Waters of Arizona)



McVie-24

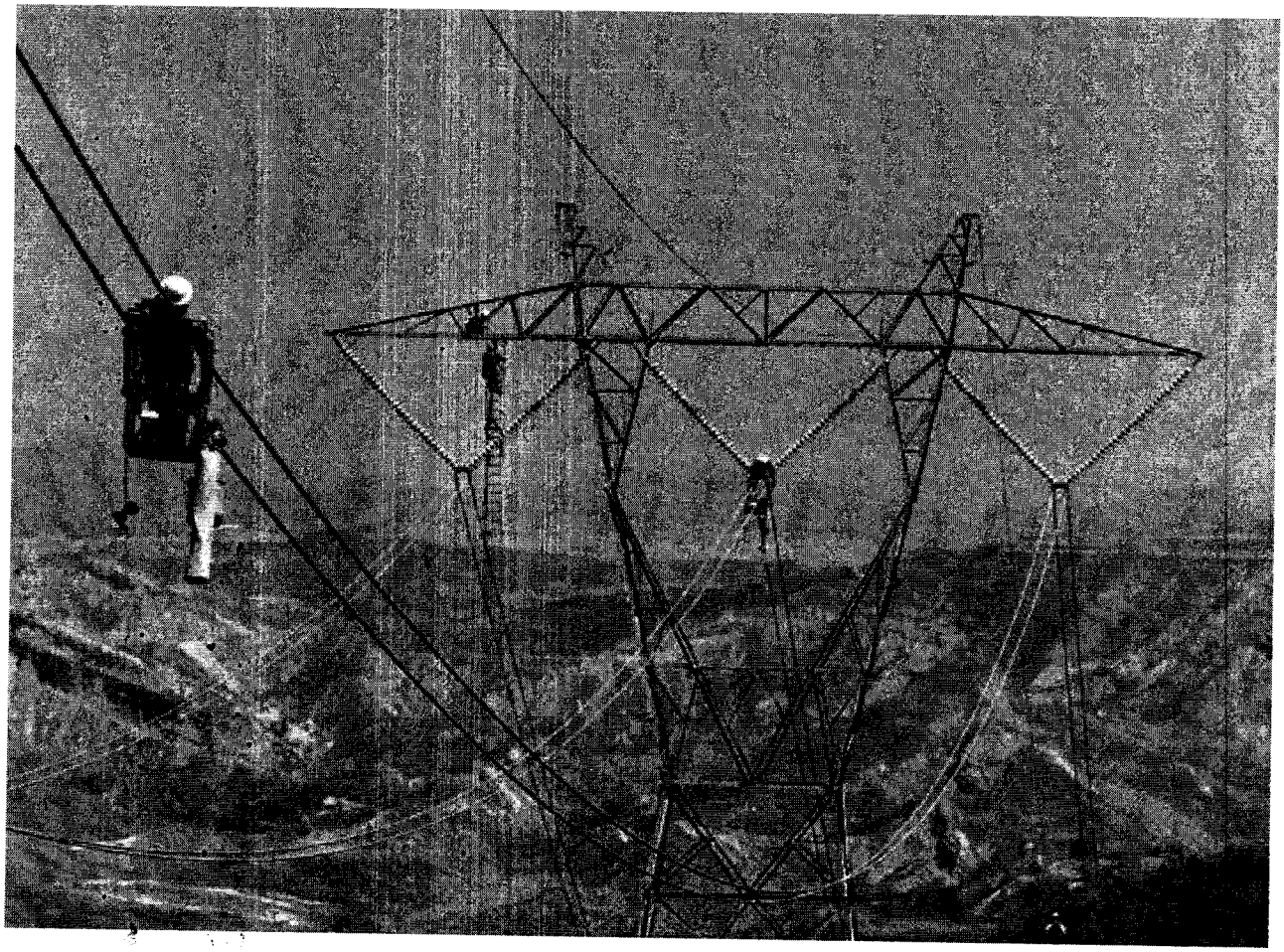
EXHIBIT
McV 24
ADMITTED

Burns & McDonnell
SINCE 1898

The Future of Transmission

As Southern California Edison builds infrastructure to bring wind power to population centers, it is fulfilling environmental requirements that may be a glimpse of things to come.

By Don Johnson, Southern California Edison; and Ken Gerling, PE, Burns & McDonnell



An excerpt of this article appeared in the September 2011 issue of *T&D World* magazine.

The Big Picture

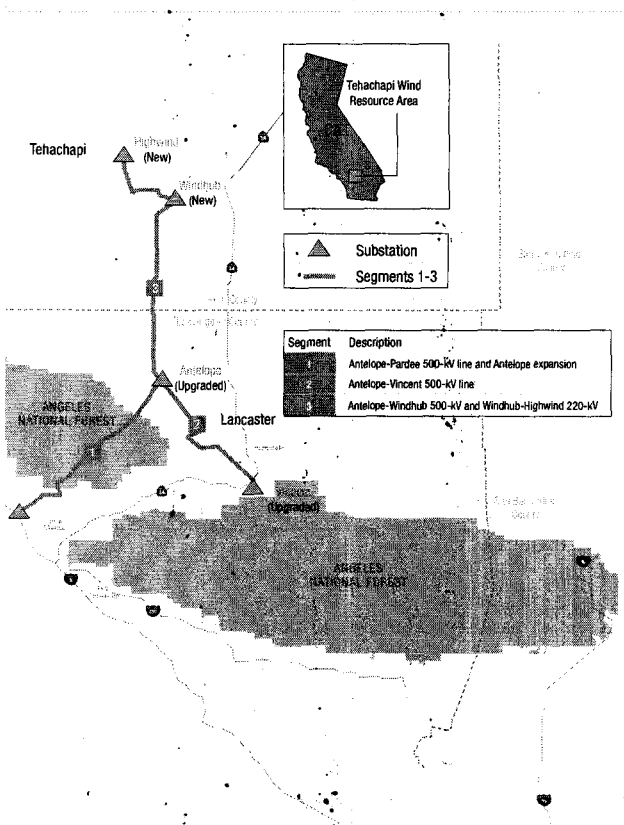
The TRTP's upgrades and additions to the transmission and substation infrastructure are divided into 11 segments. Segments 1 to 3 were substantially complete in December 2009. Segments 4 through 11 started construction in February 2010 with an in-service date in winter 2015.

Segments 1-3

- 73 miles of 500-kV transmission line
- 10 miles of 220-kV line (construction pending)
- Modifications to three substations
- Two new substations

Segments 4-11

- 4 miles of two new single-circuit 220-kV lines
- 15.6 miles of new single-circuit 500-kV line initially energized at 220-kV
- Replacement of 116.8 miles of 220-kV line with line built to 500-kV standards
- One new 500/220-kV substation
- Upgrades of five substations to accommodate new transmission line construction
- 16.8 miles of new 500-kV transmission line
- Installation of telecommunications infrastructure



California has a strong appetite for electricity. And its residents increasingly favor a supply produced through renewable resources such as wind.

Southern California Edison (SCE) is one of the utilities that leads the pack toward meeting state mandates for renewable sources of power, having put contracts in place for more than 20 percent of delivered power to come from renewable sources. A big part of SCE's effort is the Tehachapi Renewable Transmission Project (TRTP), which will deliver wind power to customers in Southern California.

The Tehachapi Wind Resource Area is in Kern County, north of Los Angeles. The route from the wind farm area to the electrical grid traverses a range of land uses from urban residential to rural farmland. The terrain varies from flat, high desert to rugged mountains. Much of the construction for the TRTP takes place in remote, inaccessible locations. Critical segments cross the Angeles National Forest.

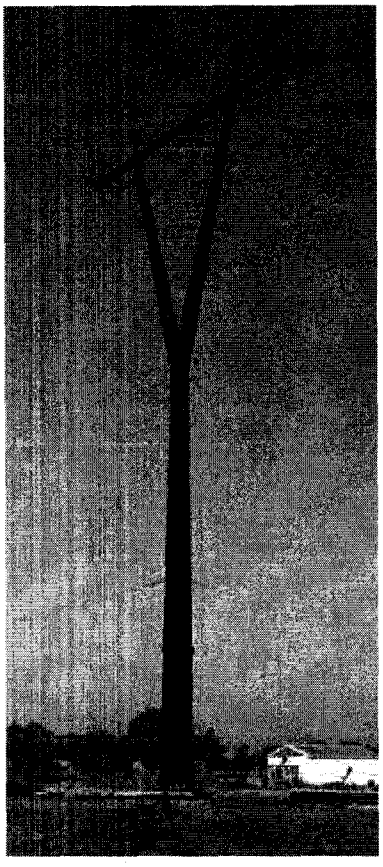
To construct a 500-kV transmission line in California and across land managed by the U.S. Forest Service, SCE and its owner's agent, Burns & McDonnell, faced a level of scrutiny not experienced when most existing lines were constructed 20 or more years ago. The environmental measures required to permit and begin construction on the line may be a harbinger of things the electrical transmission industry must be prepared to manage as upgrades to the grid are made across the country in the coming decades.

Functionality and Aesthetics

"The three initial segments of the TRTP required an unconventional approach to overhead transmission line design," says Jason Weller, Burns & McDonnell engineering lead for TRTP segments 1-3. "The project is a true representation of the design principle 'form follows function.'"

The design had to account for many environmental factors specific to the region and required by the California Public Utilities Commission (CPUC). Additionally, the varying terrain and weather zones presented numerous design challenges.

The engineer-procure-construct (EPC) contractor, PAR Electrical Contractors Inc., partnered with Dashiell Corp. as the design engineer; both companies are owned by Quanta Services Inc. This partnership allowed the construction contractor and design engineer to incorporate the construction methodologies for various project areas into the design. As the owner's agent, Burns & McDonnell provided engineering design reviews, field engineering, construction management, quality assurance/control, project scheduling, document control and environmental monitoring services.



Copyright Thomas & Betts Corporation. Photo by Aerial Pixels Photography

Thomas & Betts developed a Y-shaped tower configuration to reflect the form of modern wind turbines, responding to CPUC aesthetic concerns. The Y-pole structure is being tested to ensure it meets design capacity before mass production and delivery begin.

"One challenge in Segment 1 was accommodating construction along approximately 14 miles of mountainous terrain through the Angeles National Forest," Weller says. "Inaccessible sites and restrictions on work within the forest boundaries meant that foundation installation and lattice tower erection was largely completed using helicopters."

Dashiell worked with PAR to develop tower splice designs that accounted for helicopter load carrying capacities.

Additionally, subsurface investigation reports guided the selection of tower sites, reducing potential slope instability amid rugged terrain and potential landslide zones.

A visual specialist from the CPUC analyzed the project to determine what structure types, colors and finishes would be required to minimize the visual impacts in all project areas. Lattice steel towers were the primary choice for segments 1 and 2. Three colors were used. In Segment 2, for example, the new line parallels an existing lattice steel structure line, so the selected design and color reduces visual complexity.

Tower aesthetics also factored into the selected design for Segment 3B, which traverses several of the wind farms producing the power to be transmitted by the TRTP.

The CPUC visual specialist requested a modified tubular steel pole design that mimics the form of a modern wind turbine mounted on a monopole. This Y-shaped configuration, developed by Thomas & Betts Inc., meets both aesthetic and loading requirements. This segment is also likely to experience the greatest wind and ice loading in the Tehachapi Mountain area, so structural integrity was critical.

"One challenge in Segment 1 was accommodating construction along approximately 14 miles of mountainous terrain through the Angeles National Forest."

Outside Factors

"Despite Southern California's reputation as a weather paradise, climatic conditions vary through the diverse geographical areas and dramatic elevation changes from one end of the project to the other," Weller says. "An intensive meteorological study, ordered by SCE, assisted in designing to ensure future reliability."

Data from weather stations in the project area was summarized, including wind speeds and icing conditions. In addition to SCE and General Order 95 loading conditions, 15 separate loading zones were identified, each factoring in wind, ice and wind on ice design loads. In spans where loading zones changed, the more conservative loading scenario was incorporated into the design.

The TRTP crosses numerous extra-high-voltage transmission lines owned and operated by SCE as well as other utilities. Reliability is critical through those corridors. One critical crossing in Segment 1, known as Haskell Canyon, was a 2,632-foot span crossing a 1,000-kV DC line, four 230-kV lines and two 115-kV lines. Segment 2 had eight 220-kV crossings over SCE-owned lines, four 220-kV crossings over the FPL Energy-operated Sagebrush line, and two 500-kV crossings. Segment 3A crossed 11 220-kV lines and one 1,000-kV DC line.

A Final Challenge

Subconductor oscillation became an issue during TRTP construction. The phenomenon occurred during periods of moderate to strong steady winds perpendicular to the line. The wake from one subconductor induced vertical motion in the other subconductor of the same phase bundle, which

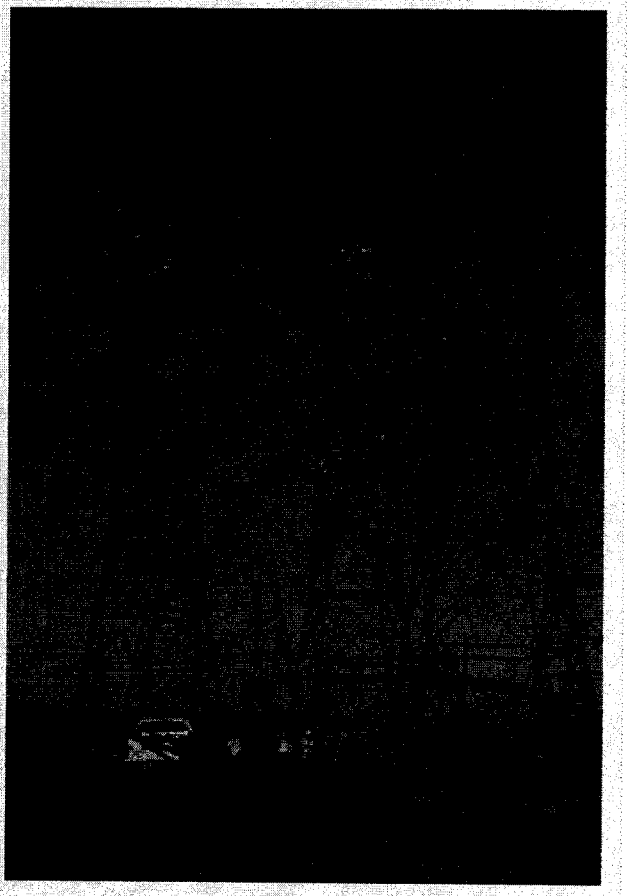
The Flight Factor

Helicopter use for constructing electrical transmission lines is not uncommon. But few projects, if any, rely on helicopters to the level of the TRTP. When working in the Angeles National Forest, nothing goes in or out on the ground. Equipment. Supplies. Crew. Inspectors. Portable toilets. That's right, nothing.

Flights into and out of construction sites in the forest were staged from three fly-yards to minimize flight time. From the fly-yards, six helicopter operators — Summit, Heliquest, Winco, Mountain Air, Swanson and Erickson, using models ranging from the MD250, MD530F and the AS350 to the K-Max and the Aircrane — ferried passengers, light materials and heavy equipment and materials to each tower site.

The challenges for helicopters working the project were amplified by the incessant winds that gust through the mountainous terrain. Pilots were on call to respond to time-sensitive material deliveries and urgent personnel evacuations.

Helicopter use enabled construction in an otherwise impossible region by keeping the construction footprint small. As new transmission infrastructure goes up across the U.S., helicopter support is likely to be an integral part of more projects.



A sky crane flies out with a body extension for tower erection.

Approval to build within the Angeles National Forest was nearly two years in coming.

caused uncontrolled oscillation of the bundle with peak amplitudes as high as six feet. This is most common in smooth areas, unobstructed by trees and other obstacles, but in this instance it also occurred in mountainous terrain. Segment 2, although not smooth throughout the alignment, experienced conductor oscillation shortly after installation.

A quick design solution prevented potential significant wear or fatigue damage to conductors, spacers, dampers and support hardware. Design engineers stepped subconductors of the horizontal bundle approximately 6 inches. This horizontal bundle design modification mitigated the oscillation. Segment 3A, which crosses mostly flat terrain, was stepped over the entire length of the alignment as a proactive measure.

Starting Out

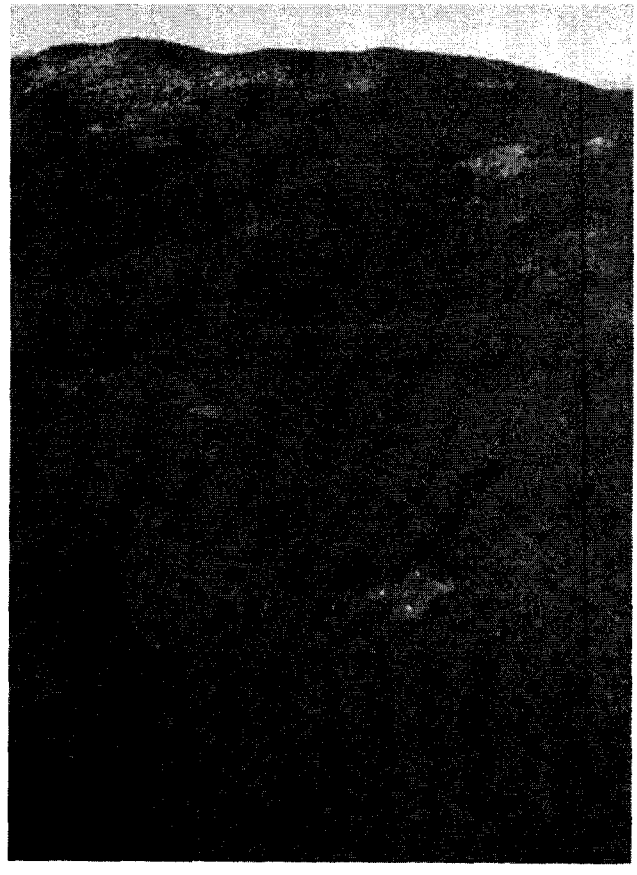
Once permitting was complete but before construction could begin, detailed mitigation, monitoring and compliance plans were required. The necessary level of planning required to receive approval to begin construction took nearly nine months for the portion of Segment 1 that was outside the Angeles National Forest. Approval to build within the forest was nearly two years in coming.

The mitigation, monitoring and compliance plans demonstrated how the construction teams would manage all aspects of the project, including complying with all CPUC regulations and U.S. Forest Service requirements. Factors considered included sensitive plant species, the protected California condor and migratory bird species.

Plant Species

As is the case in much of California, the Angeles National Forest is home to many sensitive plant species. Construction monitors worked to avoid disturbing a species of mariposa lily found in the forest. If the plant was found in the construction zone, it was avoided or transplanted to a safe area.

Construction crews also prevented the migration of weed species onto forest property via vehicles or supplies. All vehicles and equipment were washed and free of seeds



The disturbance area is a radius of 100 feet from the center hub of the tower footprint. This cannot be achieved with conventional construction methods.

and plant materials before being moved into the forest, and temporary soil stockpiles were weeded before transport to construction sites.

Protecting the Condor

"The California condor is a state and federally listed endangered species with habitat in the project area. The condors are curious creatures, attracted to colorful bits of plastic and wire or shiny bolts and nuts, known as microtrash on job sites," says Chad Richardson, Burns & McDonnell environmental monitor lead for the TRTP Segments 1-3. "When the birds swallow these things, it can interfere with their digestive system or they take the material back to chicks in the nest, where the chicks can ingest them. In either case, a death is likely."

Microtrash patrols were instituted in tower assembly yards and tower sites to remove all materials that fell to the ground during tower assembly or construction. To further protect the condor in selected canyon crossings, the project team installed swan flight diverters on static wires to make them more visible, helping avoid mid-air collisions with the wire.

SCE and Burns & McDonnell developed special environmental measures including microtrash patrols to help protect the California condor and other federally protected species during construction of TRTP segments 1-3.

Migratory Birds

Nearly all bird species in the U.S. are protected by one or more federal or state laws, especially the federal Migratory Bird Treaty Act, which prevents the capture or harm of most species. Active nests, defined as a nest with eggs or young in the nest, are included in the scope of the law.

"During nesting season, generally mid-February through mid-August, nests are often found on partially erected towers, near tower sites or wire-pulling locations, or on construction equipment," Richardson says. "An active nest has the potential to shut down work at a tower site or could cause cranes or wire-pulling equipment to be unusable until the young birds fledge."

For the TRTP, nest surveys performed using both ground and helicopter methods in advance of construction helped identify and deal with nesting birds in the project area. Construction was delayed at times during the nesting season. To mitigate these concerns, site monitors surveyed sites for several days before crews were scheduled to move in, relocating nests that were not yet active. In other cases, construction was halted for weeks until access and work on the sites were cleared with the appropriate agencies.

Making It Happen

For the 87 miles of TRTP segments 1-3, as many as 15 to 20 biological or environmental monitors were active at one time, conducting clearance surveys before crews could move onto a site, monitoring nests and spot-checking crews.

"The condors are curious creatures, attracted to colorful bits of plastic and wire or shiny bolts and nuts, known as microtrash on job sites."

"The constantly changing environment was challenging, but no shutdowns were required for environmental non-compliance, other than self-imposed measures to ensure the project stayed in compliance with all regulations," Richardson says. "Close coordination with a single point of contact for the U.S. Forest Service allowed efficient resolution of environmental and construction issues on the Angeles National Forest."

During construction, the Forest Service determined daily whether work could proceed the following day and what type of work was allowed. This Project Activity Level primarily served to minimize the potential for fires, but it did make construction planning a challenge.

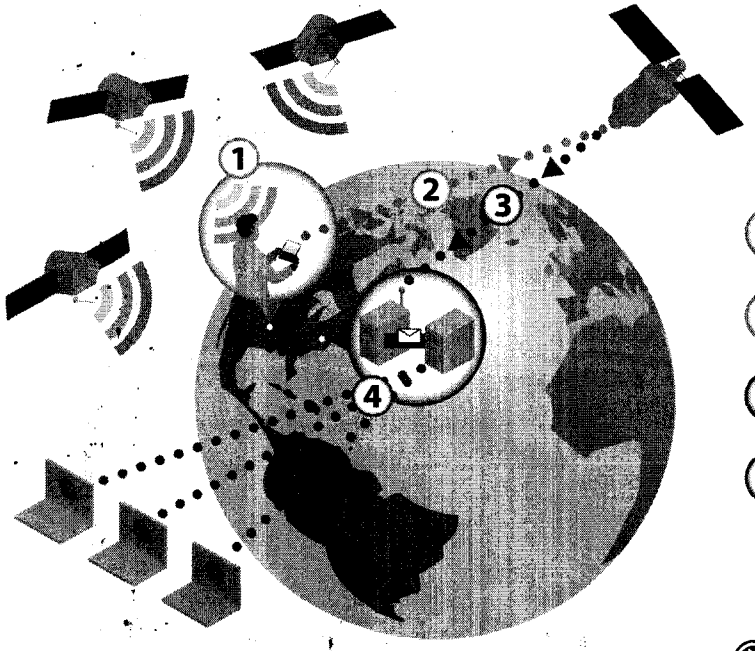
To maximize the construction team's ability to manage the entire TRTP effort, enterprise construction management software — Primavera's P6 and Contract Management suite — were selected for the project. The Burns & McDonnell OneTouchPM® geospatial project dashboard was implemented to enhance that tool set.

"Biological observations, including the potential presence of active nests and protected plant species, are tracked in OneTouchPM®. Biological monitors collect coordinate locations for observations using a handheld global positioning system (GPS) device," says Dave Smith, Burns & McDonnell information management director for the TRTP segments 1-3. "The data is aggregated, reviewed and delivered to a Burns & McDonnell analyst, who makes the data available on maps and by OneTouchPM®."

The Safety Factor

Building transmission lines through rough terrain like the Angeles National Forest requires unconventional methods. Many tower sites within the forest were remote. Construction of the initial segments had to be done either without building access roads or the roads had to be removed upon

How It Works: OneTouchPM®



1. Device carried by construction worker receives a signal from the global positioning system (GPS) satellites to determine its location.
2. The device relays its serial number and the position coordinates to a commercial satellite.
3. The commercial satellite sends information to a data processing center, which delivers the information to Burns & McDonnell by email or file transfer protocol.
4. Burns & McDonnell translates the information into Google Earth symbols that are tracked by OneTouchPM®.

For more information on OneTouchPM®, visit www.burnsmcd.com/onetouchpm.

"The OneTouchPM® tool was customized to integrate satellite tracking of crew members."

completion of construction. That made helicopters the primary mode for bringing equipment, crews and materials to each job site.

Construction safety plans must factor in the rapidly changing weather and wind in the region. Crews able to get on-site for the day have no guarantee of being able to get back out. Sites have all necessary provisions for overnight stays, including food, equipment and first aid kits. Crews receive survival training to prepare for the threat of sudden weather changes or forest fires in the area. All personnel had to be capable of recognizing and responding to the presence of varied wildlife, including mountain lions and rattlesnakes.

All crews were prepared to handle weather issues from snow and fog to high winds and dust. High winds, in particular, made it impossible at times for helicopters to construct tall towers and string conductor. It was also difficult to retrieve crews. Crews on several occasions had to hike out of the forest because helicopters were grounded by high winds.

"The OneTouchPM® tool was customized to integrate satellite tracking of crew members," Smith says. "Each crew member is outfitted with a satellite transmitter, similar to what hikers use. OneTouchPM® interfaces with Google Earth Enterprise software to enable live tracking of each person's location."

Moving Forward

Before beginning construction on segments 4-11, SCE evaluated the methods and programs that enabled segments 1-3 to remain in compliance with all regulations.

In meeting California's goals for renewable power, SCE is breaking new ground to comply with environmental controls that are unprecedented in the industry. As the electrical transmission industry nationwide moves to upgrade an aging infrastructure and accommodate wind, solar, biomass and other renewable sources, utilities and their partners are likely to see a similar regulatory environment.

Development of programs and procedures to manage the complex planning and execution of these projects will be the challenge of all.

Don Johnson is Manager, Third-Party Interconnection Projects at Southern California Edison, an Edison International (NYSE:EIX) company and one of the nation's largest electric utilities, serving a population of nearly 14 million in a 50,000-square-mile service area. He was project manager for TRTP Segments 1-3. He has more than 27 years of diverse project management, engineering and design experience in the transmission, substation and distribution business. Johnson earned his Bachelor of Science in electrical engineering from the University of Alabama and completed the project management certification program at the University of California at Irvine.

Ken Gerling is an associate project manager at Burns & McDonnell and was the project manager for the Southern California Edison Tehachapi Renewable Transmission Line Project segments 1-3. He has also worked on major scale transmission line programs for Northeast Utilities, San Diego Gas & Electric and Vermont Electric. His expertise is in project planning, design management and construction management from project inception through closeout. Gerling has a Bachelor of Science in civil engineering from the University of Missouri and a Master of Science in engineering management from the University of Kansas.

Foundation Design Minimizes Environmental Impact

By Chih-Hung Chen, PE, Burns & McDonnell, and Nick Salisbury, Crux Subsurface Inc.

For construction within the Angeles National Forest, the U.S. Forest Service requires minimal disturbance of the land. An unconventional design and construction solution helped SCE gain approval from the U.S. Forest Service.

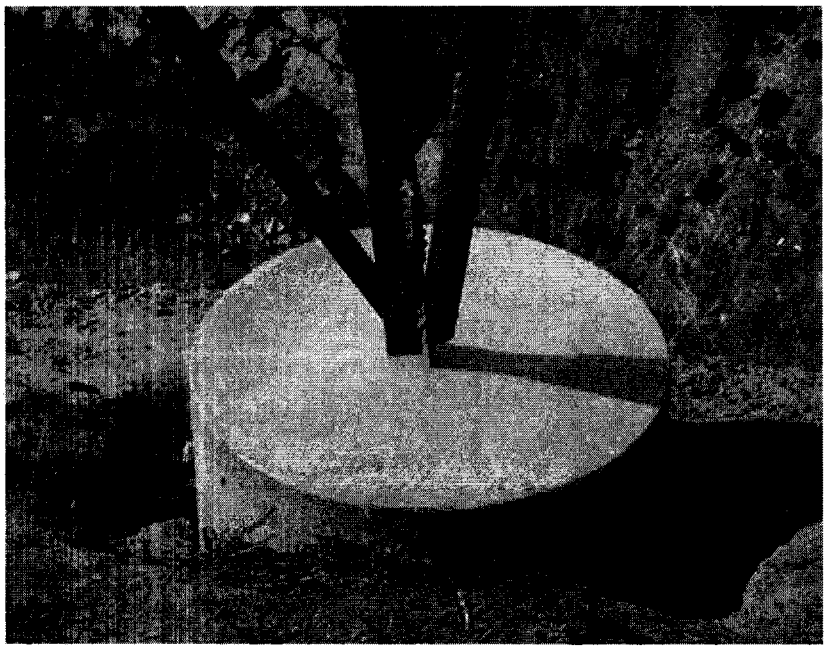
Micropile foundations, a high-capacity version of solutions sometimes known as pin piles or mini piles because of their small diameter, also provided cost and schedule advantages over other designs because of restrictions imposed by working within the forest.

Design Selection

The initial design for the TRTP included a typical drill shaft foundation, which would require miles of access roads for drilling and construction equipment. Within the forest, access roads were not approved. Hand-digging would be a high-cost, inefficient method for the shafts, which would range from 42 to 72 inches in diameter and 15 to 30 feet in depth. Hand-dug excavations create worker safety hazards that are difficult to mitigate in the eyes of contractors and the Occupational Safety and Health Administration. Explosives were not an option because of fire risk and environmental disturbance.

The use of micropile foundations enables the construction of transmission towers with a smaller overall footprint, disrupting less of the sensitive forest environment.

Several alternatives, including prestressed or post-tensioned rock anchors and micropile foundations, were considered. Rock anchor foundations, which use anchors to resist uplift and utilize bearing between concrete cap and rock to resist foundation rotation, compression, and shear loads, were deemed impractical because of the highly variable near-surface rock and soil conditions.



The final appearance of a micropile foundation does not indicate its internal structure.

Micropile foundations were proposed by the general contractor, PAR Electrical Contractors, as the preferred foundation alternative. Foundations were designed by Crux Subsurface and its subconsultant and reviewed and approved by Burns & McDonnell and SCE. The foundation system was constructed by Crux and PAR.

Micropiles combine the uplift resistance consistent with a rock anchor foundation and the compression and lateral bending resistance of a drill shaft foundation. Because micropiles typically range from 4 to 12 inches in diameter, lightweight drill rigs can be configured to install the small, high-capacity deep foundation members that can be transported by helicopter and assembled at each site.

Beyond environmental advantages realized by the elimination of road building, the lightweight materials and construction equipment create benefits including a significant reduction in spoils, elimination of fluids commonly used in drilled shaft construction, reduced emissions compared to conventional equipment, and a smaller foundation footprint. These combine for an overall reduced impact on the environment, which contributed to the approval of the Forest Service.

On the TRTP, micropile diameters range from 5.5 inches to 8.625 inches at depths between 25 and 51 feet. Groups of three to 12 micropiles per tower leg are constructed, depending on the tower type and soil condition.

A geotechnical report for the project served as a basis for identifying soil type and condition. The Federal Highway Administration Micropile Design and Construction Guidelines Implementation Manual and the Post Tensioning Institute's Recommendations for Prestressed Rock and Soil Anchors were used for initial assumptions of soil strength.

The micropile design was advantageous because it could be adapted to accommodate individual site conditions.

Several sacrificial preproduction micropiles were tested to evaluate the ultimate grout-to-ground bond stress before construction began. A licensed geologist characterized the soil on-site for each tower footing during construction.

The micropile design was advantageous because it could be adapted to accommodate individual site conditions by varying the pile length and/or adding additional piles to address anomalies that were not identified in the more general geotechnical investigation. The 224 micropile foundations (four per tower) installed were grouped into three tower families. The number of piles and length of each upper cased section and lower bond section were installed to meet a minimum criteria for a variety of soil and rock conditions. After micropile installation, proof load tests were conducted at each tower site to confirm that piles met factored design loads.

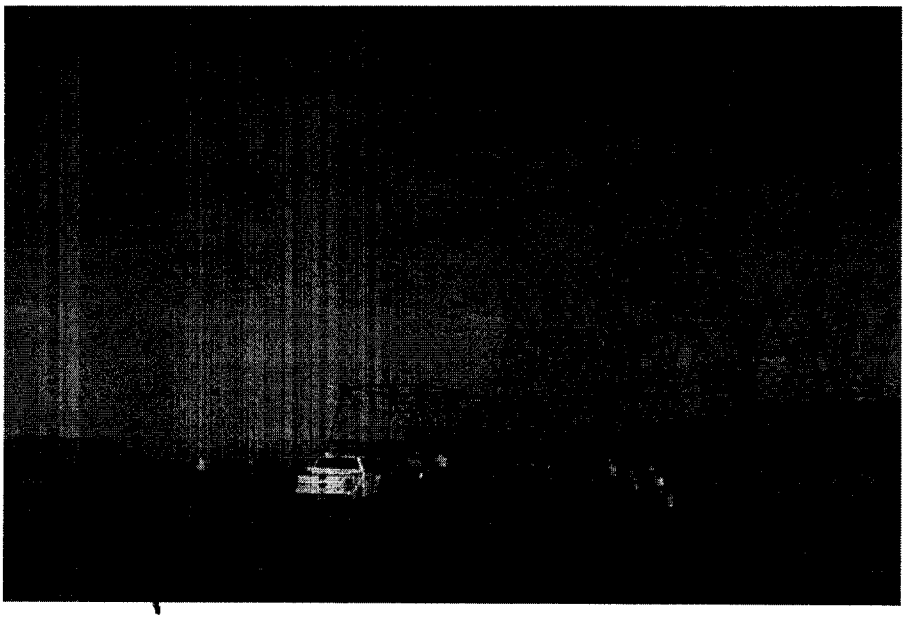
Technical Challenges

Micropile foundations utilize the complex interaction of numerous components including rock or soil, steel micropile reinforcement and casing, cast-in-place concrete and steel lattice stub angles. Comprehensive design of the entire foundation system is essential to ensure long-term tower performance.

Micropiles are inherently slender, flexible members. SCE required that the foundations meet stringent deflection criteria and have built-in safety factors to minimize stress buildup in the stub angle transferred up the tower leg and adjacent bracing member. Compliance with the desired deflection criteria was achieved by the arrangement of the piles within the group.

Environmental factors such as wind, fog, and dry, hot weather that increased fire risk all had impacts on this helicopter-supported project. Scheduling of critical items such as placement of concrete and micropile grout, each within a specified time of batching, enhanced the need for project planning and execution.

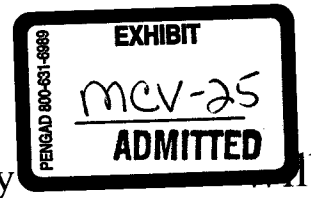
In the end, helicopter-supported micropile installations provided foundations that could meet strict design criteria, minimize ground disturbance and environmental impact, and provide scalability to adapt to varying ground conditions without downtime for further design or agency review.



A sky crane flies out with a body extension for tower erection.

Scott Wilbor

- B.S. Wildlife Biology, Colorado State University, 1985
- M.S. Wildlife Biology, University of Alaska Fairbanks, 1996
- M.S. Natural Resource Studies, GIS Certificate, School of Natural Resources and the Environment, University of Arizona, 2014
- 30+ years in the field of wildlife and natural resource conservation
- 11 years as Program Coordinator/Conservation Biologist for Audubon Society
- On-the-ground experience in San Pedro watershed since 2002 to present
- Master's thesis: Ecosystem Assessment for Lower San Pedro Watershed



AzGFD HabiMap Arizona

- Generated for the AzGFD State Wildlife Action Plan (2012)
- "Mapping wildlife and conservation potential"
- Unfragmented areas layer depicted
- The darker the blue, the less habitat fragmentation. The lower San Pedro watershed/Aravaipa-Galiuro-Santa Teresa region remains the second least fragmented landscape in Arizona, surpassed only by the Grand Canyon area.

AzGFD HabiMap Arizona

Habitat fragmentation would occur in the largest intact habitat block south of the Grand Canyon block, as determined by the Arizona Game and Fish Department's analysis of their Habimap Project in 2011.

Sept. 14, 2009 DOI Secretarial Order 3289

"Subject: Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources

- Sec. 1 **Purpose and Background**. Secretarial Order No. 3285, issued on March 11, 2009, made production and transmission of renewable energy on public lands a priority for the Department. This Order establishes a Department-wide approach for applying scientific tools to increase understanding of climate change and to coordinate an effective response to its impacts on tribes and on land, water, ocean, fish and wildlife, and cultural heritage resources that the Department manages."

Sept.14, 2009 DOI Secretarial Order 3289

- "The Department of Interior, with its 67,000 employees and scientific and resource management expertise, is responsible for helping protect the nation from the impacts of climate change. In particular the Department must:
- Adapt its water management strategies to address the possibility of shrinking water supplies and more frequent and extended droughts…"
- "Wisely manage millions of acres of parks, refuges and other public lands…"
- "Conserve and manage fish and wildlife resources, including over 800 native migratory bird species and nearly 2,000 federally listed threatened and endangered species.
- Protect cultural and archaeological resources…"

Sept. 14, 2009 DOI Secretarial Order 3289

- "Continue to provide state-of-the-art science to better understand the impacts of climate change and to develop science-based adaptive management strategies for natural and cultural resource managers."
- "(c) Landscape Conservation Cooperatives.
- Given the broad impacts of climate change, management responses to such impacts must be coordinated on a landscape-level basis.
- For example, wildlife migration and related needs for new wildlife corridors, the spread invasive species and wildfire risks, typically will extend beyond the borders of National Wildlife Refuges, BLM lands, or National Parks."

Sept. 14, 2009 DOI Secretarial Order 3289

- "Additionally, some bureau responsibilities (e.g., Fish and Wildlife Service migratory bird and threatened and endangered species responsibilities) extend nationally and globally."
- "Because of the unprecedented scope of affected landscapes, Interior bureaus and agencies must work together, and with other federal, state, tribal and local governments, and private landowner partners, to develop landscape-level strategies for understanding and responding to climate change impacts."

Sept.14, 2009 DOI Secretarial Order 3289

- The Order established 21 multi-national, regional Landscape Conservation Cooperatives, including the Desert Landscape Conservation Cooperative (DLCC).

U.S. Fish & Wildlife Service Emphasis Area in Arizona

- The Southwest Regional Office of the US Fish & Wildlife Service in 2015 identified the Mogollon Rim Emphasis Area as a priority in the Southwest Region.

Desert Landscape Conservation Collaborative

A DLCC Workshop was held in Tucson in August 2015 to develop conservation planning design for "pilot landscapes" in the DLLC region.

- Within the DLCC, three pilot proposals of the nine presented encompassed the San Pedro River Valley watershed:
- the Trans-boundary Madrean Proposal,
- the BLM SE Arizona Proposal, and
- the San Pedro Watershed Proposal

Arizona's Wildlife Linkages Assessment

- A follow-up to a 2004 Workshop in Payson.
- Biologists, engineers, planners and land managers from nine public agencies and additional non-profits worked together to identify **large blocks of protected habitat, the potential wildlife movement corridors through and between them, the factors that could possibly disrupt these linkage zones and opportunities for conservation**.
- The Assessment was a 2006 work product of the Arizona Wildlife Linkages Working Group, led by the Az. Department of Transportation and Az. Game & Fish Department.
- The Assessment produced a state-wide initial scale designed to be refined to more local spatial scales.

Arizona's Wildlife Linkages Assessment

- Wildlife linkages will be interrupted and impacted by the proposed SunZia project. Larger mammals will find altered vegetation, new human infrastructure, and new human disturbance in their movement corridors.
- Corridors will be less functional as linkages in terms of suitable habitat for species' movement needs.
- Species may be more likely to not use them (and thus not disperse and/or migrate) or species may be prompted to take more difficult travel routes, exposing them to higher stress conditions that diminish their reproductive fitness or expose them to higher mortality risk.

Arizona's Wildlife Linkages Assessment
Santa Catalina/Rincon - Galiuro Linkage Design

- AzGFD used the methodology employed by the Arizona Wildlife Linkages Working Group, developed by Dr. Paul Beier of NAU, to model corridors for 18 species, based on habitat characteristics specific to those species.
- The results were synthesized into an ensemble landscape-level wildlife linkage network across the San Pedro River valley, connecting the Santa Catalina/Rincon Mountains and the Galiuro Mountains.
- The AzGFD modeled corridors between these wildland blocks would be interrupted by towers, guywires, overhead transmission lines, numerous extensive access roads, and increased human activities.

U of A's Desert SW Cooperative Ecosystem Unit climate adaptation model of landscape linkages promoting biodiversity resilience

- The climate adaptation landscape linkage model I developed was based on landscape characteristics that can provide climate refugium, micro-habitats, topographic and vegetative heterogeneity, elevational continuum, and connectivity, all of which can promote species population persistence under anticipated hotter, drier, and more extreme climate conditions.
- My model evaluated sub-basins, and encompassed heat load index, topographic roughness, elevational gradients, springs, perennial water, and landscape connectivity between high value climate adaptation sub-basins.

U of A's Desert SW Cooperative Ecosystem Unit climate adaptation model of landscape linkages promoting biodiversity resilience

- Paige Canyon-Hot Springs Canyon, Soza/Youtcy Canyon Creeks-Soza Canyon, Buehman/Edgar Canyon-Redfield Canyon, Alder/Stratton Washes-Kielberg Canyon, and Peppersauce Wash-Whitlock Wash, are all tributaries of the San Pedro River.
- This model contributes to a landscape conservation design providing the connections and landscape conditions for species to adapt behaviorally, seasonally, and through promoting evolution of adaptations within populations.
- These linkages would be degraded by the SunZia project.

A Prominent Wildlife Linkage between the Galiuro Mountains and Rincon Mountains: the Hot Springs Canyon – Paige Canyon Wildlife Corridor

- Climate Adaptation Model - One of five critical landscape linkages identified in my research.
- Cascabel Conservation Association Remote Wildlife Camera Project monitoring of wildlife linkages began 5 months ago.
- The National Park Service has high concern for the Paige – Hot Springs Canyon Linkage.
- Major investments have been made by the Cascabel Conservation Association and the Saguaro Juniper Corporation to protect Hot Springs Canyon – 1,500 deeded acres and 7,500 acres of grazing leases.
- Conservation/protection of the Paige Canyon linkage is a future planned project of importance to the region.

Potential adverse impacts to the soils, plants and animals, including riparian and wetland habitats

- Habitat fragmentation, interruption of elevation gradient connections
- Soil erosion, increased siltation & sedimentation
- Vegetation impacts - construction & maintenance
- Bird collisions & electrocutions
- Habitat loss and alteration to:
- US Fish & Wildlife Service Endangered Species Act covered species
- Arizona Game & Fish Department Species of Greatest Conservation Need

Potential adverse impacts to the soils, plants and animals, including riparian and wetland habitats

- SunZia threatens the least fragmented section of the San Pedro River watershed.
- Cascabel Road is a mostly two-lane gravel road with minimal width dirt side roads.
- SunZia would open up a **new** 30 mile north-south corridor and numerous new access roads.
- Impacts wilderness-like remote backcountry adjacent to designated Wilderness Areas.
- Impacts wildlife movement corridors & linkages.
- Wildlife presently use the entire region with highest use along washes and canyons as natural movement corridors.
- Wildlife need to move to avoid inbreeding fitness depression, to find new mates, for seasonal migration, and to adapt to changing environmental conditions.

Potential adverse impacts to the soils, plants and animals, including riparian and wetland habitats

- Creates potential for future infrastructure co-location.
- SunZia states in Exhibit C: "reduction of woody vegetation such as Mesquite within the Project's right-of-way would be a potential benefit to wildlife by improving grassland condition". To the contrary, in the San Pedro watershed, wildlife movement corridors and linkages will be impacted and their use by mammals and other species seeking tree/shrub habitat & cover will be detrimentally affected.
- There is no evidence for the SunZia statement (Exhibit C Areas of Biological Wealth) that "large transmission lines are typically assumed to be permeable to wildlife movement…". It is an assumption without supporting data.

Potential adverse impacts to the soils, plants and animals, including riparian and wetland habitats

- The evidence of the efficacy of bird diverters installed on ground wires, transmission lines, and/or guywires is mixed in areas of heavy bird use were birds could be at risk for collisions with transmission lines and guywires.
- Many avian species are known to move seasonally along upslope-downslope gradients to take advantage of food availability and some may avoid going into cleared areas such those caused by access and maintenance roads.
- Especially vulnerable to collisions are hunting raptors, woodpeckers, quail, martins, and especially birds foraging at night, such as owls.
- The threatened Mexican Spotted Owl (MSO), a nocturnal raptor, is likely at risk from this project. Although Critical Habitat is mapped upslope from the transmission corridor, these birds move down canyon/wash systems in their nightly foraging rounds and to over-winter.
- Buehman, Edgar, Peppersauce, and Paige Canyons are sites where this risk is most elevated within the range of the MSO.

Potential adverse impacts to the soils, plants and animals, including riparian and wetland habitats

- Non-native buffelgrass is highly flammable: fires burn hot (up to1600 degrees F) and spread rapidly.
- Buffelgrass alters plant communities, excludes native species, depletes soil nutrients, decreases soil moisture infiltration, and creates a fire-prone monoculture.
- The Sonoran Desert ecosystem is not adapted to wildfire: fire kills saguaros, other cacti and succulents, desert trees & shrubs, and most native desert plants.
- Invasive species will spread via access roads, construction sites, and along the transmission line corridor with devastating impacts to terrestrial & avian species.

Cultural, Recreation and Visual Impacts

- Pima County and Archaeology Southwest have documented that the western slopes of the San Pedro Valley are rich archaeological resources, both archaic and historical.
- New access and maintenance roads will result in increased unauthorized vehicle users and new access points that will open up previously remote backcountry leading to Sonoran desert ecosystem degradation (e.g., trash, trails, erosion, vegetation destruction, invasive species introduction), and adverse impacts to cultural resources, including looting.
- Scenic vistas from Oracle State Park, particularly from the Kannally Ranch House Visitor Center, across the San Pedro to the Galiuros, is one of the most accessible and spectacular vistas in southern Arizona, would be irrevocably damaged.
- The San Pedro Valley overlook on the Mount Lemmon Highway would also be severely affected.
- SunZia acknowledges that visual impacts will be moderate to high along the Cascabel Road within the San Pedro Valley.

Global, Hemispheric Importance of the lower San Pedro Watershed

- Supports numerous AzGFD Species of Greatest Conservation Need and US Fish & Wildlife Service threatened and endangered species.
- Major north-south migration corridor for birds and pollinating insects and of high regional importance to climate adaption for mammals, reptiles, and amphibians.
- 2007 Identified as a Arizona Important Bird Area by Audubon.
- 2008 Identified as a Global IBA by the National Audubon Society IBA Technical Committee
- Identified as a hemispherically important migratory flyway and support of high densities of riparian-dependent bird species.
- Upslope-downslope connections of certain bird populations has been documented by Audubon studies, as well as close association of montane and riparian inter-region avian populations, such as the Yellow-billed Cuckoo.

State, local and private plans - conservation efforts over the last 4 ½ decades?

- The Nature Conservancy began conserving in 1970.
- Many partners have worked alongside TNC including: Cascabel Conservation Association, Saguaro-Juniper Corporation, Archaeology Southwest, Arizona Land and Water Trust, Arizona Game & Fish Department, Arizona State Parks, Bureau of Land Management, Bureau of Reclamation, Pima County, Salt River Project, U.S. Fish & Wildlife Service, and most recently the Resolution Copper Company.
- A total of 192,000 acres in the watershed have been protected with over $42.5M in investments.

State, local and private mitigation conservation lands in the lower San Pedro River Valley

- The 2,156 acre Three Links Farm is a critical conservation property 1,500 feet downstream of the proposed SPR crossing.
- A portion of the Farm is a TNC and Bureau of Reclamation conservation project: 1,420 acres were purchased to mitigate for CAP canal impacts, to restore perennial flow and to protect riparian habitat for biodiversity and endangered species.
- Beaver have returned to the Farm.
- Downstream parcels have mitigated for impacts to endangered species, such as impacts to the Southwestern Willow Flycatcher, by the construction of the Roosevelt Dam.
- Pima County's Six Bar, M Diamond, and A-7 Ranches comprise over 66,000 acres and cost over $14M of Pima County voter-approved bond monies.

State, local and private mitigation conservation lands in the lower San Pedro River Valley

- The three ranches are part of Pima County's Sonoran Desert Conservation Plan and Multi-Species Habitat Conservation Plan under the Endangered Species Act, conserved to mitigate for development in Pima County.
- The majority of federal, state and Pima County investments are required to mitigate for otherwise lawful development elsewhere.
- Compromising these investments creates legal consequences and potential litigation.
- Recreation, including hunting, would be adversely impacted (mule deer, turkey, etc.), and poaching potential will be increased.

State, local and private future conservation opportunities in the San Pedro River Valley

- Ranches and their associated grazing leases conserve unfragmented habitats.
- Large ranches on the slopes of the Rincon and Little Rincon Mountains, near the Saguaro National Park & CNF Wilderness Area, are eligible to be purchased or put under conservation easements.
- Private lands nearer the main river channel are also eligible for purchase or conservation easements.
- Water rights are eligible for lease or purchase to maintain instream flows for threatened and endangered species and other wildlife.
- The SunZia transmission line would degrade the value of these properties.

AzGFD HabiMap Arizona

- SERI – Species of Economic and Recreational Value layer.
- The darker the blue, the higher the value for economic and recreational uses.

Ecosystem Services

- Ecosystem services are the free and important benefits for human beings that arise from healthily functioning ecosystems, such as the production of oxygen, soils, and water purification.
- In the early 2000s, the Millennium Ecosystem Assessment grouped ecosystem services into four broad categories:
- ***provisioning***, such as the production of food and water;
- ***regulating***, such as the control of climate and disease;
- ***supporting***, such as nutrient cycles and crop pollination;
- and ***cultural***, such as spiritual and recreational benefits.
- To help inform decision-makers, many ecosystem services are being assigned economic values.

Ecosystem Services

Provided that the San Pedro River watershed remains relatively undisturbed, unfragmented and mostly undeveloped, it provides a number of socially and ecologically valuable ecosystems services including:

- unimpeded mountain front and in-tributary groundwater recharge,
- nutrient transport from highlands to lowlands,
- productive soils development,
- natural fire cycles,
- clean air and water provisioning,
- support of high biodiversity and thus climatic resilience,
- ecological trophic function and population regulation,
- dark sky values for astronomical viewing,
- sustainable ranching, and
- desert solitude values for personal rejuvenation.

Ecosystem Services

Ecosystem services contribute to the local and regional economy by:

- sustaining valley bottom high groundwater levels and surface flows benefiting vegetation diversity, supporting high native biodiversity, benefiting eco-tourism;
- developing deep soil horizons and high nutrient availability within these soils;
- promoting natural fire cycles that support native vegetation communities;
- benefitting wildlife-based recreation and hunting by maintaining unfragmented uplands and rural, very low-density, productive lowlands; and
- supporting outdoor recreation and eco-tourism offered by local service providers within the valley.

Summary

- SunZia will likely cause significant impacts to the lower San Pedro watershed's biological and cultural landscape integrity and connectivity of habitats for the wildlife it currently supports.
- Invasive species entry potential will rise dramatically, leading to increased risks of significant altered wildfire regimes.
- Mitigation measures will not fully compensate for lost biological resources, impacts to select species, and ecosystem services, function and health.

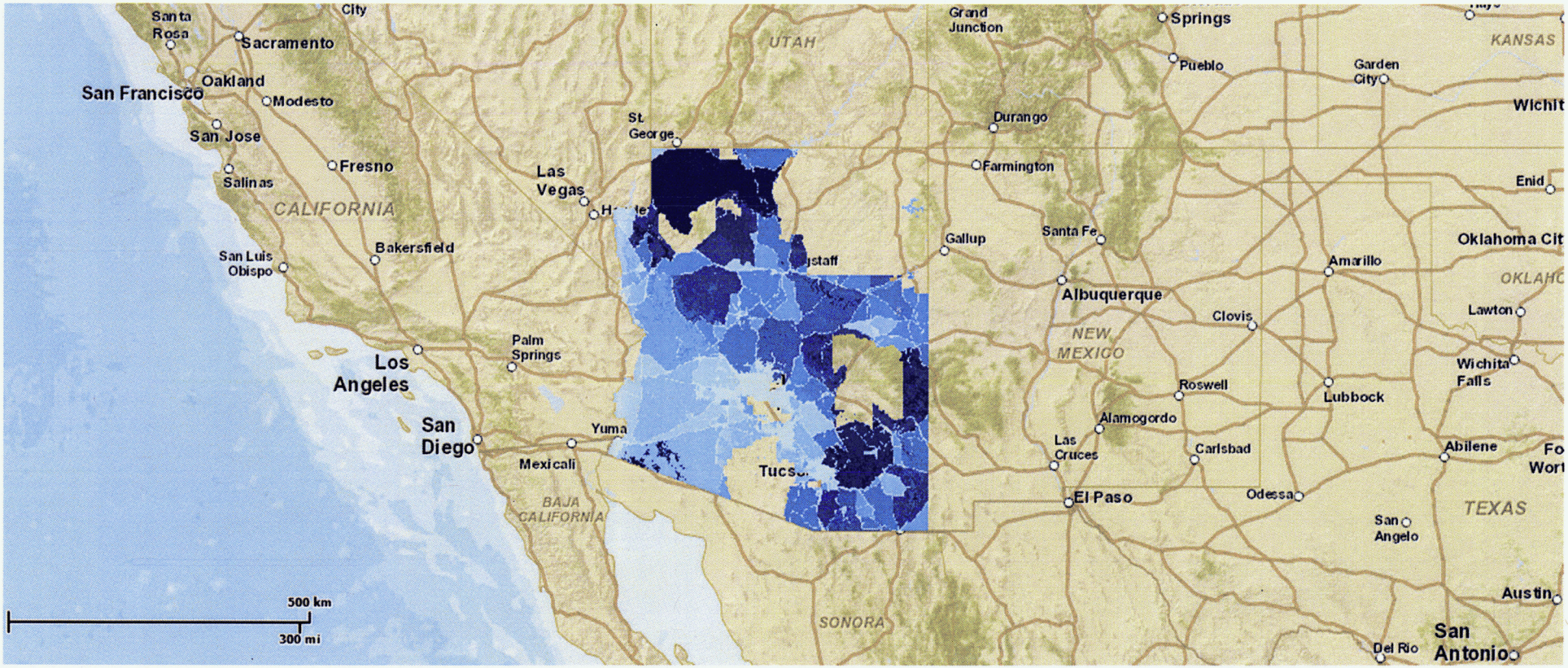
Summary

- If the SunZia Project is to proceed, it would be better to co-locate this transmission line with other existing transmission lines and follow major highways, such as the I-10 interstate or other interstates, rather than disturb lands specifically being conserved for their biological and ecosystem values such as the efforts undertaken over the last 45 years to conserve the lower San Pedro River Valley watershed.

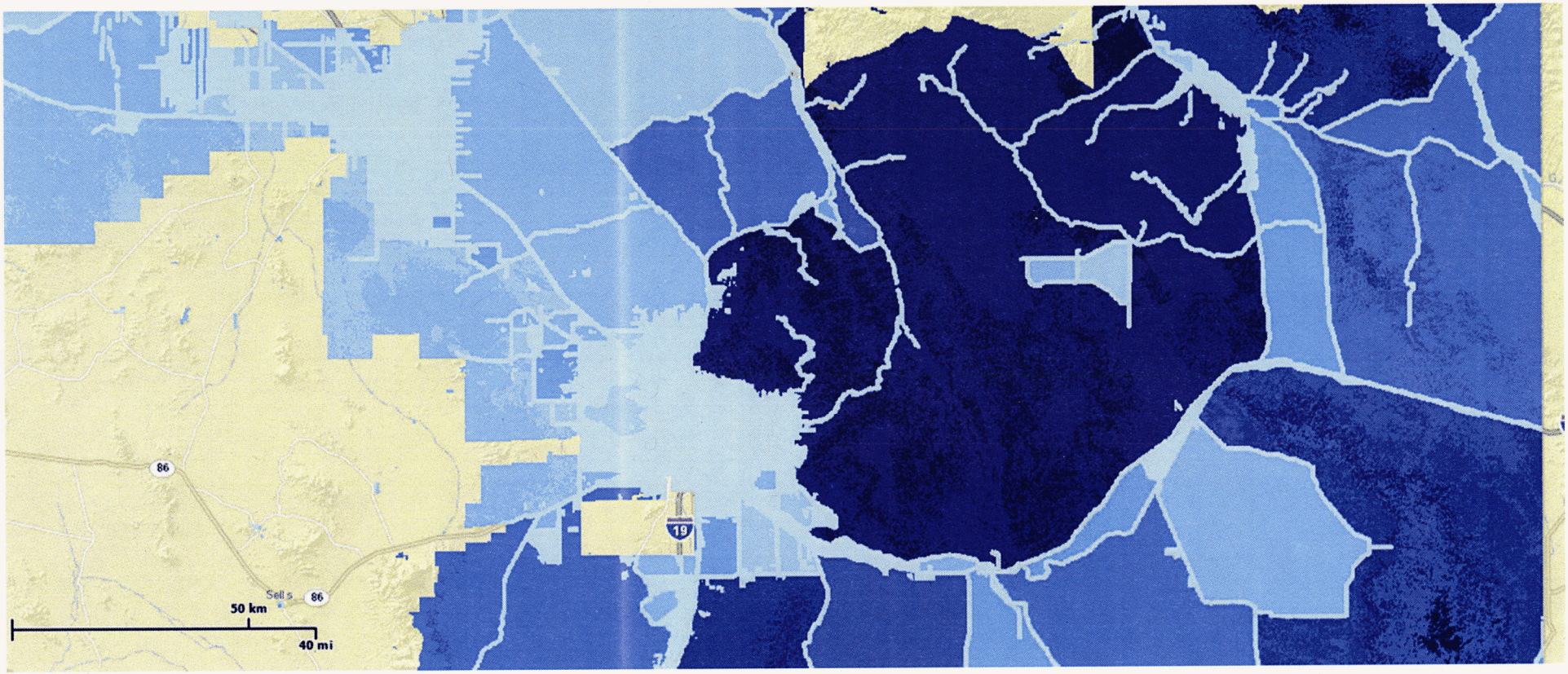
Summary

- The state, regional, and local economies would suffer from adverse impacts to conservation mitigation properties, sustainable ranching operations, and the loss of tourism.

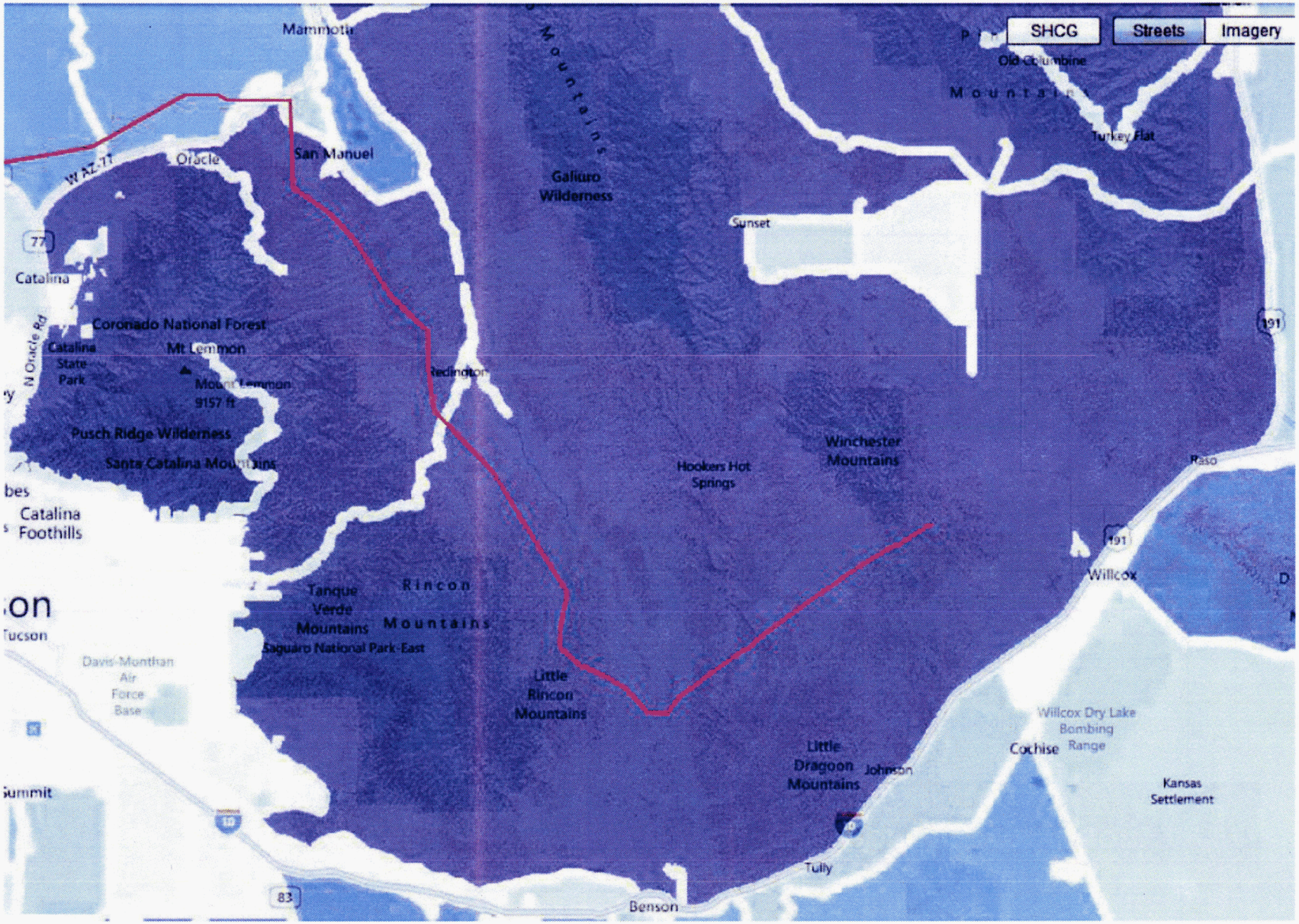
AzGFD HabiMap: Unfragmented Blocks



AzGFD HabiMap: Unfragmented Blocks



AzGFD HabiMap: Unfragmented Blocks



Boykin, Kepner *et al* 2012

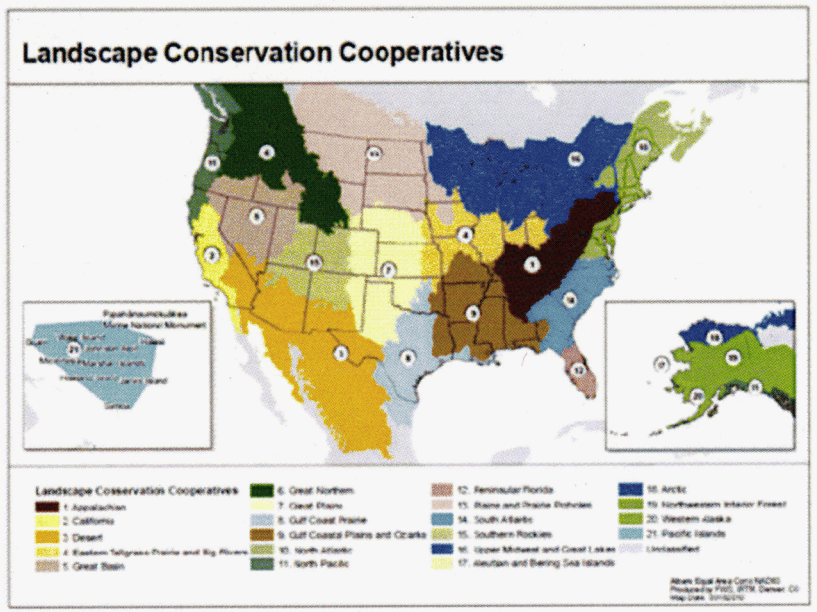
Local Efforts

ASSESSMENT OF GOODS AND VALUATION OF ECOSYSTEM SERVICES

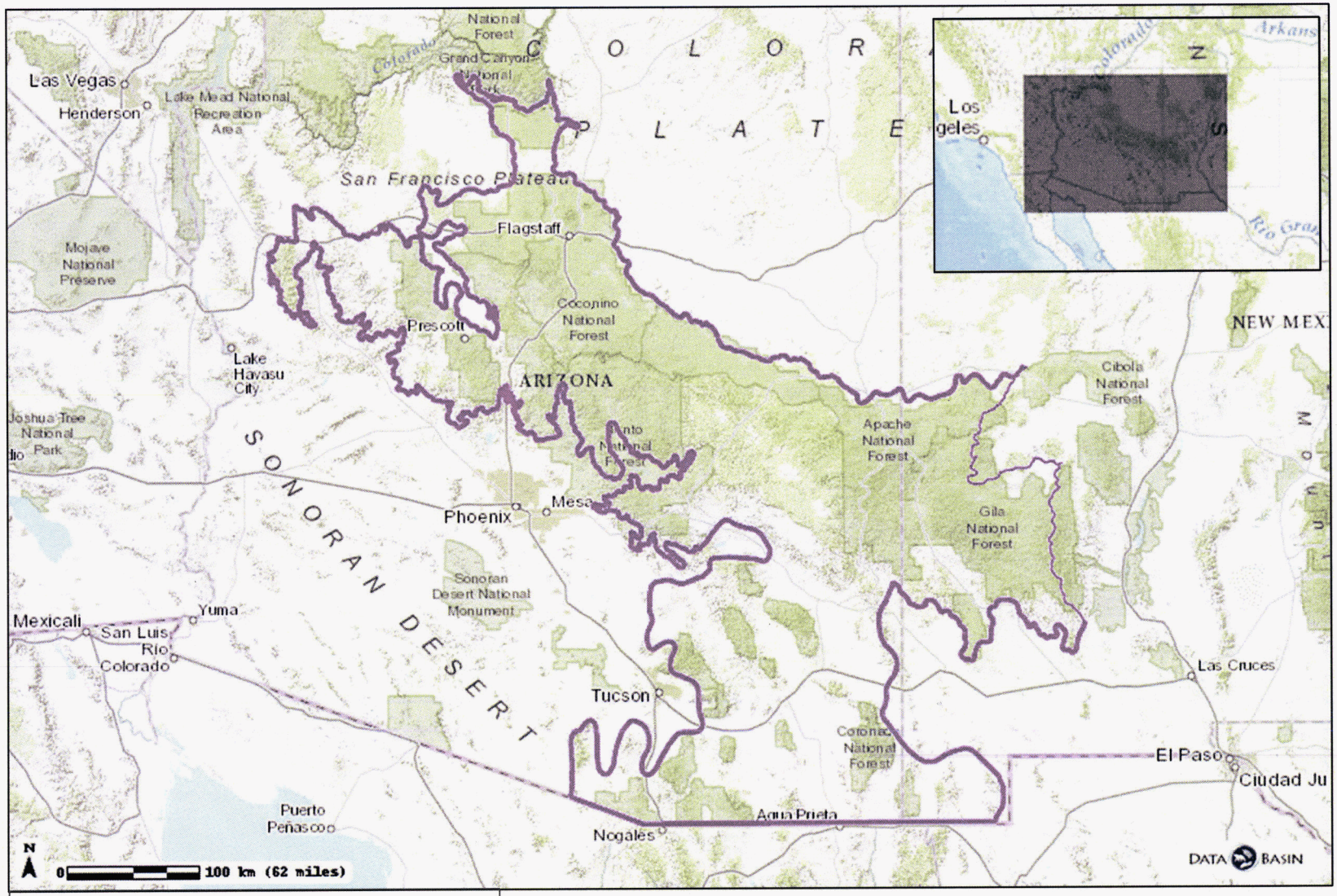
AGAVES

State Wildlife Action Plans

Landscape Conservation Cooperatives



Secretarial Order No. 3289 establishes Landscape Conservation Cooperatives, which are management-science partnerships that inform integrated resource-management actions across landscapes (February 22, 2010).



Legend

DATA BASIN

U.S. Fish and Wildlife Service Southwest Region 2 Emphasis Areas

Mogollon Rim Emphasis Area

U.S. Fish and Wildlife Service Southwest Region 2 Emphasis Areas

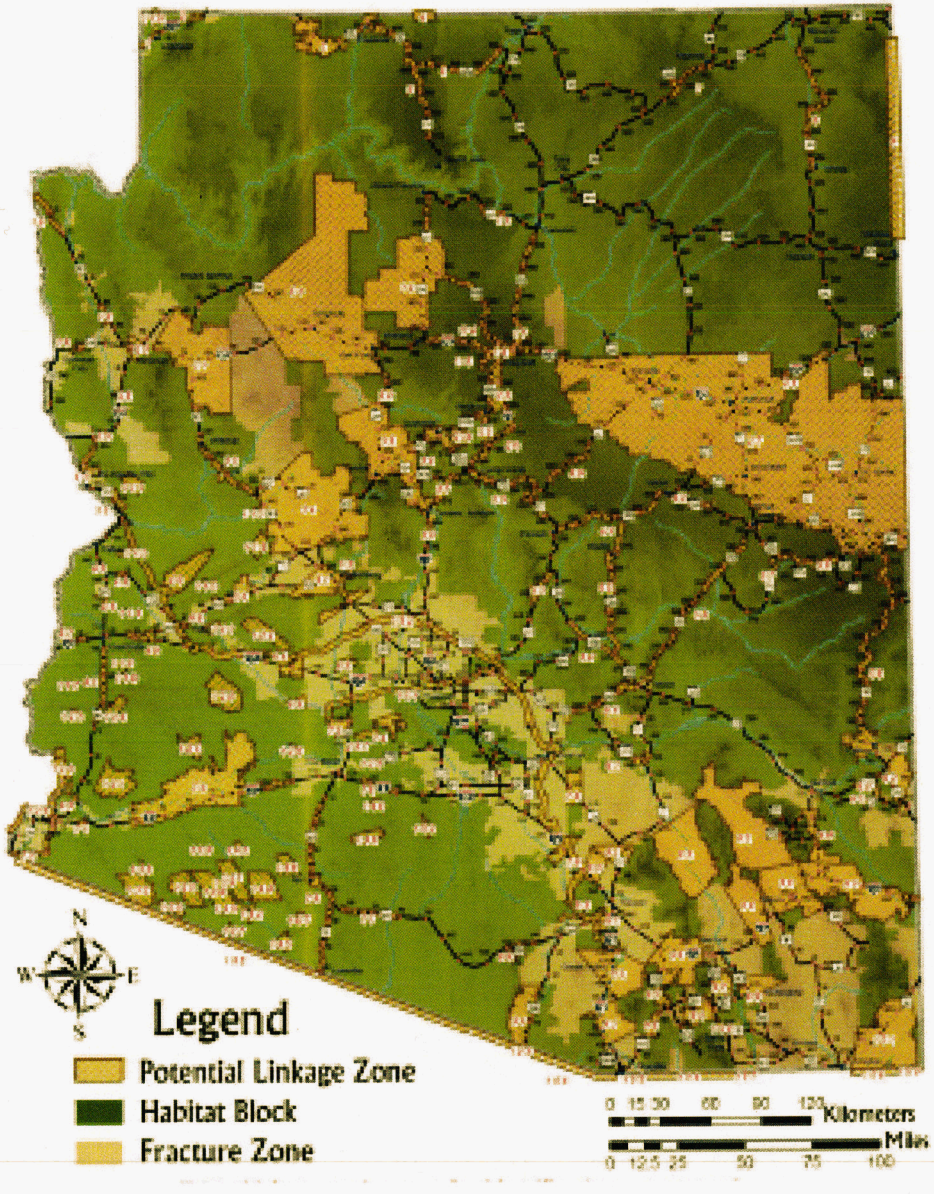
http://dlcc.databasin.org/datasets/32ca5b4cb7a0401c900cbf1917adcb4b

Credits:

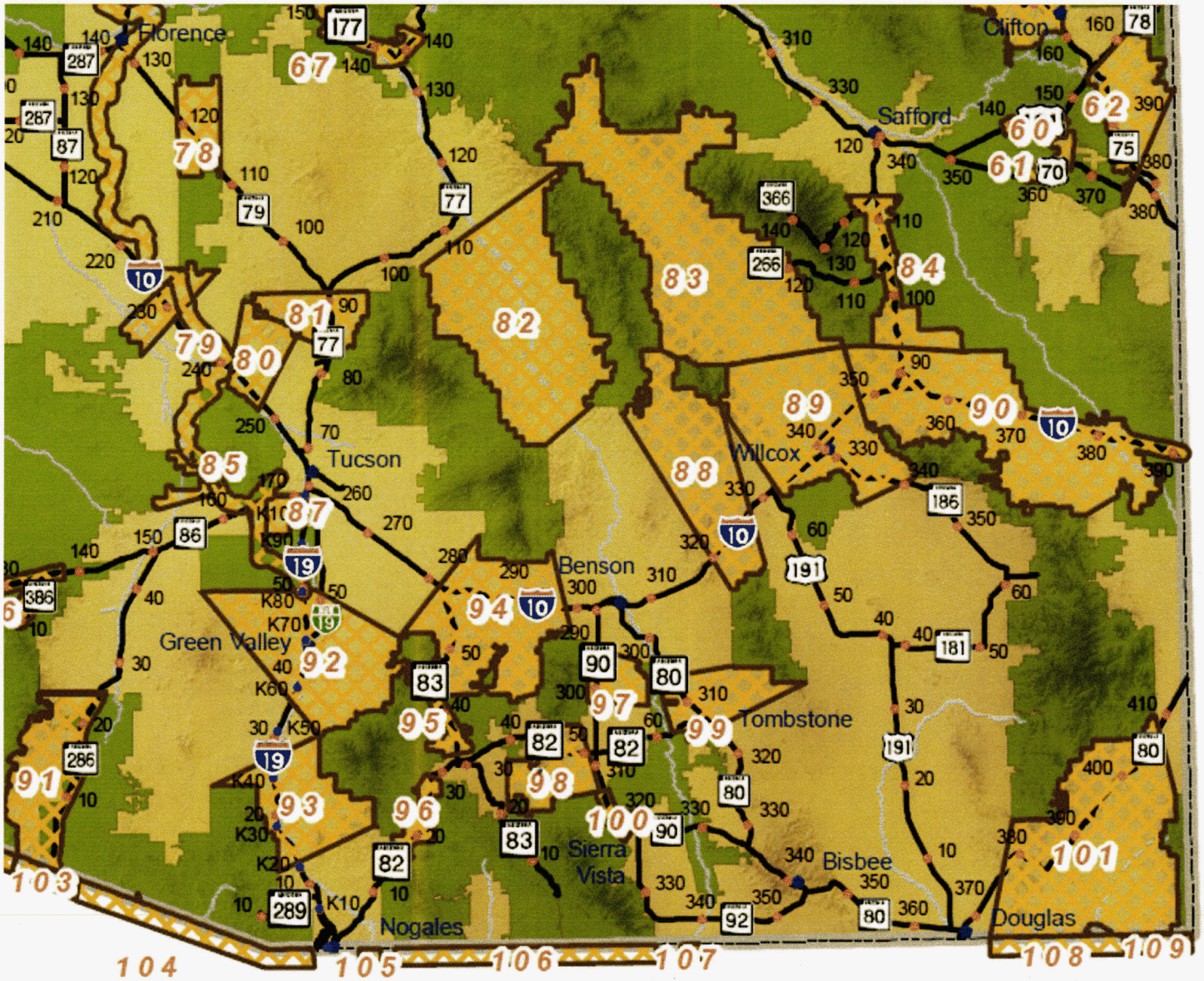
Contact: Jim Dick, Regional Branch Chief Technical Support, Division of Decision Support, U.S. Fish & Wildlife Service, Southwest Region 2500 Gold Ave., SW Room 6002Albuquerque, NM 87102505-248-6660 (office)505-248-6922 (fax), jim_dick@fws.gov

Desert Landscape Conservation Cooperative
Nominated Landscape Conservation Designs
Traversed by the Proposed SunZia Southwest Transmission Line

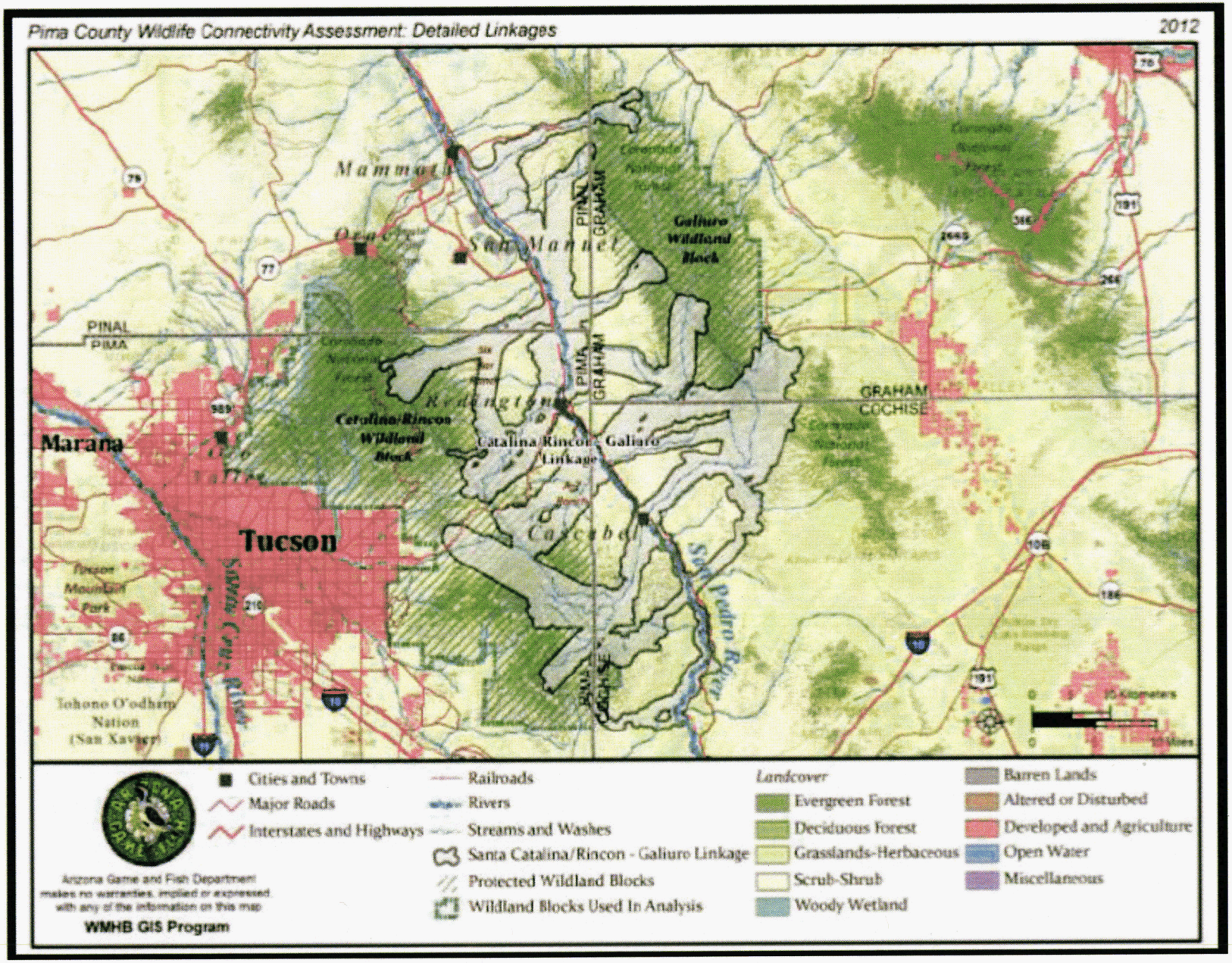
ARIZONA'S WILDLIFE LINKAGES

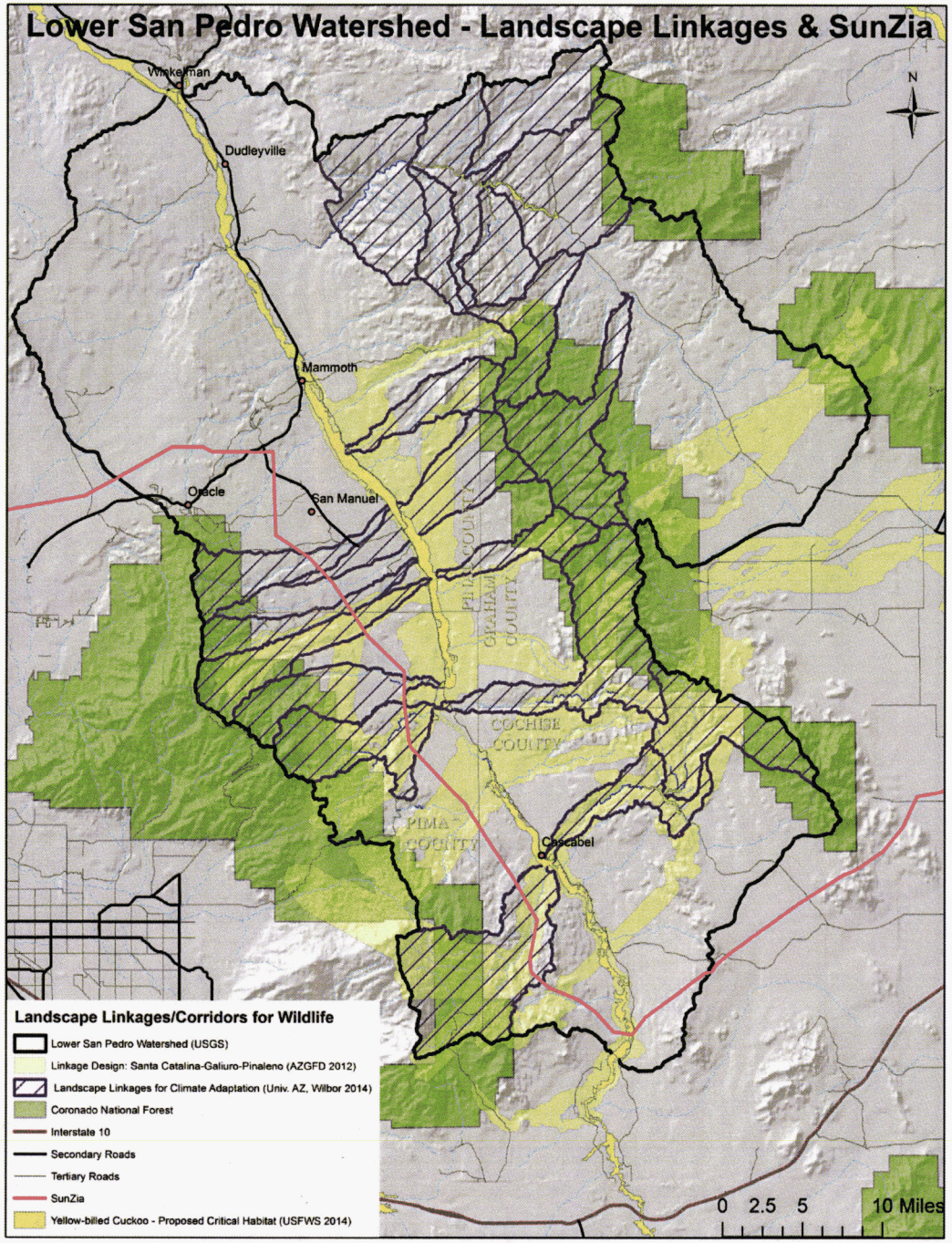


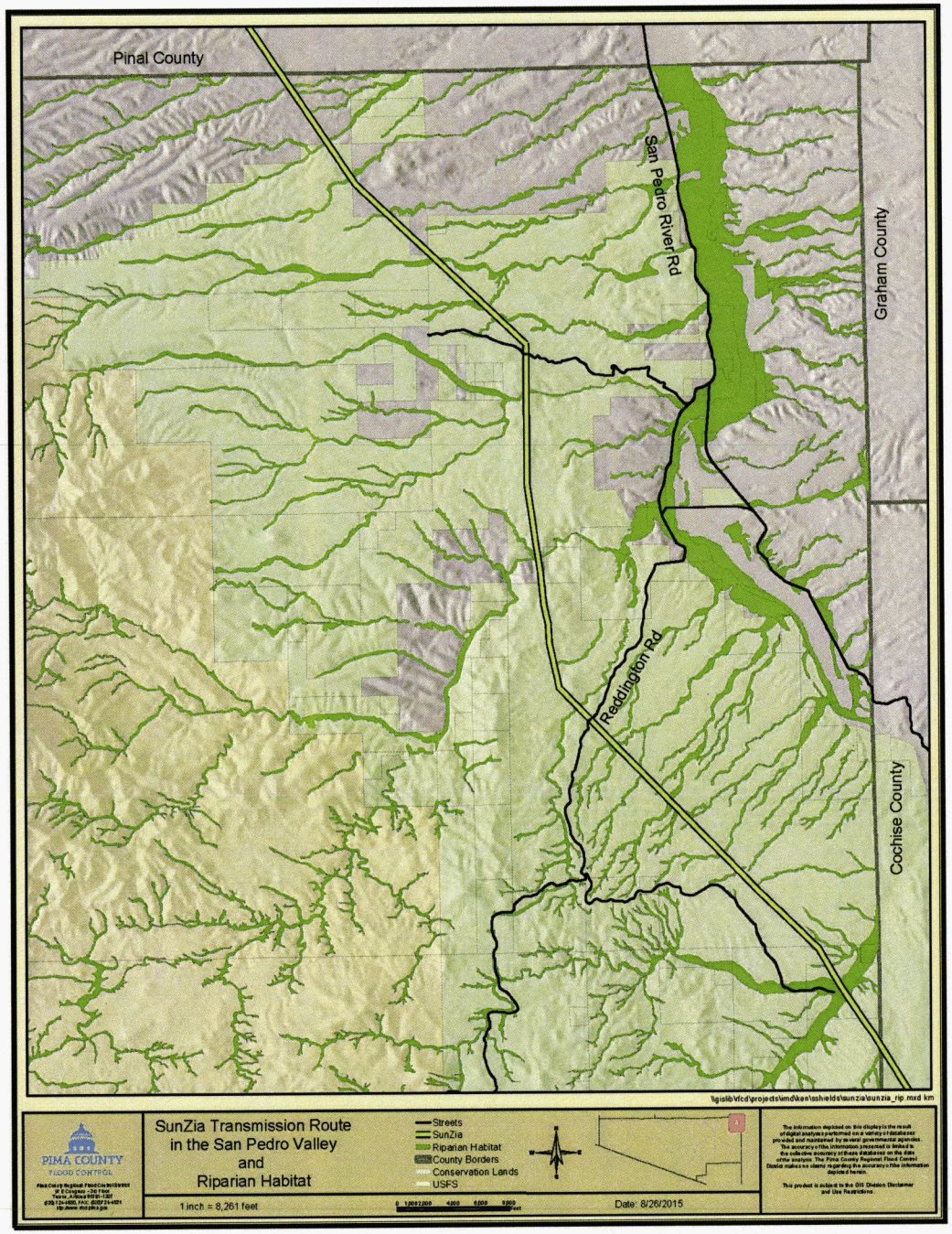
Arizona Wildlife Linkages – Southeast Arizona



Pima County Wildlife Connectivity Assessment – Santa Catalina / Rincon-Galiuro Linkage

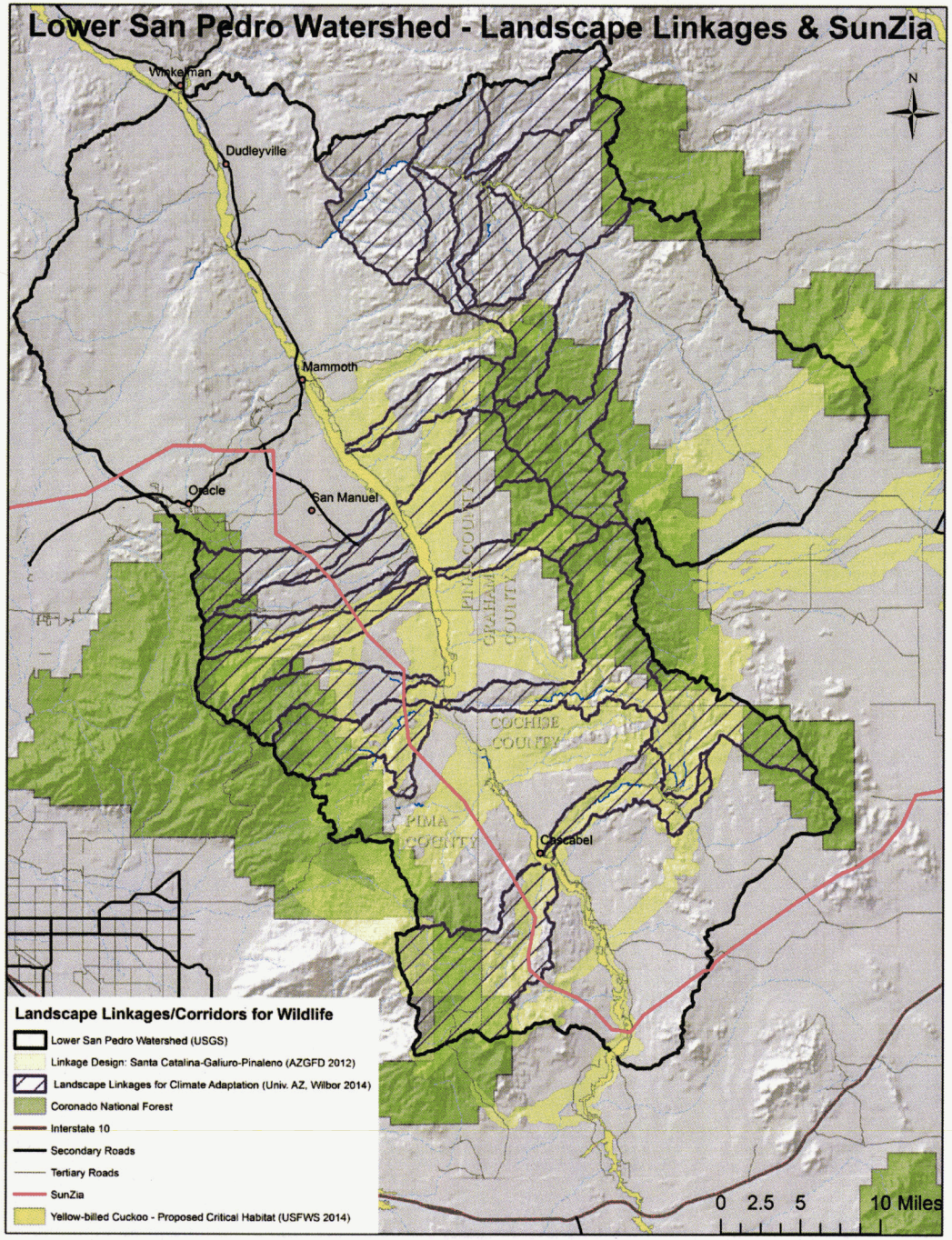



Lower San Pedro Watershed - Landscape Linkages & SunZia
Winkelman
Dudleyville
Mammoth
Oracle
San Manuel
Cascabel
GRAHAM COUNTY
COCHISE COUNTY
PIMA COUNTY
N
Landscape Linkages/Corridors for Wildlife
Lower San Pedro Watershed (USGS)
Linkage Design: Santa Catalina-Galiuro-Pinaleno (AZGFD 2012)
Landscape Linkages for Climate Adaptation (Univ. AZ, Wilbor 2014)
Coronado National Forest
Interstate 10
Secondary Roads
Tertiary Roads
SunZia
Yellow-billed Cuckoo - Proposed Critical Habitat (USFWS 2014)
0 2.5 5 10 Miles

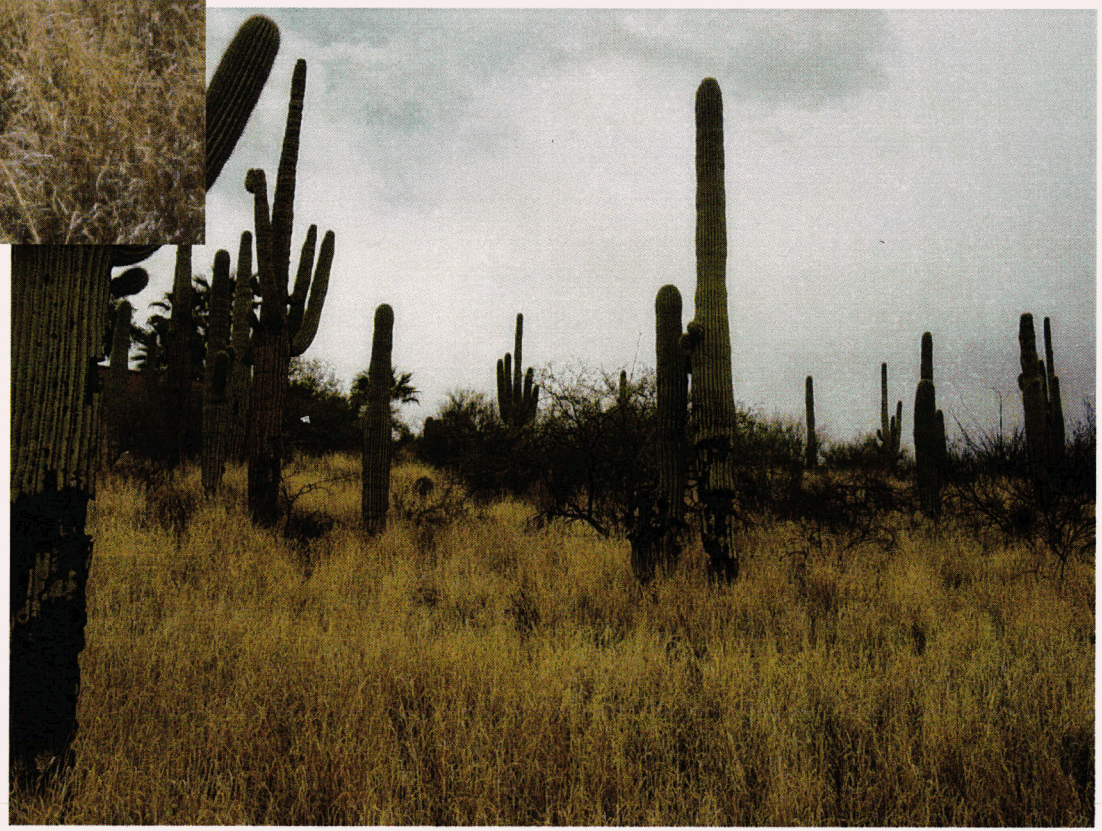


DOCKET NO. L-00000YY-15-0318-00171_Pima_County_Limited_Appearance

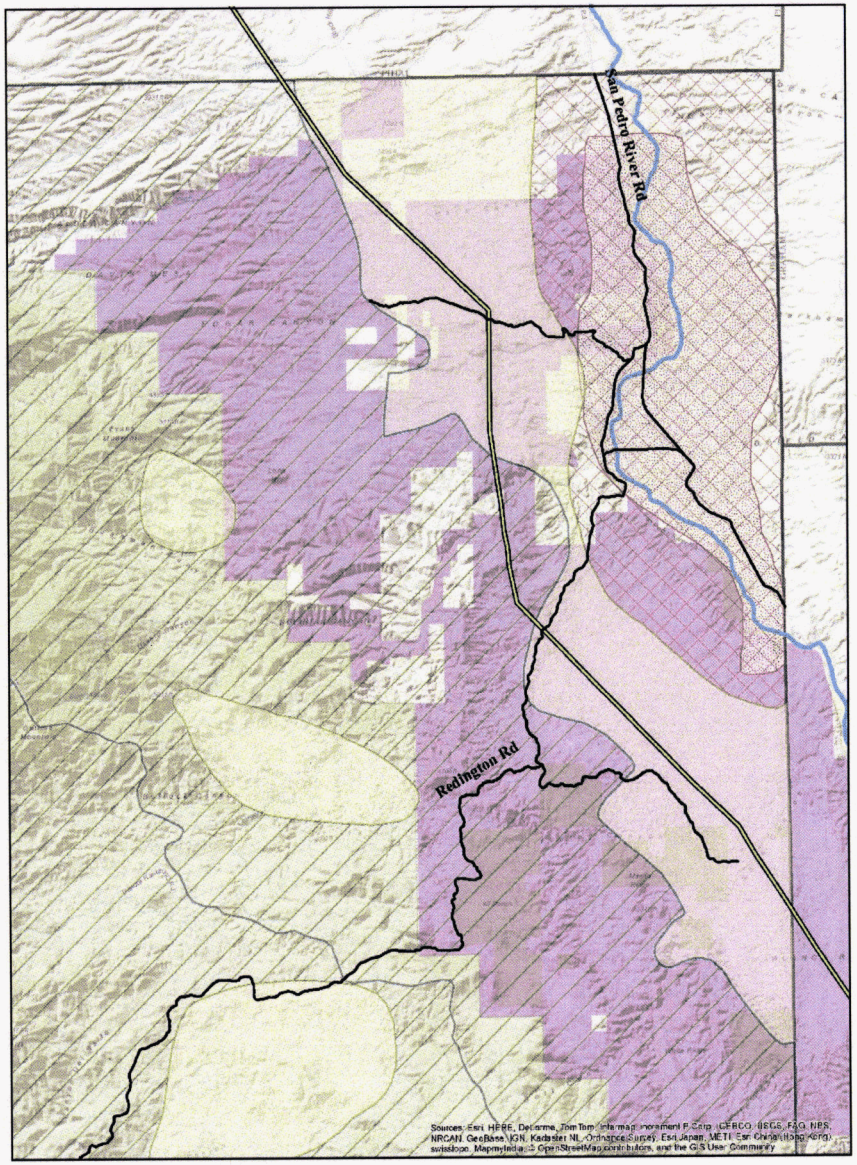
Wilbor-R-17-18


Lower San Pedro Watershed - Landscape Linkages & SunZia
Winkelman
Dudleyville
Mammoth
Oracle
San Manuel
Cascabel
PINAL COUNTY
GRAHAM COUNTY
COCHISE COUNTY
PIMA COUNTY
N
0 2.5 5 10 Miles
Landscape Linkages/Corridors for Wildlife
Lower San Pedro Watershed (USGS)
Linkage Design: Santa Catalina-Galiuro-Pinaleno (AZGFD 2012)
Landscape Linkages for Climate Adaptation (Univ. AZ, Wilbor 2014)
Coronado National Forest
Interstate 10
Secondary Roads
Tertiary Roads
SunZia
Yellow-billed Cuckoo - Proposed Critical Habitat (USFWS 2014)

Buffelgrass burn in Avra Valley



Saguaros post burn



PIMA COUNTY
SUSTAINABILITY & CONSERVATION

SunZia Transmission Route in the San Pedro Valley and Cultural Resources

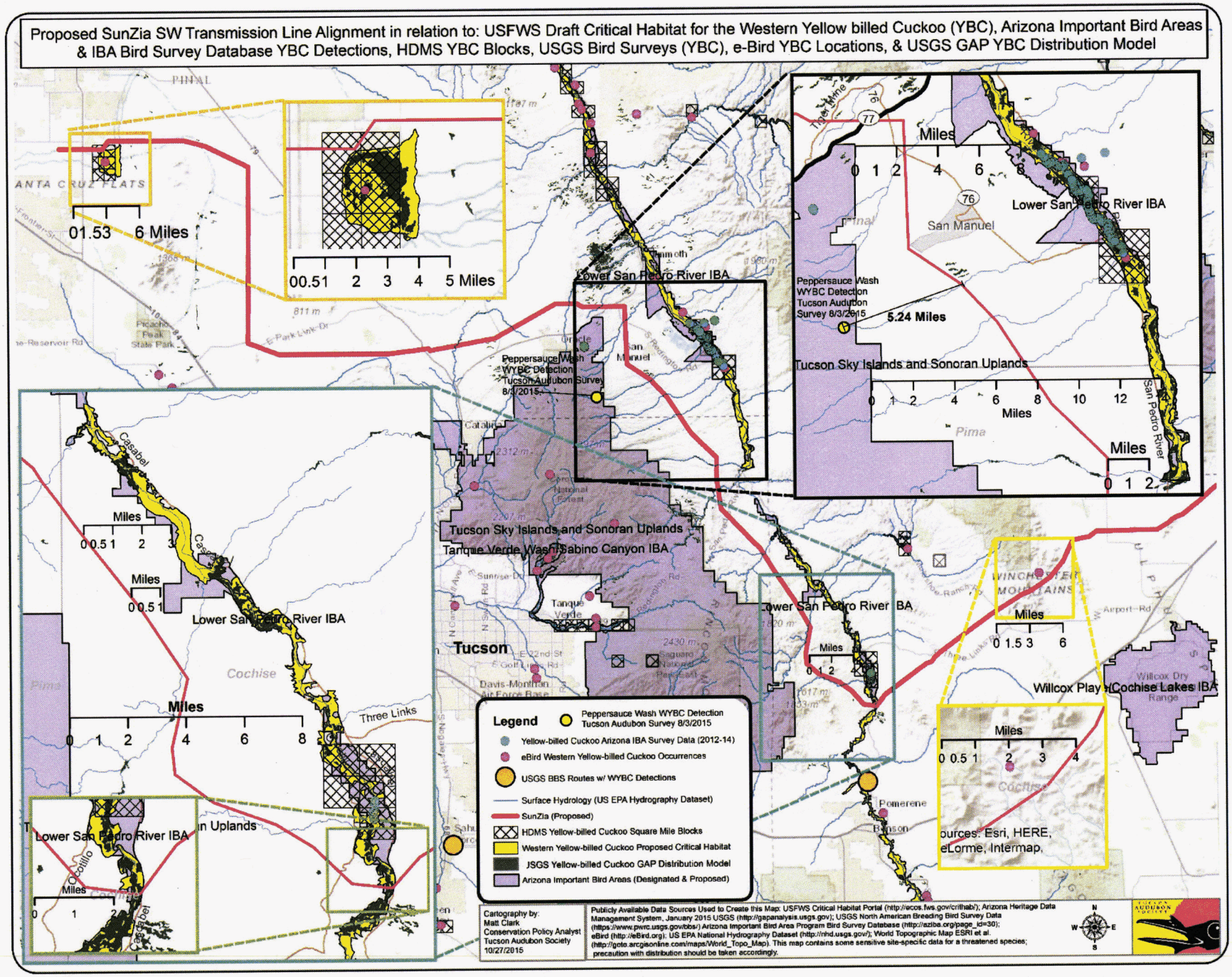
- SunZia
- Streets
- USFS
- Conservation Lands
- County Borders
- San Pedro River

SDCP Sensitivity Zones

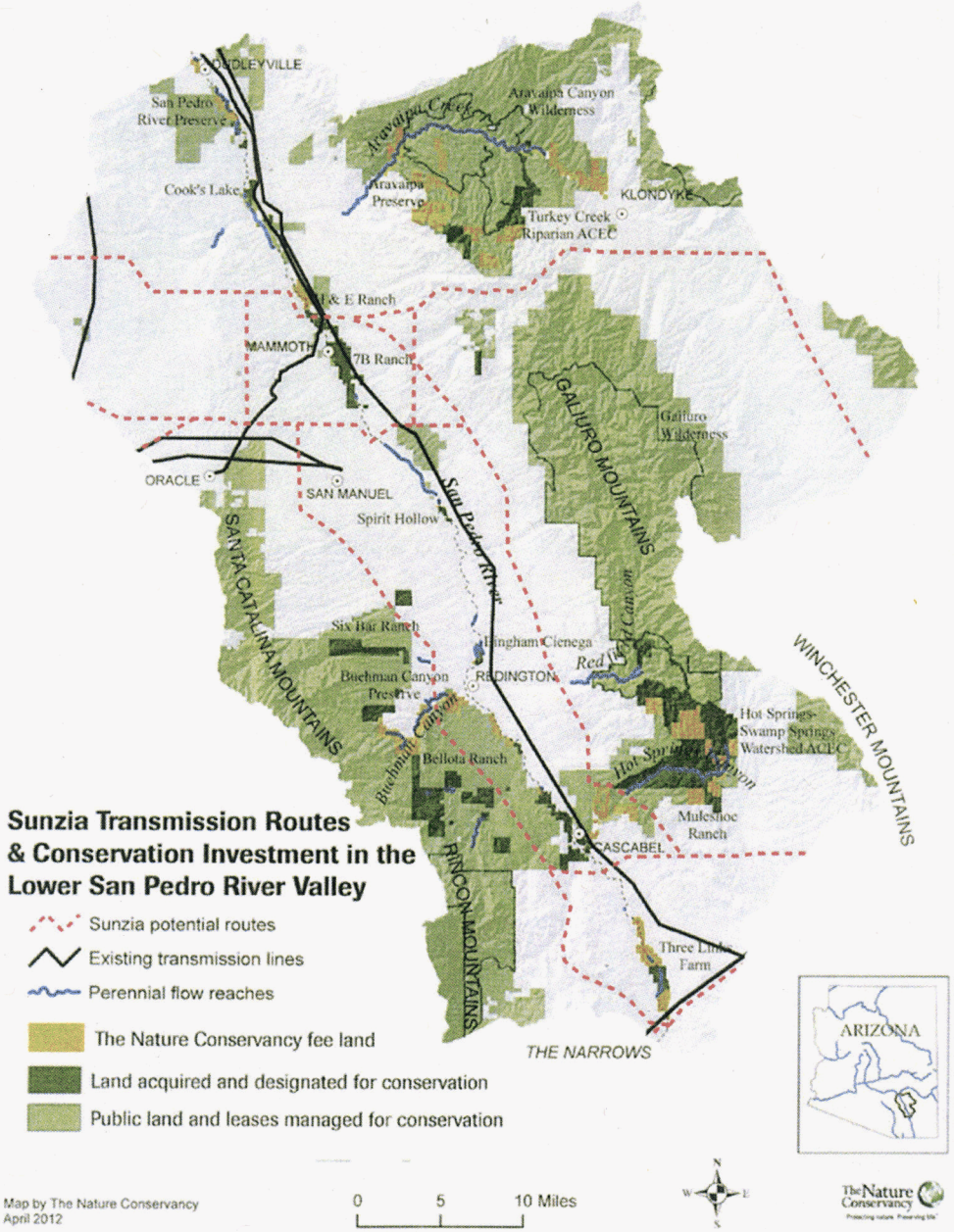
- High
- Moderate
- Low
- Redington SDCP Priority Archaeological Site Complex

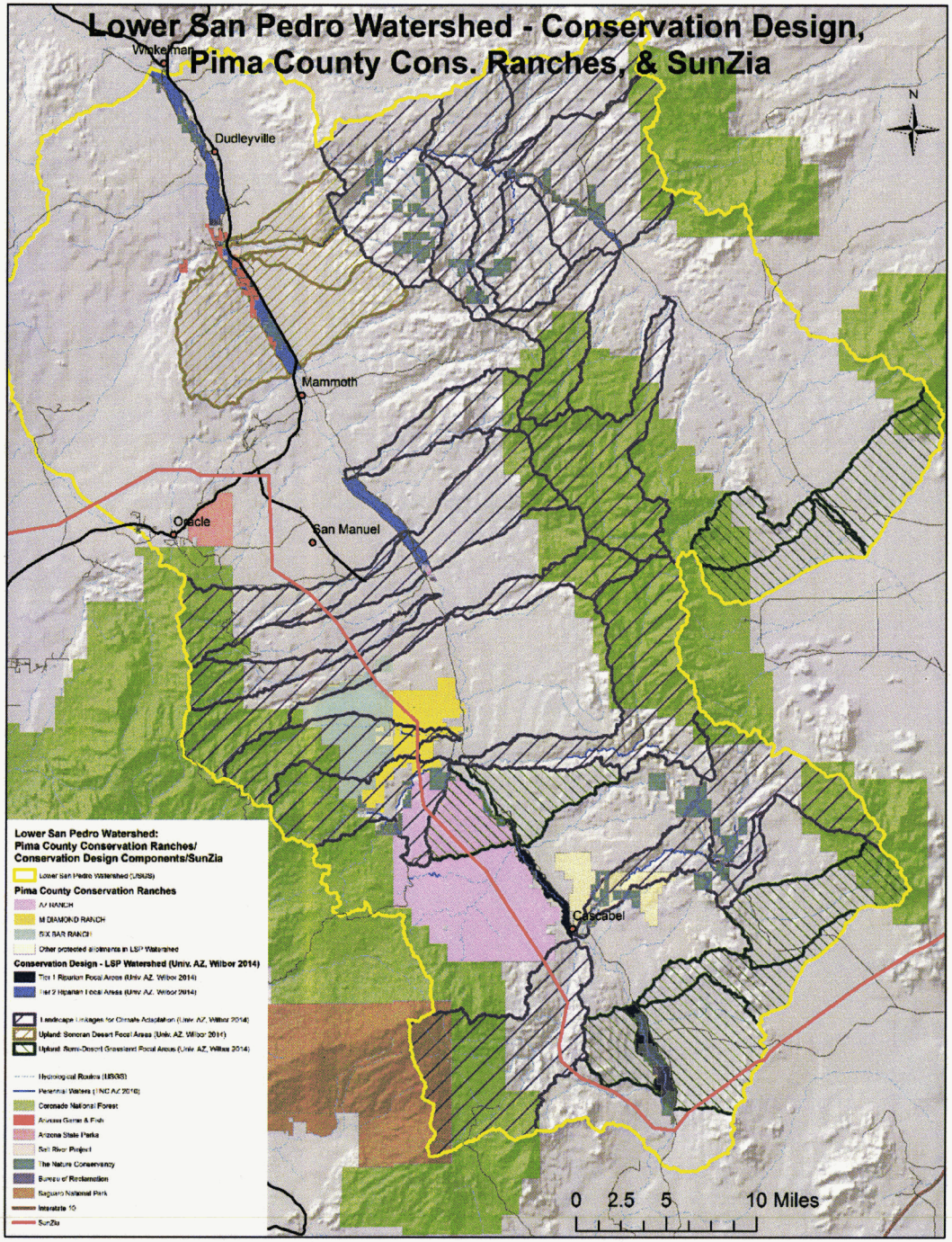
N, W, E, S

0 1 2 3 Miles

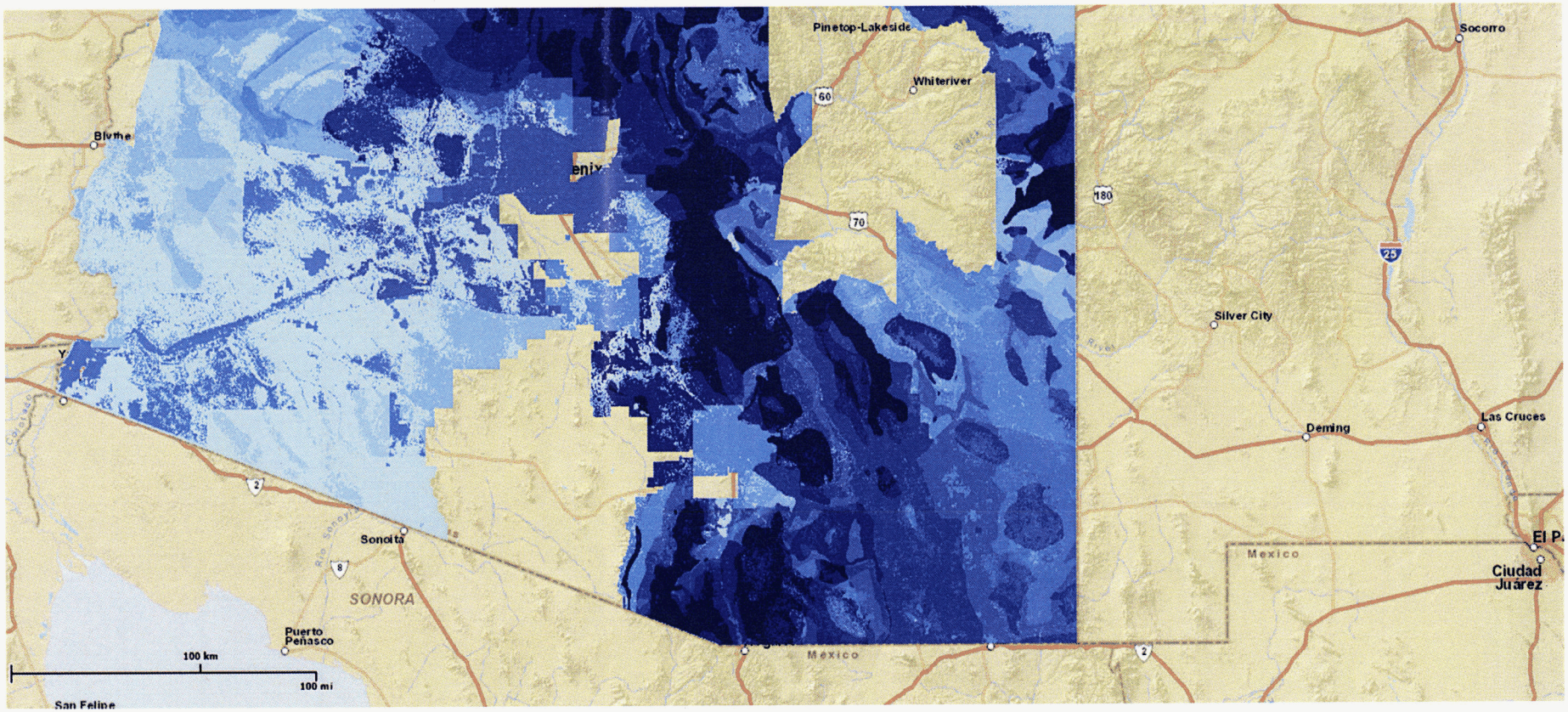

Proposed SunZia SW Transmission Line Alignment in relation to: USFWS Draft Critical Habitat for the Western Yellow billed Cuckoo (YBC), Arizona Important Bird Areas & IBA Bird Survey Database YBC Detections, HDMS YBC Blocks, USGS Bird Surveys (YBC), e-Bird YBC Locations, & USGS GAP YBC Distribution Model
Lower San Pedro River IBA
Peppersauce Wash WYBC Detection Tucson Audubon Survey 8/3/2015
5.24 Miles
Tucson Sky Islands and Sonoran Uplands
Tanque Verde Wash/Sabino Canyon IBA
Tucson
Cochise
Three Links
Willcox Playa/Cochise Lakes IBA
Legend
Peppersauce Wash WYBC Detection Tucson Audubon Survey 8/3/2015
Yellow-billed Cuckoo Arizona IBA Survey Data (2012-14)
eBird Western Yellow-billed Cuckoo Occurrences
USGS BBS Routes w/ WYBC Detections
Surface Hydrology (US EPA Hydrography Dataset)
SunZia (Proposed)
HDMS Yellow-billed Cuckoo Square Mile Blocks
Western Yellow-billed Cuckoo Proposed Critical Habitat
USGS Yellow-billed Cuckoo GAP Distribution Model
Arizona Important Bird Areas (Designated & Proposed)
Cartography by:
Matt Clark
Conservation Policy Analyst
Tucson Audubon Society
10/27/2015
Publicly Available Data Sources Used to Create this Map: USFWS Critical Habitat Portal (http://ecos.fws.gov/crithab/); Arizona Heritage Data Management System, January 2015 USGS (http://gapanalysis.usgs.gov); USGS North American Breeding Bird Survey Data (https://www.pwrc.usgs.gov/bbs/) Arizona Important Bird Area Program Bird Survey Database (http://aziba.org/page_id=30); eBird (http://eBird.org); US EPA National Hydrography Dataset (http://nhd.usgs.gov/); World Topographic Map ESRI et al. (http://goto.arcgisonline.com/maps/World_Topo_Map). This map contains some sensitive site-specific data for a threatened species; precaution with distribution should be taken accordingly.

TNC-2012

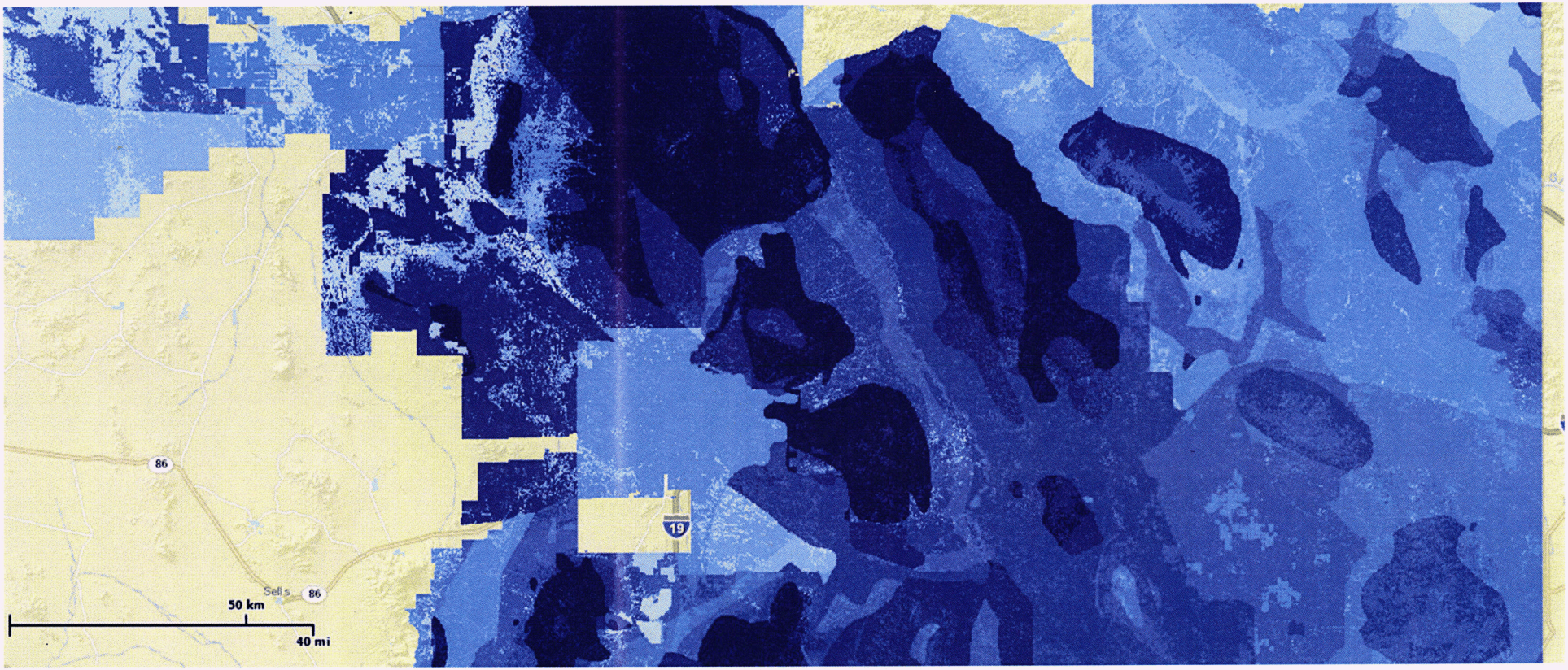

DUDLEYVILLE
San Pedro River Preserve
Aravaipa Canyon Wilderness
Aravaipa Creek
Aravaipa Preserve
Cook's Lake
KLONDYKE
Turkey Creek Riparian ACEC
L & E Ranch
MAMMOTH
7B Ranch
GALIURO MOUNTAINS
Galiuro Wilderness
ORACLE
SAN MANUEL
Spirit Hollow
San Pedro River
SANTA CATALINA MOUNTAINS
Six Bar Ranch
Bingham Cienega
Red Tail Canyon
Buehman Canyon Preserve
REDINGTON
WINCHESTER MOUNTAINS
Hot Springs-Swamp Springs Watershed ACEC
Buehman Canyon
Bellota Ranch
Hot Springs Canyon
Muleshoe Ranch
CASCABEL
RINCON MOUNTAINS
Three Links Farm
THE NARROWS
Sunzia Transmission Routes & Conservation Investment in the Lower San Pedro River Valley
Sunzia potential routes
Existing transmission lines
Perennial flow reaches
The Nature Conservancy fee land
Land acquired and designated for conservation
Public land and leases managed for conservation
ARIZONA
Map by The Nature Conservancy
April 2012
0
5
10 Miles
N
W
E
S
The Nature Conservancy

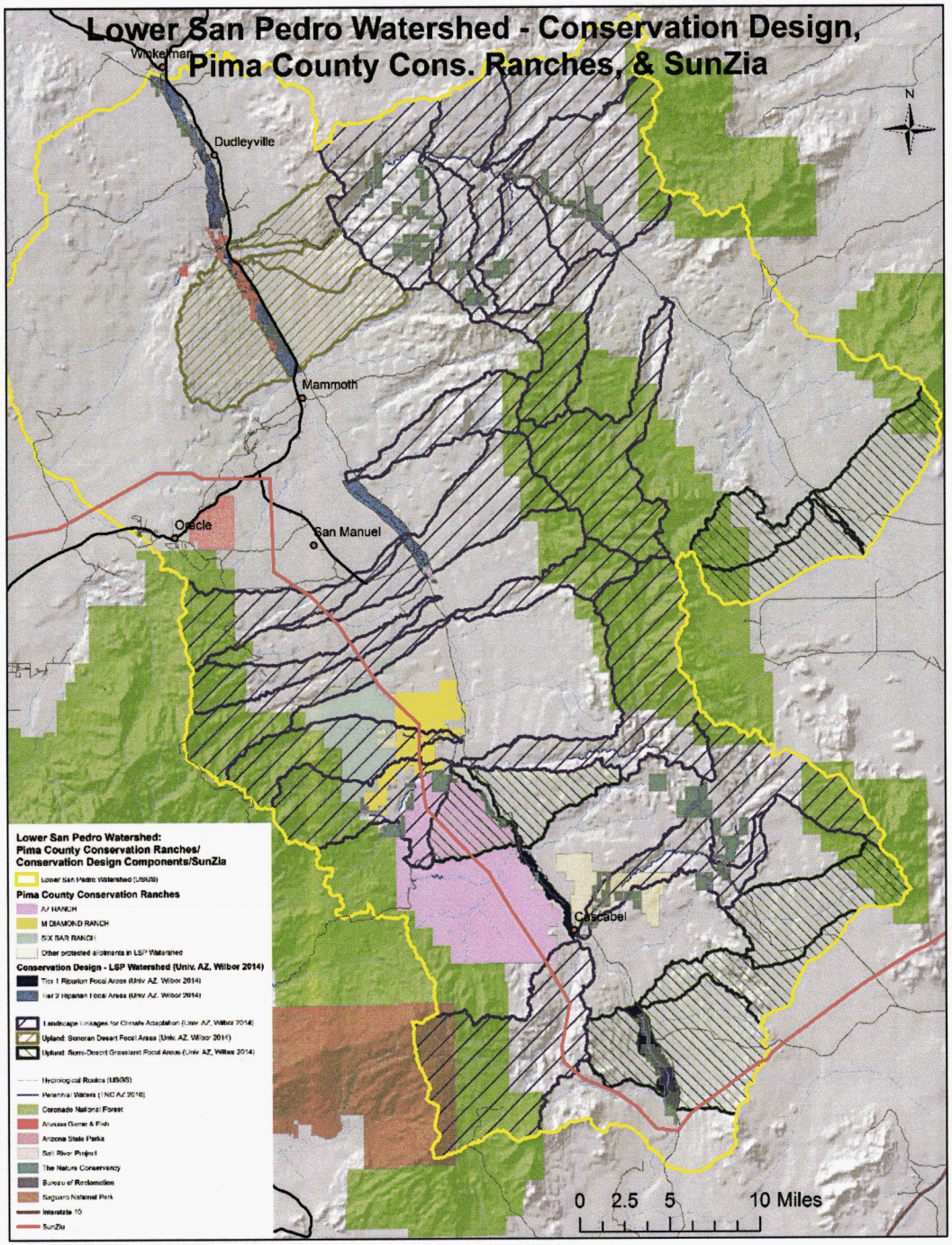

Lower San Pedro Watershed - Conservation Design,
Pima County Cons. Ranches, & SunZia
Wickenburg
Dudleyville
Mammoth
Oracle
San Manuel
Cascabel
N
0 2.5 5 10 Miles
Lower San Pedro Watershed:
Pima County Conservation Ranches/
Conservation Design Components/SunZia
Lower San Pedro Watershed (USGS)
Pima County Conservation Ranches
AJ RANCH
M DIAMOND RANCH
SIX BAR RANCH
Other protected allotments in LSP Watershed
Conservation Design - LSP Watershed (Univ. AZ, Wilbor 2014)
Tier 1 Riparian Focal Areas (Univ. AZ, Wilbor 2014)
Tier 2 Riparian Focal Areas (Univ. AZ, Wilbor 2014)
Landscape Linkages for Climate Adaptation (Univ. AZ, Wilbor 2014)
Upland: Sonoran Desert Focal Areas (Univ. AZ, Wilbor 2014)
Upland: Semi-Desert Grassland Focal Areas (Univ. AZ, Wilbor 2014)
Hydrological Routes (USGS)
Perennial Waters (NHD AZ 2010)
Coronado National Forest
Arizona Game & Fish
Arizona State Parks
San River Project
The Nature Conservancy
Bureau of Reclamation
Saguaro National Park
Interstate 10
SunZia

AzGFD HabiMap: SERI Species of Economic and Recreational Value



AzGFD HabiMap: SERI
Species of Economic and Recreational Value




Lower San Pedro Watershed - Conservation Design,
Pima County Cons. Ranches, & SunZia
Wakeman
Dudleyville
Mammoth
Oracle
San Manuel
Cascabel
N
0 2.5 5 10 Miles
Lower San Pedro Watershed:
Pima County Conservation Ranches/
Conservation Design Components/SunZia
Lower San Pedro Watershed (USGS)
Pima County Conservation Ranches
AV RANCH
M DIAMOND RANCH
SIX BAR RANCH
Other protected allotments in LSP Watershed
Conservation Design - LSP Watershed (Univ. AZ, Wilbor 2014)
Tier 1 Riparian Focal Areas (Univ AZ, Wilbor 2014)
Tier 2 Riparian Focal Areas (Univ AZ, Wilbor 2014)
Landscape Linkages for Climate Adaptation (Univ AZ, Wilbor 2014)
Upland: Sonoran Desert Focal Areas (Univ. AZ, Wilbor 2014)
Upland: Semi-Desert Grassland Focal Areas (Univ. AZ, Wilbor 2014)
Hydrological Routes (USGS)
Perennial Waters (TNC AZ 2010)
Coronado National Forest
Arizona Game & Fish
Arizona State Parks
Salt River Project
The Nature Conservancy
Bureau of Reclamation
Saguaro National Park
Interstate 10
SunZia

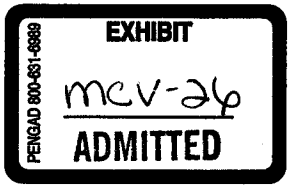
Tice Supplee

Experience

- Arizona Audubon Interim Executive Director, January 2015-present
- Arizona Director of Bird Conservation, National Audubon Society, 2005-present
- Phoenix College (Maricopa County Community Colleges), Adjunct Faculty, 2006-present
- Game Branch Chief, Arizona Game and Fish Department, 1988-2004
- Wildlife Habitat Program Manager, Tucson, Arizona Game and Fish Department 1979-1988
- Research Assistant, Arizona Game and Fish Department 1975-1979
- Research Assistant, University of Arizona Environmental Research Lab 1973-1975

Education

- M.S. University of Arizona, Wildlife Management 1981
- B.S. Cornell University, Wildlife Ecology 1973



Tice Supplee

Certifications

- Arizona Certified Public Manager 1988
- The Wildlife Society - Certified Wildlife Biologist 1983
- Certified Arizona Peace Officer (retired Arizona Game Ranger) 1979-2004

Achievements

- National Audubon Society Fellowship 2008
- U.S. Department of Interior Cooperative Conservation Award-2008
- National Audubon Society ACE Award-2007
- Arizona Wildlife Federation-Thomas E. McCullough Award-2005
- Arizona Wildlife Federation-Wildlife Conservationist Award-1987
- The Wildlife Society Professional Service Award - Arizona Chapter 1985

Tice Supplee

Boards and Organizations

- Arizona Elk Society Board Member, 2005-2007; Vice President 2014 to present
- Phoenix Sonoran Preserve and Mountain Parks/Preserves Committee member 2014 to present
- Arizona Antelope Foundation President, 2008-2009; board member 2005-present
- Audubon Arizona representative Upper San Pedro Partnership Advisory Committee 2007-2010
- Sonoran Joint Venture technical committee member 2005- present
- Sonoran Audubon Society board member, recording secretary, and chapter representative to the Arizona Audubon Council 2000-2004
- Intermountain West Joint Venture - managing board member and technical committee chair 1993-2004
- Southeastern Arizona Environmental Council board member 1980-1988
- The Wildlife Society Southwest Section President 1983 and 2008
- The Wildlife Society Arizona Chapter member 1975-present and President 1981

Audubon's Important Bird Area Program

- Bird Life International Program sponsored by National Audubon in the US and initiated in Arizona by Tucson Audubon.
- Arizona IBA Program now co-administered Tucson Audubon and National Audubon's State Office in Arizona (Audubon Arizona) in partnership with AzGFD.
- Scientific review process on a state and national level.
- 45 designated IBA's in Arizona.
- State, Continental and Globally Important Designations.

Audubon's Important Bird Area Program

- IBAs potentially affected by SunZia:
- Pinaleno Mountains Global IBA,
- Willcox Playa and Cochise Lakes Global IBA,
- Lower San Pedro and Tucson Sky Island Global IBAs,
- Cienega Creek Potential Important Bird Area. Located southeast of Tucson, this small riparian habitat is a Pima County designated conservation area that has habitat for riparian obligate birds and native fishes. One of the Tucson route alternatives cuts through this site and another is immediately adjacent, closer to the interstate corridor. Audubon strongly recommends avoidance of this riparian habitat.

Pinaleño Mountains State IBA

- **State: Species of Conservation Concern**, Global Spotted Owl.
- **State: Species in rare/unique habitat**.
- One of the Western Apache's four holiest mountains, considered sacred by all of the region's Native peoples, Dził Nchaa Si An ranks as the largest (~330,000 acres) property listed on or formally determined eligible for the National Register of Historic Places.
- University of Arizona Tree Ring Laboratory researchers have discovered living trees that date back to 1257 and 1270 AD.
- **Species of Conservation Concern** include: Wild Turkey, Peregrine Falcon, Mexican Whip-poor-will, Mountain Pygmy Owl, Magnificent Hummingbird, Dusky-capped Flycatcher, Olive Warbler, Virginia's Warbler, Black-throated Warbler, Grace's Warbler, Red-faced Warbler and Yellow-eyed Junco.
- **Threatened Mexican Spotted Owl** surveys have documented enough breeding pairs to qualify this site as a Global IBA.

Willcox Playa and Cochise Lakes Global IBA

- **Important to Special Status Avian Species** – Swainson's Hawk, Scaled Quail, Chestnut-collared Longspur and Cassin's Sparrow
- **Significant Concentrations of Birds** – Shorebirds (100+)
- **Significant Concentrations of Birds** – Cranes (2000+)
- Over-wintering Sandhill Cranes and migratory and wintering shorebirds, waterfowl, and water birds use the area for roosting, resting, and feeding.
- Wilson's Phalarope, Willet, Least Sandpiper, Western Sandpiper, Long-billed Dowitcher, Black-necked Stilt, White-faced Ibis, and American Avocet stop-over in substantial numbers.
- Cochise Lakes support many species of ducks and grebes including Pied-billed Grebe, American Wigeon, Northern Shovelor, Ruddy Duck, Lesser Scaup, Ring-necked Duck, Cinnamon Teal and Green-winged Teal .

Willcox Playa and Cochise Lakes Global IBA

- Sandhill Cranes, typically 4,000 to 9,000 birds, depend heavily on the surrounding agricultural lands of the broader Sulphur Springs Valley for feeding.
- Peregrine Falcon and Merlin prey on the duck and shorebird community.
- Scaled Quail, Cassin's Sparrows, Bendire's Thrashers, and Swainson's Hawks nest on the perimeter of the playa.
- Occasionally, flocks of Chestnut-collared Longspurs and McCown's Longspur over-winter and/or pass through during migration, foraging in the grasslands.

Lower San Pedro River Global IBA

- This River's forest is host to 345 species of birds including 13 species of breeding raptors, and is a major hemispheric migratory pathway for neotropical birds such as Gray Hawk and the rare Western Yellow-billed Cuckoo
- 80 species of mammals (including beaver), 40 species of reptiles and amphibians, 100 species of butterflies and 20 species of bats
- The San Pedro River serves as a corridor between the Sky Islands of the Madrean Archipelago in northern Sonora and southern Arizona and, in the north, Arizona's Central Highlands. The river is not only a major corridor between varied habitat types and ecoregions; it represents a ribbon of water and riparian vegetation in an otherwise arid environment. The river thus exhibits a remarkably high biodiversity, both in resident and migratory species.

Lower San Pedro River Global IBA

- **Global IBA** for Bell's Vireo.
- **Continental IBA** for Abert's Towhee.
- **Conservation Stewards**: Tucson Audubon Society, The Nature Conservancy, Cascabel Working Group, Redington and Winkleman NRCDs.
- The majority of the land is privately owned and only select properties in public ownership or under conservation easement and management are specifically included in the IBA.
- **Ownership and Management**: Arizona Game and Fish Department, BLM, Bureau of Reclamation, Salt River Project, The Nature Conservancy, Pima County, Private.
- **Special Status Avian Species:** SW Willow Flycatcher, Gray Hawk, western DPS of the Yellow-billed Cuckoo, Bell's Vireo, Northern Beardless-Tyrannulet, Lucy's Warbler, Abert's Towhee, Brewer's Sparrow.

Lower San Pedro River Global IBA

- **Rare, Unique, or Exceptional Representative Habitat/Ecological Community** – Low Elevation Riparian River.
- **Significant Concentrations of Birds**: Southwestern Willow Flycatcher >40% Arizona breeding population, Mississippi Kite >40% Arizona breeding population, and Gray Hawk >30% Arizona breeding population.
- **Land birds** (significant #s, density, and/or diversity): Bell's Vireo, Yellow Warbler.
- **State Species of Conservation Concern**: Western Yellow-billed Cuckoo, Belted Kingfisher, Red-naped Sapsucker, Olive-sided Flycatcher, Southwestern Willow Flycatcher, Tropical Kingbird, Thick-billed Kingbird, Western Purple Martin, Gray Hawk, Common Black Hawk, Zone-tailed Hawk, Mississippi Kite.

Tucson Sky Island Global IBA

- **Global IBA** for Mexican Spotted Owl
- **Conservation Stewards:** Tucson Audubon Society
- **Ownership and management:** US Forest Service, National Park Service, Pima County
- **Special Status Avian Species:** Costa's Hummingbird, Gilded Flicker and Elf Owl. Wild Turkey, Red-faced Warbler, Grace's Warbler, Olive Warbler, Buff-breasted Flycatcher, Elf Owl, Whiskered Screech-Owl and Mexican Spotted Owl, Elegant Trogon.
- **Rare, Unique, or Exceptional Representative Habitat/Ecological Community**: Arizona Upland subdivision of the Sonoran desert, riparian areas and canyons, mixed conifer forests, and Madrean evergreen pine and oak woodlands.

Tucson Sky Island Global IBA

- **State Species of Conservation Concern:** Northern "Apache" Goshawk, Golden Eagle, Gould's Turkey, Whiskered Screech-owl, Northern Pygmy Owl, Mexican Spotted Owl (1a), Broad-billed Hummingbird, Magnificent Hummingbird, Gila Woodpecker, Arizona Woodpecker, Gilded Flicker, Buff-breasted Flycatcher, Bell's Vireo, Desert Purple Martin, MacGillivray's Warbler, Abert's Towhee, Rufous-winged Sparrow, Lincoln's Sparrow

SunZia Route Alternatives: Impacts to IBAs

Riparian woodlands comprise a very limited geographical area that is entirely disproportionate to their landscape importance, recreational value, and immense biological interest. It has been estimated that only 1% of the western United States historically constituted this habitat type, and that 95% of the historic total has been altered or destroyed in the past 100 years. Riparian woodlands are among the most severely threatened habitats within Arizona. Maintenance of existing patches of this habitat, and restoration of mature riparian deciduous forests should be among the top conservation priorities in the state.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- Services provided to humans from ecological systems have become a key issue of this century in resource management, conservation planning, and environmental decision analysis.

- Mapping and quantifying ecosystem services have become strategic national interests for integrating ecology with economics to help understand the effects of human policies and actions and their subsequent impacts on both ecosystem function and human well-being.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- The study maps 20 biodiversity metrics reflecting ecosystem services or other aspects of biodiversity for all vertebrate species except fish.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- The study maps metrics throughout large multi-state regions and compares the metric values obtained for selected watersheds within the regional context.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- Metric values for the two southwestern watershed study areas were generally greater than those for the southwest region as a whole.
- The Southwest study area represents approximately 20% of the conterminous United States.
- SWReGAP modeled habitat for 817 terrestrial vertebrate species that reside, breed, or use the habitat within the 5-state Southwest study area for a significant portion of their life history.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- The San Pedro watershed has significant ecological value. It supports one of the highest numbers of mammal species in the world and provides critical habitat and a migration corridor for hundreds of bird species.
- Total species richness is a fundamental metric of biodiversity that is used to characterize conservation areas of interest.
- Metrics reflecting harvestable species and high bird species richness represent economic, recreational, and esthetic value.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- AzGFD has established a recreation strategy to "identify, assess, develop, and promote watchable wildlife recreational opportunities" in addition to promoting sustainable harvests via hunting.
- Among the harvestable subgroups, metric values for big game, small game, and upland game are greater in the San Pedro study area and provide recreational and cultural services.
- The majority of diversity metrics for the San Pedro study area are greater than for the Rio Grande study area.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- This bar graph represents another way of visualizing the comparison of maintenance of biodiversity and habitat provided by the San Pedro study area, the Rio Grande study area, and the Southwest region.

- The vast majority of metrics reflect the regional importance of the San Pedro River watershed.

Boykin, Kepner et al
Quantifying Biodiversity and Ecosystem Services

- This slide illustrates the relative values of the regions modeled for high biodiversity and species richness.

- The San Pedro River watershed demonstrates the highest levels of species richness and biodiversity in the Southwest and Southeast regions of the nation.

The lower San Pedro River Valley watershed

- Approximately one third of the lower river valley corridor is now in protected status, and stream flow and habitat conditions are improving.
- The Valley has been a focal point for conservation and mitigation investments because of the opportunity to protect and restore a relatively undisturbed river system, cross-valley wildlife movement, and ecological processes such as fire that maintain ecosystem health.
- The proposal to cross any protected conservation lands with a disrupting power line diminishes the value of these lands for ecological conservation, land owner or manager agreement not-with-standing. Audubon Arizona believes that the FEIS and BO inadequately studied the Arizona portion of the proposal, in comparison to the extensive studies done in New Mexico.

Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

- This report assesses the 2011 economic contributions of watchable wildlife recreation in Arizona, statewide, by county and by specific types of activity.
- Direct spending by both residents and non-residents for wildlife watching was analyzed, along with the multiplier effects of that spending.
- Only watchable wildlife activities that occurred within Arizona were considered.
- Overall, 1.6 million people participated in some form of residential or non-residential watchable wildlife recreation in Arizona in 2011.

Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

- The primary residential and non-residential watchable wildlife activity was observing wildlife.
- **The number one type of wildlife observed by residential recreationists in Arizona was birds.**
- **The second most prominent category to be observed by residents was mammals, followed by amphibians and reptiles.**
- Regarding trip expenditures, residents spent the largest amount on private transportation ($90.5 million) followed by food, drink and refreshments ($78.2 million).
- Non-residents, on the other hand, spent the most on food, drink and refreshments ($63.9 million), followed private transportation ($47.1 million).
- The largest equipment expenditures by Arizona residents were for pickups, campers or motor homes ($121.7 million), followed by cameras ($58.5 million) and plantings for wildlife ($56.6 million).

Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

- In total residents spent $665.0 million for watchable wildlife recreation.
- Non- residents spent $183.7 million, which represents new dollars brought into the state economy by out-of-state visitors.
- Original expenditures made by watchable wildlife recreationists generate rounds of additional spending throughout the economy.
- This results in additional indirect and induced impacts that are commonly called the multiplier effect.
- Economic activity associated with both the direct spending and multiplier effects impacts is the total economic contribution resulting from the original expenditures.
- The total economic effect from 2011 watchable wildlife activities in Arizona was $1.4 billion ($1.1 billion by residents and $314.6 million by non-residents).
- The sample size for Greenlee County was too small – data was unavailable.

Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

- Total personal income (salaries and wages) supported by watchable wildlife recreation in Arizona was estimated at $463.6 million ($356.6 million by residents and $106.9 million by non-residents).
- During 2011, watchable wildlife recreation supported approximately 12,900 full and part-time jobs in Arizona (approximately 9,900 related to residents' spending and approximately 3,000 related to non-residents' spending).
- These are jobs that are associated with direct spending by wildlife watchers plus the jobs in industries that are indirectly affected by wildlife watching through the multiplier effect.
- The economic activity related to wildlife watching by residents and non-residents generates sales tax revenues for the state and local governments.
- Total state and local tax revenues generated by watchable wildlife recreation are estimated at $71.7 million by residents and $22.2 million by non-residents.
- Total federal tax revenues generated by watchable wildlife recreation are estimated at $105.8 million.

Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

Economic Contributions of All Watchable Wildlife Recreation in Arizona, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	Non-Residents	TOTAL
Cochise	Retail Sales	$7,357,921	$3,546,665	$3,227,150	$14,190,743
	Total Multiplier Effect	$12,470,790	$6,031,619	$5,528,034	$24,130,389
	Salaries and Wages	$3,830,269	$1,913,801	$1,878,401	$7,651,115
	Full & Part-Time Jobs	127	56	53	234
	State & Local Tax Revenue	$816,778	$359,172	$390,684	$1,570,931
	Federal Tax Revenue	$929,261	$408,610	$425,603	$1,769,276
Graham	Retail Sales	$4,446,570	$1,447,610	$1,440,366	$7,283,288
	Total Multiplier Effect	$7,455,617	$2,457,967	$2,467,315	$12,292,101
	Salaries and Wages	$2,378,423	$781,026	$838,383	$3,977,764
	Full & Part-Time Jobs	61	22	24	105
	State & Local Tax Revenue	$475,759	$159,869	$174,373	$806,268
	Federal Tax Revenue	$541,824	$181,325	$189,958	$908,067

Contributions of Wildlife Viewing to the Arizona Economy: A County-Level Analysis

Economic Contributions of All Watchable Wildlife Recreation in Arizona, by County where the Activity Occurred in 2011

		County Residents	Residents From Other Counties	Non-Residents	TOTAL
Pima	Retail Sales	$95,440,007	$40,537,825	$42,208,205	$179,459,718
	Total Multiplier Effect	$161,002,669	$68,771,763	$72,301,688	$304,368,133
	Salaries and Wages	$51,012,094	$21,869,589	$24,567,791	$97,947,943
	Full & Part-Time Jobs	1406	614	688	2736
	State & Local Tax Revenue	$10,252,806	$4,411,036	$5,109,794	$19,866,395
	Federal Tax Revenue	$11,666,952	$5,016,001	$5,566,505	$22,374,716
Pinal	Retail Sales	$23,141,009	$13,572,187	$14,677,151	$52,631,795
	Total Multiplier Effect	$39,067,381	$23,007,700	$25,141,624	$89,450,156
	Salaries and Wages	$12,384,663	$7,321,508	$8,543,012	$28,733,395
	Full & Part-Time Jobs	341	203	239	812
	State & Local Tax Revenue	$2,490,479	$1,468,670	$1,776,840	$5,826,399
	Federal Tax Revenue	$2,833,792	$1,670,505	$1,935,653	$6,562,038

ECONOMIC SECTORS STIMULATED BY RESIDENT+NONRESIDENT WILDLIFE WATCHING SPENDING

	Total Output (Sales)	Employment	Income
Ag, Forestry, Fish & Hunting	79,221,793	1,402	15,464,831
Mining	38,683,906	324	6,086,188
Utilities	15,826,239	27	3,265,830
Construction	10,375,163	77	4,044,720
Manufacturing	249,473,696	574	38,188,913
Wholesale Trade	118,192,670	719	53,432,251
Retail trade	191,677,954	2,864	90,472,109
Transportation & Warehousing	79,399,937	521	29,874,434
Information	36,494,376	137	7,822,203
Finance & insurance	86,161,603	470	23,901,612
Real estate & rental	141,594,658	581	11,747,431
Professional- scientific & tech svcs	42,773,983	392	23,378,904
Management of companies	12,005,983	78	5,848,491
Administrative & waste services	28,584,852	452	14,902,529
Educational svcs	7,623,480	116	4,435,439
Health & social services	56,391,568	578	31,885,933
Arts- entertainment & recreation	7,434,417	152	3,233,180
Accomodation & food services	148,140,231	2,199	51,483,151
Other services	57,419,015	985	27,147,402
Government & non NAICs	30,722,079	245	16,954,174
TOTAL	**1,438,197,603**	**12,892**	**463,569,725**

The Importance of Grasslands

- Grasslands are of great conservation concern for birds and other species.
- TNC has studied grasslands throughout the southwest and found that, while they are threatened by shrub and non-native species incursion, many of our them are restorable.
- The National Fish & Wildlife Foundation has developed a business plan for sky island grasslands to compliment the ongoing conservation work in the region.
- NFWF describes these grasslands are one of America's great hotspots for wildlife diversity, hosting more than twice as many mammal species as Yellowstone National Park and supporting the nation's highest diversity of reptiles, bees and ants.
- $13-15 M targeted for investment from 2010-2020 to leverage an additional $265 M for the region.

The Importance of Grasslands

- Of the original 13 million acres of grassland, at least 2 million acres still have exceptional wildlife values and another 4 to 7 million acres of grassland could be restored.
- Target species include jaguar, bison, pronghorn, black-tailed prairie dogs, Chiricahua leopard frogs, and grassland sparrows as wildlife whose population response to conservation investments will be the best indicators of success.
- Threats include fragmentation, drought, altered fire regimes, invasive species, development, roads and other infrastructure.
- One valley can contain >50 species of native perennial grasses that provides habitat for grassland-specialist wildlife like pronghorn and prairie dogs, and movement corridors for wide-ranging species like jaguar and black bear.

TNC's Ecoregional Assessment

- TNC evaluated 238 million acres across 11 states and two countries; .>1300 species and 350 native plant communities and ecological systems were analyzed.
- TNC identified 42% of the study area where conservation should play a significant role if we are to maintain the region's biological diversity.
- BLM and USFS lands comprise 47% of the total network. Private lands comprise 19% of the network.
- In rapidly-growing areas, such as the southwest U.S., conservation options are foreclosed on a daily basis and 54% of the network has at least 3 major land managers responsible for on-the-ground management.
- Ecosystems don't stop at jurisdictional boundaries.
- The assessments better enable decision-makers, other institutions and agencies to plan unrelated activities in a manner that minimizes further losses of biological diversity.

TNC's Ecoregional Assessment

- TNC's assessments lend themselves to "watershed" or "ecosystem-based" management.
- Planning efforts underway, such as State Comprehensive Wildlife Conservation Plans, Habitat Conservation Plans, etc., can ensure integration of terrestrial and aquatic realms into a cohesive and effective set of management strategies.
- The Sonoran Desert Ecoregional Assessment relied on data and input from 110 experts from 54 public agencies, academic institutions, conservation organizations, tribes, and private resource professionals.
- AzGFD was represented on both the Apache Highlands and Sonoran Desert assessment teams.

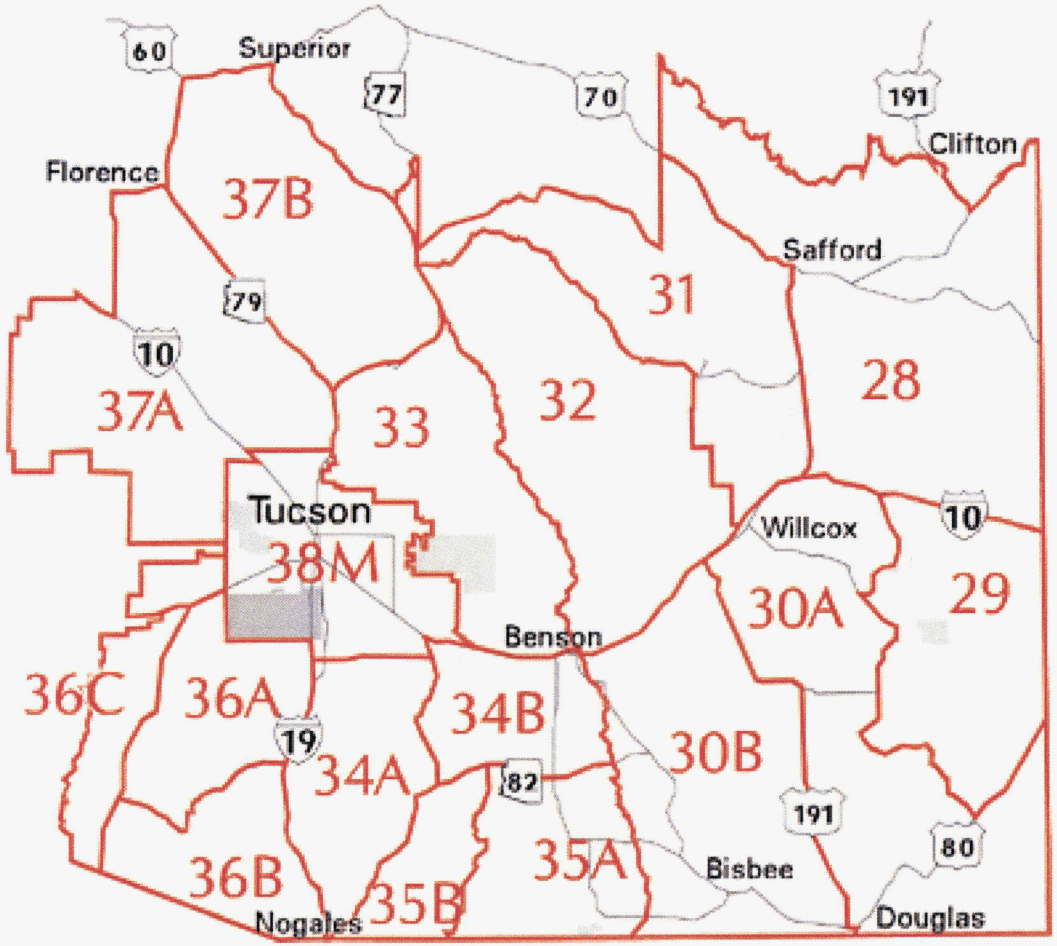
Recommendations and Concerns

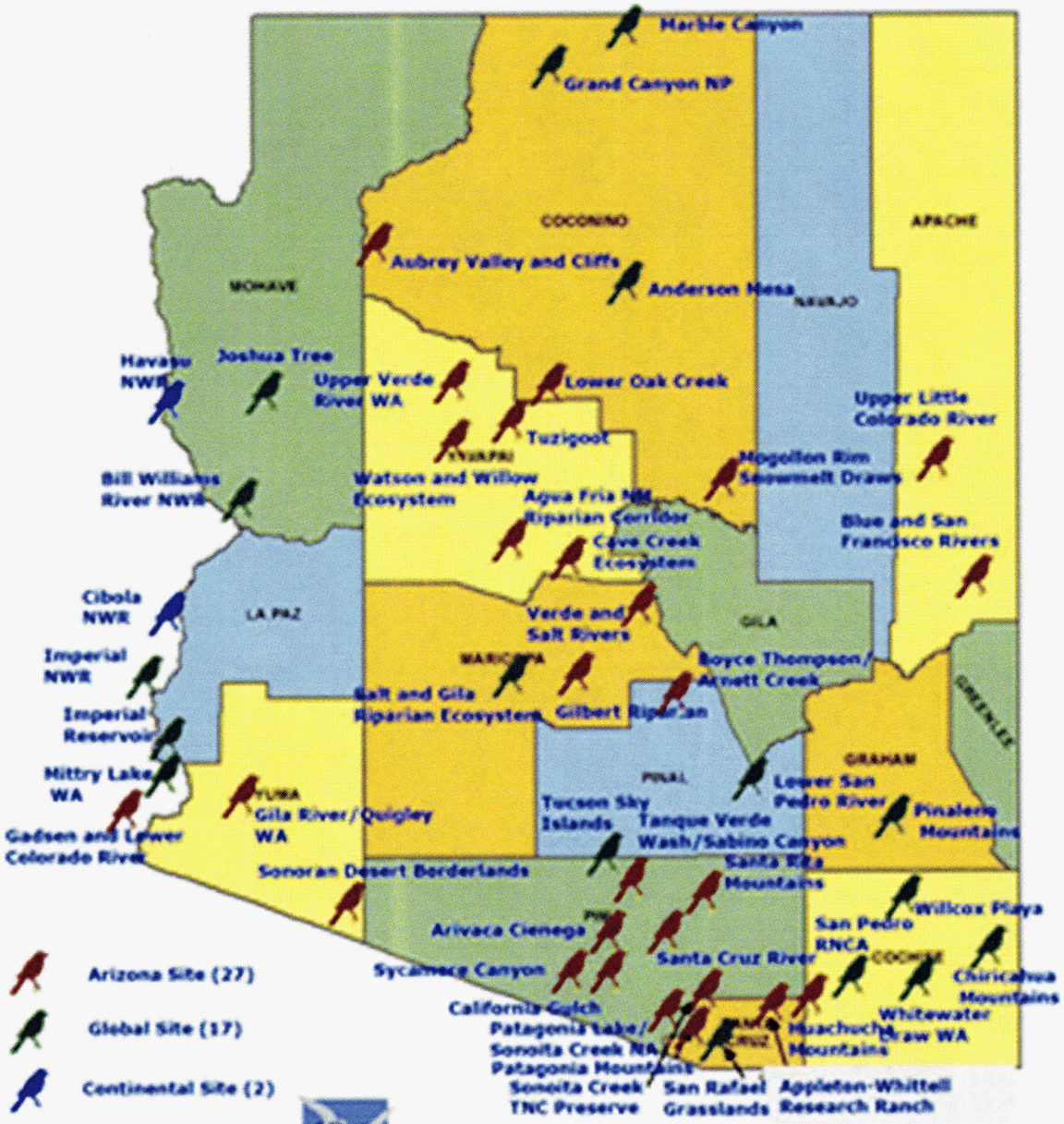
- Factors contributing to the susceptibility of a bird species to collision and the risks associated with a transmission line are (1) biological, (2) topographical, (3) meteorological, and (4) technical aspects.
- Biological aspects to consider include bird vision, flight abilities, flight speed, activity patterns, and behavior during displays, hunting, or landing.
- Topographical factors to consider include the transmission line height and alignment in relation to the surrounding terrain. Bird flight lanes often concentrate in low spots in the landscape, e.g., river and tributary drainages. Lines that run perpendicular to these areas are more apt to be hit by birds.
- Especially in the Sulphur Springs Valley segment, SunZia should consider these factors and obtain information about the major Sandhill crane and avian flight corridors north to south across Interstate 10 between the Willcox Playa and Bonita valley to the north. SunZia has yet to do studies in Arizona.
- SunZia lines should be buried through identified Sandhill crane movement and migration corridors. Research at diverse locations reveals that Sandhill crane collisions with powerlines are most prevalent for birds moving to and from feeding and roosting locations. An inferior solution to buried lines is installation of avian collision averters.

Recommendations and Concerns

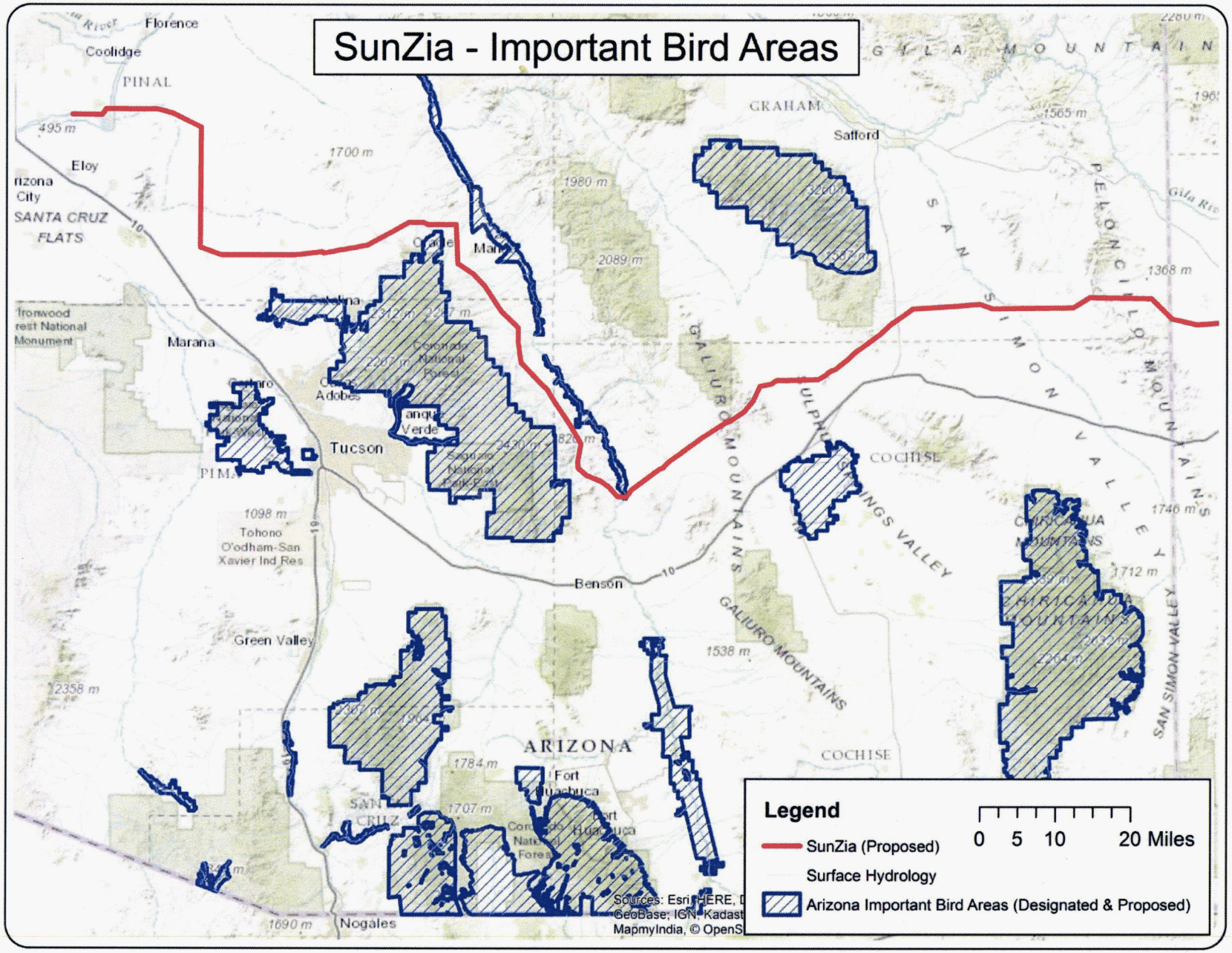
- Collisions with power transmission and distribution lines are estimated to kill as many as 175 million birds annually, and an additional tens to hundreds of thousands more birds are electrocuted.
- On certain sections of transmission lines in the San Luis Valley, where wetlands and agricultural foods are bisected by transmission lines, Sandhill Crane collision events have been as high as 75 birds a night.
- To date, specifics of construction, design, and land disturbing impacts related to surface access for construction and maintenance in sensitive habitats has been lacking.
- Of particular concern is the accidental introduction of invasive plant species including, but not limited to, African buffelgrass (a State noxious weed), blue panic (a Federal Noxious Weed), Bermuda grass, Sahara mustard, and other African Lovegrasses.
- The FEIS and BO did not specify specific design requirements to prevent the need to remove or cut trees in all riparian corridors or avoid bird strikes.
- The FEIS and BO did not include an analysis of specific construction methods to reduce and/or eliminate the need for new roads in Arizona.
- To date, suggested "mitigation measures" may reflect some best management practices, at best. Though Audubon prides itself on collaboration, in this case, meaningful mitigation may not be achievable.

Arizona Game & Fish Department Map of Region 5

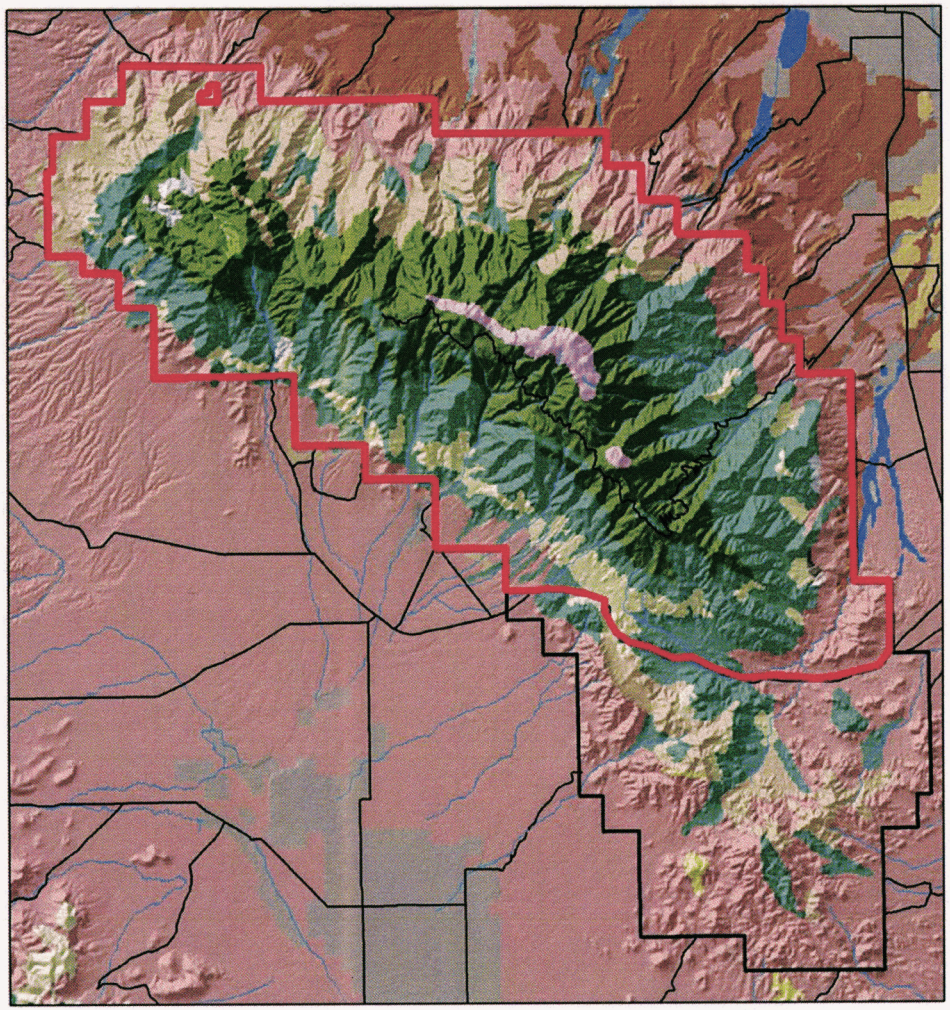



Marble Canyon
Grand Canyon NP
COCONINO
APACHE
Aubrey Valley and Cliffs
Anderson Mesa
NAVAJO
MOHAVE
Havasu NWR
Joshua Tree
Upper Verde River WA
Lower Oak Creek
Tuzigoot
YAVAPAI
Bill Williams River NWR
Watson and Willow Ecosystem
Agua Fria NM Riparian Corridor
Cave Creek Ecosystem
Mogollon Rim Snowmelt Drawn
Upper Little Colorado River
Blue and San Francisco Rivers
Cibola NWR
LA PAZ
Verde and Salt Rivers
GILA
Imperial NWR
MARICOPA
Boyce Thompson/ Arnett Creek
Salt and Gila Riparian Ecosystem
Gilbert Riparian
Imperial Reservoir
GRAHAM
Nittry Lake WA
PINAL
Lower San Pedro River
YUMA
Tucson Sky Islands
Pinaleno Mountains
Gadsen and Lower Colorado River
Gila River/Quigley WA
Tanque Verde Wash/Sabino Canyon
Sonoran Desert Borderlands
Santa Rita Mountains
Wilcox Playa
Arivaca Cienega
San Pedro RNCA
COCHISE
Sycamore Canyon
Santa Cruz River
Chiricahua Mountains
California Gulch
Whitewater Draw WA
Patagonia Lake/ Sonoita Creek NA
Huachuca Mountains
Patagonia Mountains
Sonoita Creek TNC Preserve
San Rafael Grasslands
Appleton-Whittell Research Ranch
Arizona Site (27)
Global Site (17)
Continental Site (2)
IBA
Arizona Important Bird Areas

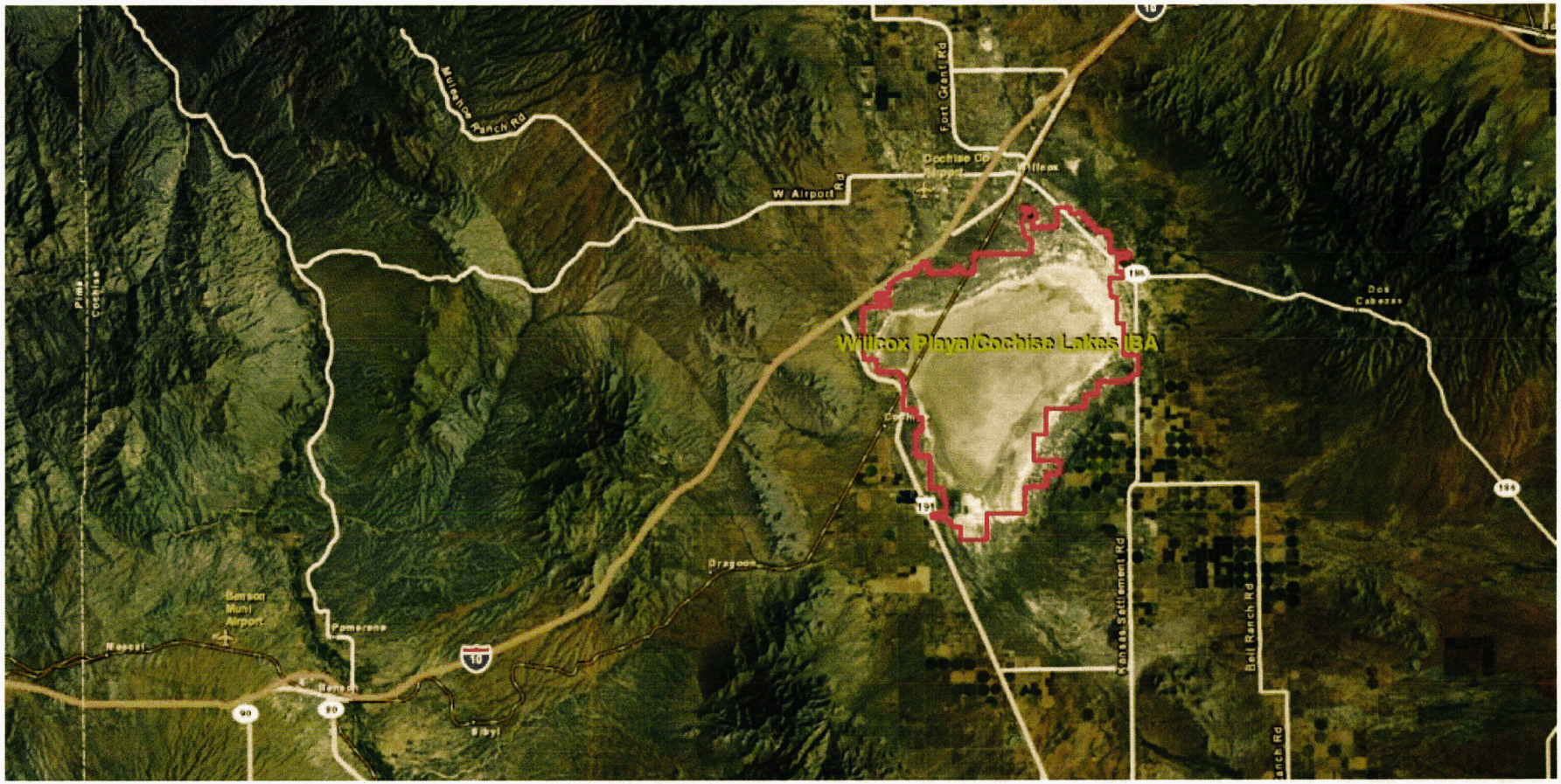
Map illustrating SunZia proposed route in relationship to IBAs



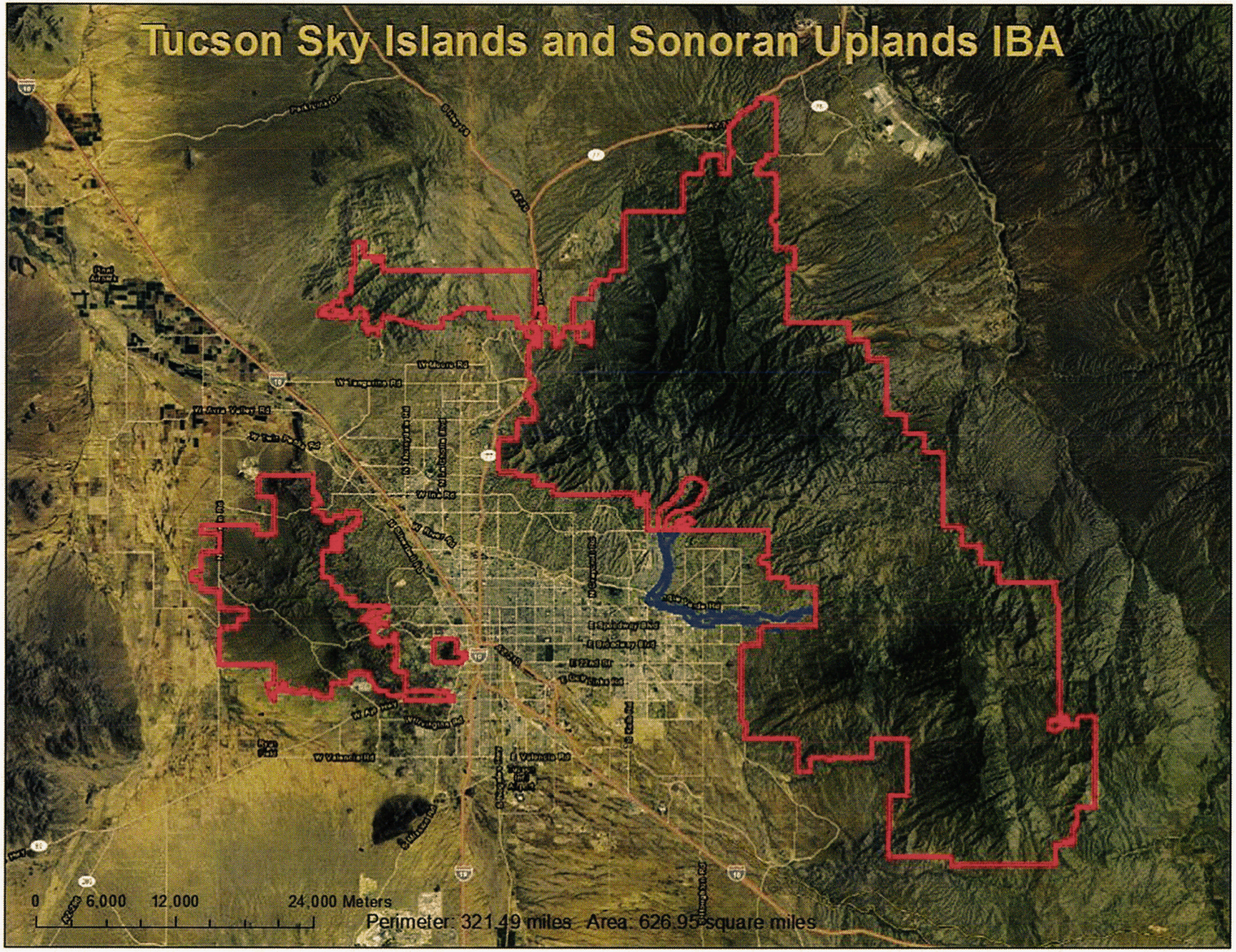
Pinaleño Mountains State IBA



Willcox Playa Global Important Bird Area



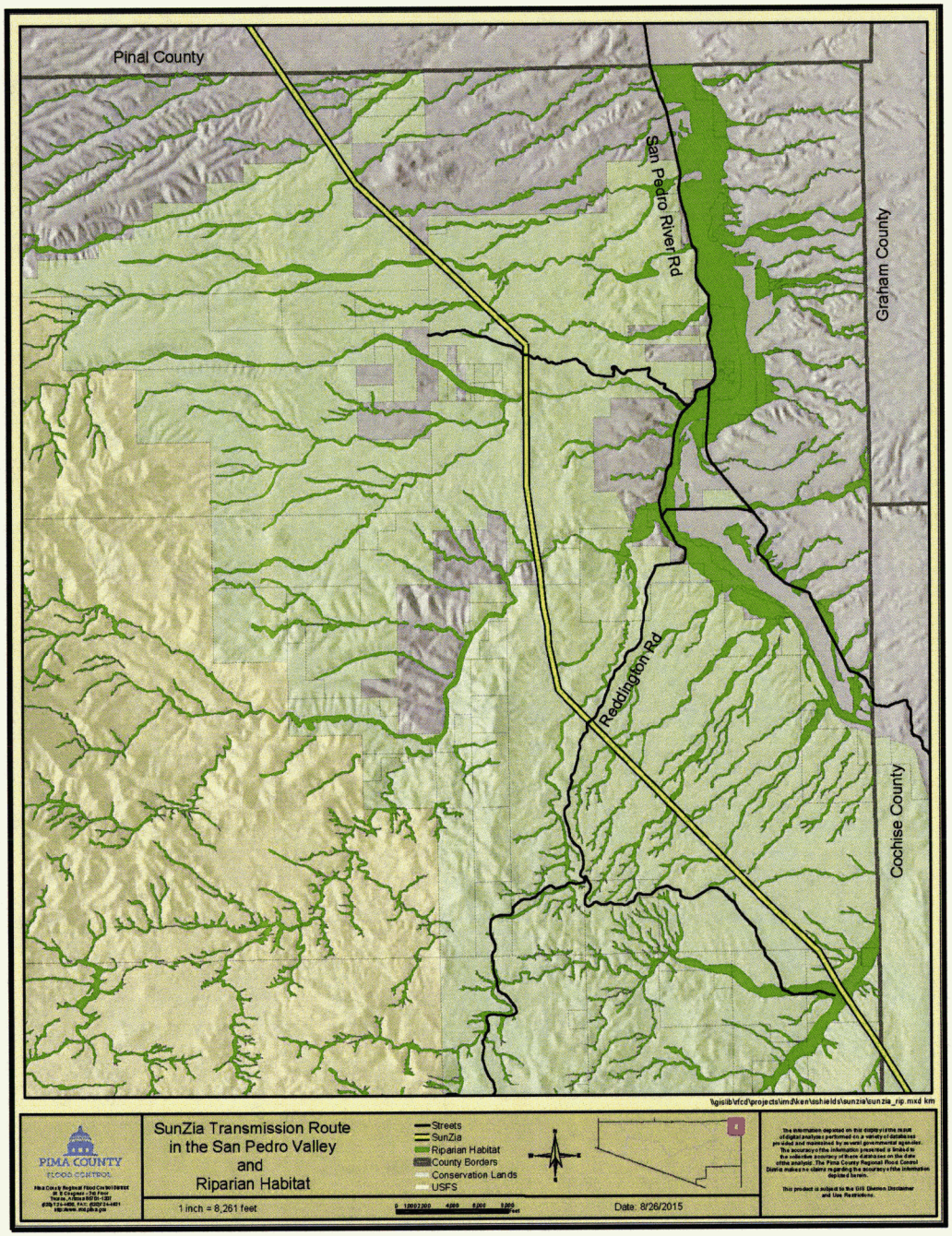
Lower San Pedro River Global IBA Map (zoomed out)



DOCKET NO. L-00000YY-15-0318-00171_MCV_1

Supplee_R-10 & 11

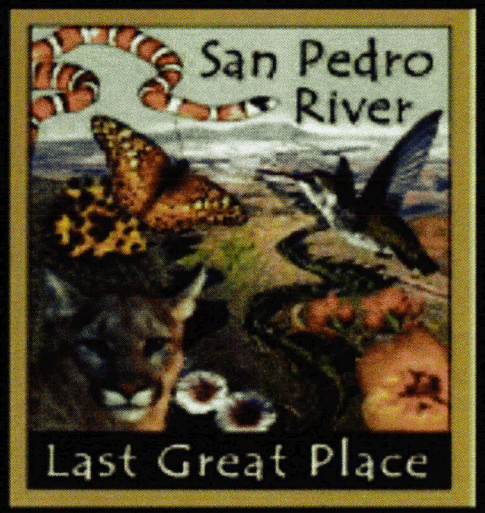
Pima County
Riparian Habitat
8/26/2015



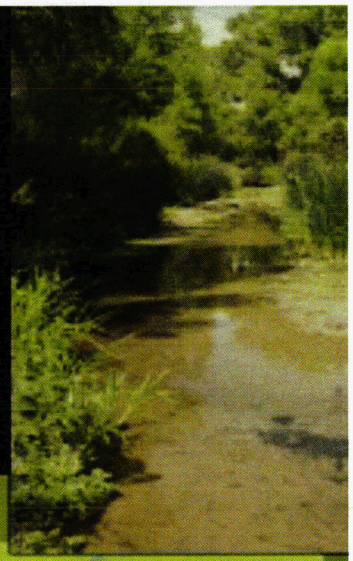
Boykin, Kepner *et al* 2012

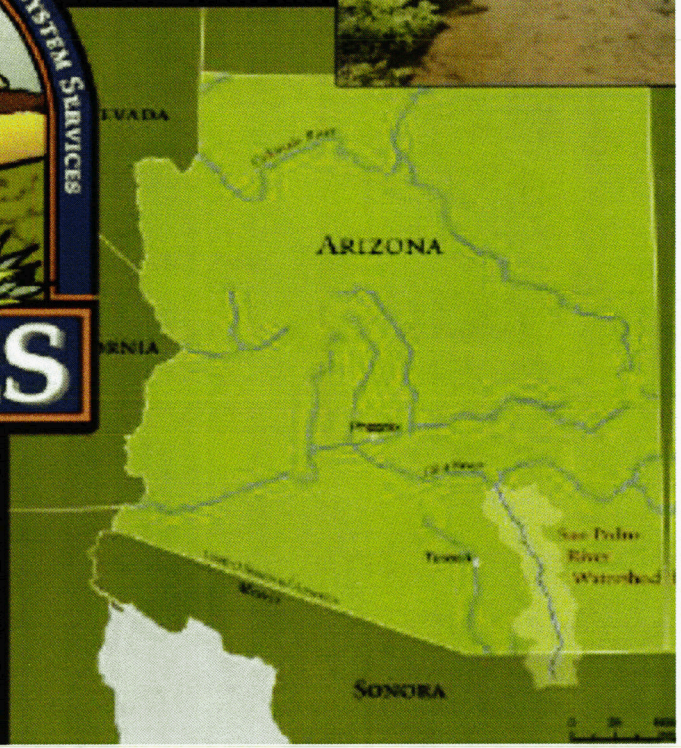
San Pedro River Basin

- AGAVES (Assessment of Goods and Valuation of Ecosystem Services)
- Prioritized Ecosystem Services
  - Water provisioning
  - Habitat provisioning
  - Carbon sequestration
  - Cultural / Recreation



ASSESSMENT OF GOODS AND VALUATION OF ECOSYSTEM SERVICES
AGAVES





Boykin, Kepner *et al.* 2012

Metrics to Measure Biodiversity

Outcomes of joint EPA/USGS/FWS Workshop on Biodiversity/Habitat Metrics (Oct. 2009, Reston, VA)

Category
Recreational Hunting
Wildlife –cultural, spiritual, intrinsic
Biodiversity for its intrinsic value, ecosystem resilience
Species Composition Intactness
Rarity/scarcity of ecological systems

Terrestrial Vertebrates	Species of Greatest Conservation Need	Harvestable Species	Ecological Systems (Land Cover)
All Species	All Species	Big Game	Richness/Diversity
Amphibians	Amphibians	Upland Game	
Birds	Birds	Furbearers	
Mammals	Mammals	Waterfowl	
Reptiles	Reptiles		
Bats			
T & E Species			

Boykin, Kepner *et al* 2012

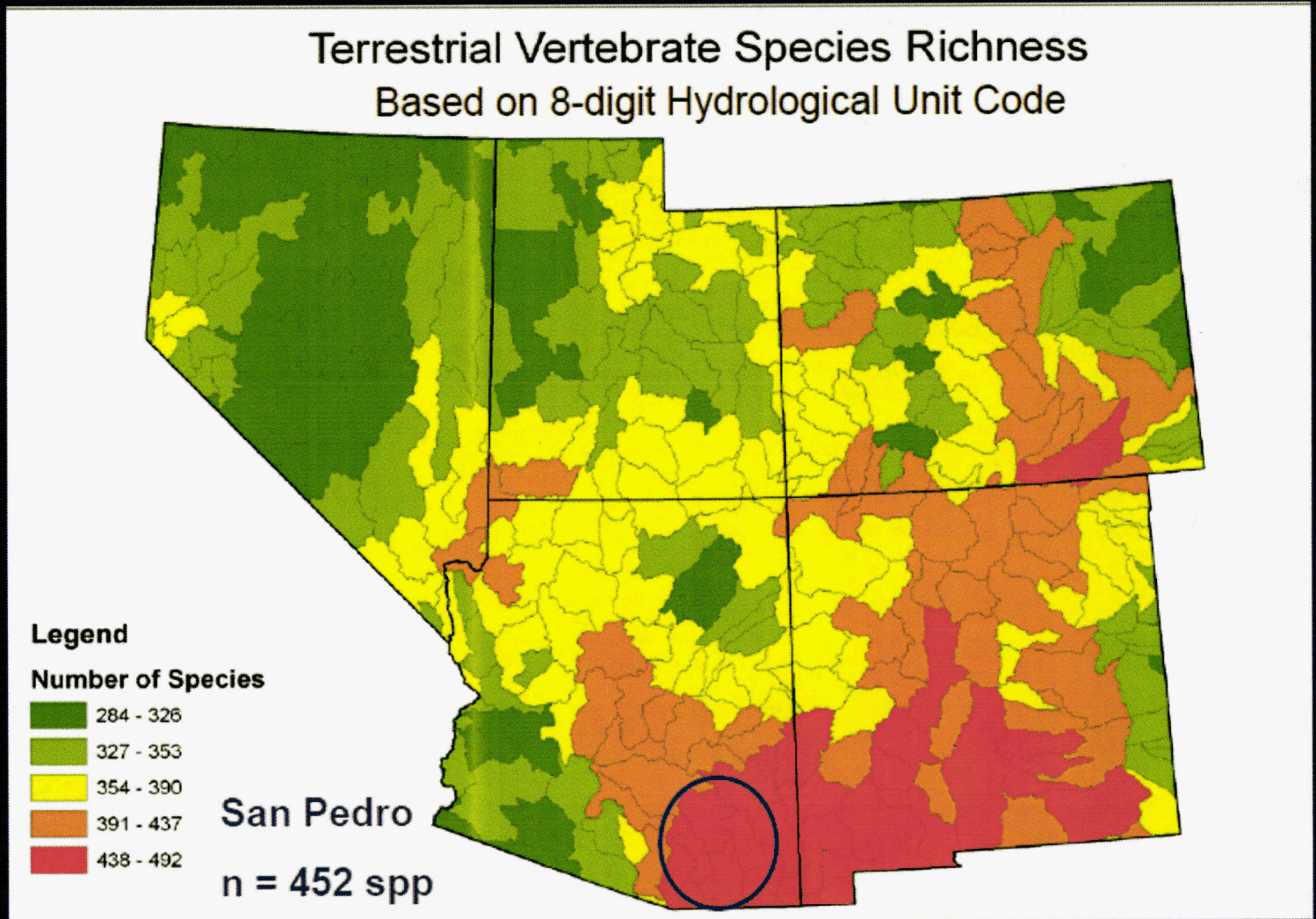
Scaling of Services

Objective

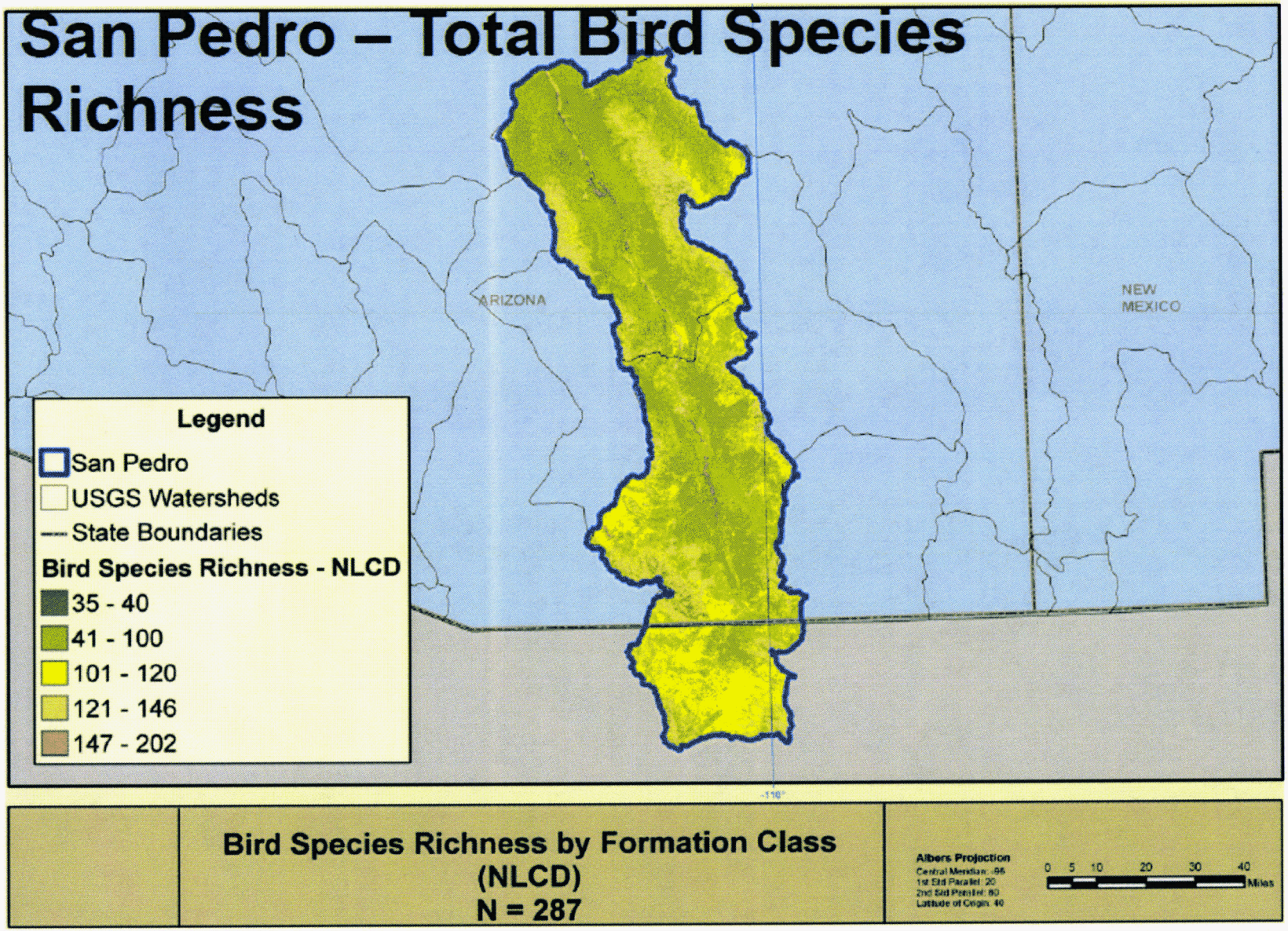
Develop and produce maps of an ecosystem service (e.g., habitat provisioning…a surrogate measure of biodiversity) based on current condition and available data for place-based, regional, and national scales of interest.

Boykin, Kepner *et al* 2012

Southwest Terrestrial Vertebrate Richness

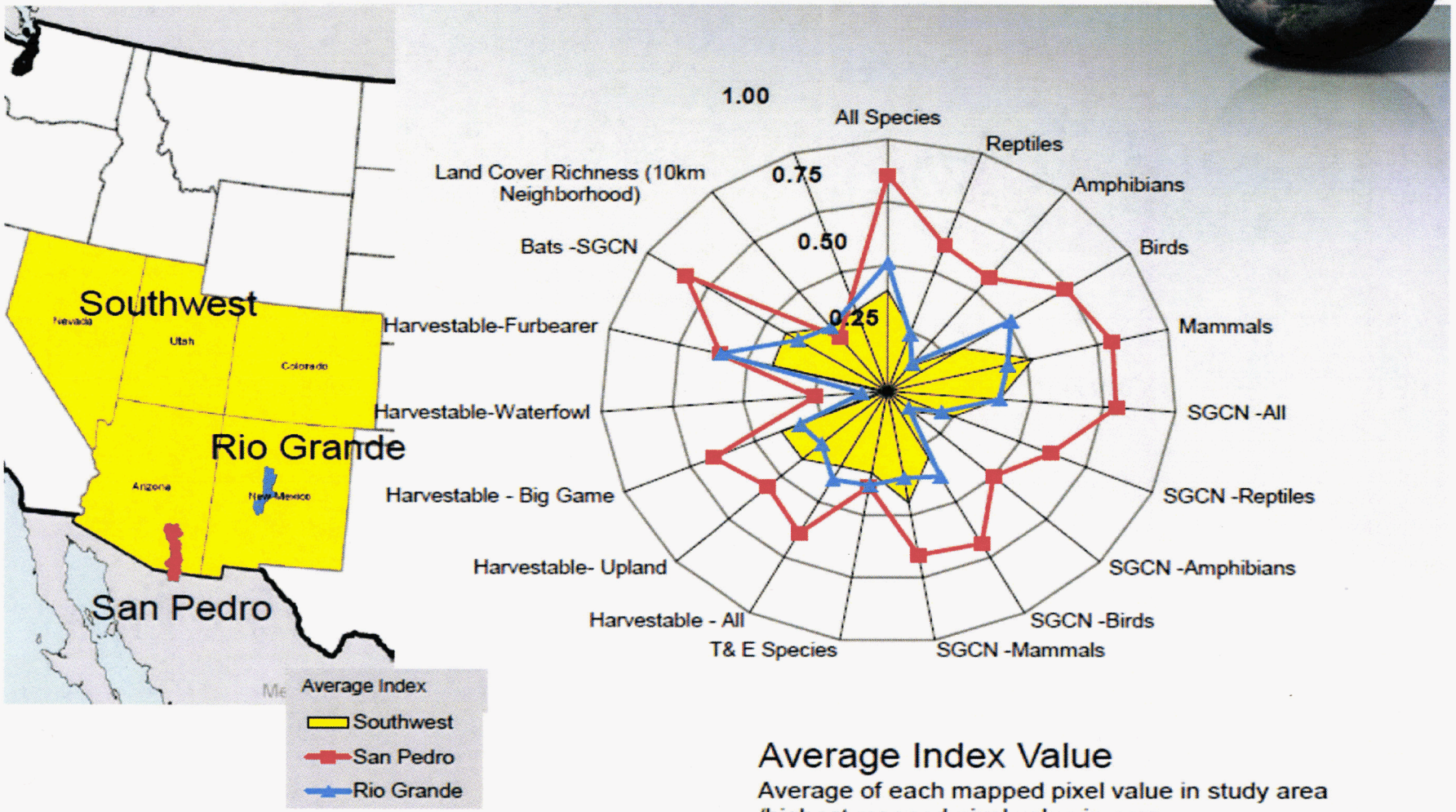


Boykin, Kepner *et al* 2012



Boykin, Kepner *et al* 2012

Radar Graphs

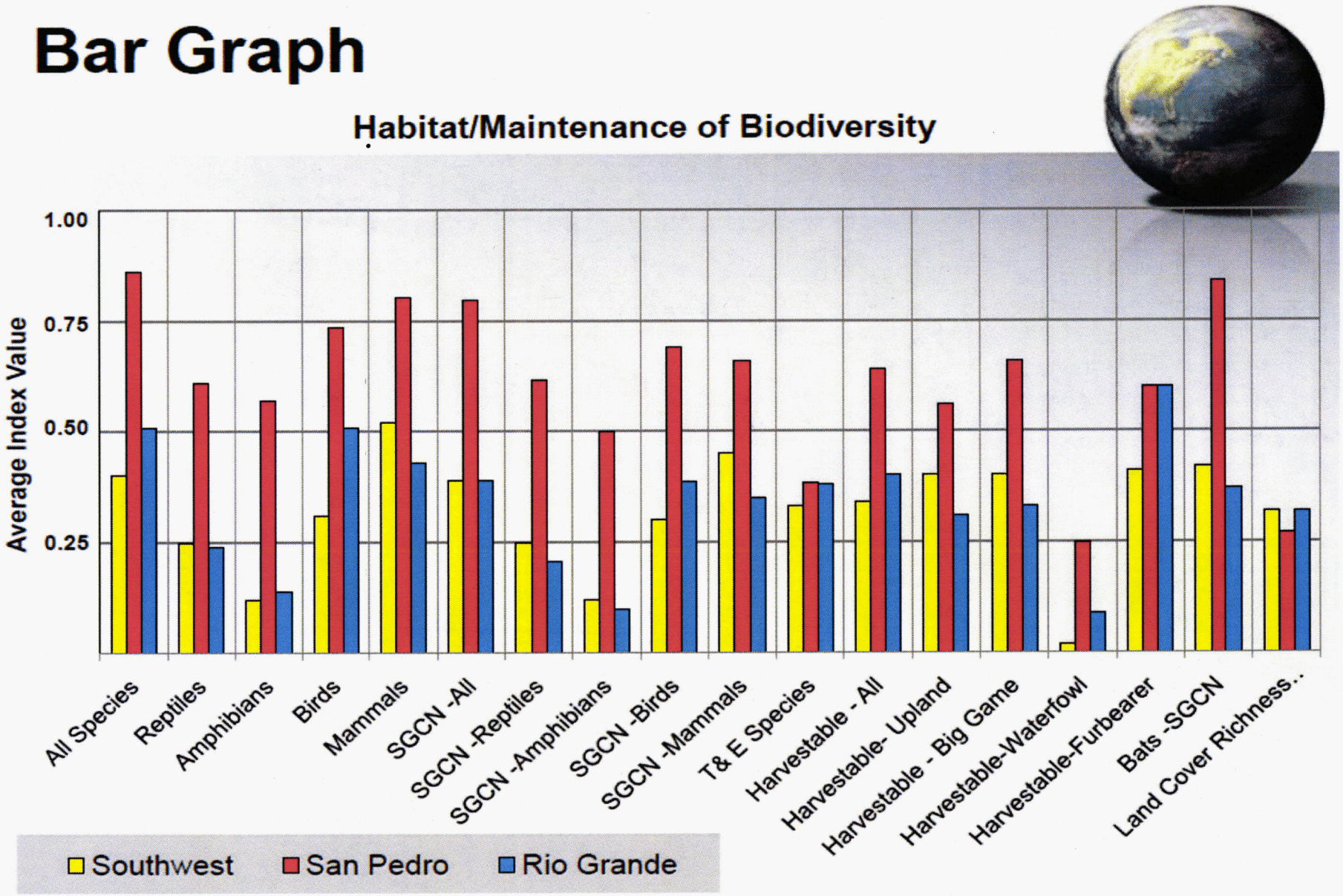


Average Index Value

Average of each mapped pixel value in study area /highest mapped pixel value in area.

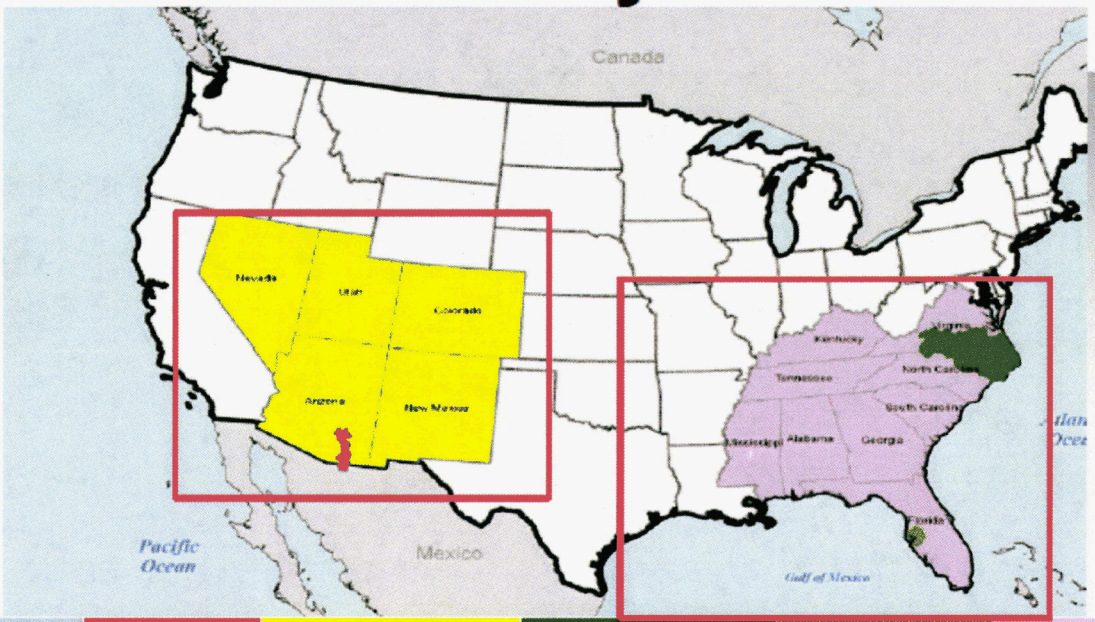
Boykin, Kepner *et al* 2012

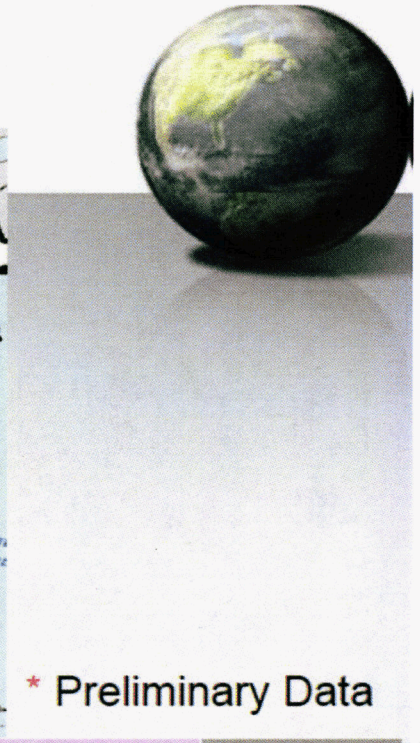
Bar Graph



Boykin, Kepner *et al* 2012

Species Richness by Scale

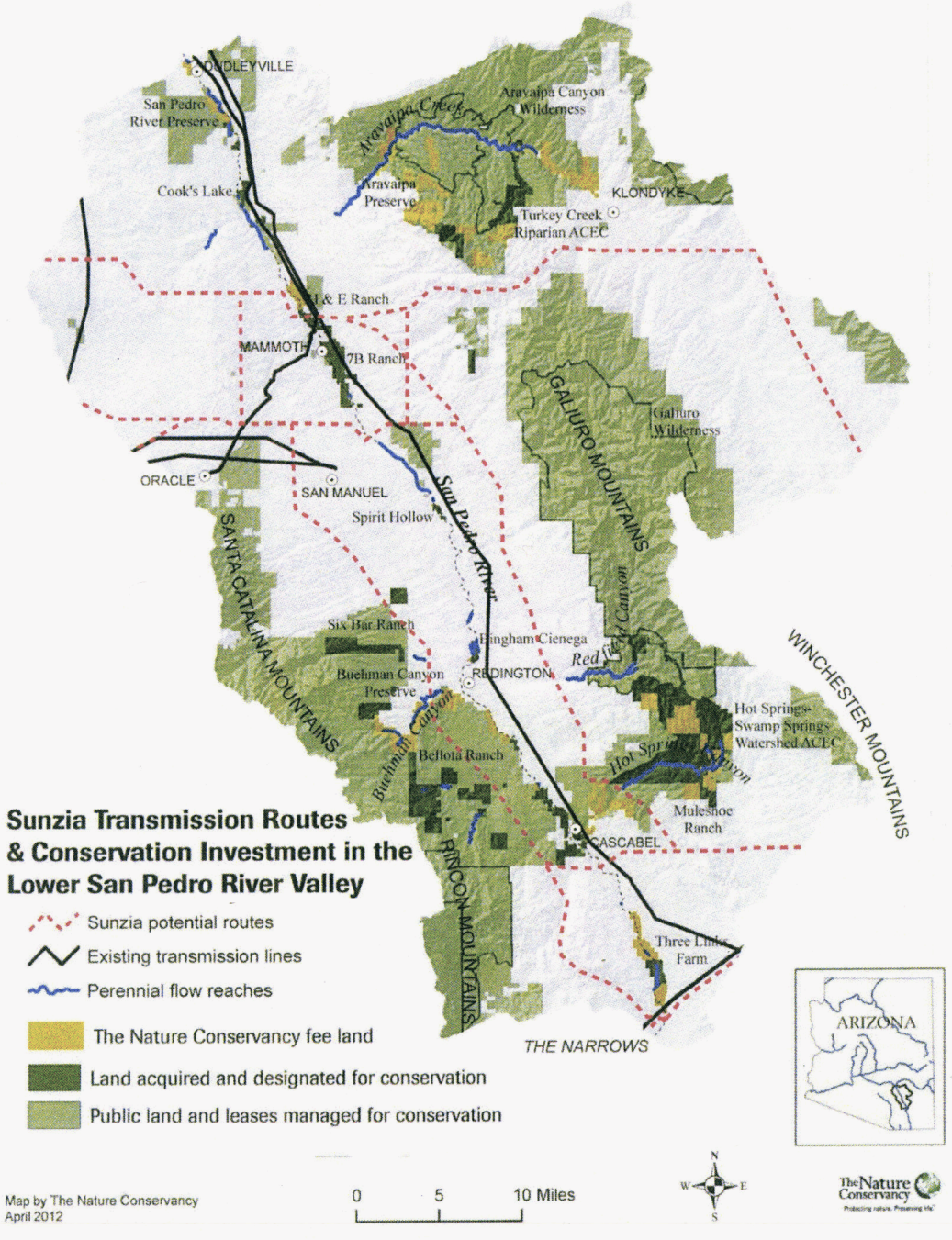


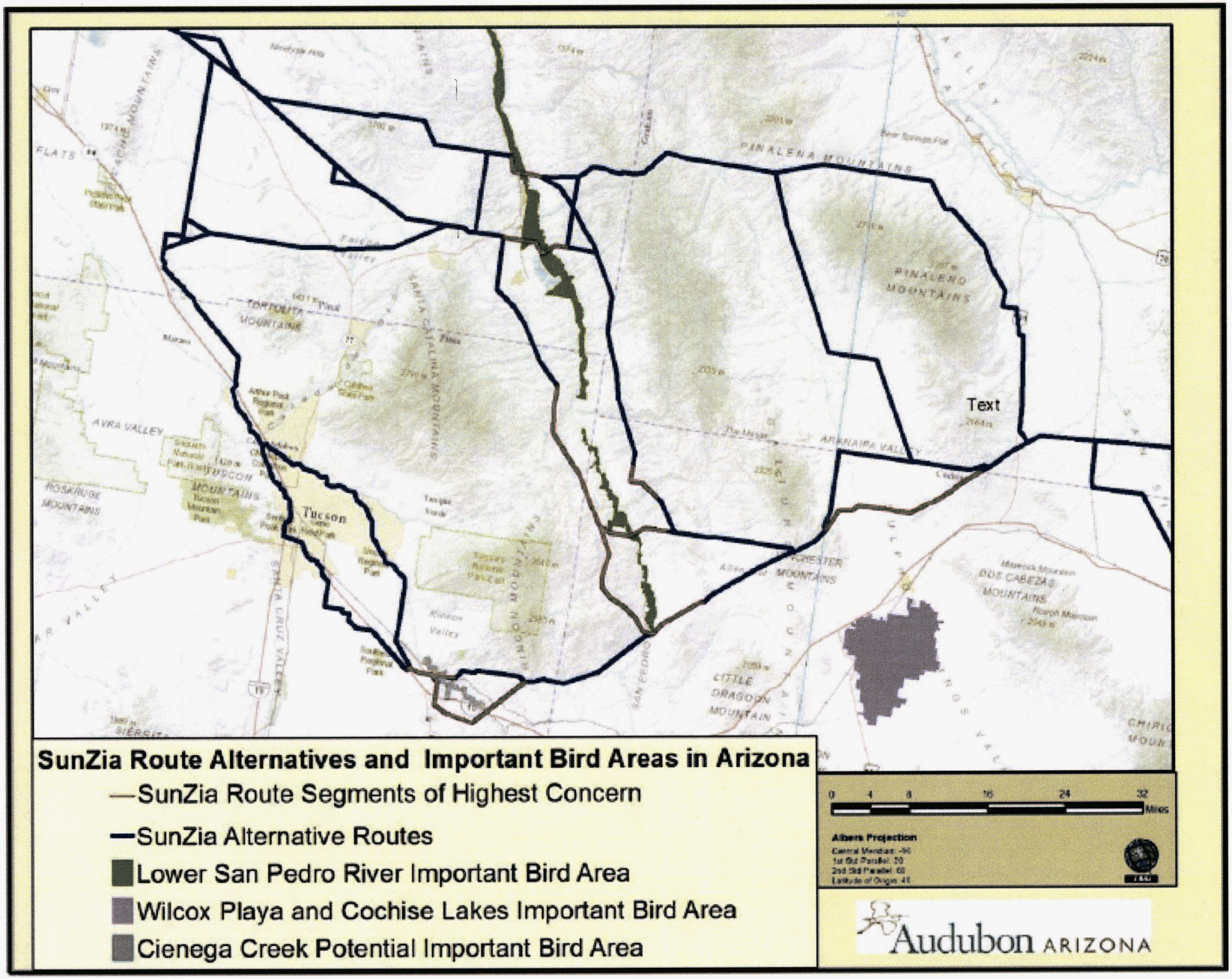


* Preliminary Data

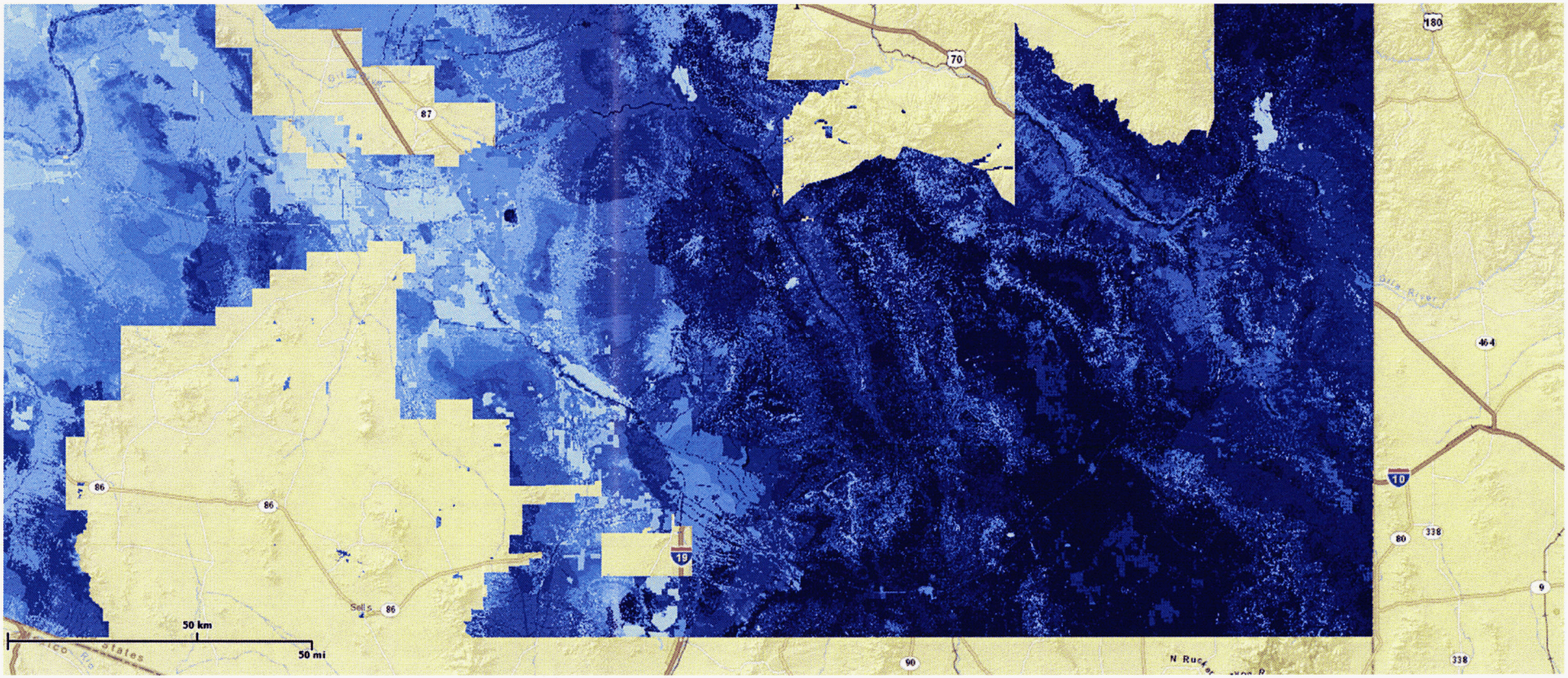
Taxon	San Pedro	Southwest	Albemarle Pamlico	Tampa Bay *	Southeast	Nation
Amphibians	16	37	40	9	124	310
Birds	287	435	155	192	259	719
Mammals	88	215	52	5	99	555
Reptiles	61	130	57	18	124	509
Total Species	452	817	304	224	606	2094

TNC 2012

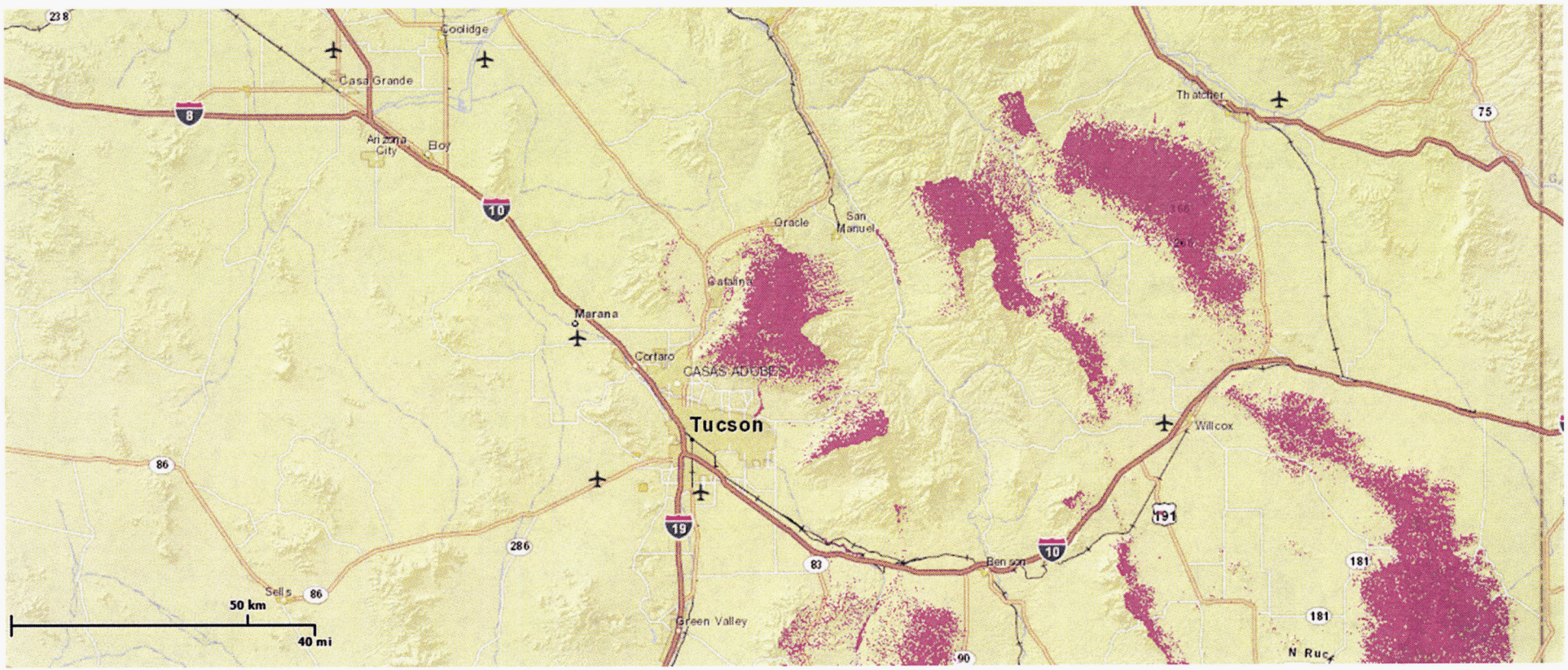

DUDLEYVILLE
San Pedro River Preserve
Aravaipa Canyon Wilderness
Aravaipa Creek
Aravaipa Preserve
Cook's Lake
KLONDYKE
Turkey Creek Riparian ACEC
L & E Ranch
MAMMOTH
7B Ranch
GALIURO MOUNTAINS
Galiuro Wilderness
ORACLE
SAN MANUEL
Spirit Hollow
San Pedro River
SANTA CATALINA MOUNTAINS
Six Bar Ranch
Bingham Cienega
Red
Buehman Canyon Preserve
REDINGTON
WINCHESTER MOUNTAINS
Hot Springs-Swamp Springs Watershed ACEC
Buehman Canyon
Bellota Ranch
Hot Springs Canyon
Muleshoe Ranch
CASCABEL
RINCON MOUNTAINS
Three Links Farm
THE NARROWS
Sunzia Transmission Routes & Conservation Investment in the Lower San Pedro River Valley
Sunzia potential routes
Existing transmission lines
Perennial flow reaches
The Nature Conservancy fee land
Land acquired and designated for conservation
Public land and leases managed for conservation
ARIZONA
Map by The Nature Conservancy
April 2012
0
5
10 Miles
N
W
E
S
The Nature Conservancy


SunZia Route Alternatives and Important Bird Areas in Arizona
—SunZia Route Segments of Highest Concern
—SunZia Alternative Routes
Lower San Pedro River Important Bird Area
Wilcox Playa and Cochise Lakes Important Bird Area
Cienega Creek Potential Important Bird Area
Text
Tucson
PINALENO MOUNTAINS
RINCON MOUNTAINS
SANTA CATALINA MOUNTAINS
TORTOLITA MOUNTAINS
AVRA VALLEY
ARIVAIPA VALLEY
SANTA CRUZ VALLEY
SAN PEDRO VALLEY
ROSKRUGE MOUNTAINS
DOS CABEZAS MOUNTAINS
LITTLE DRAGOON MOUNTAIN
Albers Projection
Audubon ARIZONA

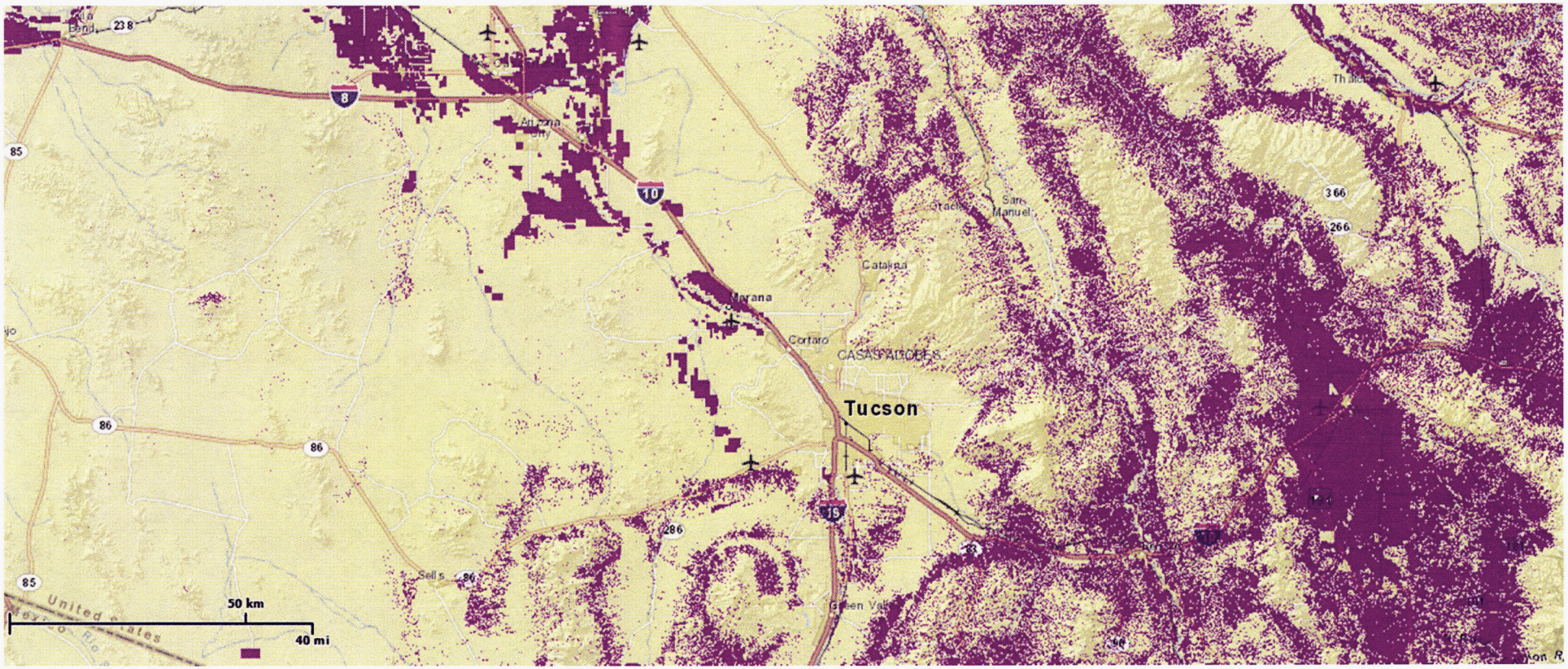
AzGFD HabiMap Species of Greatest Conservation Need



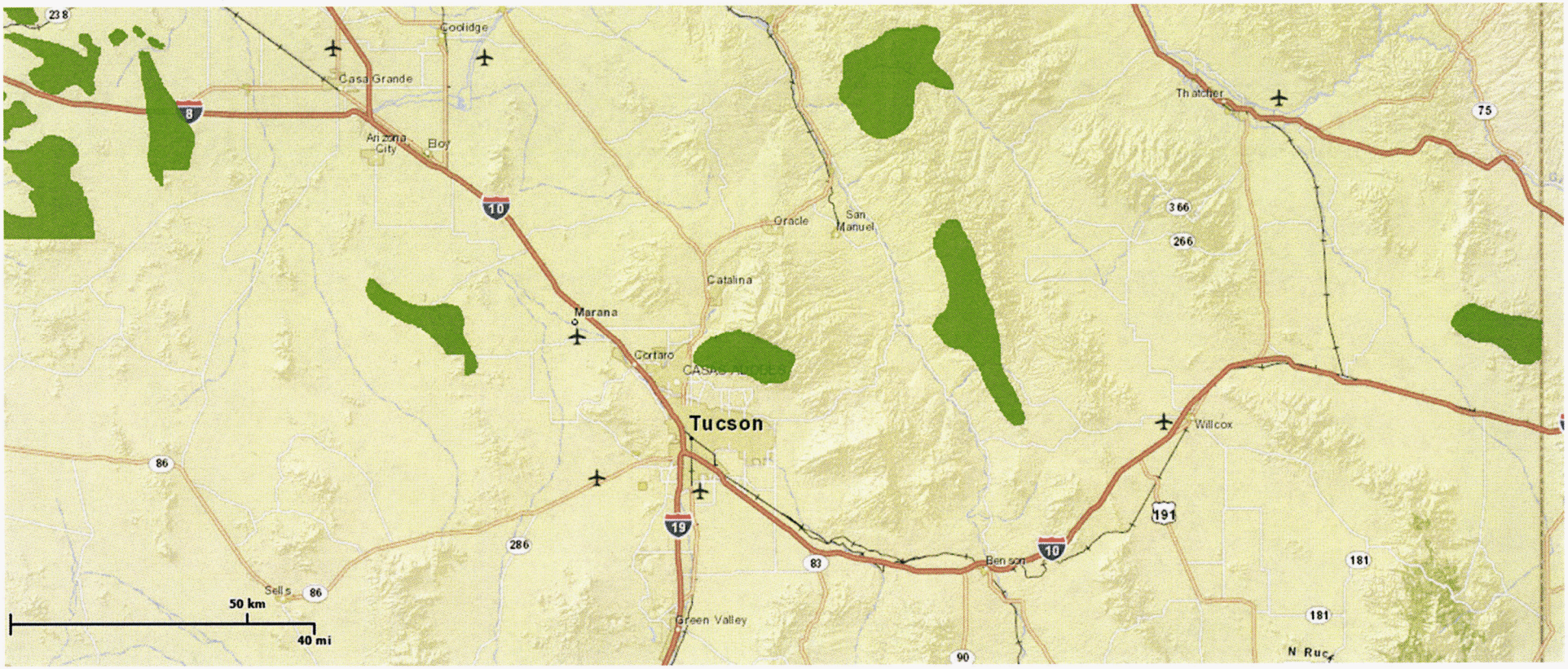
AzGFD HabiMap SGCN: Goulds Turkey Habitat



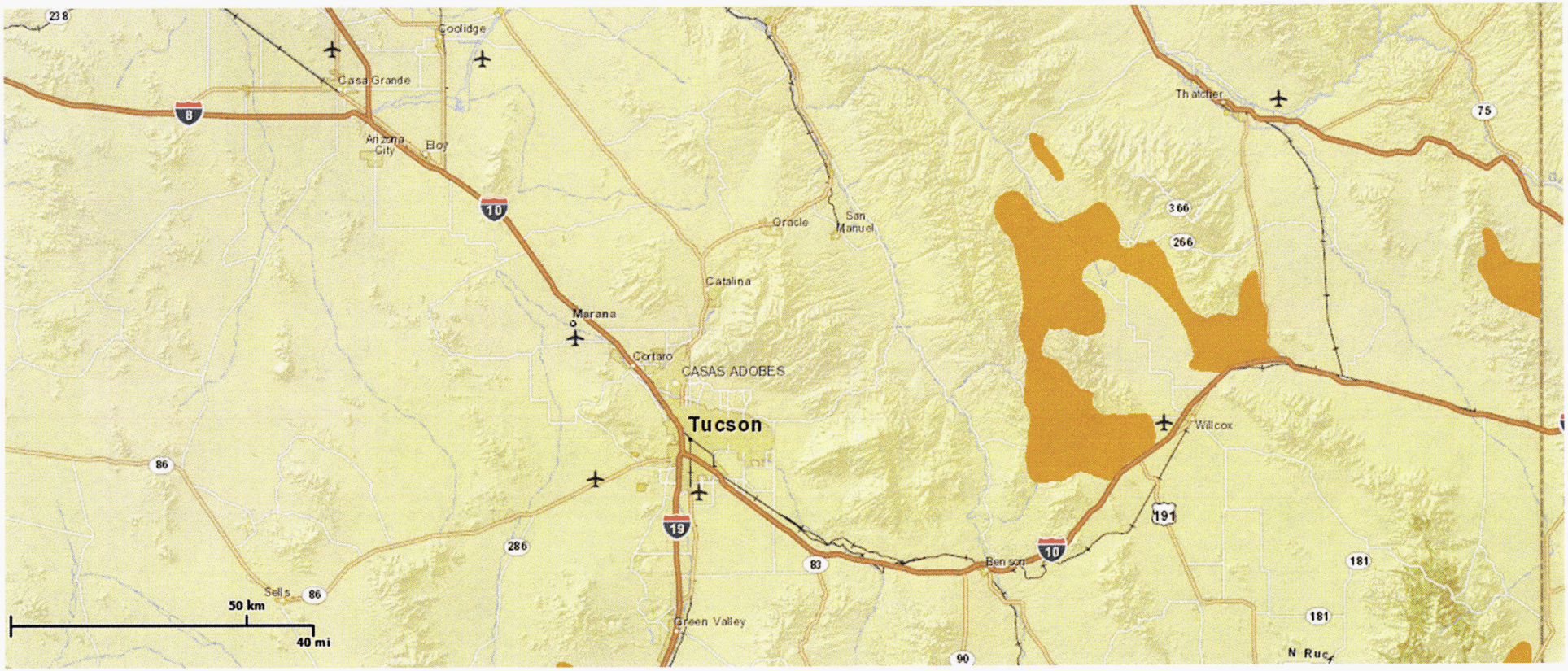
AzGFD HabiMap SGCN: Ferruginous Hawk Habitat



AzGFD HabiMap SGCN: Desert Bighorn Sheep Habitat



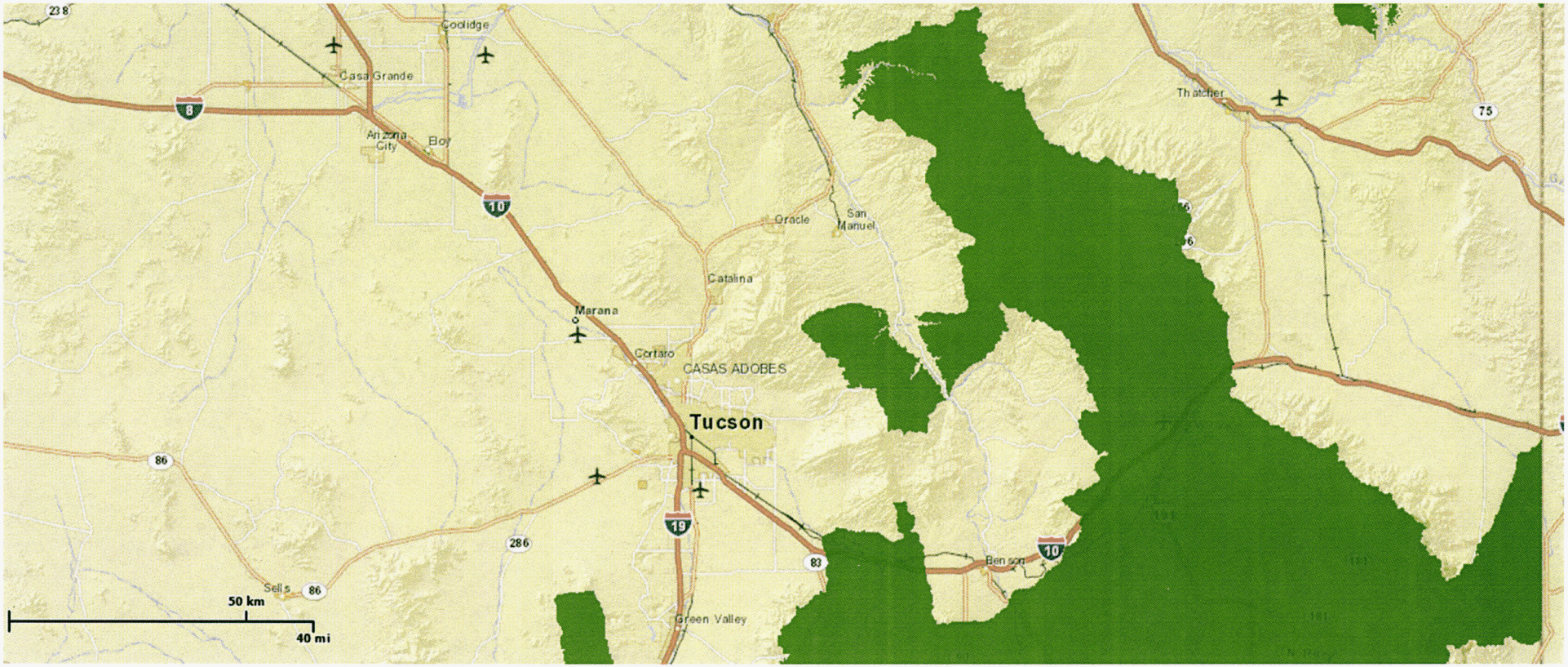
AzGFD HabiMap SGCN: Pronghorn Habitat



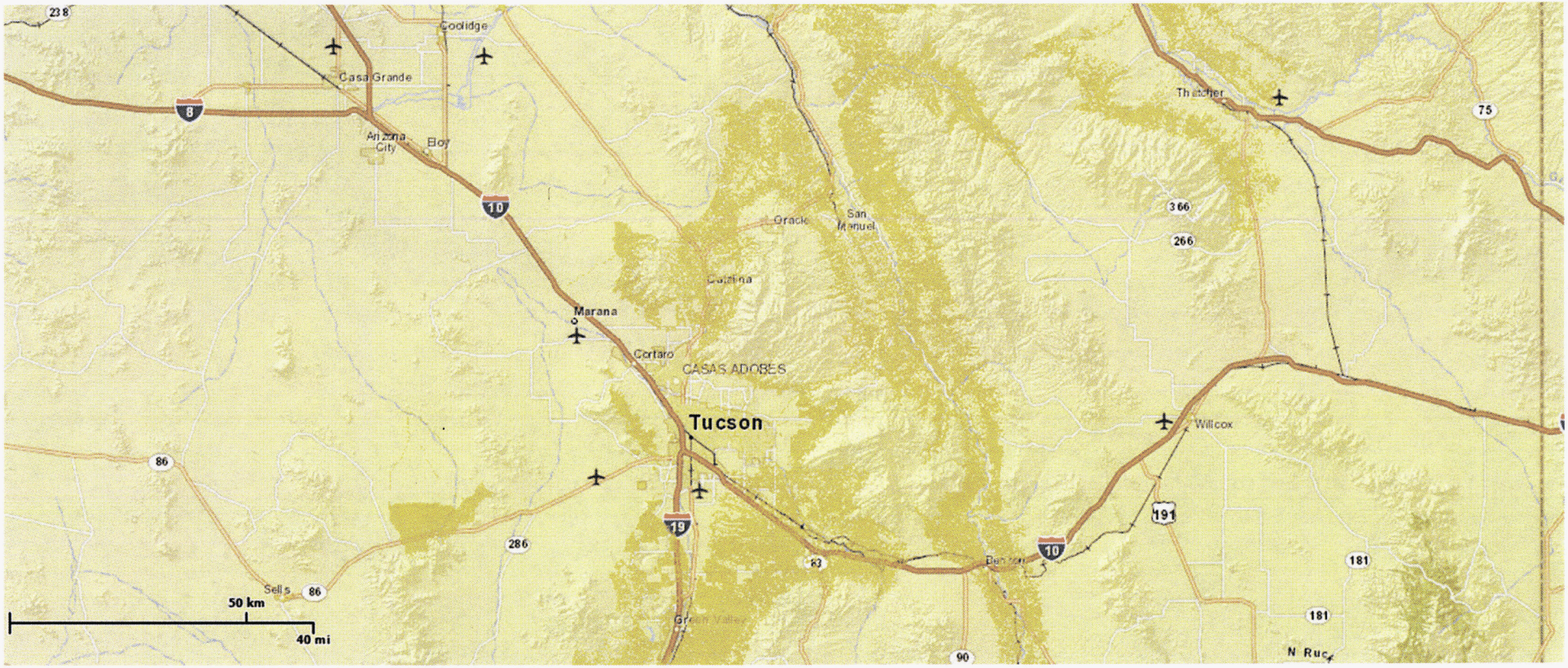
AzGFD HabiMap SGCN: Sonoran Desert Tortoise Habitat

AzGFD HabiMap SGCN: Thick-billed Kingbird Habitat

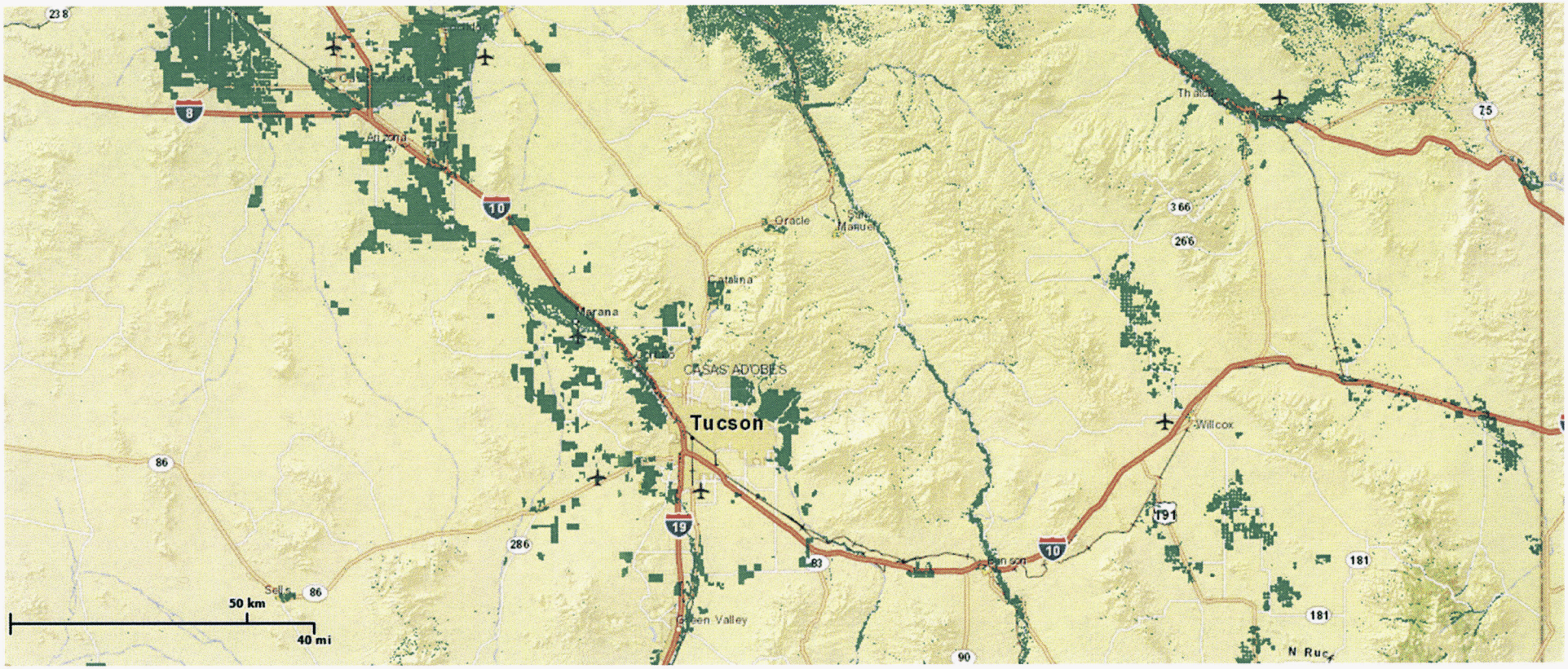
AzGFD HabiMap Threatened Chiricahua Leopard Frog Habitat



AzGFD HabiMap SGCN: Canyon Spotted Whiptail Habitat



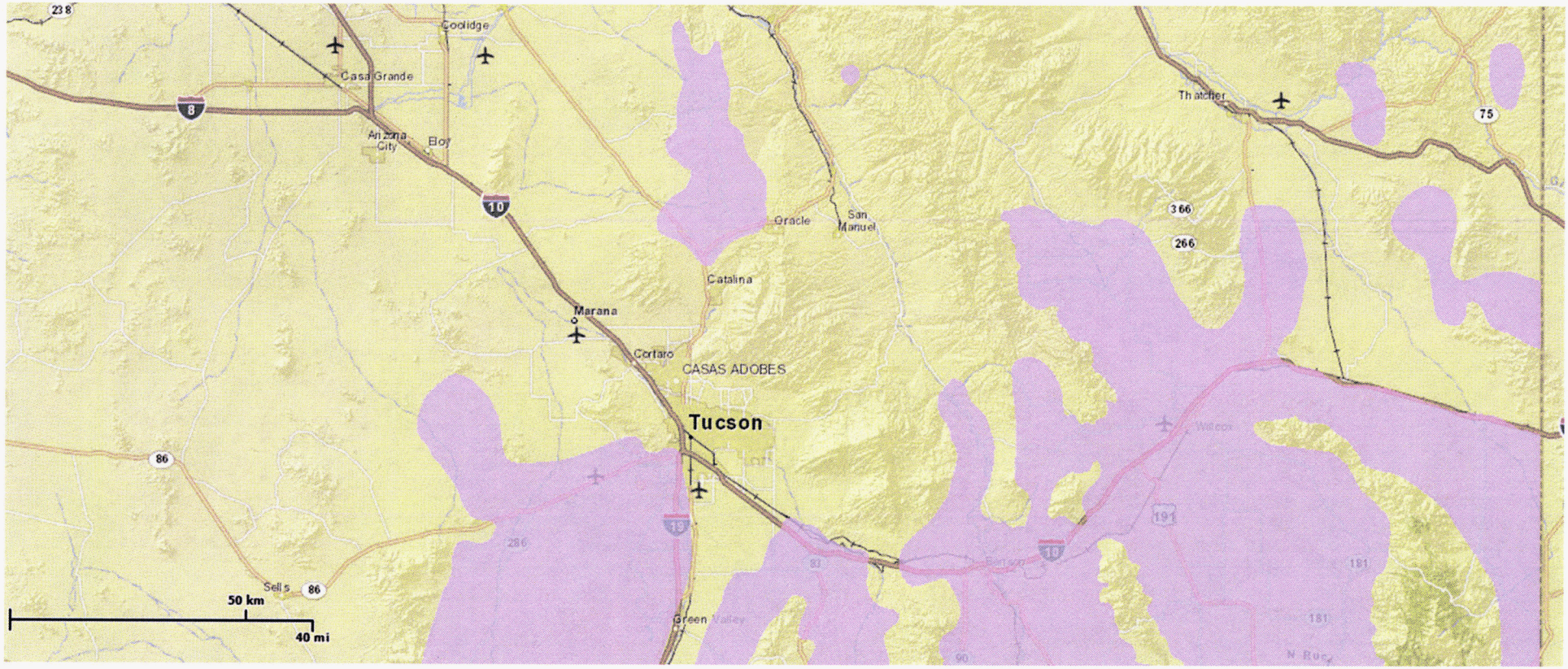
AzGFD HabiMap SGCN: Bald Eagle Habitat

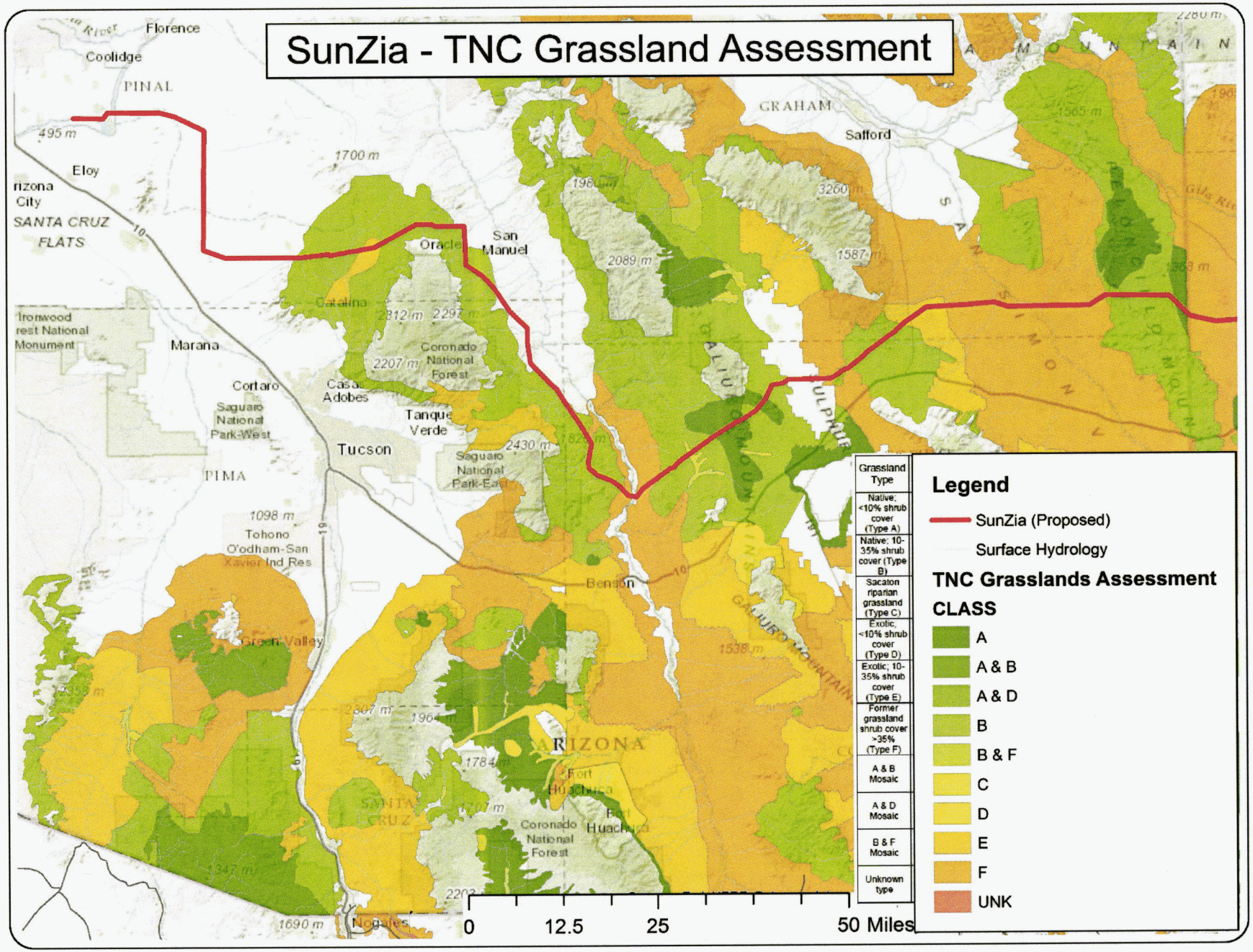


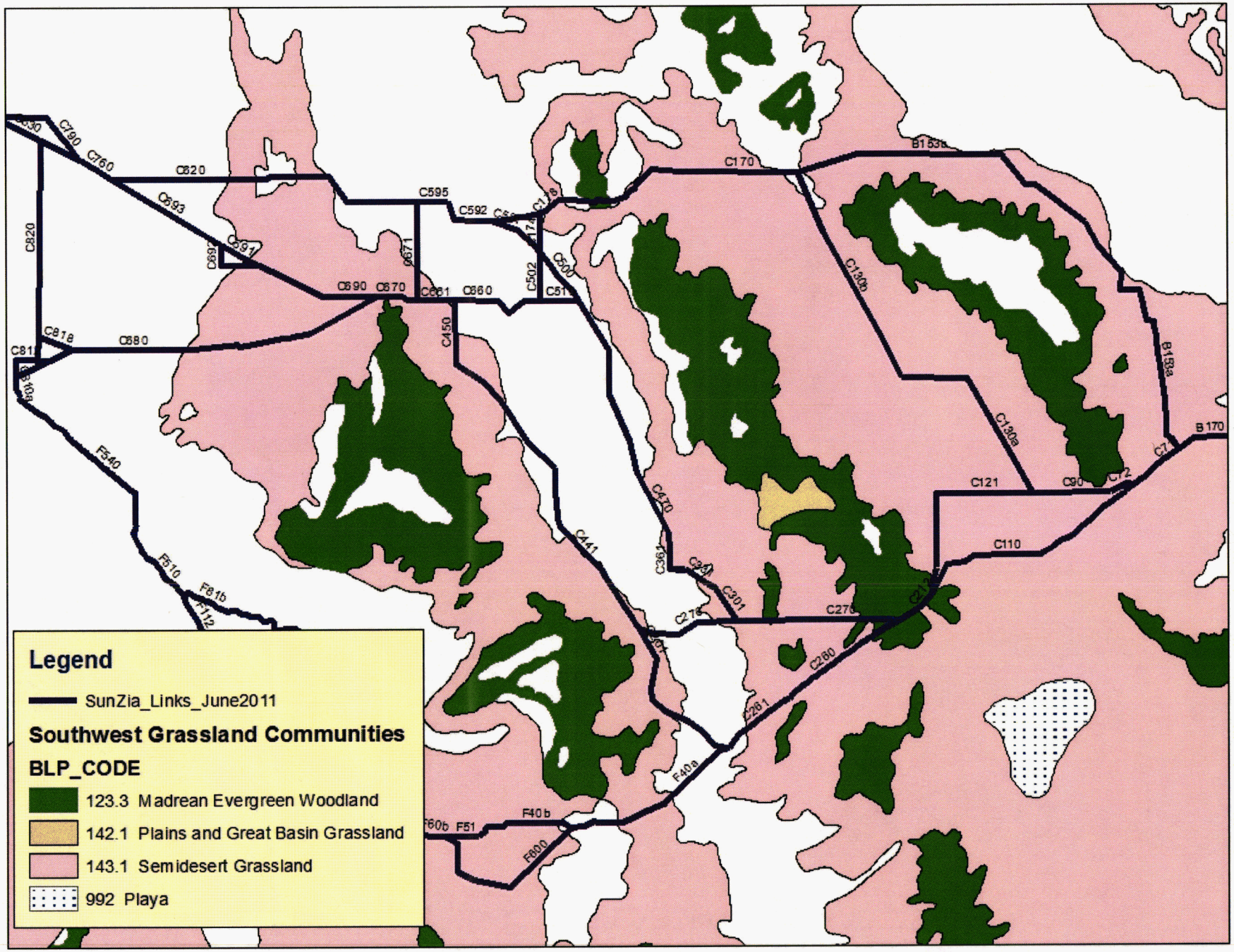
AzGFD HabiMap SGCN: Tucson Shovel-Nosed Snake Habitat

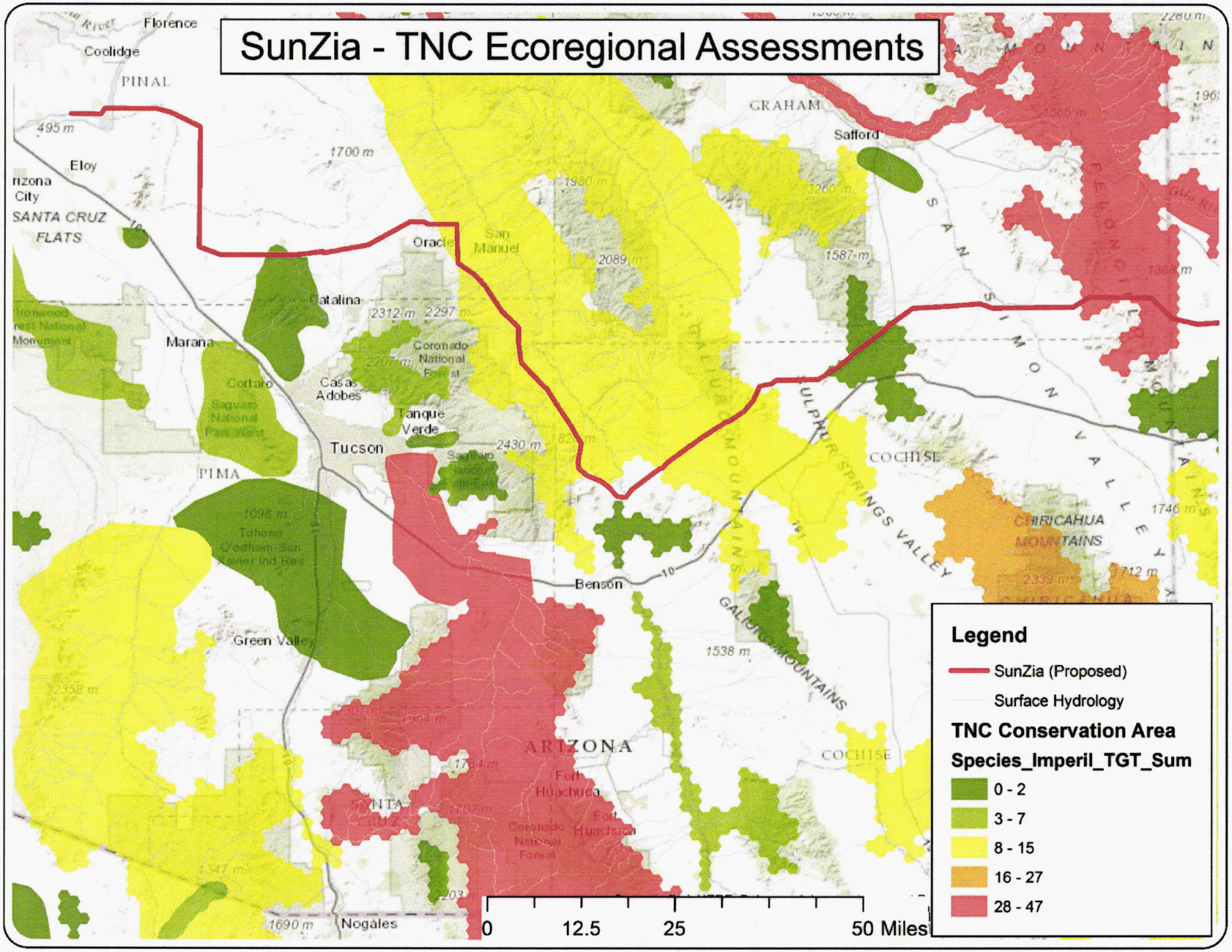
AzGFD HabiMap SGCN: Black-tailed Prairie Dog Habitat

AzGFD HabiMap SGCN: Scaled Quail Habitat




SunZia - TNC Grassland Assessment
Florence
Coolidge
PINAL
Eloy
SANTA CRUZ FLATS
Oracle
San Manuel
GRAHAM
Safford
Marana
Cortaro
Saguaro National Park-West
Casa Adobes
Tanque Verde
Coronado National Forest
Tucson
PIMA
Tohono O'odham-San Xavier Ind Res
Benson
Green Valley
Nogales
Fort Huachuca
Coronado National Forest
0
12.5
25
50 Miles
Grassland Type
Native; <10% shrub cover (Type A)
Native; 10-35% shrub cover (Type B)
Sacaton riparian grassland (Type C)
Exotic; <10% shrub cover (Type D)
Exotic; 10-35% shrub cover (Type E)
Former grassland shrub cover >35% (Type F)
A & B Mosaic
A & D Mosaic
B & F Mosaic
Unknown type
Legend
SunZia (Proposed)
Surface Hydrology
TNC Grasslands Assessment
CLASS
A
A & B
A & D
B
B & F
C
D
E
F
UNK


Legend
SunZia_Links_June2011
Southwest Grassland Communities
BLP_CODE
123.3 Madrean Evergreen Woodland
142.1 Plains and Great Basin Grassland
143.1 Semidesert Grassland
992 Playa
C820
C790
C760
C693
C697
C692
C671
C595
C592
C690
C670
C661
C660
C502
C500
C51
C450
C818
C680
C170
C130b
C130a
B153a
B170
C121
C90
C72
C110
C470
C441
C301
C276
C280
C201
F540
F510
F81b
F112
F40a
F40b
F51
F600


SunZia - TNC Ecoregional Assessments
Florence
Coolidge
PINAL
Eloy
Arizona City
SANTA CRUZ FLATS
Oracle
San Manuel
GRAHAM
Safford
Catalina
Marana
Coronado National Forest
Casas Adobes
Cortaro
Saguaro National Park West
Tanque Verde
Tucson
PIMA
Tohono O'odham San Xavier Ind Res
Green Valley
Benson
COCHISE
CHIRICAHUA MOUNTAINS
SULPHUR SPRINGS VALLEY
GALIURO MOUNTAINS
SAN SIMON VALLEY
ARIZONA
Fort Huachuca
Nogales
0
12.5
25
50 Miles
Legend
SunZia (Proposed)
Surface Hydrology
TNC Conservation Area
Species_Imperil_TGT_Sum
0 - 2
3 - 7
8 - 15
16 - 27
28 - 47

TNC Ecoregional Assessment

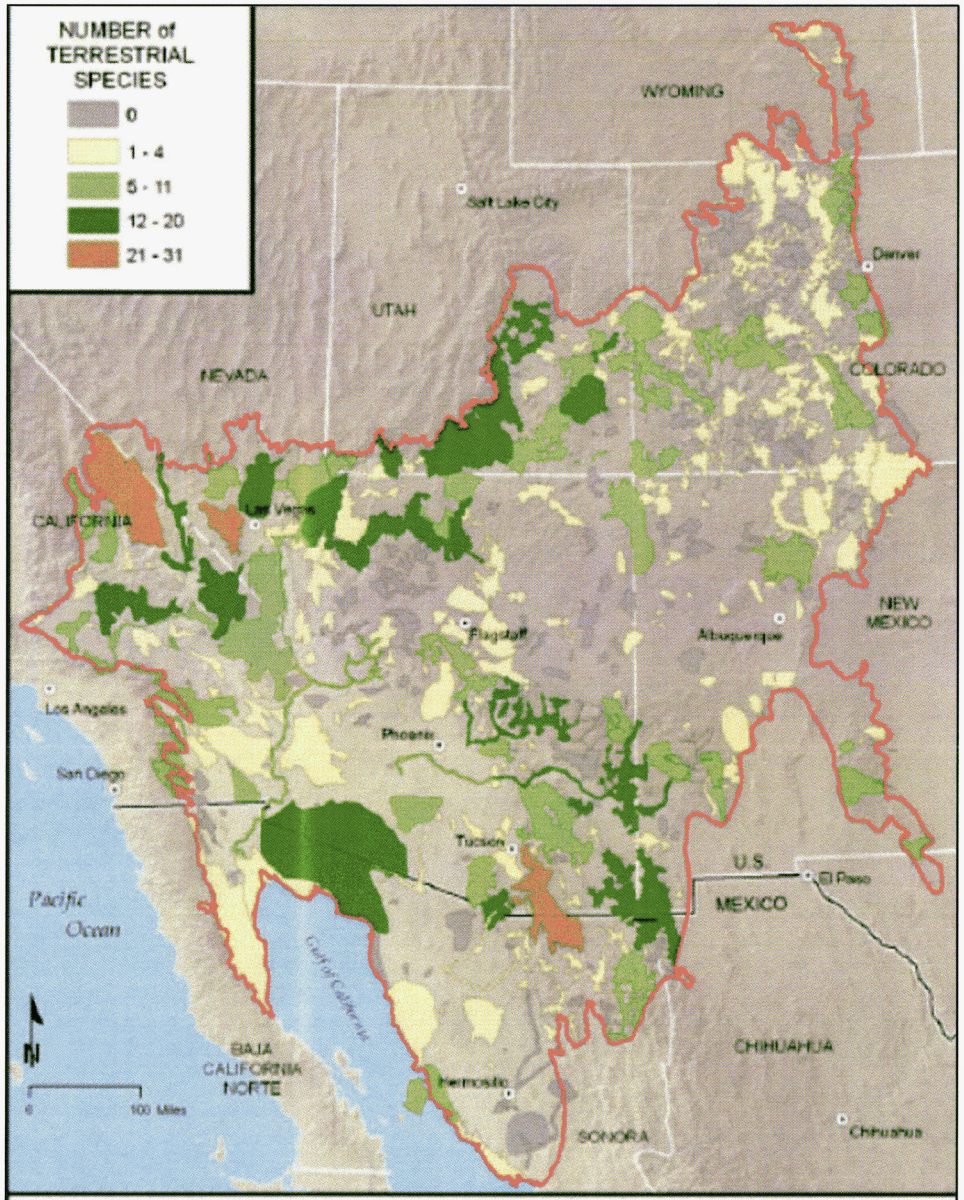
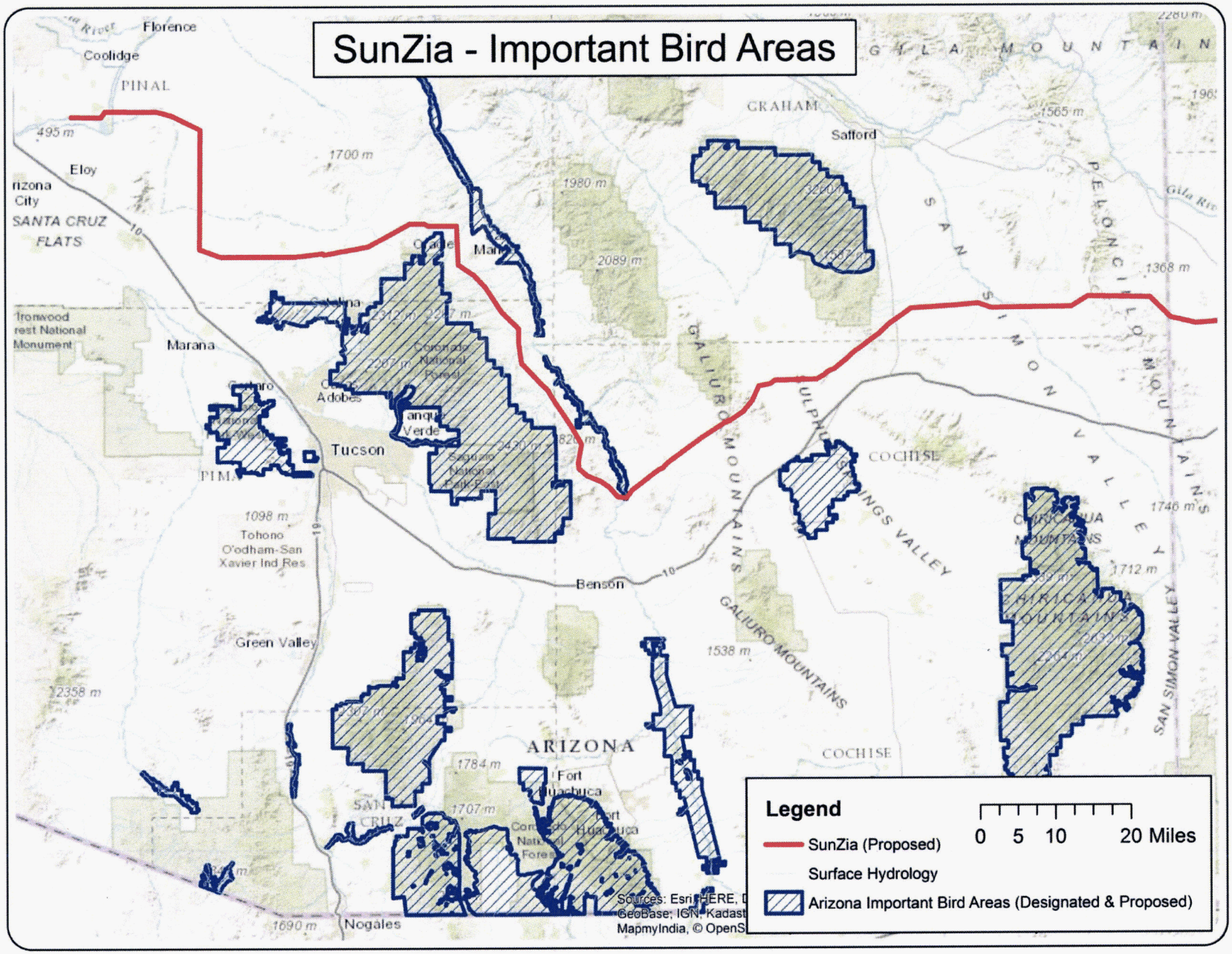


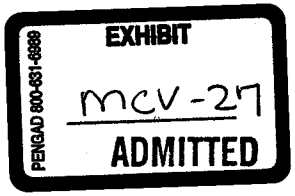
Figure 10. Conservation areas by number of terrestrial ESA-listed species and non-listed rare species.

Map illustrating SunZia proposed route in relationship to IBAs



Christina McVie

- Retired Critical Care and Emergency Registered Nurse
- Involved in local and regional land use planning and conservation efforts in southeast Arizona from 1996-Present
- Co-founded the non-profit organization Desert Watch
- Mapped and helped to establish the Pima County Silverbell Mountain Park, which later became the Ironwood Forest National Monument
- Co-founded the Coalition for Sonoran Desert Protection, comprised of national, regional, local and neighborhood organizations; Chair ADCOM 2005-present
- Steering Committee Member and Science Contributor to the Sonoran Desert Conservation Plan (1999-2003)



Christina McVie

- Supported the formation of the Arizona Wildlife Linkages Working Group and participated in county-level Wildlife Linkage Workshops in Pima and Pinal Counties.
- Conservation Bond Advisory Committee Member (2004)
- Conservation Chair, Tucson Audubon Society (2005-Present)
- Pima Association of Government's Regional Transportation Authority Wildlife Linkages Working Group (2006-Present)
- Property owner of a 40-acre parcel in Pinal County located 2.13 miles north of the proposed SunZia corridor (1998-Present)
- Desert Landscape Conservation Cooperative Landscape Conservation Plan Design Working Group Member and co-author of the San Pedro Watershed DLCC LCD Pilot Proposal

Galiuro-Pinaleno-Dos Cabezas Wildlife Linkage 2008

- One of eight additional linkages within 5 miles of an incorporated city, selected after initial 2006 Assessment
- 18 species modeled within Madrean Archipelago - a unique ecological zone lying south of the Rocky Mountains and north of the Sierra Madre Occidental
- Dominated by semi-desert grasslands and desert scrub, with Sonoran desert and thornscrub vegetation to the west and Chihuahuan desert to the east, and isolated patches of pine-oak woodlands
- Strand A is made up of the best biological corridors for black bear, bobcat, jaguar, wolf, and mountain lion
- Strand B provides habitat for badger, javelina, kit fox, mule deer, and pronghorn

Galiuro-Pinaleno-Dos Cabezas Wildlife Linkage 2008

- Strand C provides habitat for badger and pronghorn
- Strand D provides habitat for black bear, bobcat, jaguar, javelina, wolf, mountain lion, and mule deer
- Strand E provides habitat for kit fox
- The Willcox Playa attracts over 500 species of birds, including tens of thousands of migratory Sandhill Cranes, and a similar number of tourists for an annual birding festival, Wings Over Willcox
- WOW generates approximately $155,000 per year in direct income for local businesses
- $1.96 M direct economic impact to Willcox since 1994

Santa Catalina/Rincon-Galiuro Wildlife Linkage 2012

- "...The proposed right-of-way corridors may be up to 1,000 feet wide..."
- "This proposed [SunZia] route threatens habitat connectivity for numerous wildlife species... may have numerous negative impacts on wildlife in the San Pedro Valley."
- "However, the construction of large-scale utility infrastructure, like that proposed by SunZia Southwest Transmission Project, may be devastating to the area's wildlife, regardless of the mitigation measures implemented."

Ironwood-Picacho Linkage 2007

- 20 species focal species for this report including Ironwood Trees and the Cactus-Ferruginous Pygmy-owl

- Ironwood Forest National Monument to the Picacho Mountains and the Durham-Coronado Plains - all managed by BLM and designated as Regional Parks, with connecting trails, by Pinal County's Open Space and Trails Master Plan (2007) and Comprehensive Plans since 2013

- In the Pinal County Wildlife Connectivity Assessment (2013)

Pima and Pinal County Wildlife Linkages

- Both involved wide expert and public input and a transparent public process with diverse stakeholder participation
- Both were conscious decisions sponsored by the counties
- Both were respected by the counties and incorporated into their respective public land use planning processes
- Both are broadly endorsed by the public for recreational and prudent public trust outcomes

Pima County Comprehensive Plans

- First incorporated the Conservation Lands System (CLS) in the state mandated environmental element of the Comprehensive Plan in 2001-2002
- Established areas focused development investment and infrastructure
- Establised areas to be preserved
- Incorporated in the 2015 Pima Prospers Comprehensive Plan as the basis for science-based land use planning (the Sonoran Desert Conservation Plan) and the pending Multi-Species Habitat Conservation Plan under Section 10 of the Endangered Species Act of 1973

Pinal County Comprehensive Plans

- Pinal County Open Space and Trails Plan 2007 set the stage for the Land Use Plan adopted in 2009

- Development intentionally directed to the northwestern and west central aspects of the county leaving valuable grasslands, riparian lands and uplands in adaptive, sustainable condition for future generations

- Comprehensive Plan refined in 2014

- My husband and I, as taxpayers, supported all these efforts and thought they were reliable – we bought in to the dream

Ironwood Trees

- Old-growth forest of the Sonoran Desert
- Slow growing & climate sensitive
- Grow tall and slender for the first 200 years
- Develop broad canopy after 200 years
- Madrone or nurse plant to saguaros, vines and other species
- Over 600 species utilize them
- Can live from 1200 -1500 years
- Do not have traditional tree rings but instead respire, expanding and contracting
- Culturally significant to tribal entities

Saguaros

- Slow growing & climate sensitive
- Prefers nurse plants and well-drained soil
- 50-70 of age years before flowering begins at 6-7 feet tall
- Can grow to 50+ feet tall and live 200-300 years
- Shallow, wide-spread peripheral root system can extend beyond height of plant, up to 90 feet, with 2-3 foot taproot
- Transplant in same compass orientation asap after removal, after treating roots with antibiotic and dusting with sulfer
- Measure girth and avoid any compaction of future roots
- Water after 2-3 weeks, re-measure girth and continue protocol for the first year to observe girth growth over time
- Monitor 5-10 years to ensure survivorship

Pinal County Open Space and Trails and Pima County Trails and Recreation Elements

- Both focus on public health and wellness, undisturbed natural open space, recreation opportunities, untarnished viewsheds, dark night skies, and quality of life

- Both counties incorporated these elements into their state-mandated comprehensive plans with considerable public input and process

- Both counties offer residents and visitors quiet solitude and an integrated, linked system between them for hiking, biking, off-road and equestrian opportunities at designated locations

Pima County Land Conservation Priorities

- Tucson Mountain Park began in the mid-1920s
- 1997 Open Space Bond
- 2004 Open Space Bond
- 2015 Open Space Bond
- The need to complete the acquisitions and leases identified to qualify for a 30 year Incidental Take Permit under the Endangered Species Act of 1973 – a "get out of jail FREE" card

Pinal County Cultural Resources and Pima County SDCP Cultural Resources

- Funding for Pima County cultural and historic preservation included in Open Space Bonds
- Pinal County contemplating bonding and other funding mechanisms for open space, trails, historic and cultural preservation

- Significant properties within SunZia's proposed route listed on or eligible for the National Register of Historic Places or the Arizona Register of Historic Places
- Multiple Tribal Nations identify cultural landscapes and significant cultural sites within the proposed route

TNC Ecoregional Assessment & Natural Infrastructure

- Original synthesis of 6 eco-regions done in 2006 with considerable expert input and modeling
- Portions of 5 U.S. states, all of Arizona and portions of northern Mexico
- Introduces conservation priorities for a large region that shares similar challenges of habitat loss and fragmentation and increasing pressures on limited water resources from rapid urban and ex-urban growth, and, likely, climate-induced changes in the distribution of habitat for the region's biological diversity.
- Enables managers, planners, policy-makers, and conservationists to evaluate and implement conservation actions across jurisdictional and political boundaries
- Refined to reflect finer scale analysis

Waters of the U.S.

- Regulated and designated by the Army Corps of Engineers under the Clean Water Act of 1972

- Designed to clarify the "muddied waters" of the 2006 Rapanos decision regarding "disconnected wetlands" such as pothole lakes, seeps, springs

- New Rule promulgated in 2015 pending litigation

- New Rule was, especially for states west of the Mississippi, modeled on studies done in southern Arizona regarding the critical importance of intermittent and ephemeral streams, seeps, and springs as tributaries to perennial waters

OUTSTANDING ARIZONA WATERS (OAWs)

A.A.C. R18-11-112(G)

1. West Fork of the Little Colorado River, from its headwaters at 33°55'02"/109°33'30" to Government Springs at 33°59'33"/109°27'54" (approximately 9.1 river miles);
2. Oak Creek, from its headwaters at 35°01'30"/111°44'12" to its confluence with the Verde River at 34°40'41"/111°56'30 (approximately 50.3 river miles);
3. West Fork of Oak Creek, from its headwaters at 35°02'44"/111°54'48" to its confluence with Oak Creek at 34°59'14"/111°44'46" (approximately 15.8 river miles);
4. Peeples Canyon Creek, from its headwaters at 34°23'57"/113°19'45" to its confluence with the Santa Maria River at 34°20'36"/113°15'12" (approximately 8.1 river miles);
5. Burro Creek, from its headwaters at 34°52'46.5"/113°05'13.5" to its confluence with Boulder Creek at 34°374.5"/113°18'36" (approximately 29.5 miles);
6. Francis Creek, from its headwaters at 34°54'38"/113°20'30" to its confluence with Burro Creek at 34°44'29"/113°14'37" (approximately 22.9 river miles);
7. Bonita Creek, from its boundary of the San Carlos Indian Reservation at 33°03'08"/109°33'41" to its confluence with the Gila River at 32°53'36"/109°28'43" (approximately 14.7 river miles);
8. Cienega Creek, from its confluence with Gardner Canyon and Spring Water Canyon at 31°47'38.5"/110°35'21.5" to the USGS gaging station at 32°02'09"/110°40'34" (approximately 28.3 river miles);
9. Aravaipa Creek, from its confluence with Stowe Gulch at 32°52'10"/110°22'03" to the downstream boundary of the Aravaipa Canyon Wilderness Area at 32°54'23"/110°33'42" (approximately 15.5 river miles);
10. Cave Creek, from its headwaters at 31°50'30"/109°17'04.5" to the Coronado National Forest boundary at 31°54'38"/109°08'40" (approximately 10.4 river miles);
11. South Fork of Cave Creek, from its headwaters at 31°50'20"/109°16'33" to its confluence with Cave Creek at 31°53'04"/109°10'30" (approximately 8.6 river miles);
12. Buehman Canyon Creek, from its headwaters at 32°52'0.5"/110°39'54.5" to its confluence with unnamed tributary at 32°24'31.5"/110°32'08" (approximately 9.8 river miles);
13. Lee Valley Creek, from its headwaters at 33°55'49"/109°31'34" to its confluence with Lee Valley Reservoir at 33°56'28"/109°30'15.5" (approximately 1.6 river miles);
14. Bear Wallow Creek, from its headwaters at 33°35'54"/109°26'54.5" to the boundary of the San Carlos Indian Reservation at 33°37'52"/109°29'44" (approximately 4.25 river miles);
15. North Fork of Bear Wallow Creek, from its headwaters at 33°34'47.5"/109°21'59.5" to its confluence with Bear Wallow Creek at 33°35'54"/109°26'54.5" (approximately 3.8 river miles);
16. South Fork of Bear Wallow Creek, from its headwaters at 33°34'38.5"/109°23'58" to its confluence with Bear Wallow Creek at 33°35'54"/109°26'54.5" (approximately 3.8 river miles);
17. Snake Creek, from its headwaters at 33°37'21.5"/109°26'11" to its confluence with the Black River at 33°40'31.5"/109°28'58.5" (approximately 6.2 river miles);
18. Hay Creek, from its headwaters at 33°51'00"/109°28'48" to its confluence with the West Fork of the Black River at 33°48'30"/109°25'19" (approximately 5.5 river miles);
19. Stinky Creek, from the White Mountain Apache Indian Reservation boundary at 33°52'36.5"/109°29'45" to its confluence with the West Fork of the Black River at 33°51'21.5"/109°27'09.5" (approximately 3.0 river miles);
20. KP Creek, from its headwaters at 33°34'03"/109°21'19" to its confluence with the Blue River at 33°31'44"/109°12'04.5" (approximately 12.7 river miles);
21. Davidson Canyon, from the unnamed spring at 31°59'00"/110°38'46" to its confluence with Cienega Creek; and
22. Fossil Creek, from its headwaters at the confluence of Sandrock and Calf Pen Canyons above Fossil Springs at 34°26'48.7"/111°32'25" to its confluence with the Verde River at 34°18'21.8"/111°40'31.6" (approximately 17.2 river miles).

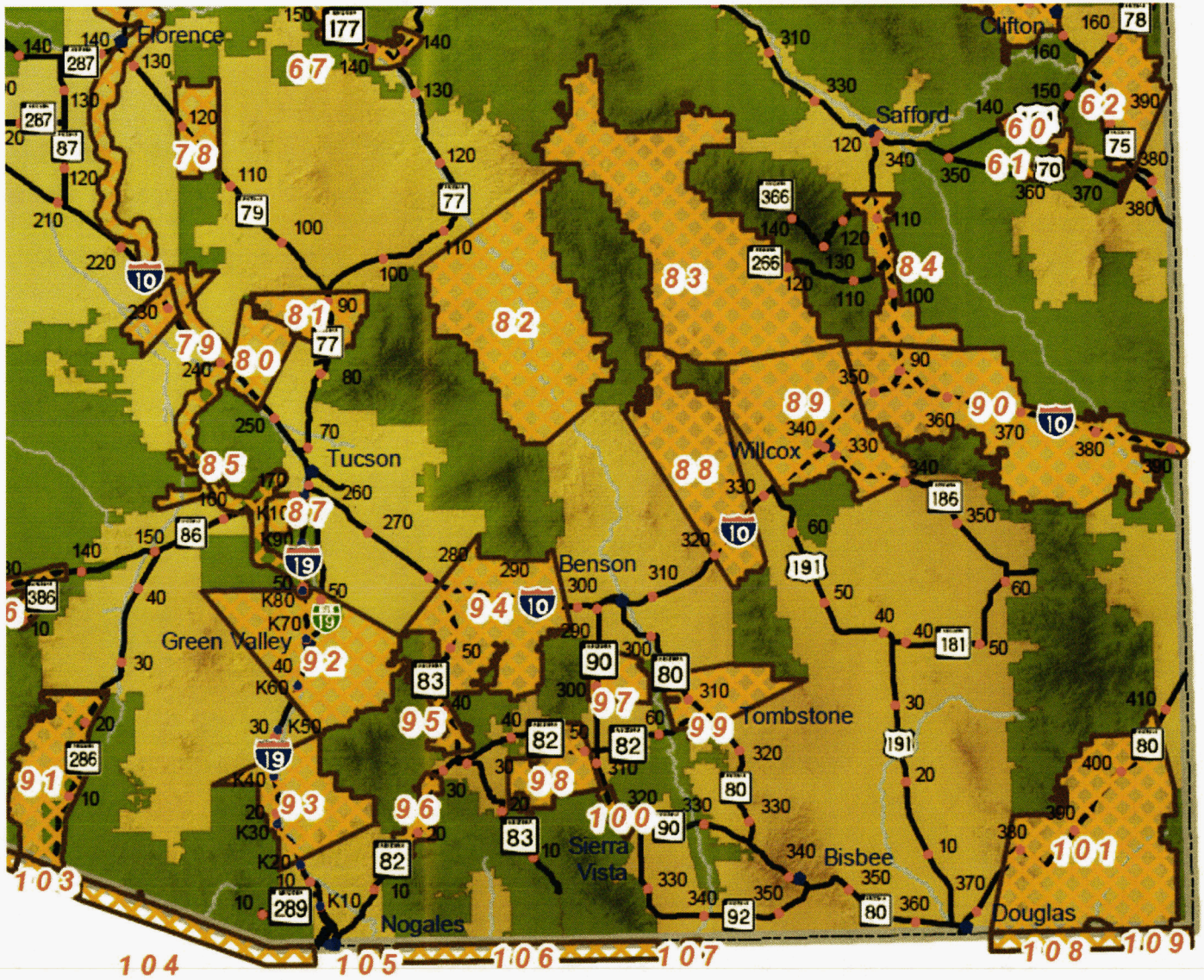
BLM's Madrean REA

- 2014 Rapid Ecological Assessment
- Mentions SunZia and Southline 5 times as risks
- "1.7.3. Conservation Elements Future Risk:
- ...Comparing the development indicator scores for the current timeframe to the 2025 development-based ecological status scores, the observable differences are subtle at the ecoregion scale and are primarily driven by urban expansion in the central and southwest portions of the ecoregional assessment area and around Tucson and the SunZia and Southline planned transmission corridors.
- ...The SunZia and Southline electrical transmission corridors bisect the entire ecoregion and numerous occurrences for several CEs."

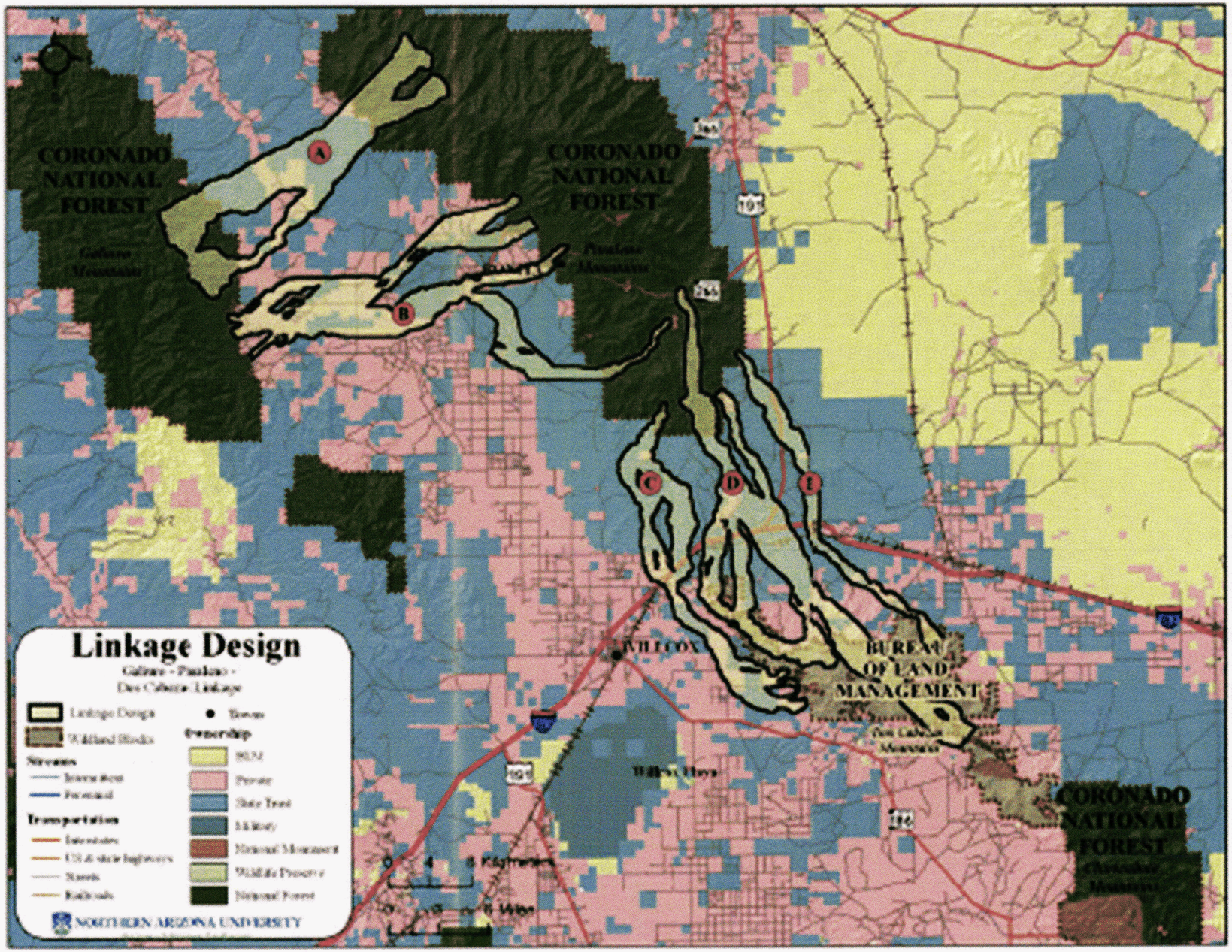
Desert Landscape Conservation Cooperative

- Secretary Salazar's Order supported by Secretary Jewell
- 5 southwestern U.S. states and much of northern Mexico
- Vision: "Resilient landscapes capable of responding to environmental challenges and supporting natural and cultural values for current and future generations."
- Developing landscape conservation planning and design process
- Developing goals and adaptive management actions for three focal ecosystem projects within the DLCC geographic area
- Involves all Department of Interior Agencies, academics, non-profits and state and local governments

Arizona Wildlife Linkages Assessment Map
Southeast Arizona



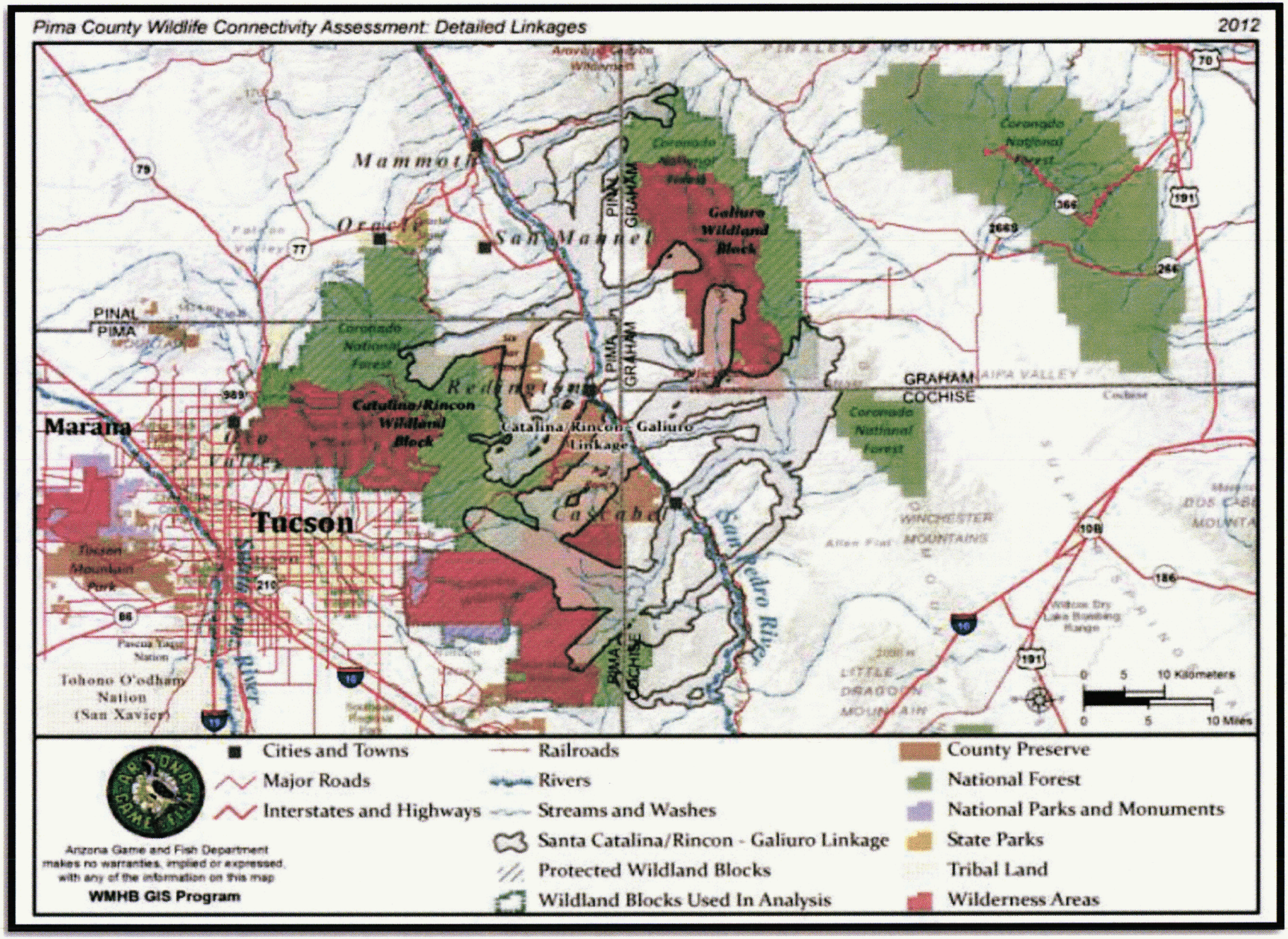
Galiuro-Pinaleño-Dos Cabezas Wildlife Linkage



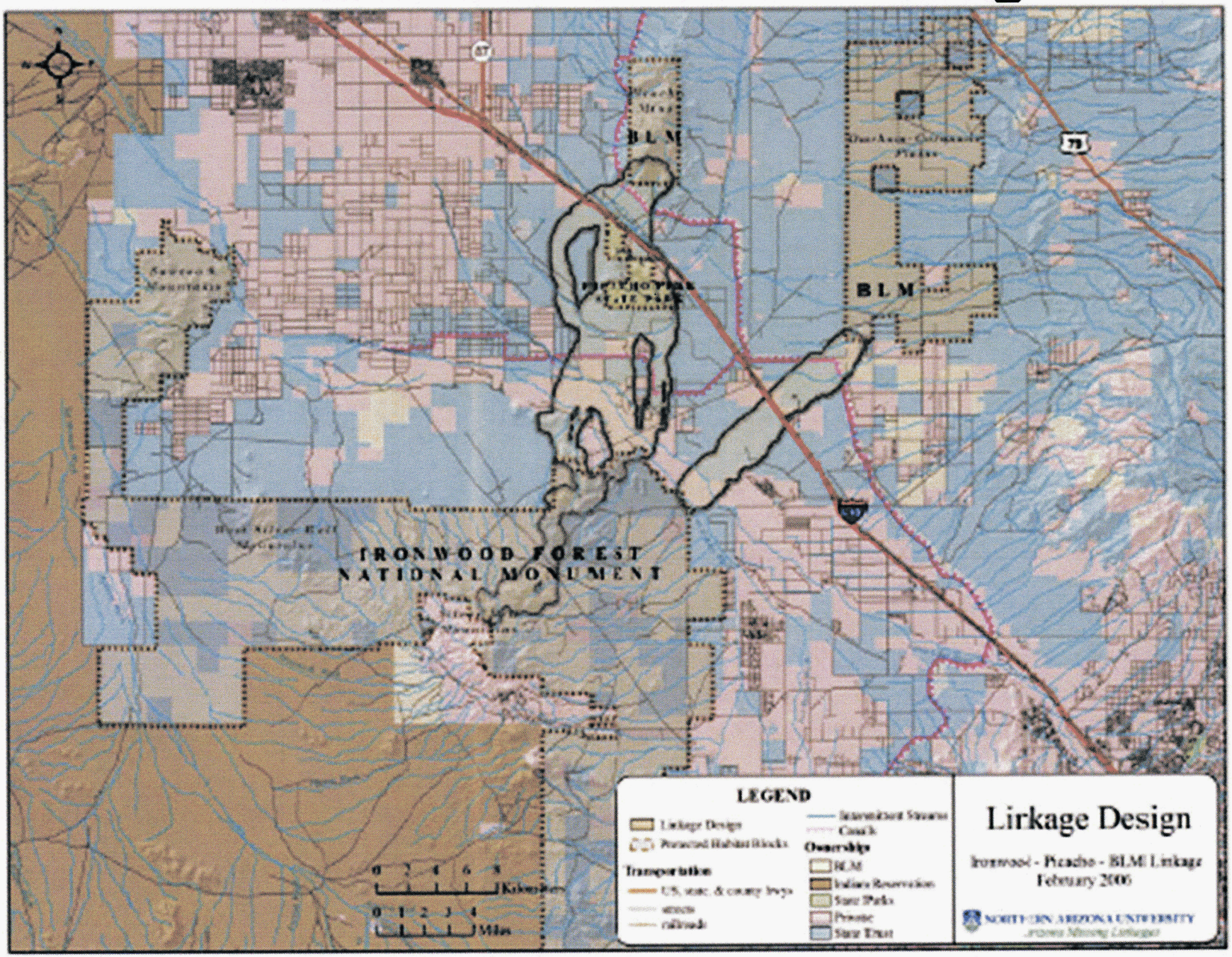
DOCKET NO_L-00000YY-15-0318-00171_MCV_17

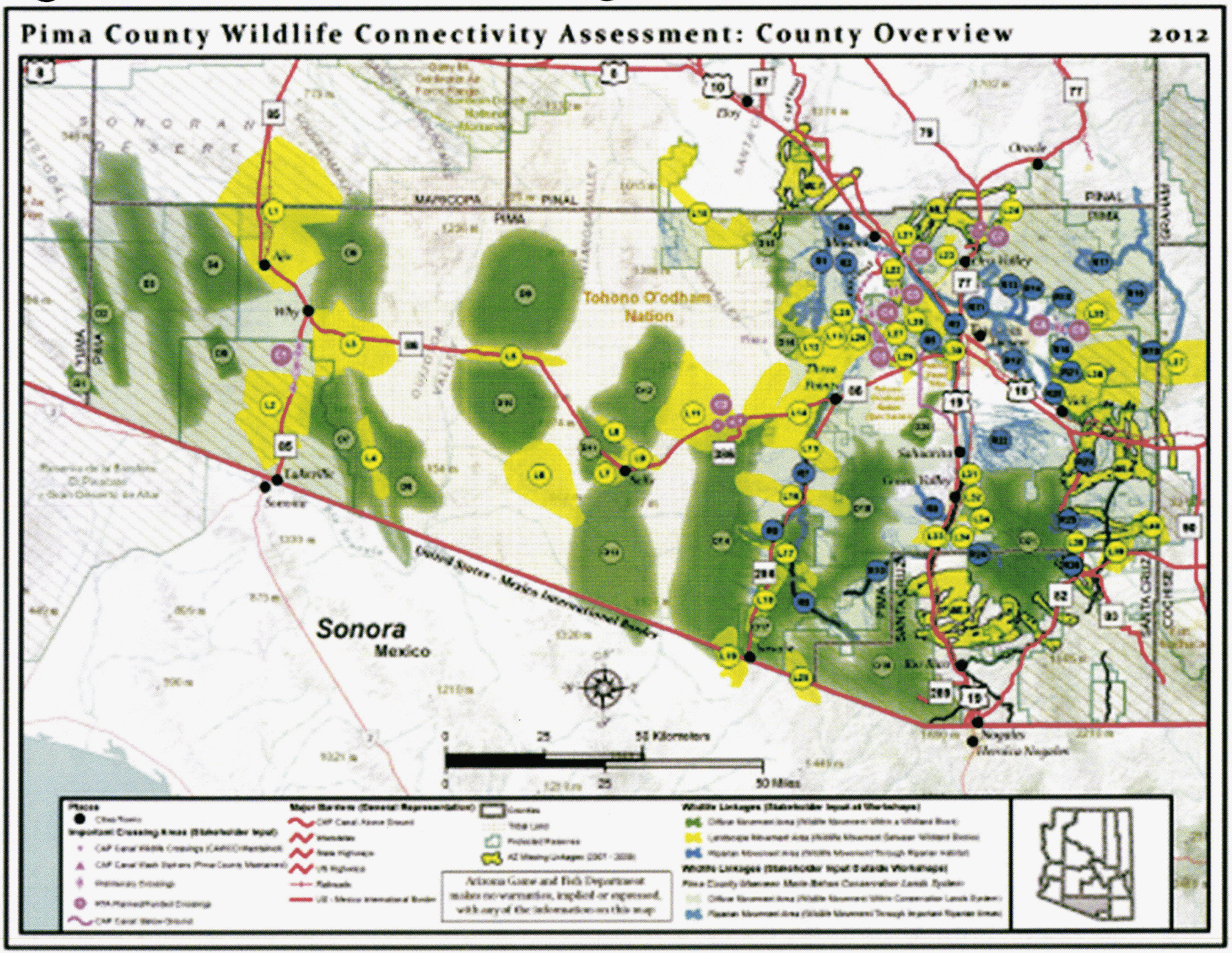
McVie-R-2

Santa Catalina/Rincon-Galiuro Wildlife Linkage



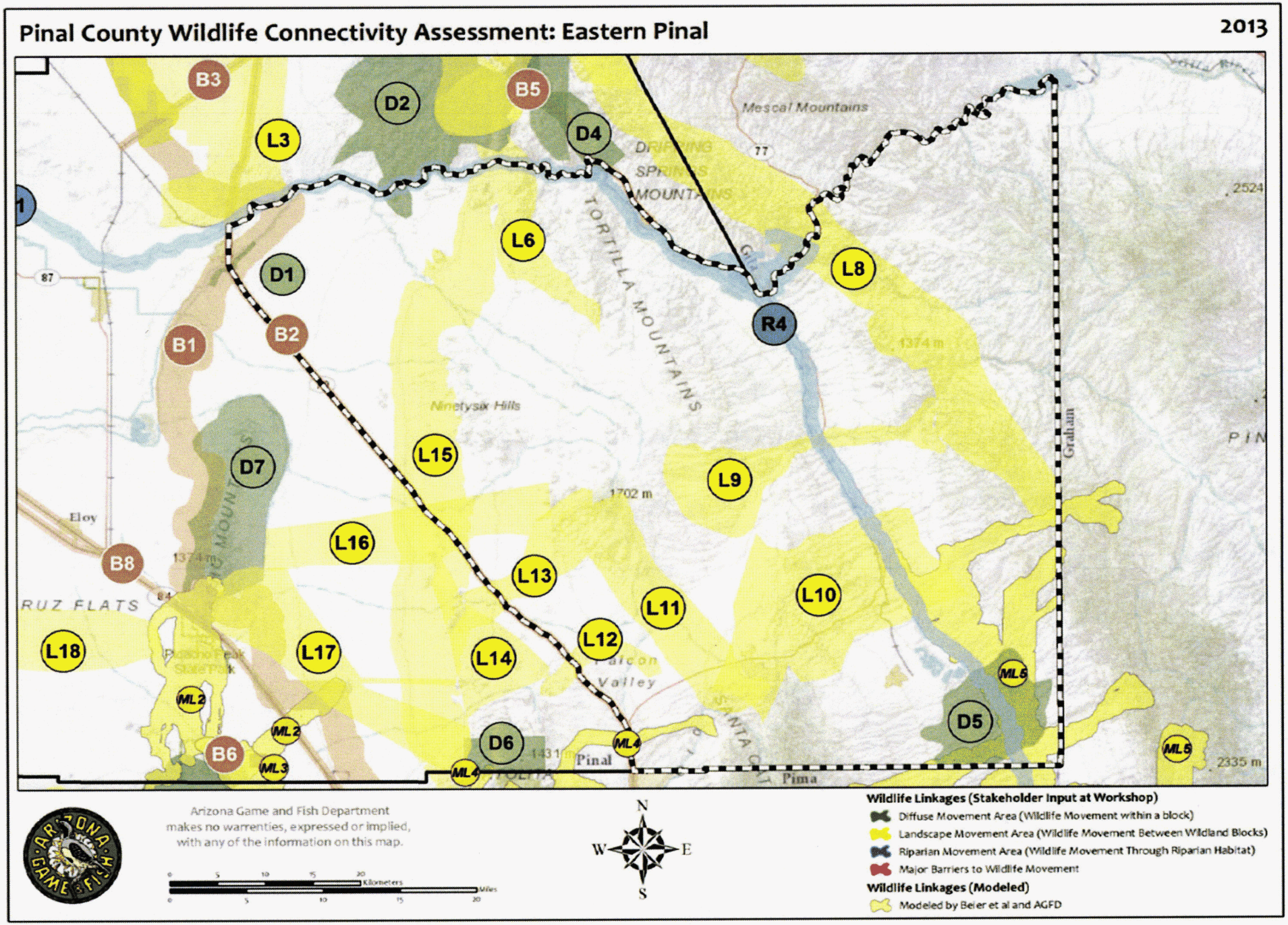
Ironwood-Picacho Wildlife Linkage





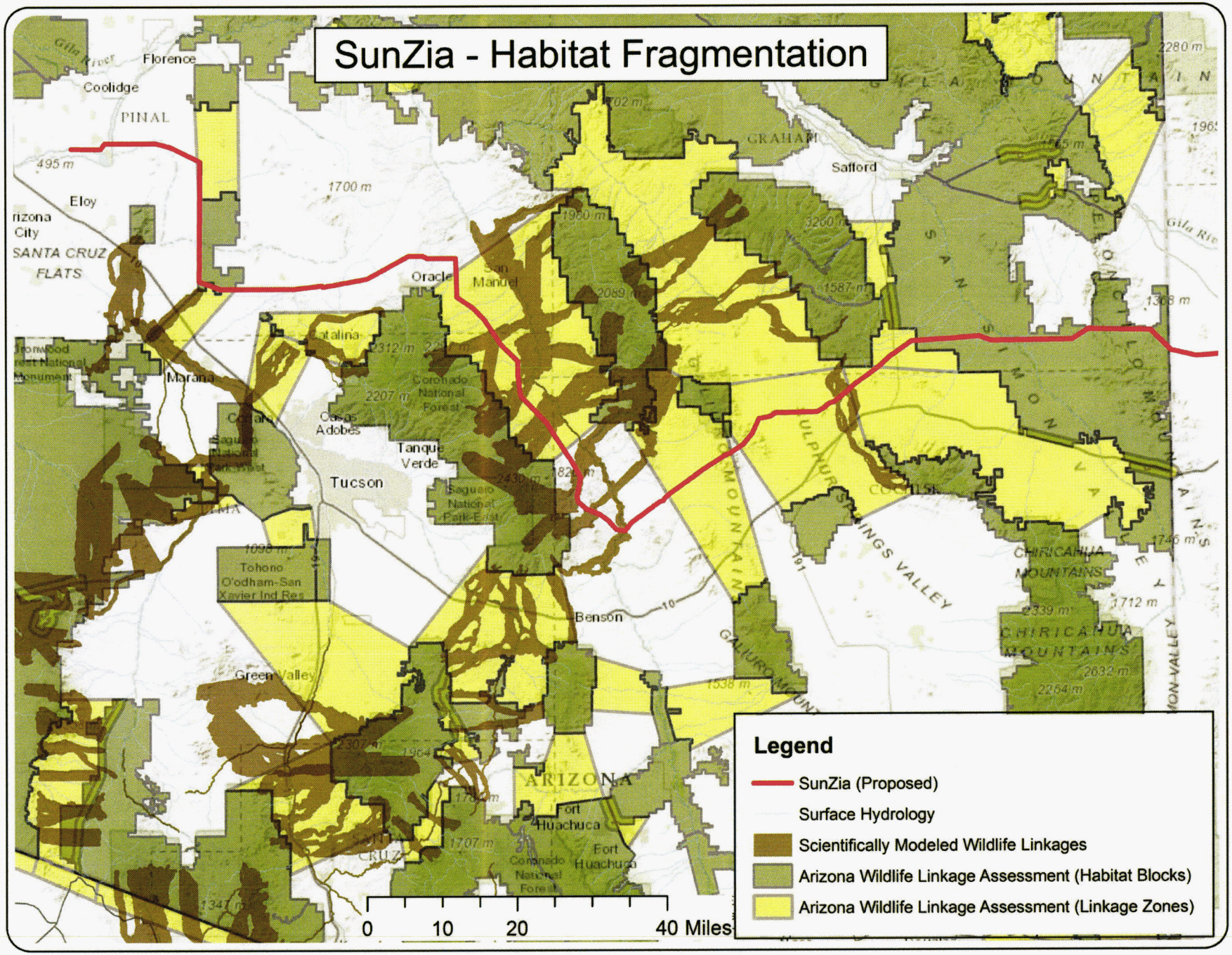
DOCKET NO_L-00000YY-15-0318-00171_MCV_6

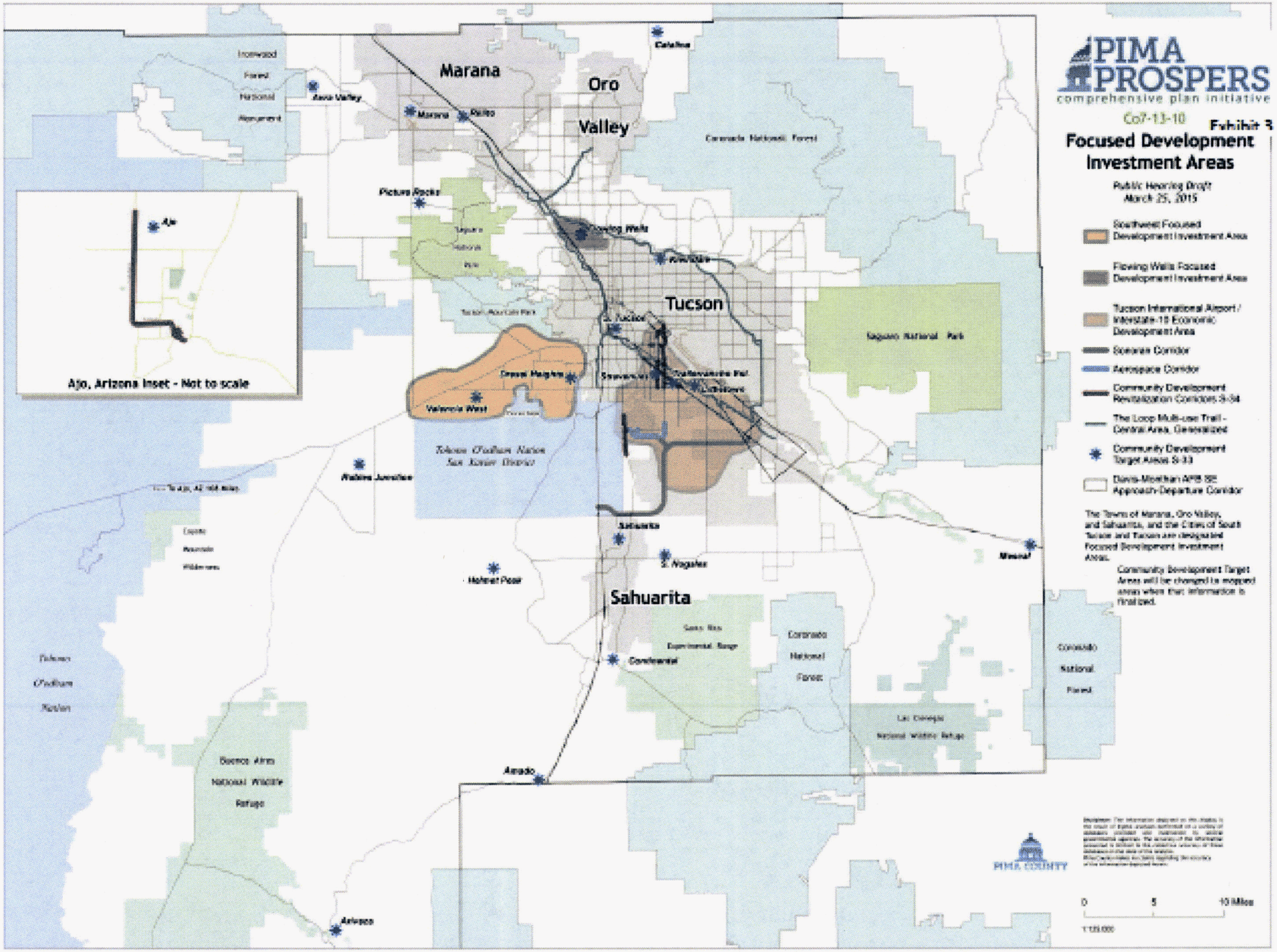
McVie-R-5a



DOCKET NO_L-00000YY-15-0318-00171_MCV_20

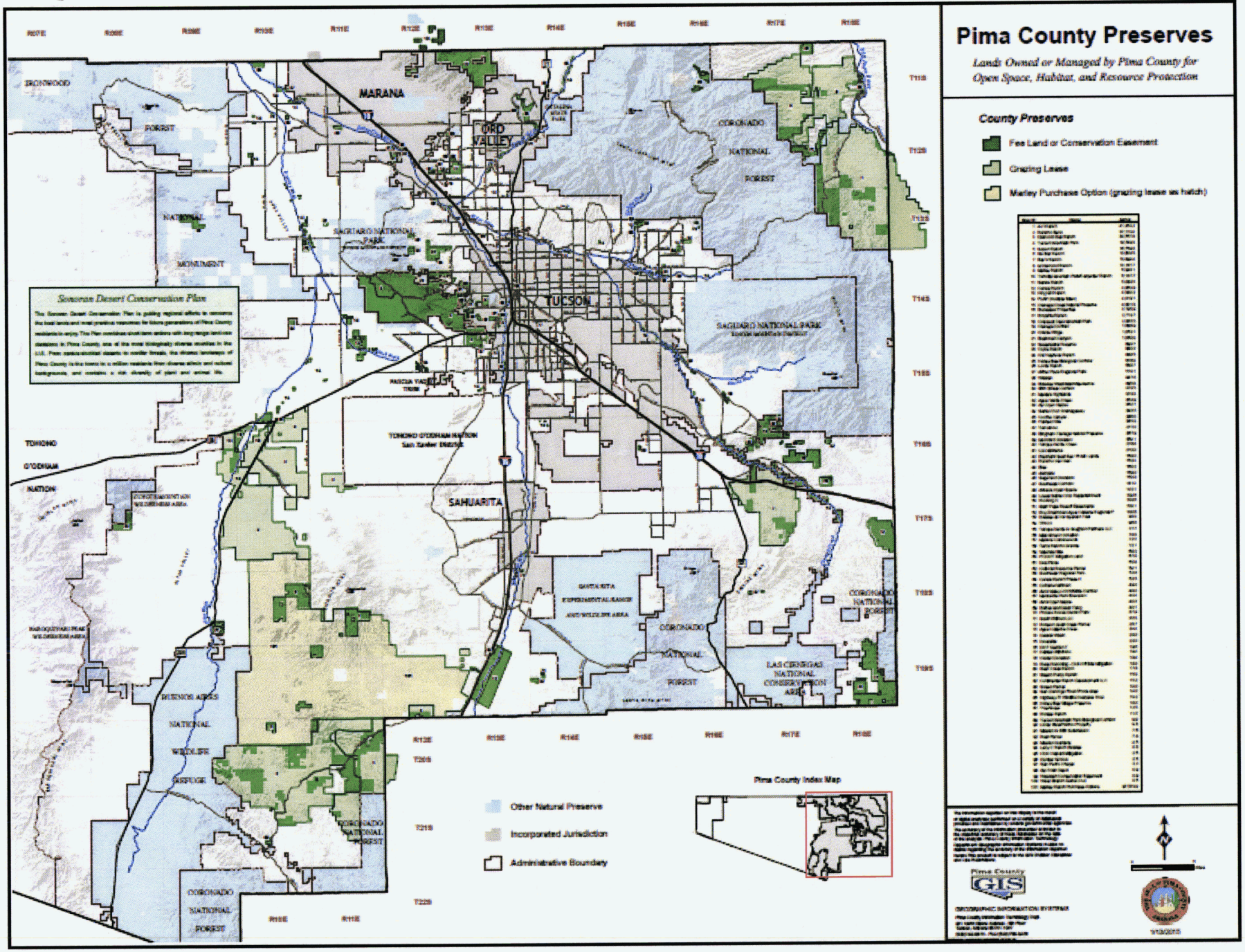
McVie-R-5b


SunZia - Habitat Fragmentation
Florence
Coolidge
PINAL
Eloy
SANTA CRUZ FLATS
Oracle
San Manuel
Safford
GRAHAM
Marana
Tucson
Casas Adobes
Tanque Verde
Catalina
Coronado National Forest
Saguaro National Park-East
Tohono O'odham-San Xavier Ind Res
Benson
Green Valley
Sonoita
ARIZONA
Fort Huachuca
Fort Huachuca
Coronado National Forest
CHIRICAHUA MOUNTAINS
CHIRICAHUA MOUNTAINS
SULPHUR SPRINGS VALLEY
Gila River
0 10 20 40 Miles
Legend
SunZia (Proposed)
Surface Hydrology
Scientifically Modeled Wildlife Linkages
Arizona Wildlife Linkage Assessment (Habitat Blocks)
Arizona Wildlife Linkage Assessment (Linkage Zones)



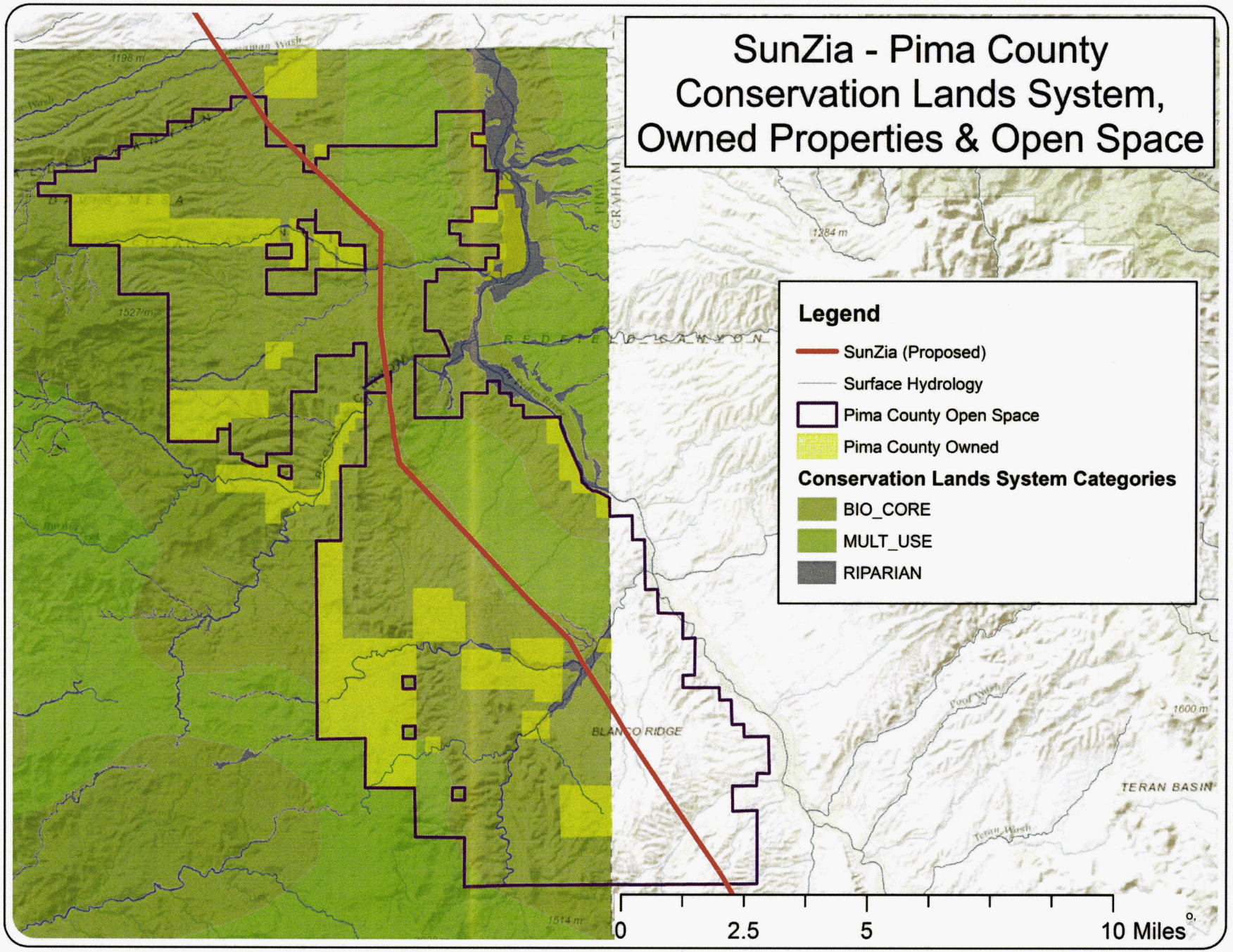
DOCKET NO_L-00000YY-15-0318-00171_MCV_6

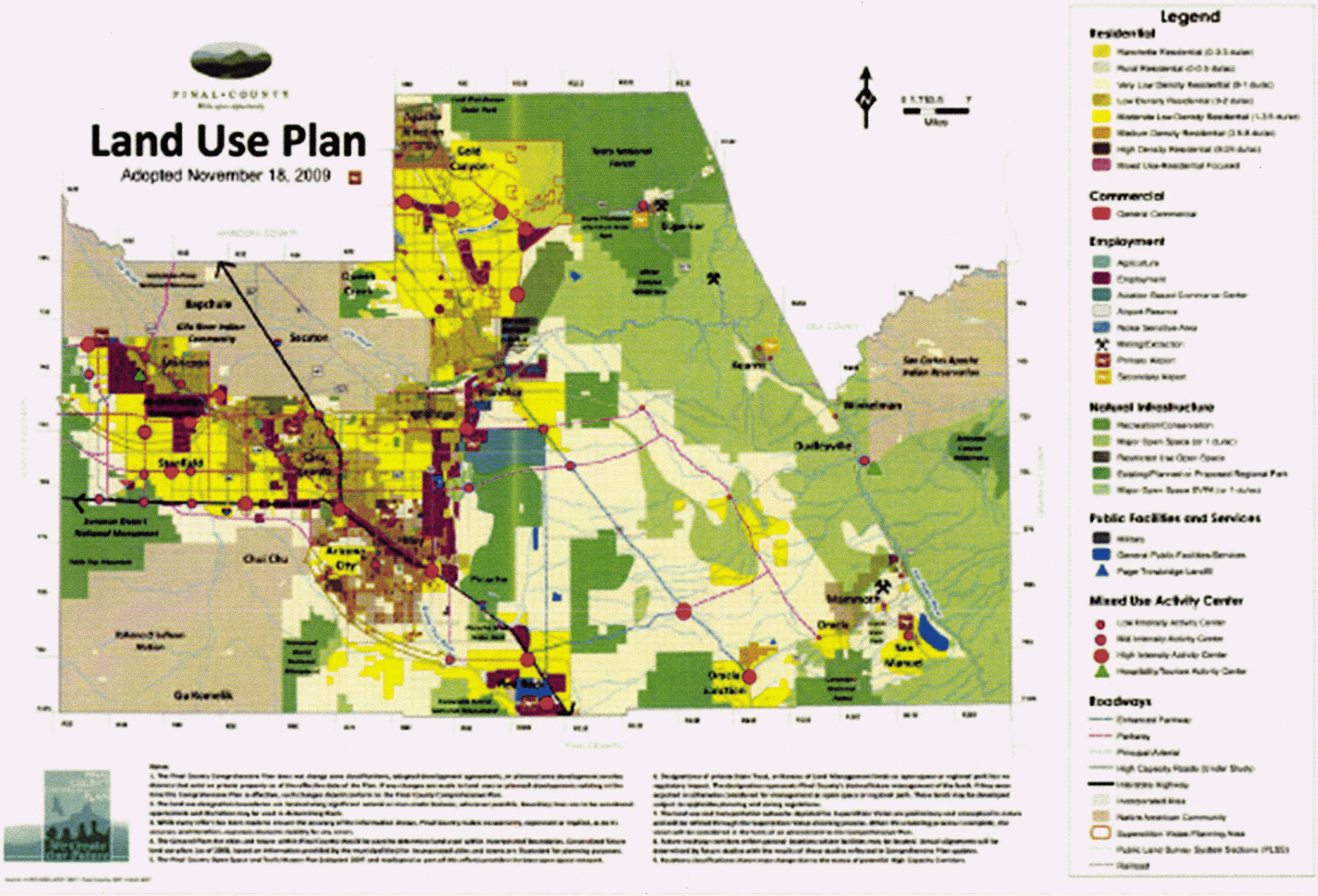
McVie-R-7a

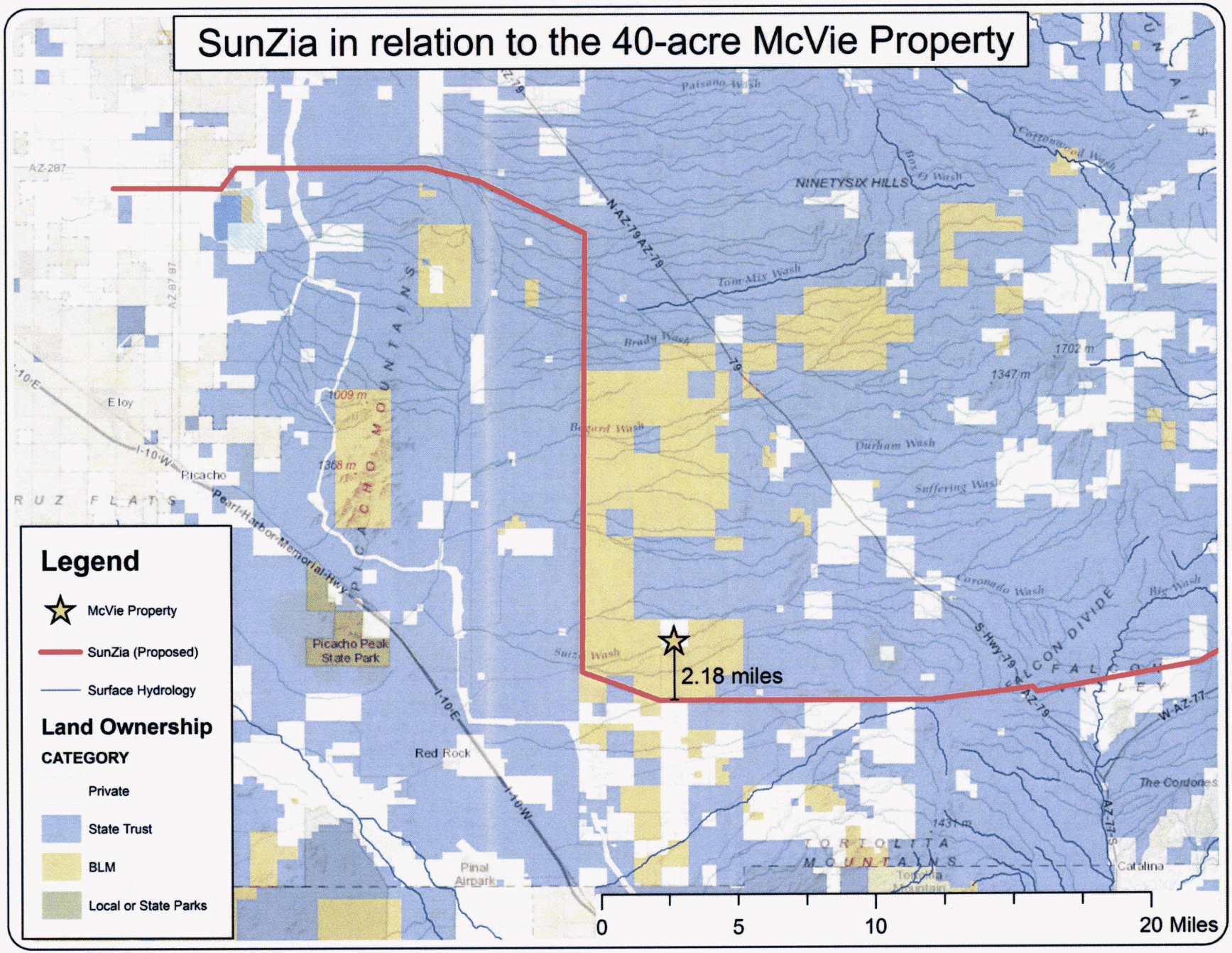


DOCKET NO_L-00000YY-15-0318-00171_MCV_6

McVie-R-7b


SunZia - Pima County Conservation Lands System, Owned Properties & Open Space
Legend
SunZia (Proposed)
Surface Hydrology
Pima County Open Space
Pima County Owned
Conservation Lands System Categories
BIO_CORE
MULT_USE
RIPARIAN
0
2.5
5
10 Miles
BLANCO RIDGE
TERAN BASIN
GRAHAM
1284 m
1600 m
1514 m
1527 m
1198 m


PINAL COUNTY
Land Use Plan
Adopted November 18, 2009
Legend
Residential
Commercial
General Commercial
Employment
Agriculture
Employment
Airport Reserve
Noise Sensitive Area
Mining/Extraction
Primary Airport
Secondary Airport
Natural Infrastructure
Public Facilities and Services
Military
Mixed Use Activity Center
Low Intensity Activity Center
Mid Intensity Activity Center
High Intensity Activity Center
Hospitality/Tourism Activity Center
Roadways
Enhanced Parkway
Parkway
Principal Arterial
High Capacity Roads (Under Study)
Interstate Highway
Native American Community
Public Land Survey Section Sections (PLSS)
Railroad
Miles
Apache Junction
Coolidge
Florence
Casa Grande
Eloy
Maricopa
Stanfield
Arizona City
Picacho
Oracle
San Manuel
Superior
Queen Creek
Gila River Indian Community
San Carlos Apache Indian Reservation
Tohono O'odham Nation
Ak-Chin Indian Reservation
Gila Bend Indian Reservation
Ironwood National Monument
Sonoran Desert National Monument
Table Top Mountain
Picacho Peak State Park
Oracle Junction



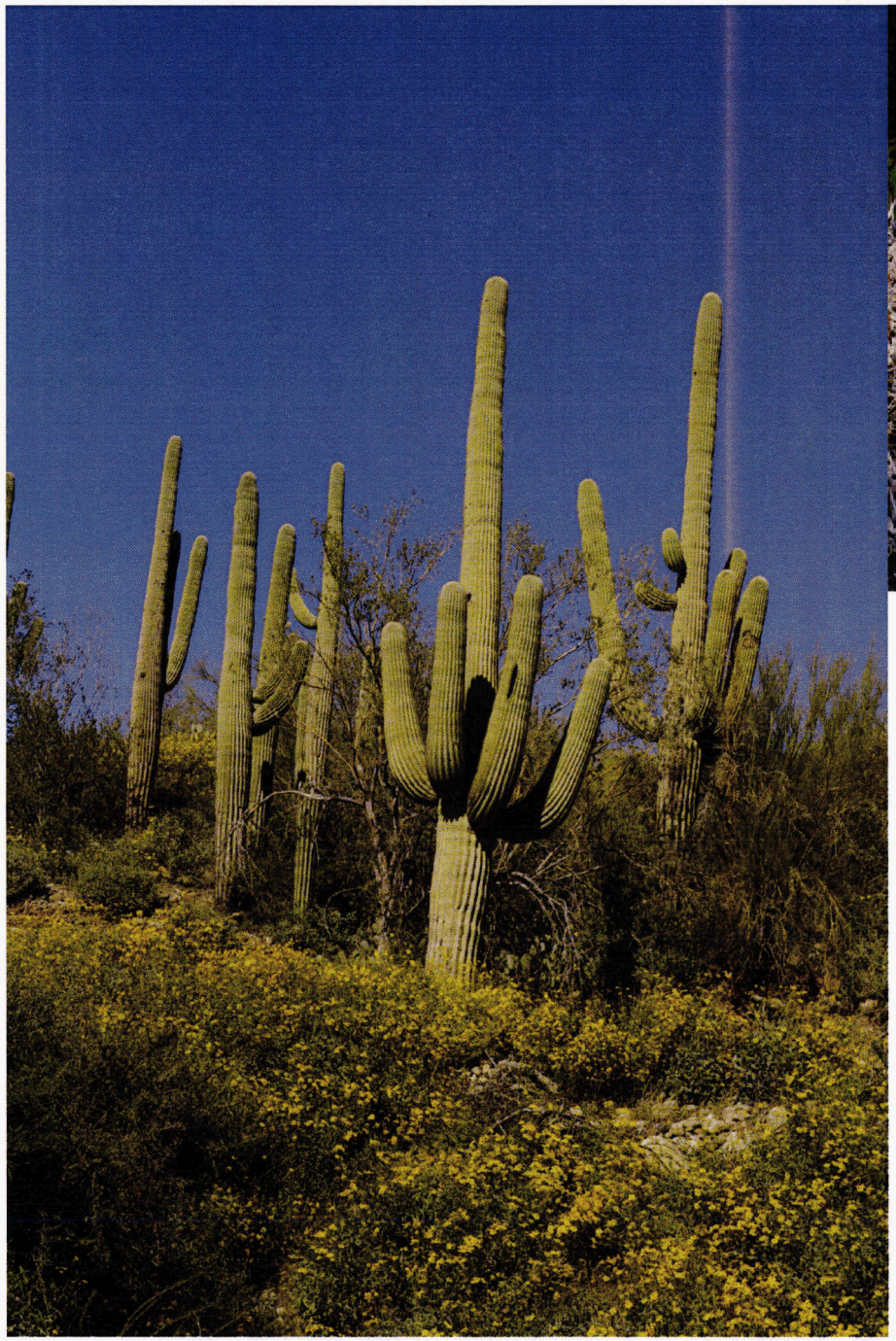
DOCKET NO_L-00000YY-15-0318-00171_MCV_21

McVie-R-8b

Ironwood (*Olneya tesota*)

Ironwood is one of the largest and longest-lived Sonoran Desert plants, reaching 45 feet in height and persisting as long as 1,500 years. It is a single or multi-trunked evergreen tree, and displays lavender to pink flowers in May . . . The shaded sanctuary and richer soils created by ironwoods increase plant diversity and provide benefits to wildlife.

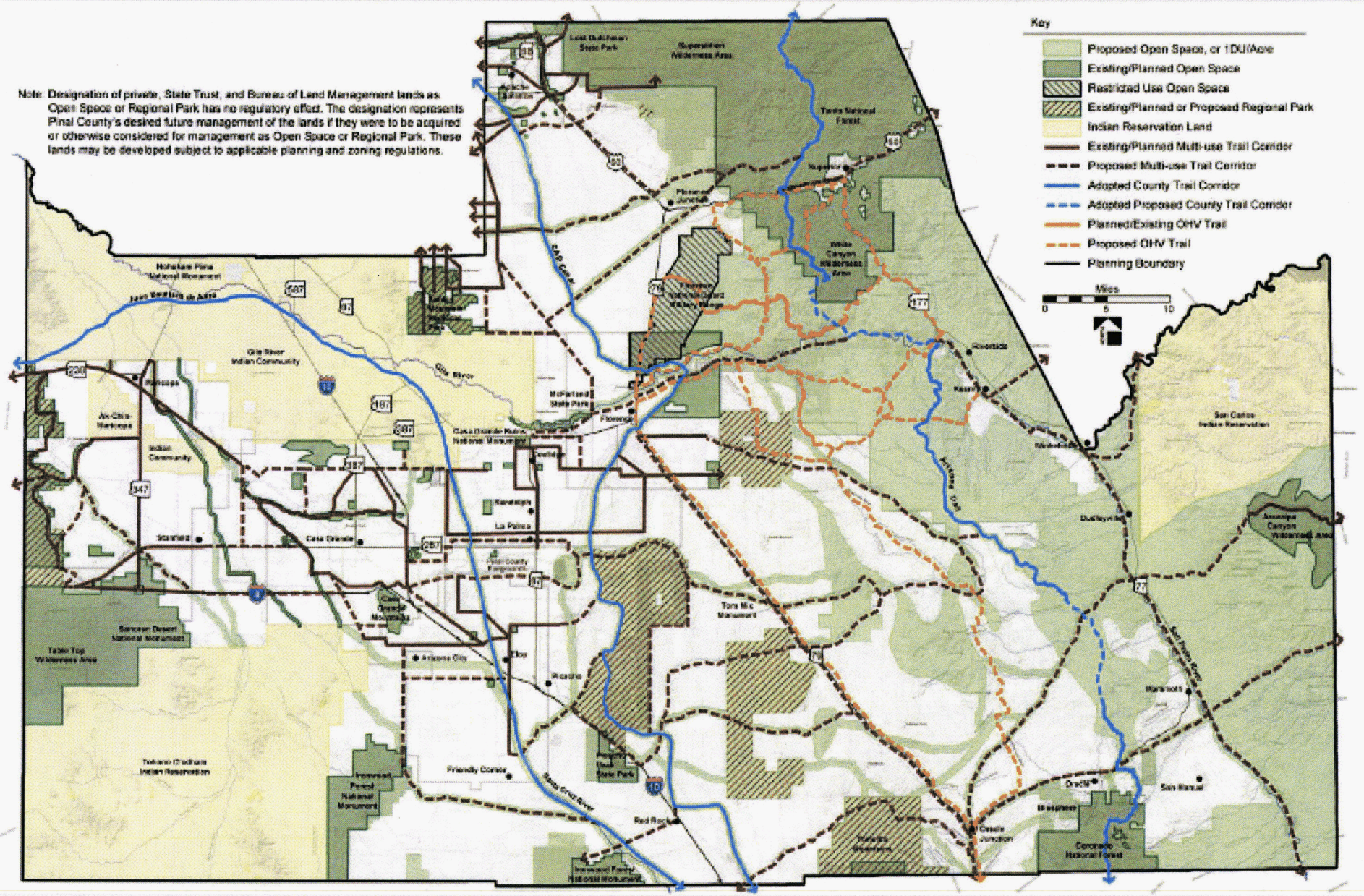
(Pima County SDCP at: http://www.pima.gov/cmo/sdcp/species/iw/illus.html)



Saguaro Cactus (*Cereus giganteus*)

The saguaro cactus is one of the dominant forms in the Sonoran Desert. While a young saguaro takes nearly a decade to reach one inch tall, over many decades it can reach heights of fifty feet, making it the largest cactus in the United States . . .The saguaro flowers from May to June . . . The flowers open at night, awaiting pollination by bats, birds, and insects. When the fruit ripens, it reveals a juicy red pulp that is enjoyed by many desert dwellers, including people.

Pinal County Open Space and Trails Master Plan



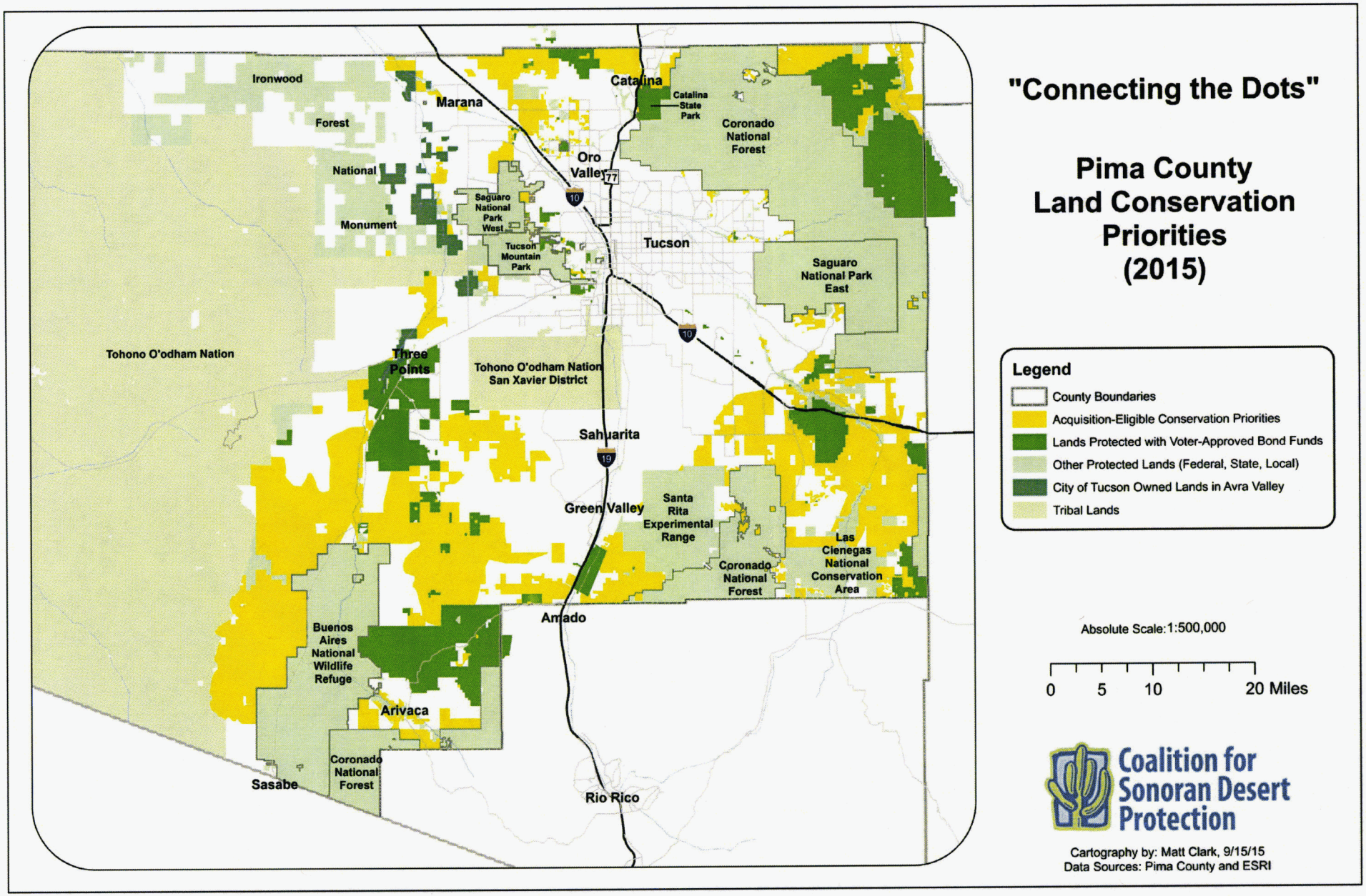
DOCKET NO_L-00000YY-15-0318-00171_MCV_18

McVie-R-11a

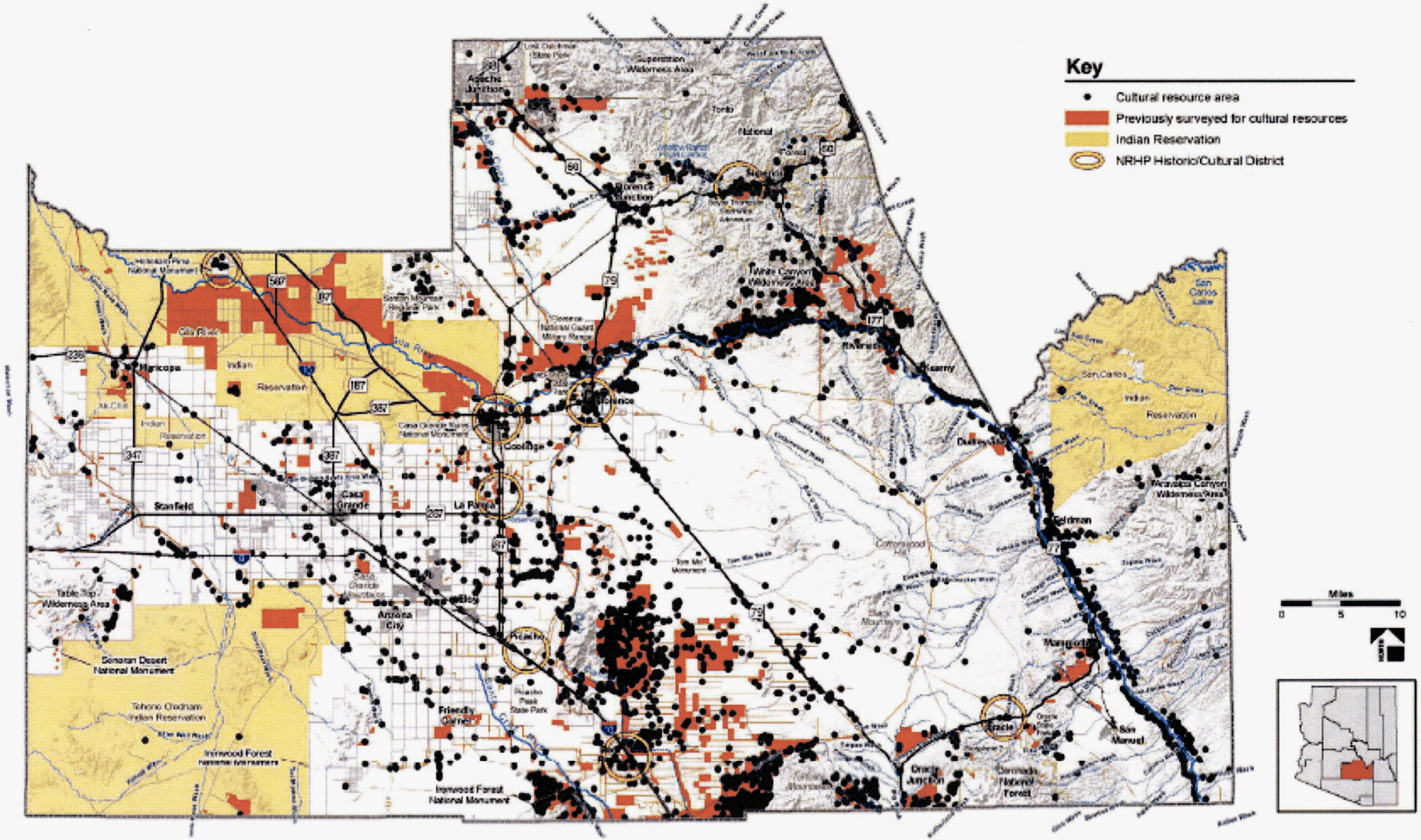
PIMA PROSPERS
comprehensive plan initiative

Comprehensive Plan

Trail System, Pima County, Arizona


"Connecting the Dots"
Pima County
Land Conservation
Priorities
(2015)
Legend
County Boundaries
Acquisition-Eligible Conservation Priorities
Lands Protected with Voter-Approved Bond Funds
Other Protected Lands (Federal, State, Local)
City of Tucson Owned Lands in Avra Valley
Tribal Lands
Absolute Scale: 1:500,000
0 5 10 20 Miles
Coalition for Sonoran Desert Protection
Cartography by: Matt Clark, 9/15/15
Data Sources: Pima County and ESRI
Ironwood Forest National Monument
Marana
Catalina
Catalina State Park
Coronado National Forest
Oro Valley
Saguaro National Park West
Tucson Mountain Park
Tucson
Saguaro National Park East
Tohono O'odham Nation
Three Points
Tohono O'odham Nation San Xavier District
Sahuarita
Green Valley
Santa Rita Experimental Range
Las Cienegas National Conservation Area
Amado
Buenos Aires National Wildlife Refuge
Arivaca
Coronado National Forest
Sasabe
Rio Rico

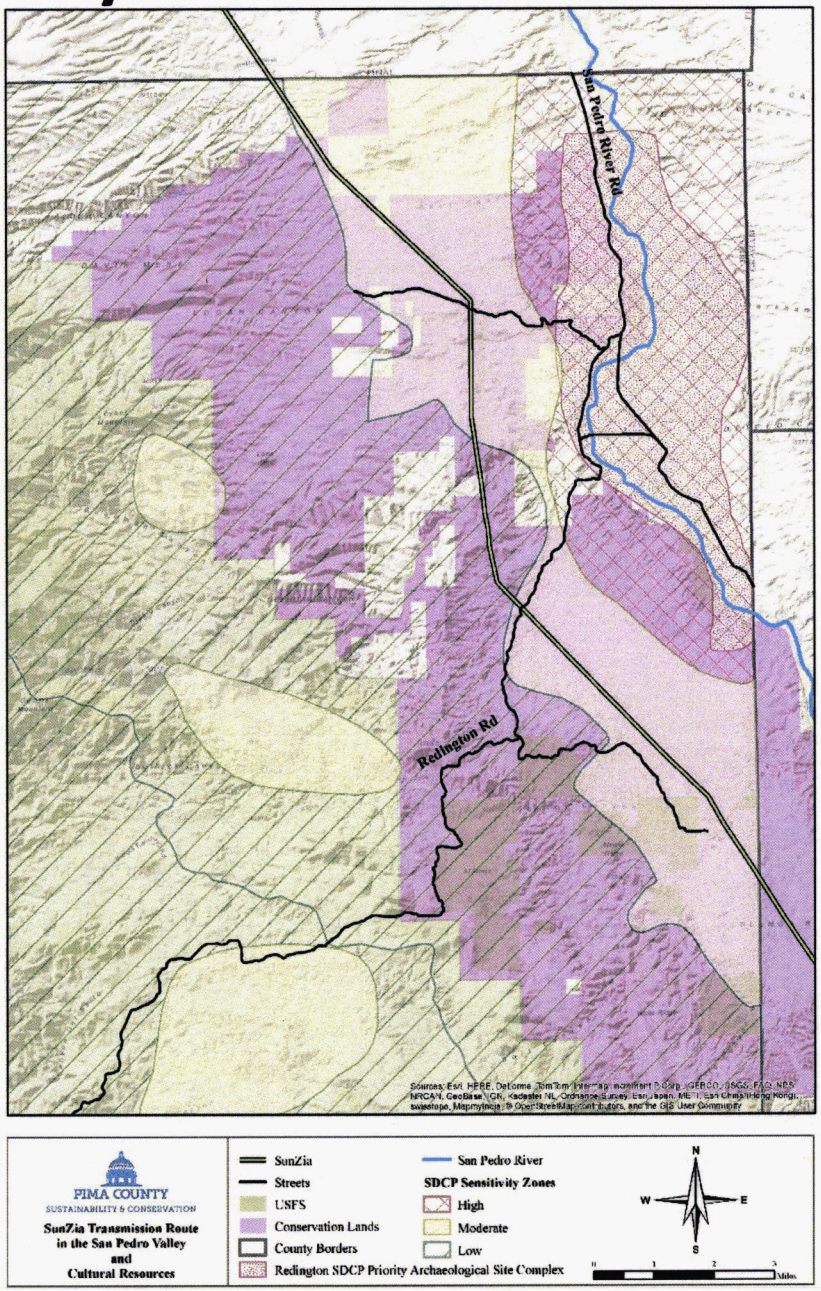
Pinal County Cultural Resources Map

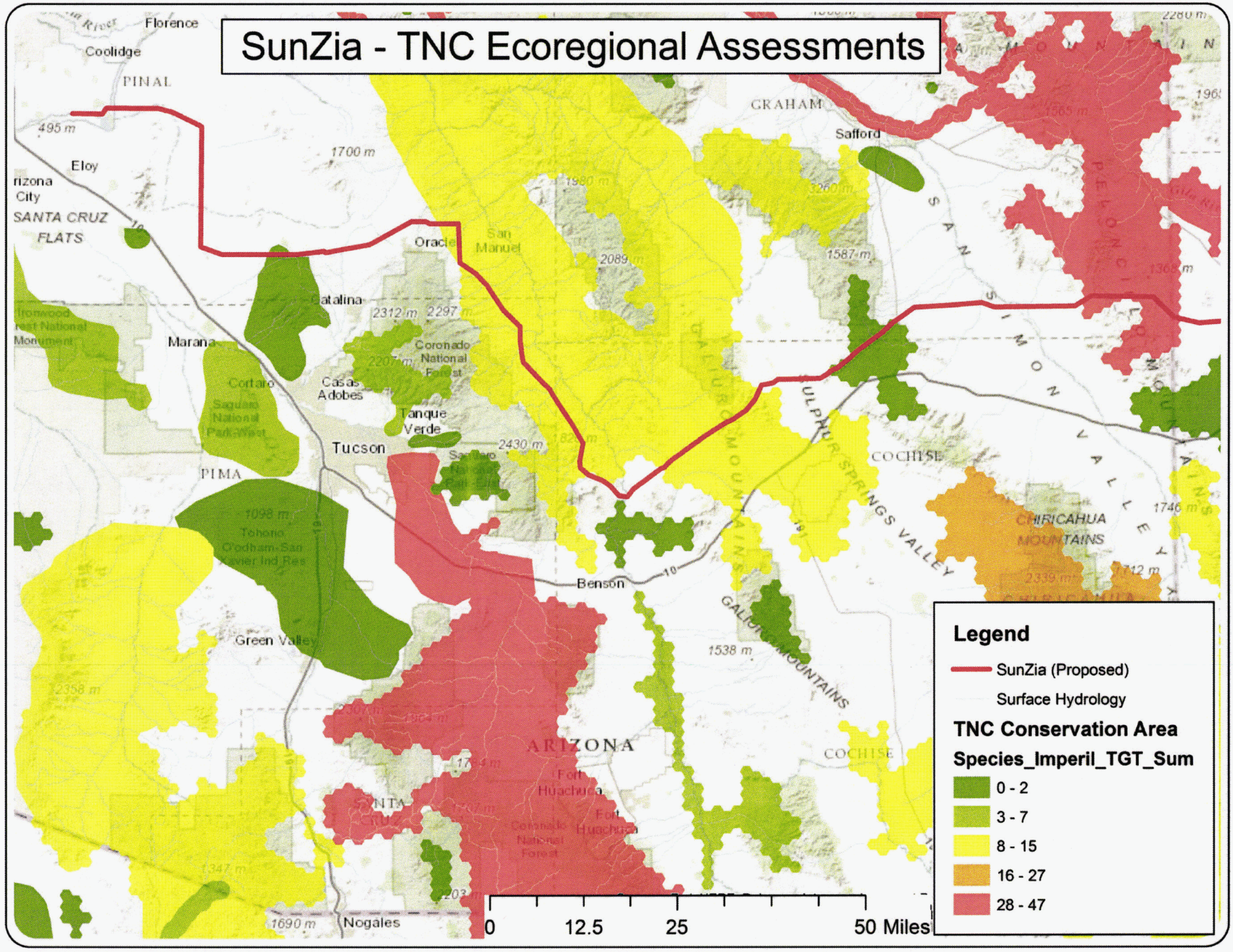


DOCKET NO_L-00000YY-15-0318-00171_MCV_18

McVie-R-13a

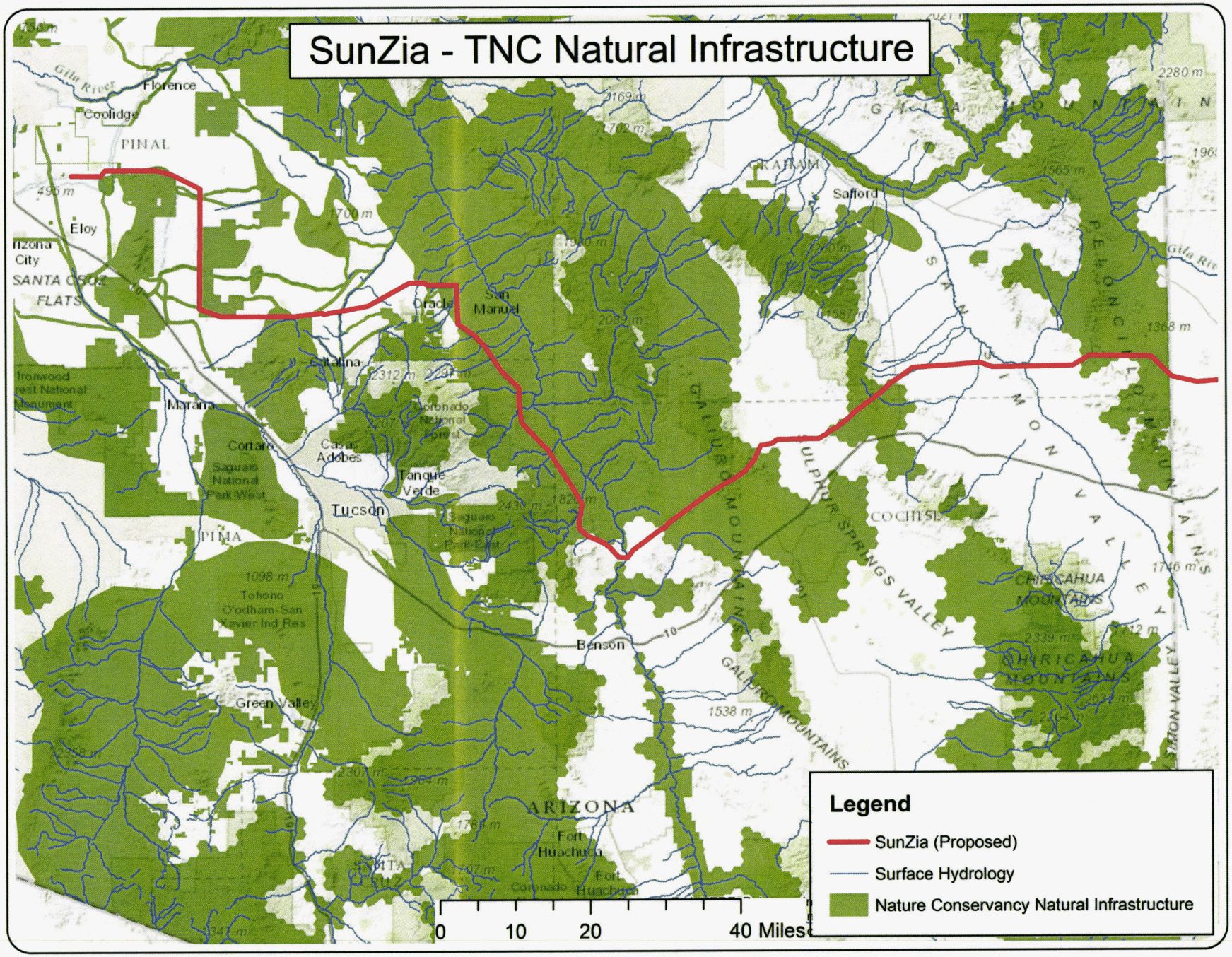
Pima County Cultural Resources and SunZia





DOCKET NO_L-00000YY-15-0318-00171_MCV_9

McVie-R-14a

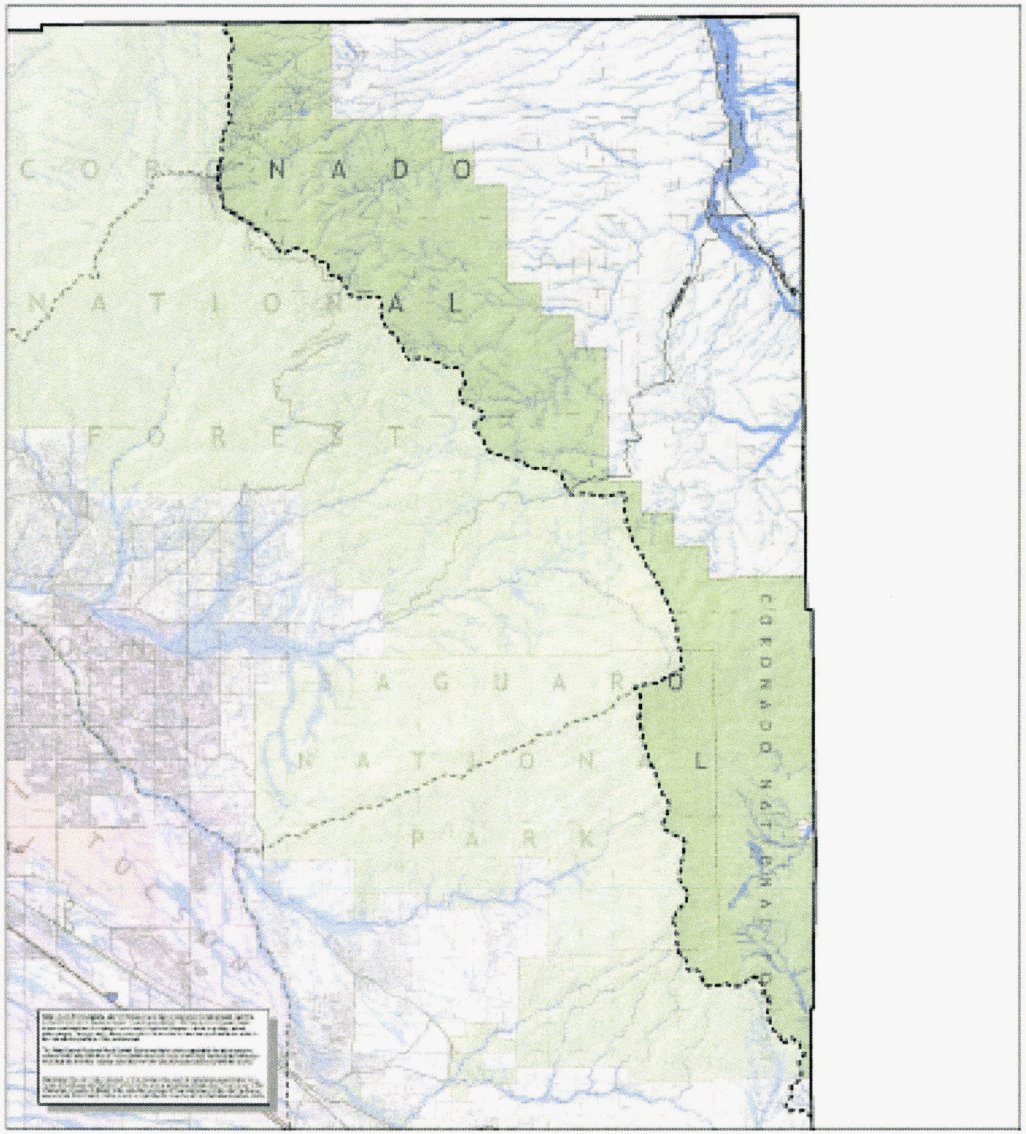

SunZia - TNC Natural Infrastructure
Florence
Coolidge
PINAL
Eloy
Arizona City
SANTA CRUZ FLATS
Ironwood Forest National Monument
Marana
Catalina
Oracle
San Manuel
Coronado National Forest
Casas Adobes
Tanque Verde
Tucson
Saguaro National Park West
Saguaro National Park East
PIMA
Tohono O'odham San Xavier Ind Res
Green Valley
Sahuarita
Benson
Safford
GRAHAM
GALIURO MOUNTAINS
SULPHUR SPRINGS VALLEY
SAN SIMON VALLEY
PERONCILLO MOUNTAINS
COCHISE
CHIRICAHUA MOUNTAINS
ARIZONA
Fort Huachuca
Legend
SunZia (Proposed)
Surface Hydrology
Nature Conservancy Natural Infrastructure
0
10
20
40 Miles

PIMA PROSPERS

San Pedro Planning Area

Regional Hydrology

PUBLIC HEARING DRAFT

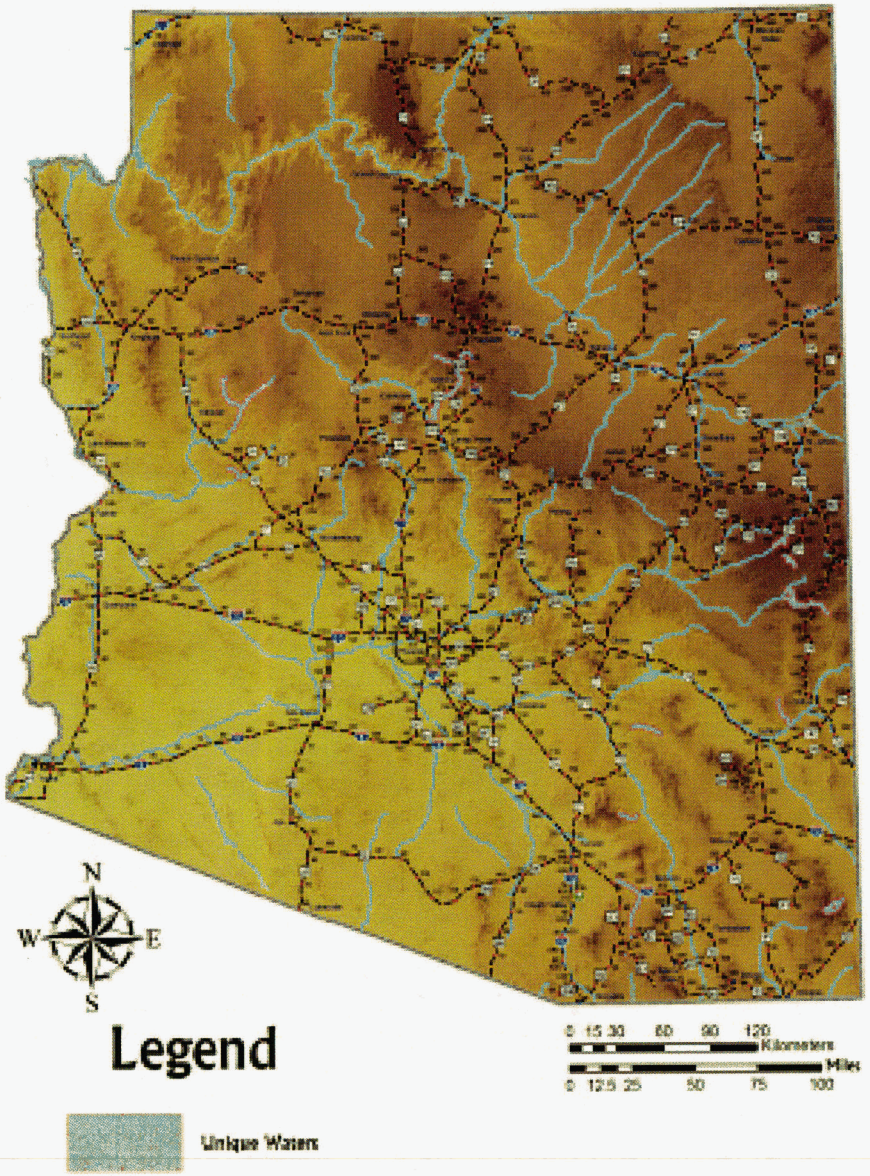


DOCKET NO_L-00000YY-15-0318-00171_MCV_6

McVie-R-15

Figure 8.7

UNIQUE WATERS



Enlargement Unique Waters outlined in red (ADEQs Outstanding Waters of Arizona)

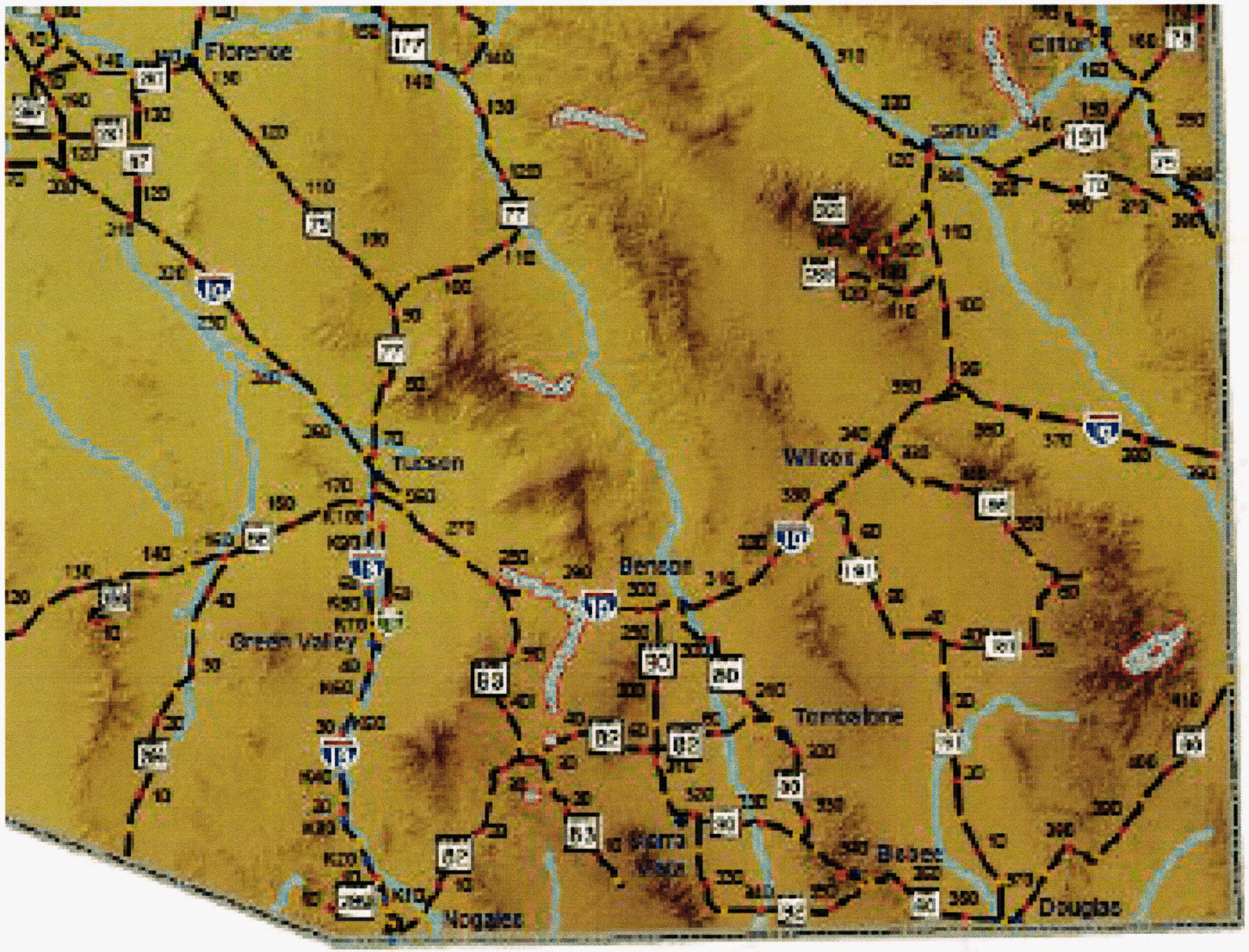
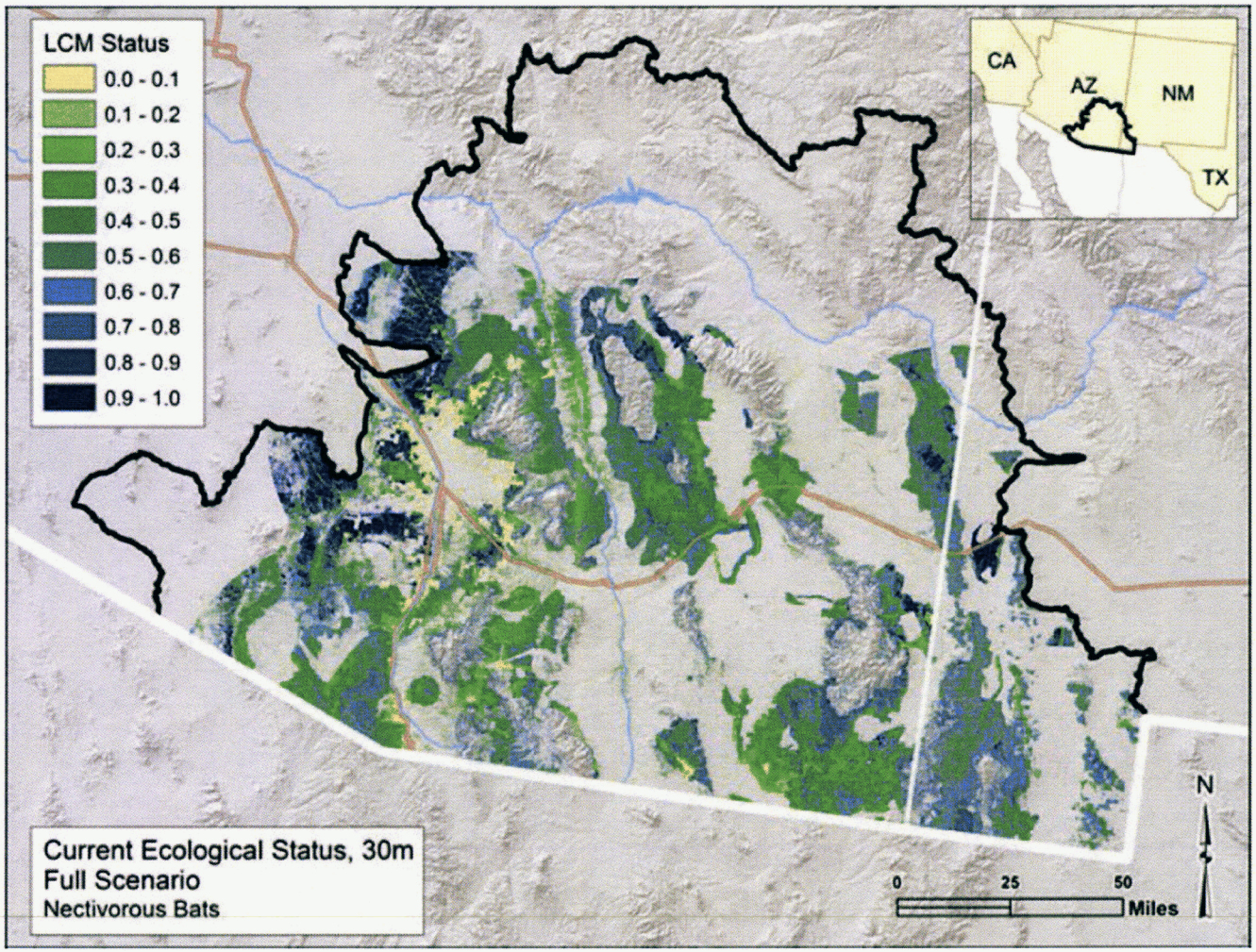


Figure 1-4. Current overall ecological status scores for the nectivorous bat assemblage for each 30m pixel (top) and 4km grid cells (reporting units, bottom). LCM = landscape condition model. Yellow scores (equivalent to 0) indicate high impacts from the CAs and correspondingly lower ecological status, dark blue (equivalent to 1) indicate little to no impact from the CAs and correspondingly higher ecological status. In the second map, the score for each 4km cell is an average of the overall ecological status scores of the 30m pixels within the 4km cell that were were scored for the CE.



Desert Landscape Conservation Cooperative
Nominated Landscape Conservation Designs
Traversed by the Proposed SunZia Southwest Transmission Line