DRAFT ENVIRONMENTAL IMPACT STATEMENT CONTRIBUTIONS

FOR PROPOSED SUNZIA TRANSMISSION LINE ROUTE TRAVERSING THE **ARAVAIPA WATERSHED AND LOWER SAN PEDRO RIVER VALLEY**

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SUBMITTED BY
FRIENDS OF THE ARAVAIPA REGION &
THE CASCABEL WORKING GROUP

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AUTHORS

NEPA requires that the preparers of the Environmental Impact Statement (EIS) and their qualifications be listed.

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I. INTRODUCTION

This document represents the initial input of Friends of the Aravaipa Region and Cascabel Working Group to the Draft Environmental Impact Statement (EIS) for the proposed SunZia transmission line route traversing the Aravaipa watershed into the Lower San Pedro River Valley (referred to hereafter as the "Aravaipa route"). Our focus, as the name implies, is primarily "environmental." NEPA's characterization is wider by virtue of its defining the EIS purview as the "human environment", thus implicating cultural and sociological resources along with natural ones. Nonetheless, those equally significant aspects of the Aravaipa route are only incidentally touched upon here and await other venues for fuller development.

Readers of the Cascabel Working Group's "Draft Environmental Impact Statement Contributions For Proposed SunZia Transmission Line Routes Traversing The San Pedro River Valley" will recognize much of the wording in this document. This is both intentional and appropriate. The geographic focus of this contribution is the Lower San Pedro River Valley and the Aravaipa watershed, the latter being a part of the San Pedro River watershed. This landscape is part of the same largely unfragmented and roadless area and is encompassed by the same ecoregions and many of the same biomes with their attendant unique and important flora and fauna species, including virtually every threatened, endangered or diminishing species addressed in the above mentioned document.

There are also substantive differences however, between this document and the San Pedro Valley DEIS Contribution, including more locally specific treatment of the biomes, flora and fauna as well as conservation efforts specific to this area. Addressed throughout this document are potential threats to these environmental resources and values arising from a major transmission project along SunZia's proposed Aravaipa alignment.

For those familiar with the work of Friends of the Aravaipa Region and Cascabel Working Group, it will come as no surprise that we believe that a fair application of National Environmental Protection Act (NEPA) laws in light of the biological evidence argues strongly against the Aravaipa route. Opposition to the Aravaipa route by every environmental organization that has weighed in on the issue is testimony to the widely held biological consensus.

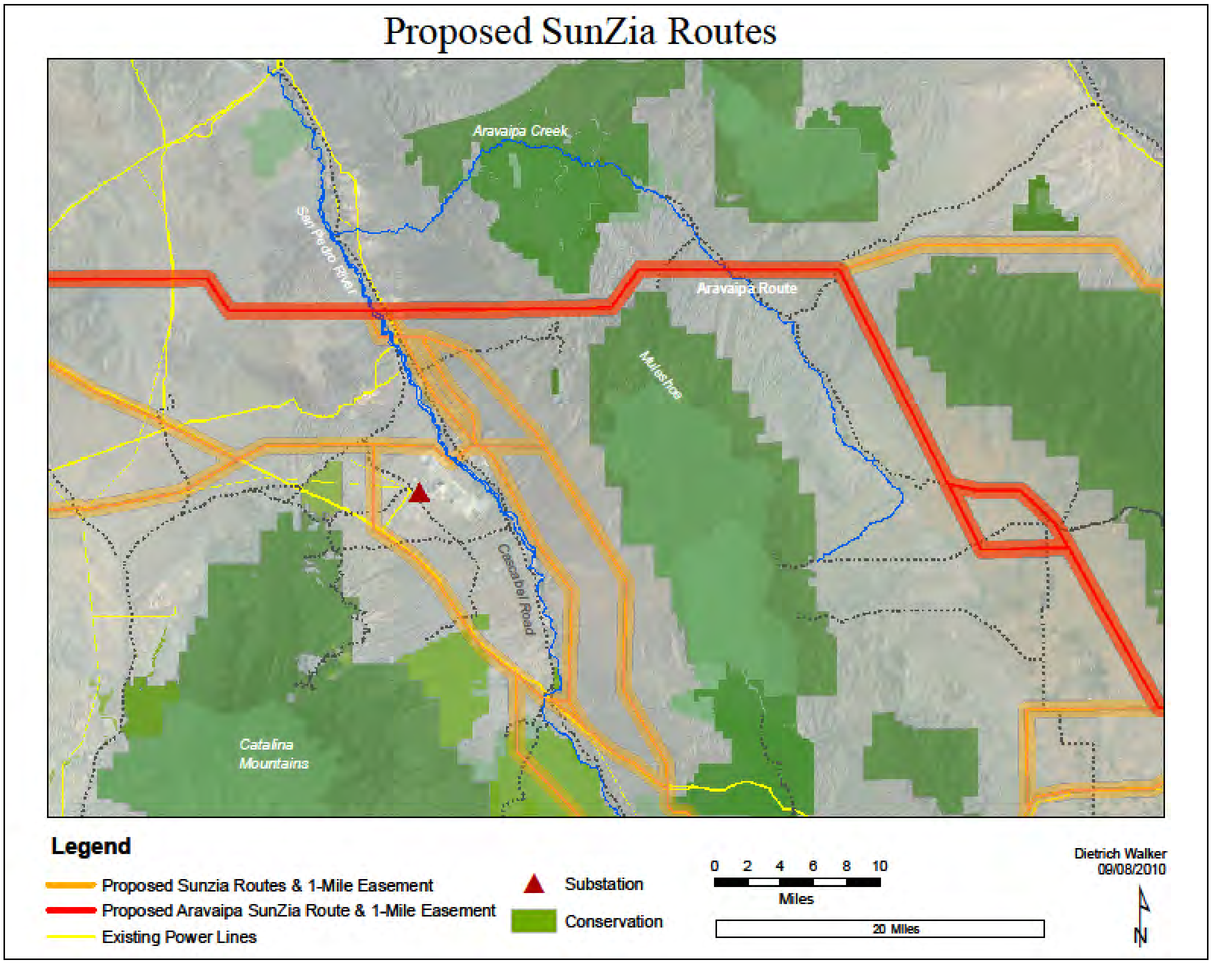

Figure 1: Proposed SunZia Aravaipa Route

II. GEOGRAPHICAL AREA

The areal focus of this document is those portions of the Aravaipa watershed and Lower San Pedro River Valley (Lower SPRV) that would be traversed by SunZia's proposed "Aravaipa route", principally parallel to and east of Aravaipa Creek to just south of Klondyke, AZ, then west to cross the San Pedro River near Mammoth, AZ.

It is important to note however that the consideration of this document is the entire Aravaipa watershed and Lower SPRV, that is, both the basin and range extent of that traverse. The Pinaleno and Santa Teresa Mountains to the east and the Galiuro Mountains to the west, as well as the attendant foothills and canyons, are equally part and parcel of the ecosystems to be considered here.

> *The complete Aravaipa watershed area is about 558 square miles (356,984 acres), with an elevation range of 2,160 to 8,441 feet. In the upper watershed, surface flow is ephemeral to intermittent in a broad alluvial valley between the Pinaleño and Santa Teresa mountains to the east, and Galiuro Mountains to the west. The creek becomes perennial at Aravaipa Spring, at the head of Aravaipa Canyon near Stowe Gulch, and cuts westward through the Galiuros.*[1]

The Lower SPRV generically describes the valley wide area from the rocky outcrop just north of Pomerene known locally as "The Narrows", to the confluence of the San Pedro River with the Gila River near Winkelman.

At the point of this writing, the Aravaipa route is largely undefined in detail. In general it primarily traverses the Aravaipa watershed for a length of approximately 30 miles across the upland foothills, bajadas and canyons before descending into the Lower San Pedro River Valley. As presently construed the Aravaipa route would bisect The Nature Conservancy's 528 acre H&E Farm located on the east side of the Lower San Pedro River.

Especially relevant to the area of consideration and impacts is the SunZia project's petition to the Federal Energy Regulatory Commission (FERC) wherein they state:

> *A right-of-way of up to 1,000 feet in width is required to construct, operate, and maintain the Project. However, in order to accommodate future expansion, the Project's EIS study corridor is one mile wide. The wider study corridor will significantly reduce the environmental obstacles to future transmission expansion along the Project's path by considering environmental resources any such expansion would be likely to affect.*[2]

While this lack of specificity is a detriment to detailed route analysis, on the other hand it argues for a wider consideration of Aravaipa and Lower SPRV impacts.

III. ARAVAIPA WATERSHED AND LOWER SAN PEDRO RIVER VALLEY– INDIRECT IMPACTS

A. NEPA – CONTEXT AND INTENSITY

The SunZia project mile-wide study corridor and the introduction of future transmission expansion greatly enlarge consideration of both the spatial and temporal impacts of the project. As NEPA warrants, "effects" in the Environmental Impact Statement (EIS) include "Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects."[3] Such considerations are also pertinent to a NEPA judgment of Environmental Objection (EO), "Where proceeding with the proposed action would set a precedent for future actions that collectively could result in significant environmental impacts."[4]

Other legal definitions explicit in NEPA also recognize that such wider consideration is germane to the modern understanding of ecological science – i.e. the interconnection and interdependence of all elements of an ecosystem. The severity, duration, or geographical scope of impacts, along with associated threats to national environmental resources is a basis for environmentally unsatisfactory reviews. NEPA Section 1508.8 also notes that "indirect effects may include… related effects on air and water and other natural systems, including ecosystems. …Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative."[5]

Another component related to wider considerations of areal impacts explicit in NEPA is the "significance of an action," or what one might call the weighted metrics to be considered. With regard to those weighted measures, NEPA requires that both the "context" and "intensity" or "severity of impact" be considered. That means that the proposed action "must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality." In evaluating the intensity of the proposed action, it requires that, "Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas" should be considered.[6]

B. ARAVAIPA WATERSHED AND LOWER SPRV GENERAL ATTRIBUTES

1. SAN PEDRO RIVER

While the loosely defined SunZia project Aravaipa route averts most of the designated conservation status lands in the Aravaipa watershed and Lower SPRV, there is an abundance of "proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas" to address.

The most renowned of course is the San Pedro River itself, often regarded as the last major free-flowing river in the desert southwest, and considered to be "…the best example of a desert riparian system remaining in the Southwest."[7] Accolades such as the following are numerous:

> *The upper San Pedro river basin sits at the ecotone between the Sierra Madre Mountains to the south, the Rocky Mountains to the north, the Sonoran Desert to the west, and the Chihuahuan Desert to the east. The basin is one of the most ecologically diverse areas in the Western Hemisphere and contains numerous different biotic communities and supports several endangered plant and animal species. …The San Pedro is one of the last free-flowing streams in the American Southwest and serves as an international flyway for more than 400 species of birds, and sixty km of riverine territory north of the U.S.-Mexico border is designated as a national conservation area.*[8]

It has in fact been recognized as having natural heritage values of global significance by several organizations, including The Nature Conservancy,[9] the Commission for Environmental Cooperation,[10] and the American Bird Conservancy.[11] Indeed, the Bureau of Land Management which is overseeing the SunZia project is itself among them.[12]

Speaking to the renown of the San Pedro River was the convening of a tri-national Commission for Environmental Cooperation (CEC) negotiated by the United States, Canada and Mexico under the North American Free Trade Agreement (NAFTA).[13] It too touted the San Pedro area as "internationally renowned for its native biodiversity," containing "one of the richest assemblages of species of any region in the United States (Simpson 1964 in Friedman and Zube, 1992)."[14] But its focus was the fact that "The San Pedro River supports one of the most important migratory bird habitats in North America; indeed, roughly half of the birds that breed in this arid region are dependent upon it."[15] Along with possessing "one of the highest bird diversities of areas its size in the United States,"[16] they called the supporting habitats "of special continental importance…."[17]

> *For these reasons, in 1995 the American Bird Conservancy, in partnership with Partners in Flight and the National Audubon Society, named the SPRNCA a Globally Important Bird Area. This was the first designation of this kind in the Western Hemisphere.*[18]

What is relevant here is that the prominence generically ascribed to the San Pedro River (SPR) is equally applicable in its lower reaches. Virtually all of the significant biological features of the Upper SPR apply to its middle and lower reaches, as should the managerial prescriptions, as it wends its way north to the Gila River. After all, "…ecosystem management efforts that end abruptly at administrative or international boundaries are, in the long-term, unlikely to accomplish the overall goal of biodiversity conservation."[19] The CEC itself concurred, noting that:

> *The expert team has adopted a bird's-eye-view of habitat availability, which transcends political boundaries. We consider the United States and Mexican reaches of the basin a single hydrologic entity. …The objective of this investigation is to provide information that will help maintain a high quality, self-sustaining riparian ecosystem within and beyond the San Pedro Riparian National Conservation Area. …all North Americans benefit from, and have a stake in preserving this riparian habitat and the migratory birdlife that it supports…..*[20]

It is clear that most attributes sited by the CEC and for the San Pedro River National Conservation Area (SPRNCA) apply to the Lower SPRV. The Lower San Pedro River was also identified as a Global Important Bird Area in January 2008.[21] This reach of the SPR also partakes of the same internationally renowned biodiversity, and perhaps more so than the Upper SPRV. While also partaking of the Petran Montane Conifer Forest (122.3) and the Madrean Evergreen Woodland (123.3) that make up the Sky Islands ranges, here the Sonoran Desertscrub (154.12) ascends from the north and west. There is also only north of Interstate-10 the Interior Chaparral (133.3) rimming the ranges of the Lower SPRV and present in the Aravaipa watershed, as well as immediately proximate biotic communities to the valley that are not present further south – the Plains and Great Basin Grasslands (142.3) and the Great Basin Conifer Woodland (122.4) in the Aravaipa Valley just east of Kielberg Canyon. In the Lower SPRV and Aravaipa watershed exist eight biotic communities, as great as any area in the American Southwest, twice as many as in the Upper SPRV.[22]

This extraordinary biodiversity will be returned to when looking more pointedly at the ecoregional influences in the Lower SPRV, and especially when reviewing in depth the vertebrate populations in the area. But when addressing the San Pedro River *per se,* it is its preeminence as the main flight corridor for neotropical migrant birds in the West that elicits the greatest attention. The studies that substantiate the SPRV's "continental importance" bear out that those migrating birds do not suddenly change watersheds when reaching the Lower SPRV.[23]

Another commonality with the Upper SPRV is the vitality of the river itself. Some tend to minimize the Lower San Pedro's significance because of its apparent dependence upon the Upper, and its admittedly more intermittent flow regime. Nonetheless, its downstream locale does not make it second in significance – migrants require, and by virtue of the visiting numbers apparently receive, as much nutrition in their migrations here as they do upstream.

It is true that less recharge would be expected as the elevation of the river descends into the drier Sonoran zone. However, as Skagen's study demonstrated, there is actually more utilization by neotropical migrants of the upland oases in the riparian habitats of the SPRV mountains and foothills than on the river itself.[24] The river appears to be the green "ribbon through the desert" that is the navigational arrow pointing the way, while many of their best stopover resorts seem to be those permitted by the uplands. Still, if the river itself were not important, the birds would be following other drier valleys.

This connection of the uplands and the river is a point that will be continually returned to, for it is the most glaring ecological misapprehension of the SunZia proposed routes through the Aravaipa watershed and LSPRV that somehow the connection between watercourse, foothills and mountains does not exist and can be transected without deleterious impact to an ecosystem of critical continental importance.

2. THE ARAVAIPA WATERSHED

The NEPA directive to address "proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas" is equally relevant to the Aravaipa watershed. Again, though the Aravaipa route does not pass directly through conservation status areas, the watershed's ecosystem realities are substantially the same outside the boundaries as within. As demonstrated in this document, ecological impacts do not stop at political boundaries.

Aravaipa Creek drains 537 square miles, the largest tributary of the Lower San Pedro River, and the only one that penetrates the mountain ranges that bound the east and west sides of the valley. This is a currently unfragmented landscape with low human population and high conservation value. The latter is evidenced by the extensive conservation lands within the Aravaipa watershed, including a national forest, three federally designated wilderness areas, three Areas of Critical Environmental Concern, numerous holdings of The Nature Conservancy and a downstream assemblage of rare and endangered aquatic species.

The recently released Bureau of Land Management (BLM), The Nature Conservancy (TNC) and Arizona Game and Fish Department (AGFD) Draft Aravaipa Ecosystem Management Plan (EMP) details many of the exceptional features of the watershed. Though the managerial reach and prescriptions of the EMP include only conservation status lands, it should be noted that the descriptors are of the Aravaipa watershed ecosystem as a comprehensive unit.

- *Aravaipa Creek's 22-mile-long perennial-flow stretch has one of the best remaining assemblages of desert fishes in Arizona. Several tributary canyons also have perennial stream reaches. The creek and its tributaries also support rich riparian communities of plants and animals. The uplands support a different, but also diverse, community. When these areas are considered together, the Aravaipa ecosystem has a documented presence of 529 plant and 353 animal species, including 233 birds, 50 reptiles, 48 mammals, 12 fish, and 10 amphibians (Johnson 1980; Appendix 1, 2).*

- *The area includes five species currently listed under the Endangered Species Act, 13 BLM sensitive species, and 14 species on AGFD's list of Wildlife of Special Concern in Arizona (Table 3-5). The Arizona Heritage Data Management System identified 35 species of interest as occurring within the Aravaipa Creek watershed.*[25]

- *Aravaipa Creek supports seven native fish species: loach minnow, spikedace, roundtail chub, speckled dace, longfin dace, desert sucker, and Sonora sucker. …the loach minnow and spikedace are federally listed as threatened under the Endangered Species Act.*[26]

- *Two more native species, Gila topminnow and desert pupfish, were recently reestablished into three sites on the South Rim. Both are listed as endangered species….*[27]

- *The Aravaipa ecosystem supports a great diversity of wildlife due to its position at the interface between the Sonoran and Chihuahuan deserts, at the foot of sky island mountains and with a perennial stream running through it. The ecosystem provides habitat for permanent residents as well as transient animals, forming a critical linkage between mountain ranges and valleys. The most obvious and recognizable upland species include mule deer, white-tailed deer, desert bighorn sheep, javelina, black bear, and mountain lion. …Desert bighorn sheep have become the highest profile species in the ecosystem, and the species most associated with the ecosystem.*[28]

- *The large Aravaipa ecosystem provides a diversity of protected habitats that support special status species. The federally listed upland species occurring in the ecosystem are lesser long-nosed bats and Mexican spotted owls. Species that are not listed but are of concern due to rarity, limited habitat, or declining populations include yellow-billed cuckoo, Gila monster, Sonoran desert tortoise, lowland leopard frog, and possibly Mexican garter snake.*[29]

- *Several ruins throughout the Aravaipa watershed indicate long-term widespread prehistoric occupation of the region (Bronitsky and Merritt 1986).*[30]
- *In the Final Arizona Statewide Wild & Scenic River Study Report/ Record of Decision (BLM 1997b), BLM recommended to Congress that 10 miles of Aravaipa Creek be designated as Wild.*[31]

Many of these attributes of the Lower SPRV and the Aravaipa watershed will be returned to in greater detail throughout this document. A sampling of some of the sensitive species habitats through which the proposed SunZia Aravaipa route pass is shown in Figure 2. Again, note that none of these habitats are defined or contained by administrative or political boundaries.

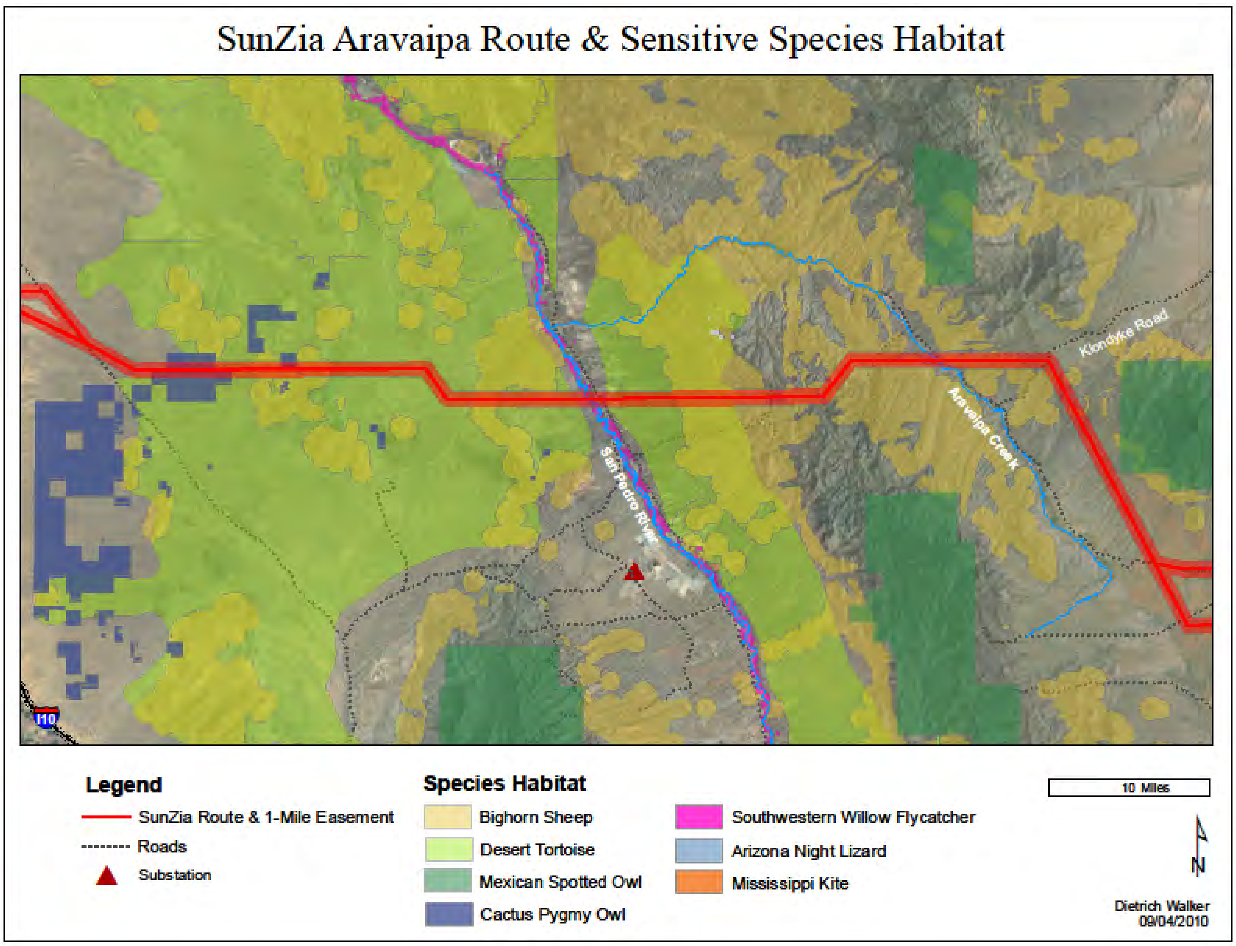

Figure 2: SunZia Aravaipa Route and Sensitive Species

3. UNFRAGMENTED AND INTACT LANDSCAPE

While the Lower SPRV and Aravaipa watershed share the Upper SPRV's biodiversity and avian flight corridor, that does not mean there is no difference, and in fact the distinction is a critical one. There is no question that SPRNCA and the political efforts of the Upper San Pedro Partnership (USPP) have garnered most of the attention for the SPR. That has been appropriate since substantive development has been an ongoing concern in the Upper San Pedro, while the Lower

SPRV has until recently escaped such large-scale impacts. It so happens however that it is the very lack of development and landscape fragmentation which has created the political upheaval in the Upper SPRV that really distinguishes the Lower SPRV and its major tributary, the Aravaipa watershed.

Unfragmented landscapes are key indicators developed by biologists in assessing the conservation value of regions and sites and the imminence of the threat they face.[32] "Large blocks of habitat have the potential to sustain viable species populations, and they permit a broader range of species and ecosystem dynamics to persist."[33] This is a concept that will be returned to in greater detail when assessing the direct impacts of the Aravaipa route.

Pinal County has recognized the unfragmented nature of the area by adopting a County Open Space and Trails Master Plan that identifies much of the Lower San Pedro Valley and Aravaipa watershed as open space. Specifically, it delineates much of eastern Pinal County as "Proposed Open Space". This is precisely the part of Pinal County through which the proposed Aravaipa route would pass. [34]

Integral to the unfragmented and open space character of the Aravaipa watershed is the lack of improved roads. It is in fact part of one of the largest "roadless areas" in the American Southwest. "Roadless area" is a technical term that means, "Literally an area without any *improved* [author's emphasis] roads maintained for travel by standard passenger type vehicles."[35] The Bonita/Klondyke road within the Aravaipa watershed does not meet that criterion. The U.S. Department of Interior classifies a road that "May or may not be graded, and has a dirt surface of any width" as an "Unimproved Road."[36]

With only a few exceptions around the margins, the area is predominantly "roadless" from the western flanks of the Rincon Mountains and crest of the Catalina Mountains to east of San Manuel and highway 77, then to the Gila River on the north, to the town of Bonita on the east, and to Three Links Road on the south. That area includes not only the Middle SPRV and its ranges, but also portions of the Lower SPRV, the Santa Teresa Mountains, the Pinaleno Mountains, most of the Aravaipa Valley and a significant portion of the San Carlos Apache Reservation.

> *...wildlife connections… extend from the San Carlos Reservation south through the Aravaipa and Santa Teresa Wilderness Areas, and then further south into the wilderness land of the Galiuro Mountains. There exists a 100-mile-long stretch of land, extending from the San Carlos Apache Reservation all the way south through Gila, Pinal, and Graham Counties to northern Cochise County, containing a network of wildlife trails that has never been interrupted by a motorized vehicle road, one of the last remaining wildlife migration corridors of this type and magnitude in the Southwest.*[37]

Indeed, the Aravaipa watershed and portions of the Lower SPRV are part of a largely unfragmented area of more than 1.5 million acres.

It may be objected that the areal extent here considered is already fragmented by county and ranch roads. In that regard, the point here is not that the Aravaipa watershed is "pristine" and without scars, but rather that it is "*largely* unfragmented and intact."

The SunZia project however, with its twin 16-story 500Kv towers and access roads traversing the Aravaipa route is enormously greater in its scope and projected impact than anything existing in the Aravaipa watershed. That is not to mention the expansion to other infrastructure projects along the same corridor that are clearly foreseen by SunZia's FERC application. Were it implemented, the "largely unfragmented" appellation for the Aravaipa watershed would have to be altered.

Since NEPA directs us to consider issues of context, threat and proximity, it is noteworthy to consider that west of the Rincon and Catalina Mountains is a metropolitan area of a million people. On the east side, as circumscribed above, is a largely wild, open and environmentally intact area 2-1/2 times the size of the state of Rhode Island with a population of only a few hundred people.

> *Although the lower basin is close and accessible to the burgeoning Tucson and Phoenix metropolitan areas, it has so far not undergone extensive population growth and urban/suburban development.*

Indeed, the Arizona Department of Water Resources gives the 2000 population of the entire 500 square mile Aravaipa watershed as 135 people.[38]

Another related term applied to the Aravaipa watershed and also to the Lower SPRV is that it is a relatively "intact landscape." "Intact habitat represents relatively undisturbed areas that are characterized by the maintenance of most original ecological processes and by communities with most of their original suite of native species."[39] The term cannot honestly be applied to the Aravaipa watershed and Lower SPRV without some qualification. Significant impacts to the dominance pattern of plant species caused by heavy grazing as well as alteration of the hydrologic regime by entrenchment of the SPR occurred around the turn of the twentieth century.[40] Exotic species are present, and natural fire regimes have been altered in the grasslands. Areas in the Lower SPRV and Aravaipa watershed where those aspects persist are more characteristic of "altered" habitats. But as distinct from "heavily altered" habitats, "Original habitat is likely to return with time, moderate restoration, and adequate source pools."[41]

So long as one does not resort to absolutist categories of "pristine" and "original" landscapes which rarely occur in present day lowland areas of the Southwest, the Aravaipa watershed and Lower SPRV represents a relatively intact landscape that is characterized by the maintenance of most original ecological processes and by communities with most of their original suite of native species. As the Aravaipa Ecosystem Management Plan confirms, "The Aravaipa ecosystem remains relatively intact and provides rich communities of plants and animals."[42]

With regard to the great extent of the Lower SPRV which is rangeland, a Middle SPRV rangeland assessment by the nearby Redington NRCD found that,

> *The data indicate that about 40% of the rangeland is in high or very high similarity to the historic condition. In other words, the species present and the proportions making up those species are fairly similar to presumed "historic" conditions for the site. Moderate similarity was found on 53% of the area, indicating either different species occurred or, more likely, the species deviated from the "historic" proportions. This probably indicates shrub increases in most cases. Only 7% were in low similarity.*[43]

> *…there is general agreement that overall range and watershed condition has improved greatly since the early 1900s and especially since the 1950s. Numbers of livestock have declined dramatically and management (pasture rotation, distribution of grazing) has greatly improved. …Other than roads, there is probably less human impact on the vegetation of the watersheds now than at any other time since settlement.*[44]

The Aravaipa Ecosystem Management Plan (EMP) comes to some mixed but overall similarly positive conclusions about grassland conditions in the Aravaipa watershed, despite an extended drought which is frequently referenced in the document:

> *Overall, Aravaipa experienced significant decreases in frequency of both annual and perennial grasses and increases in forbs between 1990 and 2000. Despite reduced grass frequency, the diversity of perennial grasses has significantly increased between 1990 and 2000. The average number of species grew from 7.3 to 11.2, with increases found on all plots. ...the 2000 data showed an average canopy cover of 26.9%. This suggests a large increase over the cover measured in 1980. Thus, grazing rest appears to have resulted in improved watershed condition throughout the allotment, but shrub cover remains at unhealthy levels.*[45]

That condition of unhealthy levels of shrub cover in the grasslands, as well as its relation to riparian conditions and flow regimes, is extensively addressed in the EMP. It proceeds to document relevant results from the nearby Muleshoe CMA.

> *The relationships between watershed vegetation, watershed hydrological processes, stream hydrology, and riparian condition have been studied at the Muleshoe Cooperative Management Area about 25 miles south of the Aravaipa ecosystem. …That plan featured a conceptual model which links conditions of the watershed vegetation to those of the aquatic and riparian habitat through the mechanisms of sediment transport and runoff characteristics that affect flood magnitude and water storage (Figure 3-5). A key goal was to increase the land area dominated by perennial grasses while reducing the dominance of shrubs.*
>
> *Implementation of the Muleshoe Plan included an aggressive program of prescribed burning. During the period 1998-2000, nearly 17,000 acres were treated with fire in three large burns. These caused immediate reductions of shrub cover by 77-83%, though some regrowth from rootstock showed the need for periodic burns to maintain reduced shrub cover. In most cases, the fires also resulted in increased ground cover, with increases in both annual and perennial grasses (Brunson et al. 2001). Since 1994, stream vegetative cover and the amount of undercut bank have increased dramatically in Hot Springs Creek, the major stream in the area being intensively managed. In addition, the mean maximum depth of aquatic habitats has increased as has the number of deep pools. Associated with these aquatic habitat changes, the population density of native fish increased significantly. These improvements occurred despite decreased base flows due to persistent drought (Gori and Backer 2005).*[46]

The Aravaipa EMP's conclusion is imbedded in Objective B.3: "Maintain naturally occurring plant communities and shrub-grass ratios by returning fire to the landscape through prescribed and natural fires."[47] Thus intact grassland conditions within the Aravaipa watershed can only be surmised to continue to improve.

Similarly to the grasslands, many of the riparian woodland areas along the SPR have also continued to be maintained or improved to relatively intact status. The acquisition of protected conservation sites on significant portions of the riparian areas by various agencies and NGO's has certainly been a factor. "Close to one third of the lower river corridor is now in protected status, and stream flow and habitat conditions are improving."[48]

> *Dryland rivers have some of the most variable flow regimes in the world…. However, the very unpredictability of streamflows in dry regions, over time, has produced ecosystems with high resilience. Despite having undergone extensive change, the San Pedro River today sustains productive and diverse biotic communities.*[49]

Likewise, the documentation of Webb, Leake and Turner indicate substantial increases in riparian vegetation throughout Aravaipa Creek and its tributaries over the past century.[50] Further, despite extended drought in the watershed, some Aravaipa tributaries are experiencing increased flow regimes.

> *[I]t appears that perennial flow increased in Oak Grove Canyon from 453 yards in two reaches to 4,925 yards in three reaches. …The presence of riparian-obligate trees along Oak Grove suggests that the observed flows were accurately identified, and were likely associated with improved watershed conditions.*[51]

Since relatively intact, lower-elevation riparian woodland is now extremely rare throughout the Sky Island region,[52] it is altogether appropriate to state that "There are few places remaining in the southwestern U.S. that are as intact and have the quality and extent of aquatic and riparian habitat as that found on the San Pedro River."[53] That statement could be expanded to include its major tributary, the Aravaipa watershed. Conditions can only be anticipated to improve with continued good management and the implementation of the EMP's recommended prescribed burn program.

Similar to largely unfragmented landscapes, relatively intact habitats are key indicators developed by biologists in assessing the conservation value of regions and sites. As noted by The Nature Conservancy in their ecological analyses of the Sonoran and Apache Highlands ecoregions, "Landscape-scale Conservation Sites capture entire ecosystems, such as a complex of mountain ranges and valleys, where ecological processes remain largely intact."[54] Thus it can be inferred that the imprimatur "largely intact" pertains to the Lower San Pedro as their fourth highest ranking conservation sites out of 100 in the Sonoran Desert.[55]

By the same reasoning, the imprimatur "largely intact" also pertains to the 90 conservation sites designated by The Nature Conservancy in their ecoregional assessment of the Apache Highlands. Four of these 90 Conservation Sites are located within the area addressed in this document.[56] All four are either directly impacted by or are proximate to the proposed Aravaipa route.

- The Aravaipa Watershed Conservation Site, through which a significant portion of the Aravaipa route would pass, is ranked 10th out of 90 conservation sites in terms of target species richness. It is ranked 12th in terms of irreplaceability and total species targets and 7th among 69 for conservation areas with aquatic systems.
- The Pinaleno Mountains Conservation Site ranked 5th of 90 in terms of irreplaceability and total species targets. It ranked 12th in terms of target species richness, and 14th among 69 for conservation areas with aquatic systems.
- The Pinaleno Foothills Conservation Site ranked 47th in terms of irreplaceability and species targets. It ranked 48th in terms of target species richness.
- The Santa Teresa Mountains Conservation Site ranked 57th in terms of target species richness. It ranked 61st in terms of irreplaceability and species targets. [57]

The Arizona Game and Fish Department's "Comprehensive Wildlife Conservation Strategy: 2005-2015" depicts the entire proposed Aravaipa route as being within an area of high "strategic value for protecting ecosystems and viable populations of native species of animals and plants."[58]

Indeed, when large blocks of unfragmented landscape come together with extensive intact habitats in a region of significant biodiversity, a region may take on global significance. As we shall examine shortly, the renowned World Wildlife Fund assessment of terrestrial ecoregions gives the highest priority to "Globally or regionally outstanding ecoregions that present rare opportunities to conserve large blocks of intact habitat," which not incidentally includes the Chihuahuan Desert, Sonoran Desert, Arizona Mountains and Madrean Sky Islands ecoregions, all of which predominate in the Aravaipa watershed and Lower SPRV.[59] In fact, each of these same ecoregions was elevated to "Global 200 status" because of their extraordinary ecological phenomena containing extensive intact habitats and large vertebrate assemblages,[60] all of which are again characteristic of the Aravaipa watershed and Lower SPRV.

The Upper San Pedro Partnership referenced above continues to fight the legal and artificial distinctions between the river and its surrounding watershed that continues to develop and threaten the sustainability of the river and its habitat. The distinctive virtue of the Lower SPR is that in addition to all of the same biological attributes of the Upper SPR it flows within a relatively intact and largely unfragmented landscape. If the San Pedro River can lay claim to being the last major free-flowing river in the desert Southwest, the Lower SPRV and Aravaipa watershed can make a correlate claim to being part of the largest intact and unfragmented landscape in the desert Southwest through which courses a major free-flowing river.

4. PROTECTED STATUS LANDS AND PARTNERS

Given the international significance of the San Pedro River, the outstanding biodiversity of the region, and the extent of the largely unfragmented and relatively intact landscape of the Aravaipa watershed and Lower SPRV, it is not surprising that there is a profusion of protected status lands and working partners in the area. Perhaps the only surprise is that there are so many, exhibiting nearly as much diversity as the land itself. Here follows a brief summary of those efforts.

- The first institutional conservation work in the Lower SPRV and Aravaipa watershed dates to 1910 with the establishment of U.S. Forest Service (USFS) holdings in the Galiuro Mountains on the east side of the Valley.

- The Galiuro Wilderness was designated in Congress in 1964 and was enlarged in 1984.

- USFS holdings were expanded to include extensive lands of the Coronado National Forest in the surrounding Santa Teresa and Pinaleno mountains. The former includes the Santa Teresa Wilderness Area.

- The 77,400-acre Aravaipa Ecosystem Management Area includes the Aravaipa Canyon Wilderness, three Areas of Critical Environmental Concern (ACEC), and The Nature Conservancy's Aravaipa Canyon Preserve. The perennial Aravaipa Creek is widely recognized as one of the most important refugia for native fish in the Southwest. The Ecosystem Management Area, including the canyon and its surrounding uplands are jointly managed by the Bureau of Land Management (BLM), Arizona Game and Fish Department (AGFD), and The Nature Conservancy.

- The Aravaipa Canyon Wilderness was established by Congress in 1984 "for the preservation and protection of this relatively undisturbed but fragile complex of desert, riparian and aquatic ecosystems, and the native plant, fish, and wildlife communities dependent on it, as well as to protect the area's great scenic, geologic, and historical values". That gave legal protection to 6,699 acres and replaced the earlier Primitive Area designations. Much of the upland area around Aravaipa was transferred from the Arizona State Land Department to the BLM in 1986, adding 51,077 acres to BLM ownership… Congress expanded the wilderness in 1990 to 19,410 acres, protecting roadless uplands and tributary canyons on both north and south rims.[61]

- The Aravaipa Canyon Wilderness is now part of the National Landscape Conservation System (NLCS) that was created by the BLM in June 2000 and officially designated by Congress in March 2009 to include the crown jewels of the public lands managed by the BLM. The purpose of the NLCS is to conserve, protect, and restore nationally significant landscapes recognized for their outstanding cultural, ecological and scientific values.[62]

- Turkey Creek Riparian ACEC contains 2,326 acres, including portions of Oak Grove and Maple canyons. It was established to protect and enhance riparian vegetation, wildlife, scenic values, and cultural resources. Maple Canyon contains big-tooth maple at its lowest-known elevation in Arizona. These sensitive resources require special management of recreation, livestock, access, and vegetation to improve ecological conditions.[63]

- Table Mountain Research Natural Area ACEC contains 1,220 acres. The top of Table Mountain supports an alligator juniper savanna, a plant community known in less than 20 locations. The ACEC includes Sycamore and Saddle canyons, which contain a white oak woodland containing Mexican blue oak at the northernmost limit of its range. These plant communities require special management of off-highway vehicles, woodcutting, fire, and livestock.[64]

- In 1982, the Arizona Game and Fish Commission (AGFC) established the Aravaipa Canyon Wildlife Area to incorporate specific regulations enacted by the Bureau of Land Management in their management of the Aravaipa Canyon Primitive Area. It is notable that "Lands that qualify as Wildlife Areas: 1) have unique topographic or vegetative characteristics that contribute to wildlife, 2) are home to certain wildlife species that are confined because of habitat demands, 3) can be physically managed or modified to attract wildlife, or 4) are identified as critical habitat for certain wildlife species during critical periods of their life cycles."[65]

- The Nature Conservancy's 528 acres H&E Farm located on the east side of the Lower San Pedro River includes endangered willow flycatcher habitat. The Conservancy is restoring the natural washes and native grasses thereby improving the floodplain and returning water to the river. The Arizona Department of Water Resources is a partner. The proposed Aravaipa route would bisect the H&E Farm.

- Cook's Lake [approximately 7 miles north of the Aravaipa SunZia route SPR crossing] is owned by the U. S. Bureau of Reclamation and surveyed for Southwestern Willow

Flycatchers. 26 adults and 10 nesting pairs were recorded there in 2009.[66] 198 bird species have also been recorded there (See Appendix).

- The 7B Ranch [just south of H&E near Mammoth] is a 3,100 acre property being managed by TNC to eliminate invasive species and restore its wetlands and the largest mesquite bosque remaining in the Southwest.

- Though many of the Aravaipa watershed and Lower SPRV ranches are not part of protected status lands, their long history of conservation work cannot be ignored or diminished. Some of the local ranching families go back generations to the late 1800's and have been instrumental in keeping open spaces in the valley. In recent decades they have been increasingly involved in local conservation work. Ranchers have a deep understanding of sustainability since their livelihoods depend upon it.

The Nature Conservancy in their scoping comments to the BLM with regard to the SunZia transmission project summarized well a good deal of these conservation efforts:

> *Over the last three decades The Nature Conservancy and many other agencies and organizations have been working steadily to protect the Lower San Pedro Basin. This area has become 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.*
>
> *Partners in this effort include the Bureau of Land Management, Bureau of Reclamation, Salt River Project, Arizona Game and Fish Department, Pima County and a number of private landowners. The Resolution Copper Company has offered to protect additional lands in the valley through its proposed land exchange for a mine site in Superior. Together, these partners have protected close to 40,000 acres and invested over $25 million in acquisition of conservation lands and appurtenant water rights. Close to one third of the lower river corridor is now in protected status, and stream flow and habitat conditions are improving.*[67]

Now these many efforts are beginning to coalesce into a locally generated conservation vision, which may eventually include Valley wide cooperative management status between area landowners, conservation groups and state and federal agencies that would put an end to further utility development here, would actively conserve its myriad environmental and cultural resources and would furthermore encourage not merely the possibility, but the viability, of traditional land uses such as ranching and outdoor recreation.[68]

C. ECOREGIONAL ANALYSES

In transitioning from general attributes of the Aravaipa watershed and Lower SPRV to a more biological focus, perhaps the place to begin is with Brown and Lowe's iconic map of "The Biotic Communities of the Southwest."[69] The map goes beyond political and bureaucratic boundaries to catalogue biotic baselines, largely defined by the temperate deserts of the Southwest – Mohave, Sonoran and Chihuahuan. It extends to the westward edges of the Mohave including Baja California, eastward to the edge of the Texas panhandle and the eastern edge of the Mexican state of Chihuahua, north to the Utah state line, and to the southern tip of the Mexican state of Sonora.

Focusing on biologic rather than political divisions allows one to see that the Aravaipa watershed and Lower SPRV partake of every one of the basic biotic formations in the Southwest and draw from four ecoregions that roughly correspond to the cardinal directions.

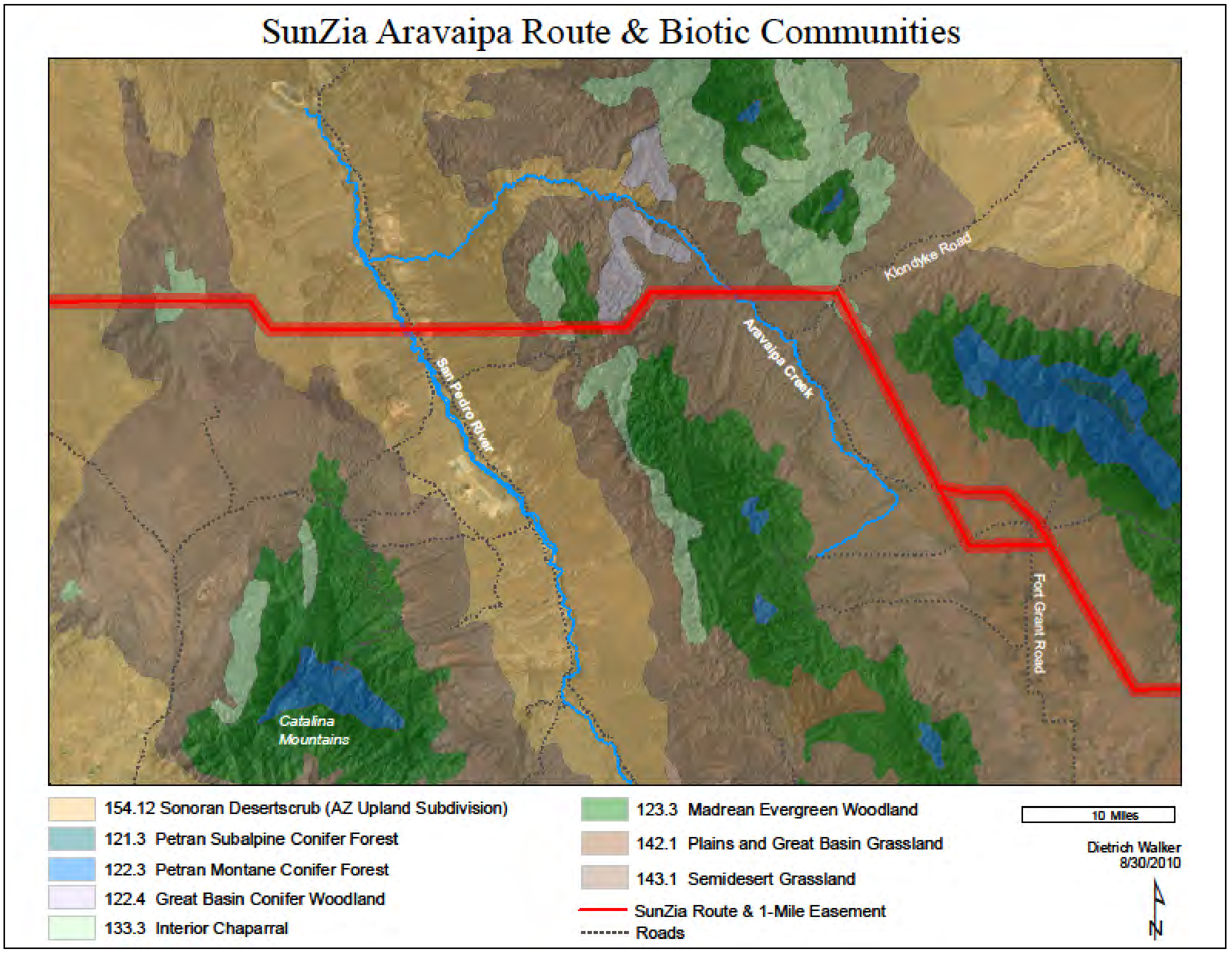

Figure 3: Map of SunZia Aravaipa Route & Biotic Communities

Using Lowe's descriptors and catalog numbers, in the Aravaipa watershed and Lower SPRV the Forest Formation is represented by the Petran Subalpine Conifer Forest (121.3) and Petran Montane Conifer Forest (122.3) in the mountain ranges' highest portions. The Woodland Formation is represented by the Madrean Evergreen Woodland (123.3) flanking those peaks, and the Great Basin Conifer Woodland (122.4). The Scrub Formation is represented by the Interior Chaparral (133.3) in a lower transition zone. The Grassland Formation is represented by the Semidesert Grassland (143.1) in the upland slopes. The Desertscrub Formation is represented by the Arizona Upland Subdivision of the Sonoran Desertscrub (154.12) in the northern SPRV valley basin and lower Aravaipa watershed.

Those biotic formations or biomes "are not provinces *per se*, which are biotic, faunistic, or floristic in structure, function or other aspects."[70] Nonetheless, they do either roughly correlate to or fit within the four great terrestrial ecoregions that merge in the Aravaipa watershed and Lower SPRV, one of the few areas in North America where such convergence occurs and in large part explanatory of the great biodiversity resident here.

The World Wildlife Fund (WWF) distinguishes those ecoregions as Sonoran Desert (western), Chihuahuan Desert (eastern) Madrean (southern) and Arizona Mountains (northern). This region is in fact so complex (mirroring the complexity of the underlying geologic strata) that there is some variance as to how biologists conceive them. The Nature Conservancy (TNC), for example, due perhaps to the needs of their more local conservation concerns and analyses, amalgamates some of those ecoregions together into what they call the Apache Highlands. The WWF divisions, they explain, are more suited for large scale framing.

> *Some biogeographers also consider them [the Sky Islands] distinct from the nearby major mountain systems (i.e., Sierra Madre Occidental, Arizona Mountains, and Colorado Plateau), as they combine elements from both major systems, and refer to the biogeographic region as Apachean. However, at a continental scale, we interpret the Sky Islands as primarily Madrean in character….*[71]

That noted, there is no variance in the extraordinary diversity referenced, and data from both analyses are relevant.

1. ECOREGIONAL SCIENCE

Modern conservation biology and natural resource management has shifted more and more toward an "Ecoregional" or "Ecosystem" approach.[72] The reasons for this are several. Though there is clearly intra-species competition in the Darwinian sense, the relatively new science of ecology has come to better understand the interconnection and interdependence of species that make up entire biological systems. Much of this theory is derived from island biogeography which has demonstrated that over time larger intact and unfragmented areas support more species, whereas fragmentation reduces species diversity and viability.[73] "Large blocks of habitat generally contain larger and more stable species populations, and are uniquely able to support species with naturally low population densities or large home ranges (Noss and Cooperrider 1994)."[74]

Ecoregional science also helps conservationists and natural resource managers answer two critical questions, "'What are the most important places?' and 'How much conservation is enough?'"[75]

> *So called 'landscape-scale analyses' that evaluate and identify conservation priorities over large areas such as the Sonoran Desert Ecoregion are now widely regarded as a critical tool for arming conservation practitioners, policy makers, and the general public with the best scientific information upon which to implement conservation strategies.*[76]

Another important aspect of ecoregional science is the political implications. While the Endangered Species Act (ESA) is clearly an important and critical tool in conservation, its species specific focus, notwithstanding its recognition of habitat requirements, has at times been divisive. On the one hand conservation promoters may find private property concerns erupting over a particular species' habitat even while many ranches have been demonstrated to be some of the best conservers of species diversity, often due to their largely unfragmented extent.[77] On the other hand it can also encourage developers to pursue a strategy of legalistic maneuvering between islands of threatened and endangered species habitat while fragmenting the larger ecosystems upon which their long-term sustainability depends.

Ecoregional assessments have developed complex indices which avert these shortcomings, and conservation organizations have been some of the leaders in implementing this approach. The World Wildlife Federation (WWF) has "developed a detailed map of the terrestrial ecoregions of the world that is better suited to identify areas of outstanding biodiversity and representative communities (Noss 1992)."[78] Their conservation assessment of terrestrial ecoregions of North America was funded principally by the Commission for Environmental Cooperation under NAFTA with the intent of providing a frame of reference for action to conserve biodiversity in North America.[79]

The WWF notes that their ecoregions "…are classified within a system familiar to all biologists — biogeographic realms and biomes. Ecoregions, representing distinct biotas (Dasmann 1973, 1974, Udvardy 1975), are nested within the biomes and realms and, together, these provide a framework for comparisons among units and the identification of representative habitats and species assemblages. …they are built on the foundations of classical biogeography and reflect extensive collaboration with over 1000 biogeographers, taxonomists, conservation biologists, and ecologists from around the world.[80] The biological distinctiveness of these ecoregions is based on broad measures of species richness, endemism, unusual ecological and evolutionary phenomena, and the global rarity of Major Habitat Types.[81]

Likewise, in 1996 The Nature Conservancy began developing ecoregion-based conservation assessments for the entire United States and portions of the 31 other countries in which the Conservancy works.[82] They avoid the weaknesses of a solely species specific approach by combining what they call Coarse Filter and Fine Filter indices:

> *The Coarse Filter is represented by ecological groups, or assemblages of plant species…. The Fine Filter is comprised of the species for which distributional and population data are better known and catalogued in databases such as those housed in Natural Heritage Programs. …The primary advantages of the Coarse Filter-Fine Filter approach include: (1) evaluates biodiversity at two different scales emphasizing the habitats in which the Ecoregion's species inhabit; (2) maximizes the number of species represented; (3) captures the variability in ecological conditions in which species occur; and (4) helps compensate for data gaps that result from uneven species inventory across the Ecoregion.*[83]

Indicative of TNC's approach, in their ecological analysis of the Sonoran Desert ecoregion they selected a total of 353 species from six taxonomic groups (amphibians/reptiles, birds, fish, invertebrates, mammals, plants) and also used 78 natural vegetation communities to represent a broader level of biological organization across the ecoregion.[84] Similarly in their Apache Highlands ecoregional analysis, all native vegetation community types were mapped similar to Brown and Lowe and all of the native terrestrial ecosystems were considered as coarse-filter conservation targets, while 223 species were chosen for fine-filter conservation targets.[85] The end result of their analyses is that, "Landscape-scale Conservation Sites capture entire ecosystems, such as a complex of mountain ranges and valleys, where ecological processes remain largely intact."[86]

However, it is not only conservation organizations that have adopted an ecoregional approach. Federal agencies as well are yielding to the advantages of ecoregional science. "In 1993, as part of the Forest Service's National Hierarchical Framework of Ecological Units (ECOMAP 1993), ecoregions were adopted for use in ecosystem management. They will also be used in the proposed National Interagency Ecoregion-Based Ecological Assessments."[87]

The Bureau of Land Management (BLM), which is coordinating SunZia's Southwest Transmission Project, is also lately coming on board with an ecoregional strategy. They admit that their historic local, field office approach to land use policies has been inadequate.

> *Unfortunately, the ecological consequences of some best decisions made for a local area can accumulate at intermediate landscape scales where they may contribute to ecosystem change caused by invasive species, altered wildland fire cycles, climate change, urban and industrial development, and other agents. With current ecological understanding and the availability of new tools, the BLM is beginning to systematically identify landscape-scale, ecologically-based conservation and restoration needs and place them on an equal footing with other land management and resource use objectives.*
>
> *To better address these issues, the BLM has decided to use an ecoregional approach that will allow the agency to more efficiently and effectively address broad, landscape-scale issues across administrative boundaries.*[88]

In November of 2009 the BLM announced a "Coordination of Rapid Ecoregional Assessments" with The Nature Conservancy (TNC) and the California Department of Fish and Game (CDFG).[89] Rapid ecoregional assessments are collaborative scientist-manager exercises in assembling and synthesizing targeted information about an ecoregion.[90]

These are possibly less exhaustive but equally focused assessments like those performed by TNC in the Sonoran Desert and Apache Highlands Ecoregions. The purposes and methodology are very similar. They propose that a multi-disciplinary, interagency core assessment team of scientists, ecologists, planners, etc. from BLM, CDFG, and TNC be established. Then "BLM will assess the resource values on native species of concern, and regionally important terrestrial and aquatic ecological features and the change agents of invasive species, wild land fire, development (including renewable energy), and climate change."[91] Based upon the assessment findings and other relevant considerations, BLM managers will formulate "Ecoregional Management Strategies" and identify responsive regional actions that should be taken.[92]

The coordination with TNC is hopeful and clearly recognizes their experience and expertise in ecoregional assessments. However, though the BLM is initiating rapid ecoregional assessments throughout the Southwest, their initial project is the Mojave Desert Assessment which is not slated to be completed until January 2011. The Sonoran Desert assessment will have similar goals but is still in its initiation phase. This is unfortunate since a key purpose of the assessments is to "attempt to answer high-level questions related to the appropriate siting of renewable energy and conservation areas" and could clearly bear on the issue at hand.[93] At the least, hopefully BLM's coordination with TNC and agreement to undertake an ecoregional approach will encourage them to heed the exhaustive ecoregional assessments already undertaken by TNC and WWF and the resulting management strategies for the areas being reviewed here.

What is an ecoregion? A classic definition cited by TNC is R. G. Bailey's: "Ecoregions are large areas of land and water that share similar climate, physiography, and biotic communities."[94] The WWF's definition is slightly more elaborated: "An ecoregion is defined as a large area of land or water that contains a geographically distinct assemblage of natural communities that (a) share a large majority of their species and ecological dynamics; (b) share similar environmental conditions, and; (c) interact ecologically in ways that are critical for their long-term persistence."[95]

Implicit in that definition is that ecoregions differ from one another in a large majority of their assemblage of species and natural communities. One of the earliest biogeographers determined the differentiation of species between ecoregions to be around 80%.[96] What follows here is a brief overview of the five distinctive WWF terrestrial and freshwater ecoregions that intersect and merge in the Lower SPRV and Aravaipa watershed and the biodiversity that implies. The results of TNC's more detailed ecoregional analyses as they pertain to the Lower SPRV and Aravaipa watershed will be integrated into the review.

2. SONORAN DESERT ECOREGION

The Sonoran Desert Ecoregion reaches near its easternmost extent in the Lower SPRV. Here follow some of the generic characteristics of the Sonoran Desert ecoregion in which the Lower SPRV and lower Aravaipa watershed partake.

- The Sonoran Desert has the greatest diversity of vegetative growth of any desert in the world (Nabhan & Plotkin 1994).[97]
- The Ecoregion harbors a high proportion of endemic plants, reptiles and fish.[98]
- Over 2500 pollinators are known (invertebrates, birds, and bats) including the highest known diversity of bee species in the world (Phillips and Wentworth Comus 2000).[99]
- More than 500 bird species migrate through, breed, or permanently reside in the Ecoregion – nearly two-thirds of all species that occur in northern Mexico, the United States and Canada.[100]
- The Sonoran desert, together with its eastern neighbor the Chihuahuan desert, is the richest area in the United States for birds, particularly hummingbirds.[101]
- The Sonoran Desert is ranked fourth for mammal richness among North American terrestrial ecoregions with 82 species.[102]
- The Sonoran Desert's riverine, aquatic, and riparian resources hold a disproportionate amount of the Ecoregion's biodiversity.[103] Riparian woodlands in the region are now one of the rarest habitat types in North America.[104]
- The Sonoran Desert is ranked by the WWF as one of its Global 200 terrestrial ecoregions.[105] It is among eleven ecoregions in North America "that offer rare opportunities to conserve globally outstanding biodiversity in relatively intact landscapes."[106]

Do the Lower SPRV and lower Aravaipa watershed offer such a rare opportunity to conserve globally outstanding biodiversity in a relatively intact landscape in the Sonoran Desert? In The Nature Conservancy's ecological analysis of the Sonoran Desert Ecoregion, 100 large landscapes were identified across the Ecoregion as a network of Conservation Sites where conservation opportunities should be pursued.[107] The "San Pedro River/Aravaipa Creek Conservation Site" was listed fourth out of those 100. All "Conservation Target Taxa" were represented, and it was in the top three of bird and fish targets.[108]

Ecoregional assessments, as the BLM notes, have the end purpose of formulating "Ecoregional Management Strategies" and identifying responsive regional actions that should be taken. It is likewise TNC's intent that "…a Conservation Site represents a focal point for developing public awareness and implementing conservation actions so that the Conservation Targets identified in this exercise, as well as all of the other species for which our selected targets serve as a surrogate, remain viable on the landscape."[109]

In their "Summary of Status and Priority Inventory Needs for Ecological Groups in the Sonoran Desert Ecoregion," the urgency for conservation action for the "Semi-Desert Grassland", across which the Aravaipa route is projected to pass, the urgency for action is rated as "High."[110] The WWF concurs in their "Priority Activities to Enhance Biodiversity Conservation" for the need to establish protection for habitat along the lower San Pedro River.[111] If the BLM was ready to coordinate with TNC on an ecoregional assessment in the Sonoran Desert as they are in the Mojave, it is difficult to see how they could not concur as well.

3. CHIHUAHUAN DESERT ECOREGION

The Chihuahuan Desert Ecoregion reaches near its westernmost extent in the SPRV and Aravaipa watershed. Within the Aravaipa watershed, the Aravaipa route would pass through a greater extent of the Chihuahuan semidesert grassland than any other biotic community. Following David Brown, the semidesert grasslands will largely be considered as part of the Chihuahuan ecoregion. "Semidesert grassland adjoins and largely surrounds the Chihuahuan desert, and with the possible exception of some areas in west central Arizona, it is largely a *Chihuahuan semidesert grassland*."[112] Whereas in the Sonoran portion of the LSPRV one would see forests of saguaros, here one is likely to see equally dense stands of Soaptree Yucca (*Yucca elata*).

Here follow some of the generic characteristics of the Chihuahuan Desert ecoregion in which the SPRV and Aravaipa watershed partake.

- "The Chihuahuan desert is one of the three most biologically rich and diverse desert ecoregions in the world, rivaled only by the Great Sandy Tanmi Desert of Australia and the Namib-Karoo of southern Africa (Olson and Dinerstein 1998)."[113]
- Approximately 3,500 plant species live in this desert.[114]
- Estimates of endemism state that there could be up to 1000 endemic species.[115]
- The Chihuahuan desert, together with its western neighbor the Sonoran desert, is the richest area in the United States for birds, particularly hummingbirds.[116] It is first in bird richness of North American ecoregions with 279 species.[117]
- It is first in mammal richness of North American ecoregions with 109 species.[118]
- "Reptiles show a maximum for species richness in the Chihuahuan Desert (103 species)…. Only the Great Sandy Desert of Australia supports a richer desert reptile fauna than the Chihuahuan Desert (Cogger 1992; Flannery 1994)."[119]
- The Chihuahuan Desert ranks globally outstanding in cactus richness (Olson and Dinerstein, 1998).[120] It features over 100 species of cacti.[121]

- The Chihuahuan also ranks highest among North American ecoregions in butterfly richness.[122] It features 250 species of butterflies.[123]
- The Chihuahuan Desert is ranked by the WWF as one of its Global 200 terrestrial ecoregions.[124] It is ranked as a "Class I" ecoregion, i.e., "Globally outstanding ecoregions requiring immediate protection of remaining habitat and extensive restoration."[125]

The Aravaipa route proposed by SunZia runs through vast areas of this Chihuahuan semidesert grassland and in proximity to Desert Riparian Woodlands. Whatever the logistic advantages, it seems clear that this route is seen as having the advantage of generally not partaking in the protected status of the wilderness areas, preserves or Areas of Critical Environmental Concern, being mainly state trust lands. But ecologists warn us not to relegate these "desert seas" or grassland basins between the "sky islands" to second class status, for the change in major biotic communities across the landscape gradients is critical to the biodiversity and evolution of the region.[126] Furthermore, besides serving transitional connectivity between these upland and riverine communities, the grasslands are critical in their own right and diminishing in extent.

> *Approximately 43% of the region, historically, was comprised of grasslands (Gori, Enquist 2003). Today that figure has been reduced to 22%, highlighting the fact that the basins of this region have experienced the heaviest human impacts. Among those impacts is the absence of fire, which has contributed to an increase in shrubs at the expense of grasses. …the greatest areas of grassland with restoration potential are found on federal and state lands.*[127]

Cutting through these semidesert grasslands, and connecting the mountains and the Aravaipa Creek are tributary stream systems, which support some of the same "Desert Riparian Woodland" that passes through portions of the Sonoran Desert ecoregion. "[T]he riparian communities along these streams provide migratory birds and pollinating insects and bats with critical trans-hemispheric travel corridors. …It is difficult to overstate the importance of Arizona's freshwater systems. The status of these resources – their quantity, quality, distribution, and the biological diversity they harbor, is the single most important issue to both the sustainability of biodiversity and human communities in Arizona."[128]

Were BLM to conduct a "Rapid Ecoregional Assessment" of this area in cooperation with TNC as they are proposing to do in the entire Southwest, they might be compelled to agree with TNC's findings. As noted earlier, of 90 Conservation Sites that were selected in the Apache Highlands ecoregion that are of critical ecoregional importance, the Aravaipa Watershed Conservation Site is the number 12 conservation priority in the ecoregion and the number 7 priority for conservation areas with aquatic systems.[129]

Again, a major point of these assessments is to prescribe policy and management priorities. The Chihuahuan ecoregion received the WWF's highest priority in North America, and thus it would certainly be true here that "…some ecoregions support such outstanding biological diversity and face such severe threats that they deserve immediate and proportionally greater attention from conservationists."[130] TNC's more local assessment recommendation is clear and pointed, "For private and state trust lands… directing land subdivision and development away from the conservation areas identified in this assessment."[131]

Also, in recognition of the important role these grasslands play as transitions and corridors between mountains and river, particularly in a time of climate change, the recommendations are: "(1) Reduce edge effects and promote landscape connectivity…; (2) …avoiding fragmentation of natural areas…; (3) restore or maintain natural fire regimes; (4) ensure the persistence of genetic variation within species; and (5) attempt to minimize exogenous threats to vulnerable habitats (Halpin 1997, Noss 2001, Hannah et al. 2002).[132] The import for SunZia's proposed Aravaipa route that passes substantially through this Conservation Site could hardly be greater.

4. MADREAN ECOREGION

The Madrean Sky Islands form a transition between the southern end of the Rocky Mountain cordillera and the northern end of Mexico's Sierra Madre Occidental. They can be considered the northern extension of the Sierra Madre Occidental.[133]

> *The biodiversity of the ecoregion is diverse and complex since it harbors both subtropical and temperate flora and fauna…. The mixing of subtropical and temperate plants and animals also creates unusual ecological interactions and assemblages. In general, the lower elevations of the Sky Islands include many subtropical species at their northernmost limit, while higher elevations support many montane species at their southern limit (McLaughlin, 1995).*[134]

Brown classifies this area as "Madrean Evergreen Woodland."[135] In the Aravaipa watershed and Lower SPRV, at lower elevations the woodland is typically open and often dominated by Emory Oak (*Quercus emoryi*) before transitioning to Madrean pines at higher elevations. The proposed Aravaipa route will travel through a portion of this ecoregion. Madrean fauna species cross the Aravaipa Valley, and the "Mixed Broadleaf Deciduous Riparian Forests" of the Sonoran and Chihuahuan zones intermingle up the canyons. The Sky Islands frame the Aravaipa watershed and Lower SPRV, and the watershed is an ecological unit.

Here follow some of the generic characteristics of the Madrean Sky Island Ecoregion in which the Aravaipa watershed and Lower SPRV partakes. (Some of the characteristics attributed to TNC's Apache Highlands Ecoregion include portions of other ecoregions considered here.)

- "The mountains of the Apache Highlands are unique on Earth, for they represent the only sky island complex that extends from the sub-tropical to the temperate latitudes (Warshall 1995). The result of these geographic and geologic phenomena is an unusually rich fauna and flora…."[136]
- More than 4000 vascular plant species have been identified, as have 110 mammals (Felger et al. 1997, Simpson 1964).[137]
- At least 468 bird species have been verified in southeastern Arizona during the past 50 years, along with more than 240 butterfly species and 580 species of wood-rotting fungi (Edison et al. 1995, Bailowitz and Brock 1991, Gilbertson and Bigelow 1998).[138]
- The Madrean Sky Islands Montane Forests have produced a relatively high number of endemic species.[139]
- Relatively intact, lower-elevation riparian woodland is now extremely rare throughout the region.[140]

- More than 75 reptile species, making it one of the most diverse reptile regions in North America.[141]
- More than 190 snail species, of which 60 are endemic, are found only in this ecoregion.[142]
- The Gila River Basin, a significant part of the ecoregion, contains one of the most unique fish assemblages in North America.[143]
- The Madrean ecoregion is ranked by the WWF as one of its Global 200 terrestrial ecoregions.[144] It is among eleven ecoregions in North America "that offer rare opportunities to conserve globally outstanding biodiversity in relatively intact landscapes."[145]

Again, because TNC's ecoregional assessment for the Apache Highlands does not distinguish ecoregions the same as the WWF, all of the Conservation Sites singled out as particularly important for protection in the Aravaipa watershed and Lower SPRV also range into the Madrean Sky Islands.

> …*Some conservation areas incorporate continuous landscapes from valley bottoms to mountain tops which, if fully protected, should buffer conservation targets against the impacts of climate-induced changes in habitat. Other areas form continuous mountain-to-mountain spans that are needed to maintain habitat connectivity for wide-ranging, forest-dwelling species such as black bear.*[146]

Those continuous landscapes include the Aravaipa Watershed Conservation Site referenced in the Chihuahuan Desert ecoregion section above.

Likewise, the assessment recommendations would also apply: "(1) Reduce edge effects and promote landscape connectivity…; (2) …avoiding fragmentation of natural areas…; (3) restore or maintain natural fire regimes; (4) ensure the persistence of genetic variation within species; and (5) attempt to minimize exogenous threats to vulnerable habitats (Halpin 1997, Noss 2001, Hannah et al. 2002).[147] The WWF recommendation for the area is similar: "Designate more of the Sky Islands as wilderness and identify or restore functional linkage habitat among the various ranges."[148]

5. ARIZONA MOUNTAINS ECOREGION

The Arizona Mountains Ecoregion occurs in the Aravaipa watershed and Lower SPRV in areas corresponding to Brown and Lowe's Petran Montane Conifer Forest in the higher elevations of the Sky Islands. This ecoregion corresponds to Omernik's (1995) ecoregion #23 (Arizona/New Mexico Mountains) and there is a fair degree of overlap with Bailey's (1995:64) M313, Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province.[149] The WWF identifies portions of the Galiuro Mountains as representative.[150] Ponderosa Pine (*Pinus ponderosa*) forests often dominate. "Vegetation zones in this ecoregion resemble the Rocky Mountain Life Zones but at higher elevations (Bailey 1995, 64)."[151]

This ecoregion is also the southern extent of spruce-fir forests and the northern extent of many Mexican wildlife species, including tropical birds and reptiles. "In general, this ecoregion was considered regionally outstanding because of its relatively high level of species richness (2,817 species) and endemism (132 species)."[152]

The Arizona Mountains were also selected by the WWF as one of the Global 200, i.e. one of 142 of the 867 worldwide terrestrial ecoregions, and one of only eleven in North America. This ecoregion was elevated to Global 200 status because of its extraordinary ecological phenomena, containing extensive intact habitats and large vertebrate assemblages.[153]

Among the management recommendations were several areas "as potential corridors for minimizing fragmentation and insularization effects, including connecting the Gila complex with the Sky Islands to the south for future wolf movements; and connecting riverine habitat through stream buffers designed to restore degraded fish populations."[154] A recommended priority activity to enhance biodiversity conservation is to protect and restore degraded native fish populations through habitat restoration in degraded riparian areas.[155]

6. GILA FRESHWATER ECOREGION

To this point only terrestrial ecosystems in the Aravaipa watershed and Lower SPRV have been reviewed, but similar analyses have been performed for freshwater ecosystems. Unfortunately North America's freshwater environments are among the most threatened.[156] Thus, with nearly every freshwater system suffering from some degree of degradation, there is an urgent need to establish priorities for conservationists and land managers. The World Wildlife Fund again conducted an extensive conservation assessment with support from the U.S. EPA "…as an initial step in identifying those areas where protective and restorative measures should be implemented first."[157]

The Gila freshwater ecoregion covers most of southern Arizona and part of southwestern New Mexico and extends into northern Sonora in Mexico. The major watershed in this ecoregion is that of the Gila River, a tributary to the lower Colorado River. "As many as seven fish species that are not found in the Colorado ecoregion's waters can be considered endemic to the Gila ecoregion; given a total of nineteen native species found in the Gila, this is an impressive number of endemics."[158] The Gila Ecoregion's Major Habitat Type is "Xeric-Region Rivers, Lakes, and Springs." Its Biological Distinctiveness is "Continentally Outstanding", the class just below "Globally Outstanding." Its Conservation Status is "Critical" i.e. the most severely threatened.[159]

Of 76 freshwater ecoregions in North America, 41 are "Continentally Outstanding," and only 5 of those are "Critical."[160] The term "critical" means that "The remaining intact habitat is restricted to isolated areas or stream segments that have low probabilities of persistence over the next 5-10 years without immediate or continuing protection and restoration."[161] The reason for that assessment is that the expanding urbanization of the Phoenix-Tucson area is seen as a major threat by conservationists to the increasingly rare natural constituents of the San Pedro River and Aravaipa Creek.[162] As Tom Collazo, of the Arizona Chapter of The Nature Conservancy notes:

> *…the point that I wanted to make about the Sun Corridor and the million people on the other side of the Valley is that …. all this energy is coming to support the projected future population growth of the Sun Corridor: basically the area from Prescott down to the Mexican border. We have to make some choices as to what parts of the Sun Valley we are going to set aside for conservation and where we're going to choose to have growth occur. And our opportunities to protect outstanding natural values plus wildlife as well as recreation and culture, our best opportunity here is in the San Pedro Valley.*

> *Infrastructure projects, I think this a good point to be made as well, should follow a hierarchy of avoid, minimize, and mitigate. And I think we're still at the point where there are very strong arguments that say that San Pedro Valley is definitely in a critical area.*[163]

The data supports that assessment. The WWF gathered taxonomic and regional experts to undertake a preliminary identification of sites across North America where intervention – from dam removal to increased protection – would serve as a first step toward achieving conservation targets. Sites were selected on the presence of important biodiversity targets. Priority sites were selected, for example, because they are places where rare habitats remain intact or where important species assemblages could be restored.[164]

The San Pedro River and Aravaipa Creek, tributary to the Gila, is Site Number 102 of 146 sites listed in the WWF ecoregional assessment as "Important Sites for the Conservation of Freshwater Biodiversity in North America."[165] This is not surprising for a free-flowing river within a largely intact and unfragmented landscape. In the United States, only 2 percent of the nation's 5.1 million kilometers of rivers and streams remain free flowing and undeveloped![166]

As the WWF notes however, "Continental-scale analyses can guide us to the most distinctive and threatened freshwater ecoregions, but conservation requires integrated actions at the scale of sites as well as whole ecoregions. For this we need to understand how biodiversity features are distributed within ecoregions and how individual sites, habitats, and assemblages fit into a broader conservation strategy. Ecoregion-based conservation (ERBC) approaches may be a useful way to begin to preserve or restore the distinct biological features highlighted in this study."[167]

In that regard we are fortunate, for The Nature Conservancy has already performed assessments at the scale of sites for ecoregions inclusive of the Lower SPRV and Aravaipa watershed. In their ecological analysis of the Sonoran Desert Ecoregion, the "San Pedro River/Aravaipa Creek Conservation Site" was listed fourth out of the 100 Conservation Sites identified.[168] In their analysis of the Apache Highlands, the "Aravaipa Watershed Conservation Site" is the number 12 conservation priority in the ecoregion, and the number 7 priority for conservation areas with aquatic systems. TNC has integrated the terrestrial and freshwater data into their ecoregional assessments, and thus the distinction of the higher priority when aquatic systems are considered.

In discerning "Ecoregional Management Strategies" and identifying regional actions that should be taken from these ecoregional assessments, the recommendations for aquatic systems are particularly instructive.

> *Freshwater ecoregions differ from their terrestrial counterparts in two important and related ways. First, because of the connectedness of freshwater habitats, spatial and functional linkages across large distances are strong, with upstream activities manifested in downstream effects. Second, conservation of a given freshwater site must nearly always occur at the watershed scale.*[169]

Among the recommended "Priority Activities to Enhance Biodiversity Conservation" are:

- "Reclaim and manage entire subdrainages with multiple tributaries in which populations of imperiled species persist…."
- "Work with land management agencies to sufficiently regulate potentially damaging activities on lands under their jurisdiction."[170]

In sum, there are four "Globally Outstanding" terrestrial ecoregions that merge in the Aravaipa watershed and Lower SPRV to create an environment of exceptional biodiversity. Within its largely intact and unfragmented landscape, finer scale ecological assessments have discerned five large area conservation sites that are high priority for conservation with consistent recommendations against fragmentation. But in the final analysis, it is the "Continentally Outstanding" San Pedro River subdrainage and its multiple tributaries in which populations of imperiled species persist that tie the Aravaipa and Lower SPRV ecosystem together into a priority site that must be conserved at the watershed scale.

D. CONNECTIVITY

Because four terrestrial ecoregions and a freshwater ecoregion intersect in the Aravaipa watershed and Lower SPRV does not imply that it is a fractured ecosystem. There are of course no lines. "Ecoregional boundaries are approximations of what in reality are gradual shifts in ecological communities."[171] The ecoregions and their species intergrade to create exceptional biodiversity and integrate into a complex watershed-wide interconnected ecosystem.

Two elements of that connectivity have been noted above. First, the "desert seas" or Semidesert Grassland and Sonoran Desertscrub basins between the "sky islands" serve as transitional connections between the upland and riverine communities.[172] These biotic formations integrate together along the eastern and western slopes of the Lower SPRV and are the primary biomes through which the SunZia Aravaipa route proposes to pass. This element of connectivity was particularly noted in Pima County's acquisition of the A-7 Ranch. Although the A-7 is south of the Aravaipa route, the issue of connectivity is equally valid along that route.

> *Within the San Pedro River watershed, the middle basin landscape provides a practical opportunity to create protected connections between Sky Island mountain ranges that includes high elevation forest systems and diverse tributary canyons. Furthermore, these landscape connections provide linkage in a more extensive integral landscape that connects mountains, grasslands, and desert between the White Mountains and Mexico.*[173]

Second, as just reviewed, the aquatic systems represented by riparian habitat in the mountains and canyons directly connect those regions with the riparian areas of Aravaipa Creek, its tributaries and the San Pedro River. "[B]ecause of the connectedness of freshwater habitats, spatial and functional linkages across large distances are strong, with upstream activities manifested in downstream effects.[174]

Furthermore, the grasslands and the water systems are not independent units, but are themselves intimately connected. "Because rivers are products of their watersheds, riparian preserves can be affected by off-site activities that alter the hydrologic cycle (Pringle 2000, 2001).[175] There is a strong linkage between watersheds and the rivers that drain them. That is, "watershed conditions influence important hydrologic and geomorphic processes such as the volume of surface runoff and the amount of sediment delivered to streams."[176]

> *Watershed condition is largely determined by upland vegetation and soil type. When properly functioning, watersheds capture, store, and release moisture efficiently, providing high infiltration of precipitation into the soil, low movement of soil off-site, reduced flood peaks, high quality water, and*

reduced evaporation of water from the soil profile. Attaining proper function and desired plant communities in the uplands contributes the physical and biological stability necessary to restore and maintain the aquatic and riparian ecosystem.[177]

The condition of upland areas has a major influence on the condition of riparian areas. Properly functioning uplands with good ground cover of vegetation will increase infiltration and extend base flows while reducing runoff, soil erosion and peak flows.[178]

Semidesert Grasslands, Desert Scrub and aquatic systems not only connect biotic systems, but faunistic systems as well. Wildlife corridors have received increasing attention among ecologists and conservationists in recent years.

If one overriding conclusion can be drawn from this global review of experience, it is that programmes that aim to conserve biodiversity at the landscape, ecosystem or ecoregion scale through interconnected and buffered systems of protected areas are moving into the mainstream of conservation practice. Moreover, based on the number of such programmes that have been initiated around the world in recent years, it would be fair to conclude that the increasingly broad application of the ecological network represents one of the most significant strategic developments in conservation planning over the past decade. A few simple figures are sufficient to demonstrate the magnitude of the shift: this review, although describing only a proportion of the initiatives that are currently underway, nevertheless traced about 200 ecological networks, corridors and comparable projects, plus 26 flyways, 482 Biosphere Reserves in 102 countries and 11 Bonn Convention agreements to conserve populations of migratory species. Bearing in mind that ecological networks and corridors only began to generate broad interest in the mid-1990s, this is a remarkable development. In fact, the changes that we are witnessing are more fundamental than simply the scale and the configuration of the territories that are managed for conservation purposes: they extend to the management objectives, competences, techniques and skills that are applied, the perceptions that underly the programmes, the involvement of local communities and the sources of funding. Ecological networks are above all a manifestation of an array of new insights into how conservation needs can effectively be addressed. Indeed, when viewed in a broader context these changes amount to a paradigm shift in protected-areas planning, as Phillips (2003) has elegantly demonstrated (see Table 7.1; see also Crofts, 2004).[179]

The international consensus on wildlife corridors, linkages, or connectivity (whatever the chosen terminology) is well established. The CBD-UNEP global survey of wildlife linkages gives some of the background:

…the ecological- network model evolved out of developments in ecological theory, primarily MacArthur and Wilson's equilibrium theory of island biogeography and metapopulation theory. The most important insight that followed from these theories was that habitat fragmentation increases the vulnerability of species populations by reducing the area of habitat available to local populations and limiting opportunities for dispersal, migration and genetic exchange. Interest therefore grew in developing conservation approaches that promoted ecological coherence at the landscape scale.

Corridors in the sense of functional linkages between sites — are essentially devices to maintain or restore a degree of coherence in fragmented ecosystems. In principle, linking isolated patches of habitat can help increase the viability of local species populations in several ways:

- *by allowing individual animals access to a larger area of habitat — for example, to forage, to facilitate the dispersal of juveniles or to encourage the recolonization of "empty" habitat patches*
- *by facilitating seasonal migration*
- *by permitting genetic exchange with other local populations of the same species (although this generally requires only very occasional contact)*
- *by offering opportunities for individuals to move away from a habitat that is degrading or from an area that is under threat (which may become increasingly important if climate change proves to have a serious impact on ecosystems)*
- *by securing the integrity of physical environmental processes that are vital to the requirements of certain species (such as periodic flooding)*[180]

There has been some debate as to the effectiveness of wildlife corridors, as is the nature of science.

> *A further source of evidence on the effect of ecological networks is the experience that has been generated through corridor projects. Over the past decades, a substantial literature on connectivity has been generated and many projects have produced measurable results. Good examples are the Bow Valley corridor in Canada and various elephant corridors in Africa and Asia. Although the concept of corridors has generated a lively debate over many years, evidence from the increasing number of projects shows that appropriately designed corridors generally meet the expectations of how they will function in practice. Moreover, most of the documented examples of corridors suggest that establishing or maintaining the linkage was the most cost effective means of achieving the conservation objective. Indeed, in many cases the corridor was demonstrably the only feasible and practicable option to achieve the objective, while in other cases alternative courses of action — such as enlarging a protected area — would have involved intractable problems.*[181]

The CBD global review of ecological networks makes this conclusive assessment about biodiversity conservation and connectivity:

> *The first lesson that can be drawn is that the programmes are explicitly attempting to establish and maintain the environmental conditions that are necessary to secure the long-term conservation of biodiversity rather than limiting themselves to the in-situ protection of valuable sites or threatened species populations. This involves, in the main, safeguarding assemblages of habitat large enough and of sufficient quality to support species populations, providing, where necessary, opportunities for movement between these reserves, buffering the network from potentially damaging human activities and promoting sustainable forms of land use in the contiguous landscapes. That this model applies to species that require access to very large areas or need to migrate across a landscape is obvious. …For many species, extensive linked and buffered systems of core areas are not immediately essential to their survival. …Even for many of these species, however, other factors become important for their long-term viability, such as the survival of a full complement of species within an ecosystem, the opportunity to move away from an existing area that comes under threat, and the occurrence of periodic natural disturbances that may require some form of linkage, such as flooding. Moreover, the island biogeography finding that the risk of extinction decreases as habitat size increases still holds for a large number of species.*[182]

This international embrace of the wildlife corridor and connectivity concept is no less evident in the U.S. and in Arizona. A case in point is the "Arizona Wildlife Linkages Assessment Document" conducted by Arizona Department of Transportation (ADOT) and Arizona Game and Fish Department (AGFD) with involvement by FHA, BLM, USFS, USFW, Northern Arizona University, Sky Island Alliance, and the Wildlands Project. That report recognizes, as does nearly all of the literature, that:

> *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). …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).*[183]

The AGFD Comprehensive Wildlife Conservation Strategy (CWCS) utilized a threat matrix based on both ecoregion and biotic community to map important connectivity areas in Arizona. The percentages were derived by GIS analysis from an intersection of the potential linkage zones with the biotic communities' layer.

> *Biologists and managers working in the Sonoran Desert Ecoregion took an additional step in considering landscape connectivity. Region IV of the Arizona Game and Fish Department (AGFD) identified several linkages that are at this time located within habitat blocks. In most cases these are publicly owned desert lowlands between publicly owned desert mountain ranges. Because these lowland areas could be used for roads, bombing ranges, military housing, and other human uses while remaining in public ownership, it is useful to document the connectivity value of these lands before adverse activities are proposed.*[184]

The result of their inventory was that virtually the entire Aravaipa valley area is mapped as "Potential [Wildlife] Linkage Zone #83 Galiuro--Pinaleno" between the "Habitat Blocks" of the Galiuro Mountain, Santa Teresa Mountain and Pinaleno Mountain complexes.[185]

The AGFD conclusion and recommendation is:

> *This approach should enable future projects to avoid significant barriers to wildlife movement. In the long run, being pro-active will be less expensive, and possibly more beneficial to wildlife, than some of the retrofitting projects needed in fracture zones.*[186]

The recently released BLM, TNC and AGFD Draft Aravaipa Ecosystem Management Plan likewise confirms that the Aravaipa watershed serves just such a critical landscape linkage.

> *The Aravaipa ecosystem supports a great diversity of wildlife due to its position at the interface between the Sonoran and Chihuahuan deserts, at the foot of sky island mountains and with a perennial stream running through it. The ecosystem provides habitat for permanent residents as well as transient animals, forming a critical linkage between mountain ranges and valleys. This linkage helps wildlife populations as a means of dispersion, genetic exchange and for buffering population-depressing factors such as drought, predation and human interaction.*[187]

As a neighboring area to Pima County's A7 Ranch, which lies just to the south and west within essentially the same biomes (see Figure 3 above), their rationale for maintaining the wildlife connectivity of the region is equally applicable.

> *The primary ecological value of the ranch may be in its function as a wildlife corridor, linking up large mammal populations in the Galiuro, Santa Catalina and Rincon mountains. …Forest birds (Mexican spotted owl) may also benefit as several studies have shown increased immigration rates to habitat patches when corridors are present (Dunning et al 1995, Haas 1995, Suanders and de Rebeira 1991, Machtans et al 1996). The property can function as a corridor (or part of a corridor) in several ways: (1) it can connect higher elevation habitats in the Rincons, Catalinas, and Galiuros and reduce extinction rates from these habitats, increase recolonization rates after local extinction, and permit gene flow between habitats; (2) it can allow an interchange of wildlife between different habitats (e.g., Sonoran desert to desert grassland to juniper-park savannah, etc.); (3) it can allow wildlife to migrate seasonally (e.g., elevational migration in birds, coyotes, bears, desert bighorn); and (4) permit species to change environments in response to environmental change (e.g., global warming).*[188]

The mention of the Mexican spotted owl and desert bighorn are of particular note, as these are critical species within the Aravaipa watershed as well (see Figure 2 above) and particularly vulnerable to fragmentation of habitat. The desired outcome of maintaining this connectivity is that "Wide-ranging animals (black bear, desert bighorn, mountain lion, bobcat, coati-mundi, Coue's white-tailed deer, mule deer, and possibly jaguar) would continue to move across the valley between the mountain ranges."[189]

As that quote denotes, habitat linkages are also receiving considerable attention for larger prey animals that require extensive areas of unfragmented habitat. Though highly controversial, the region was formerly discussed for Mexican Gray wolf recovery. Presently the USFWS has been requested to designate as critical habitat for Jaguar the San Pedro River corridor from Mammoth south to the Mexican border.[190] Whether or not such designations could or should occur, it is indicative of both the nature and rarity of the extensive intact habitat of the LSPRV and Aravaipa watersheds.

In addition to these landscape scale linkages, the canyons and riparian areas have been particularly recognized for their connective function. As stated in the nearby and ecologically congruent Muleshoe's Ecosystem Management Plan, "The riparian corridors are important migration and movement corridors for wildlife such as black bear, coati, and neotropical bird species."[191] The AGFD Arizona Wildlife Linkage Assessment makes similar points.

> *The riparian habitat/linkage zones are unique because they function as both habitats and linear linkage zones. They provide essential (core) habitat for aquatic organisms such as fish, aquatic plants, some amphibians, and aquatic invertebrates. In addition, the riparian vegetated areas are important for a variety of wildlife and plant species because they provide the only habitat for some species (cottonwoods, willows, some flycatchers and warblers), prime habitat for many other species, water for an even larger number of species, travel paths for mammals, reptiles, and amphibians, and migratory paths for over half of the bird species that live in or visit Arizona. Thus, each river is critical both as habitat and as the spine of a potential movement corridor.*[192]

It is important to observe that birds, and in particular neotropical migrants, also utilize these riparian areas as connective corridors. This is an important issue when it is recognized that the Aravaipa route crosses the Lower SPRV in the heart of a designated Globally Important Bird Area. However, that observation is not limited to the SPR. As Susan Skagen found in her renowned USGS study, the

SPRV watershed's mountain and canyon riparian oases are as important for migratory birds as the mainstem river.[193] Thus it is equally relevant that not only is "Aravaipa Canyon considered one of the premier riparian habitats in Arizona…,"[194] but the Aravaipa route crosses many of its tributaries which also serve as critical habitat and migratory corridors.

> *Tributaries entering Aravaipa Creek within Aravaipa Canyon have significant amounts of vegetation in their own right. Mesquite bosques are common in many of these tributaries, as are many other riparian species including Arizona walnut, sycamore, soapberry, netleaf hackberry, and Arizona ash.*[195]
>
> *Smaller but similar riparian communities grow in many of the tributary canyons, forming ecological corridors through the more arid uplands.*[196]

Finally, connectivity is also receiving increasing attention due to climate change as habitats alter and species require the ability to change environments in response.

> *Because land protection decisions are long-term, hard to reverse, and resource intensive, these decisions are important to consider in the context of climate change. Climate change may directly affect the services intended for protection and parcel selection can exacerbate or ameliorate certain impacts. Therefore, when considering long-term acquisition strategies, land protection programs should be considering both the mitigation potential of land through carbon sequestration and the adaptation potential of the land for preserving wildlife migration routes, protecting water sources, and buffering infrastructure and development from storm events.*[197]

E. SUMMARY

This first section of Friends of the Aravaipa Region and Cascabel Working Group's contributions to the SunZia Draft Environmental Impact Statement primarily considers those unique characteristics, context and ecosystem components of the Aravaipa watershed and Lower San Pedro River Valley such that the NEPA process finds germane to indirect cumulative effects of the proposed project over time. In that regard it could be compared to the "coarse filter" component of an ecoregional assessment wherein more generic landscape and habitat issues are reviewed and addressed.

A review of that data is as impressive as for any area in the American Southwest. The San Pedro River Valley is recognized as one of the most biologically diverse ecosystems in North America. It sits at the interface of four "Globally Outstanding" terrestrial ecoregions and a "Continentally Outstanding" freshwater ecoregion. In the midst of that it serves as the main migratory corridor for neotropical migrant birds in the West, and is thereby attributed to be of "continental importance" by both conservation groups and federal agencies, including the BLM.

Further, the Aravaipa watershed and Lower SPRV through which the SunZia transmission route is proposed to run is part of the largest relatively intact and largely unfragmented extended landscape in the desert Southwest through which courses a major free-flowing river. An impressive suite of federal, state and county agencies, NGOs and private partners have attested to this importance by the investment of many millions in a large amalgam of protected conservation sites.

These accolades transcend a mere collection of discrete attributes or particular species counts. Ecological science has undergone a paradigm shift in its understanding that habitat fragmentation increases the vulnerability of suites of species populations. Ecoregional assessments look at continuous blocks of habitat that are a complex of mountain ranges and valleys where ecological processes remain largely intact. In-depth ecoregional assessments of southern Arizona have discerned five Conservation Sites of high priority in the Aravaipa watershed and Lower SPRV, and the proposed SunZia Aravaipa route transects or passes in close proximity to every one of them.

The Aravaipa watershed and Lower SPRV Conservation Sites include the “desert seas” or Semidesert Grassland and Sonoran Desertscrub basins between the “sky islands” which serve as transitional connections between the upland and riverine communities. Because rivers are products of their watersheds, the grasslands and the water systems are not independent units, but are themselves intimately connected. Large swaths of the Aravaipa watershed have also been recognized for their connective attributes by Arizona Game and Fish Department’s “Arizona Wildlife Linkages Assessment Document.” It is also implicit therein that since upstream activities are manifested in downstream effects, conservation of the San Pedro River and Aravaipa Creek must occur at the watershed scale.

Ecoregional assessments are performed not only by conservation groups but in cooperation with federal agencies such as the USFS and BLM, and a primary purpose is to evaluate areas for priority conservation and to implement policy recommendations. The managerial prescriptions for these large blocks of the Aravaipa watershed are uniformly to avoid development and infrastructure fragmentation that would imperil the sustainability of the unique and rare components of such a biologically diverse ecosystem. Given the abundance of biological evidence and consensus to this effect, SunZia’s proposed route that wends its way through discrete protected habitat patches in the Lower SPRV and Aravaipa must be viewed as either naïve or disingenuous if thereby they suppose to avert major ecosystem impacts.

The evidence of the Lower SPRV and Aravaipa watersheds as a biologically critical and connected unit is both scientifically compelling and programmatically confirmed. The situation then becomes comparable to that of the Upper San Pedro wherein Endangered Species Act issues arise about off-site impacts to protected species and habitats. With endangered species such as the southwestern willow flycatcher mitigation sites on the San Pedro River, listed native fish habitat in the canyon tributaries, and a valley-wide neotropical migratory bird corridor of continental importance, similar concerns arise in the Lower SPRV and Aravaipa watershed. Here it is not so much below grade aquifer extractions impacting habitat, but above grade impacts to the ecosystem. These issues have been raised to the level of lawsuits in the Upper SPRV, and it is a matter that will be further addressed after cataloguing foreseeable direct impacts of a power transmission corridor.

Although small, this bi-national dryland river has high scientific importance and conservation value, and is oft noted as one of the most studied rivers in the nation. Many watershed groups are looking to the San Pedro as a model for river-protection efforts.[198] It has been noted that the condition of its riparian ecosystems may be the canary in the coal mine with respect to sustainable water use in the desert southwest.[199] A corollary of that statement in the Lower SPRV and Aravaipa is that the condition of its watershed may be the canary in the coal mine with respect to the possibility for a largely unfragmented and intact riverine ecosystem persisting in the desert Southwest in the midst of tremendous demographic pressures. It is apparently the last chance. A mitigation site for a last remaining mitigation site is oxymoronic.

To carry forward the metaphor of this first section as a “coarse filter” assessment of the Lower SPRV and Aravaipa watershed, given the special status of the area and the plethora of documented special attributes, the region would be red-lined for conservation priority simply on the basis of "coarse filter" assessments before proceeding to the "fine filter" species concerns. That is, before needing to address the "direct impacts" of a project of SunZia's size and scope to such an area of such great biodiversity and "continental importance," a NEPA judgment of Environmental Objection would likely already be raised. Nonetheless, if data is required, data will be forthcoming, but all as weighted metrics given the uniqueness of the region. That is, the same impacts that might be considered minor to an existing infrastructure corridor become major in an area of such import.

IV. ARAVAIPA WATERSHED AND LOWER SPRV – DIRECT IMPACTS

A. NEPA – DIRECT AND CUMULATIVE IMPACTS

The foregoing sections have dealt primarily with the "indirect effects" of the SunZia transmission line proposed routes through the Aravaipa watershed and Lower San Pedro River Valley (SPRV) that is, the related effects on the components, structures, and functioning of the ecosystem and cultural resources.[200] These effects have been determined to be significant by virtue of the context of a watershed of continental importance that in this segment is largely unfragmented and intact. The intensity of impacts are also significant, particularly with regard to proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, and ecologically critical areas.[201] In these regards the review has identified adverse environmental impacts that are of sufficient magnitude such that an Environmentally Unsatisfactory NEPA rating seems warranted:

> *The potential environmental impacts resulting from the proposed action are of national importance because of the threat to national environmental resources or to environmental policies.*[202]

The following sections will address more specifically direct effects, which are caused by the action and occur at the same time and place.[203] At the same time, the intensity of these effects will be addressed with regard to the cumulatively significant impact on the environment.[204]

> *Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.*[205]

Also addressed will be "The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973."[206]

B. LANDSCAPE FRAGMENTATION

The case has been made for the established consensus among biologists of how landscape biogeography has demonstrated that ecosystems function as a unit, and that the long-term survivability of species is dependent upon larger unfragmented and intact habitats.

> *…the ecological- network model evolved out of developments in ecological theory, primarily MacArthur and Wilson's equilibrium theory of island biogeography and metapopulation theory. The most important insight that followed from these theories was that habitat fragmentation increases the vulnerability of species populations by reducing the area of habitat available to local populations and limiting opportunities for dispersal, migration and genetic exchange. Interest therefore grew in developing conservation approaches that promoted ecological coherence at the landscape scale.*[207]

In that regard, the Aravaipa watershed and Lower SPRV's largely unfragmented landscape and intact habitat in the midst of four "globally outstanding" ecoregions and a watershed "of special continental importance" regarded as "critical" and urgently requiring conservation at the watershed scale is extraordinarily significant. The importance of critical biotic communities such as the Mixed Broadleaf Deciduous Riparian Forests and Semidesert Grasslands within the Aravaipa watershed and Lower SPRV has been addressed above. In the following sections the importance of unfragmented landscapes and intact habitats for classes of species and individual species of concern within the Aravaipa watershed and Lower SPRV will be reviewed. It is important to note that those issues are relevant even for species that are not especially wide-ranging or are locally relatively common.

> *…For many species, extensive linked and buffered systems of core areas are not immediately essential to their survival. …Even for many of these species, however, other factors become important for their long-term viability, such as the survival of a full complement of species within an ecosystem, the opportunity to move away from an existing area that comes under threat, and the occurrence of periodic natural disturbances that may require some form of linkage, such as flooding. Moreover, the island biogeography finding that the risk of extinction decreases as habitat size increases still holds for a large number of species.*[208]

As noted above, this brings into question the proposed SunZia routes that wend between protected status lands as though critical ecological processes begin and end at administrative boundaries. It reflects an outdated approach to biological science that even BLM has admitted to being inadequate, and is now changing to one more in line with the ecoregional approaches used by other agencies and conservation organizations.[209]

An overarching argument of ecological science and this report is this established fact that habitat fragmentation reduces the viability of species. As will be shown in detail in the following sections, within the Aravaipa watershed and Lower SPRV are whole classes of critical species, especially neotropical migrant birds and native fish. Among those classes are listed threatened and endangered species and species of concern. A project of SunZia's size, scope and prospective expansion will significantly fragment this largely unfragmented landscape and intact habitat. Therefore it will increase the vulnerability of these species populations by reducing the area of habitat available and increase the risks of extinction.

> *Habitat loss and degradation are probably the two most important factors contributing to the reduction of species populations, extinctions, and the disruption of ecosystem function.*[210]
>
> *There is widespread consensus that the world is currently experiencing a mass extinction event (Wilson 1992; Novacek and Cleland 2001). The biodiversity loss associated with this process is the result of several factors, including: land-use change and habitat destruction, invasive species, overexploitation of resources, pollution, and climate change. Of these factors, habitat destruction is by far the most detrimental, with infrastructure development playing a key role (Hardner and Rice 2002).*[211]

As the catalogue of species of concern accumulates throughout this section, it becomes more incumbent upon SunZia to show how habitat fragmentation is not an issue with the Aravaipa route, indeed to demonstrate that the weight of modern ecological science is incorrect. These are issues relevant to the Endangered Species Act of which the San Pedro Riparian National Conservation Area (SPRNCA) has run afoul and which will be considered later.

1. EDGE EFFECTS

How exactly would the SunZia routes within the Aravaipa watershed and Lower SPRV contribute to landscape and habitat fragmentation? There are two major impacts. One is the impacts of the towers and transmission lines themselves, which could be said to fragment the avian aerial space. That will be taken up in the following section on birds. The other major fragmentation impact has to do especially with the service roads and clearing that attend the installation and ongoing maintenance of the transmission lines.

Figure 4: GoogleEarth powerline towers and service roads

SunZia engineers during a tour of the Middle SPRV affirmed that roads would be required to each of the twin towers.[212] From the point where the Aravaipa route enters the Aravaipa watershed to where it crosses the Lower San Pedro River is about 45 miles. Approximately 30 miles of that route traverse the Aravaipa watershed and 15 additional miles are in the Lower San Pedro River Valley. SunZia's presentations say that the distance between towers is ~1300', which works out to about 4 towers per mile. This works out to about 180 towers for one line or 360 towers for both lines through the environmentally sensitive Aravaipa route.

Road width of the service road for the double 345-kV lines near the Winchester substation and near the Vail substation is about 20'-25'. It is unknown whether service roads would need to be wider for installation of larger 500-kV line towers. An image from GoogleEarth shows the service road for the four sets of towers between Houghton Road and the Vail substation (2 double-circuit 138-kV lines at the top, 2 single-circuit 345-kV lines at the bottom).

The obvious impact of these service roads is the direct removal of vegetation. As significant as that is, the more serious issue is fragmentation; the reduction and alteration of habitat as a cumulative effect over time.

In largely natural areas roads and utility corridors' subdivide the area into "islands" for some species, and create an edge effect (see Fig. 1). The design of studies examining the effects of roads and utility corridors on wildlife in natural areas is usually species specific. Without these investigations it is easy to assume that the construction of a road will merely displace the fauna from the area developed.[213]

Habitat fragmentation can occur even if the habitat area is only minimally reduced, as when it is divided by roads and powerlines. The diagram below illustrates how intersection of a road and powerline through a 64 hectare area reduces to 35 hectares due to edge effects.[214]

Edge effects are a standard biological concept and recognized component of landscape fragmentation, one that has received considerable attention in the literature.

Habitat fragmentation is widely perceived as a major threat to the conservation of terrestrial species for two major reasons. First, the resulting diminishment and dissection of species populations places many low-density species in demographic jeopardy (Berger 1990; Laurence 1991; Newmark 1991; Wilcove, McLellan, and Dobson 1986). Second, as fragmentation increases, the amount of 'core' habitat area decreases, and ecosystems increasingly experience 'edge effect' degradation from hunting pressure, fires from surrounding human activity, changes in microclimates, high levels of predation or parasitism, and invasion of exotic species over a large percentage of their area (Lovejoy 1980; Saunders, Hobbs, and Margules 1991; Skole and Tucker 1993).[215]

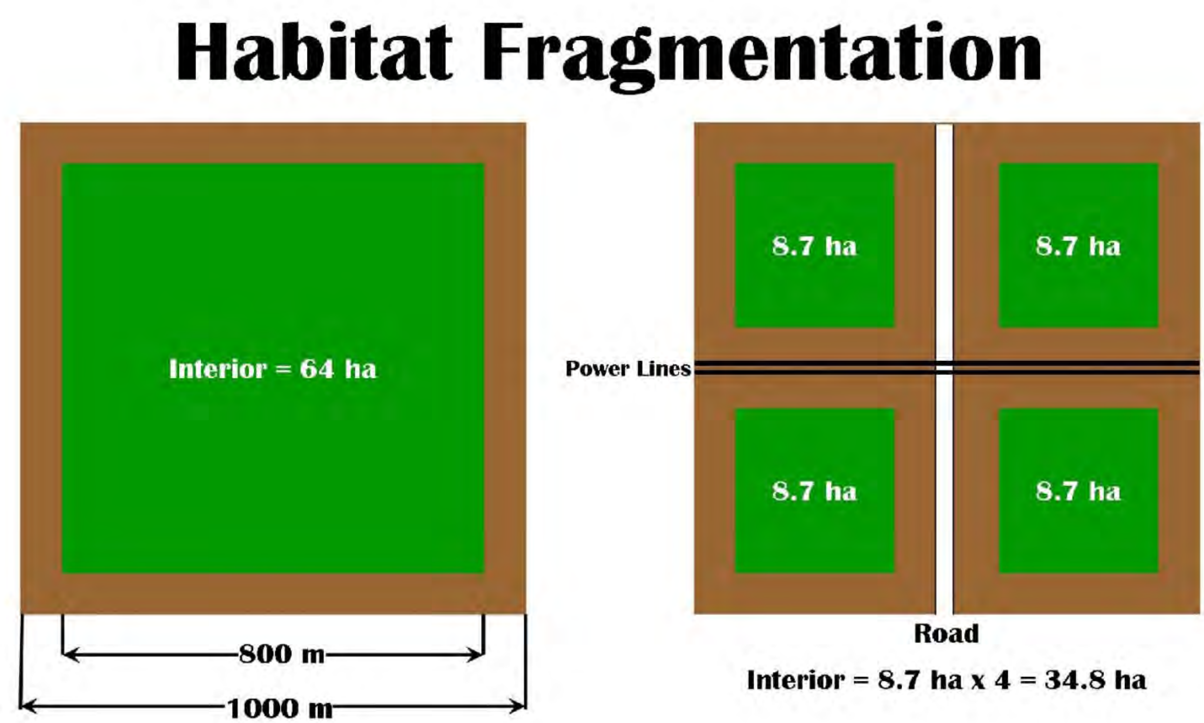

Figure 5: Habitat Fragmentation Diagram

It has been demonstrated that four terrestrial ecoregions, a freshwater ecoregion, and seven biotic communities intergrade within the Aravaipa watershed and Lower SPRV. There are no boundaries or lines, and the admixture creates extraordinary biodiversity. Roads however act in an opposite way, creating artificial lines which trend toward the diminishment of diversity.

> *Distinct communities and habitats occur naturally with intergradation of different environments, often called ecotones. The edge is a human artifact where two contrasting habitats suddenly converge without the natural gradations. The human-made edge is usually inimical to most wildlife, and species from the natural interior do not inhabit edges. Species with excellent dispersal abilities, capable of invading and colonizing disturbed habitats, are attracted to edges, and move into the core of natural habitats if a road or utility corridor carries the edge into a previously undisturbed area. The edge experiences a different wind and radiation effect, leading to a different microclimate. If habitats are fragmented too much, and the ratio of edge to interior favours edges, the habitat will no longer be suitable for the interior species we most need to conserve (Ranney et al. 1981). The core of areas important for conservation should ideally not be dissected with roads and utility corridors which create edge effects.*[216]

On a coarse or gross scale, it may appear that roads and clearings beneath power lines are porous and would have no impact on wildlife. In fact this is not even true for megafauna in some circumstances, but it is definitely an issue for smaller faunal inhabitants, both vertebrate and invertebrate. These components of an intact ecosystem are of course as critical as the larger since all elements are necessary and connected. First, there are edge effects on the distributions of wildlife along roads and utility corridors.

> *Edge effects are noticeable by differences in diversity, density and distribution of wildlife populations along roads and utility corridors. The presence of species usually found only at the edge of habitats is noticeable. When the colonizers occur with the species already present the number of species is greater than in the original habitat prior to the road. However, some fauna avoid the edges. A few widespread species can dominate the numbers in edges. These patterns have been described for small mammals along powerline corridors in forests in the USA (Johnson et al. 1979) and birds (Anderson et al. 1977; Kroodsma 1982a and b; Kroodsma 1987), and studies have indicated that the structural differences of the plants which are regularly trimmed adds to the differences in faunal populations.*[217]

Second, there are significant risks to wildlife from the edge effects of roads and clearings. "For species with poor dispersal or dispersal-related problems ... fragmentation may prove more critical than area as a determinant of extinction probabilities (Shaffer and Samson 1985)."[218] This would particularly implicate the many species of concern that will be examined in the following sections.

> *Edges have been described as "ecological traps" since studies have shown that birds may be attracted towards the vegetation on edges to breed, only to lose their offspring through nest predation (Yahner et al. 1989). Harris (1988) and Yahner (1988) warn that edges can have negative consequences for wildlife, especially those species dependent on large undisturbed areas. It is difficult to delineate the edge dimensions and to quantify the effect of the edge, but edge effects may be more a function of length than width, and the structural variation at the edge can act as a barrier to dispersal of some species (Yahner 1988). … In assessing the risk of extinction associated with fragmentation, edge effects must be considered (Wilcox and Murphy 1985).*[219]

The observation that "edge effects may be more a function of length than width" is significant with regard to a large linear installation such as the proposed SunZia Aravaipa route which traverses 30 miles through the heart of the Aravaipa watershed. That is especially the case since the establishment of the power corridor would clearly implicate further development, as their Federal Energy Regulatory Commission petition for a mile-wide study corridor demonstrates.[220] As the Arizona Wildlife Linkages Assessment notes, "Scale is a critical concept to consider when analyzing impacts to ecological pathways. Habitat quality, habitat boundaries, patch context, connectivity, and species responses change with changes in scale (Wiens 2002)."[221] Thus, though it may appear counterintuitive to the non-scientist, the edge effect of roads and utility corridor clearings can act as actual barriers. Studies examining the use of structural or landscape features have discovered a barrier effect of roads on some species.

> *A barrier need not be an impenetrable structure. There is nothing to prevent fauna crossing most roads, especially minor dirt roads which are also less used by vehicles. However, there is evidence that edges act as barriers (Yahner 1988), and a number of studies support the Canadian study by Oxiey et al. (1974), who found that total clearance of 30 m or more was the main factor inhibiting the movement of small mammals across roads.*[222]
>
> *Road studies have examined roads of different widths, surfaces and traffic volumes (Oxiey etal. 1974; Garland and Bradley 1984; Swihart and Slade 1984; Mader 1984; Bakowski and Kozakiewicz 1988; Baur and Baur 1990). Even a road in Kansas which was less than 3 m wide consisting of two dirt strips worn by the tyres of 10-20 vehicles a day, with vegetation on it, strongly inhibited crossing by prairie voles Microtus ochrogaster and cotton rats Sigmodon hispidus (Swihart and Slade 1984).*[223]

These concerns will be taken up again when reviewing off-road vehicle incursions (Section IV, B. 4), mammals (Section IV, E.) and reptiles (Section IV, F.).

2. AREAL IMPACTS

There is no precise way to forecast the areal extent of the clearing required for roads and tower pads for a project of SunZia's size until an actual route and roads are determined. The powerline service roads may follow direct routes between towers, or rely on spurs to towers from a somewhat removed transect road. Since twin towers are proposed with offsets of 400', additional spur roads between towers will be required. Also, each of the estimated 360 towers in the Aravaipa watershed and Lower SPRV would likely require clearing of almost an acre of land.[224] Whatever the final extent, the impact is likely to be considerable.

> *Considerable areas are destroyed or altered by linear constructions. In the United States of America powerline right-of-way will cover 3.4 million ha by the year 2000 (Johnson 1979), and for each kilometre of transmission line 25-40 ha of land is compacted (Brum et al. 1983).*[225]

Furthermore, revegetation recovery rates in these arid regions are notoriously slow and difficult.

> *Although vegetation can regrow on utility corridors, it is usually maintained at an earlier successional stage by cutting, mowing or spraying of herbicides. This affects the plants and animals living there. Studies undertaken in the United States have shown that in some habitats, such as deserts, the recovery of vegetation was slow, and revegetation programmes were expensive and could be unsuccessful (Brum et al. 1983). In the Sonoran Desert, areas cleared for the powerline corridor and*

towers suffered less environmental damage than the access road, and corridor succession of vegetation and insect colonization took place slowly (Johnson et al. 1981).[226]

The proposed SunZia Aravaipa route passes through Sonoran Desertscrub, Chihuahuan Semidesert Grasslands, Madrean Evergreen Woodlands, Great Basin Conifer Woodlands and Interior Chaparral, all critical biotic communities in their own right as well as serving as important connective linkages between montane and riverine communities. This large connective linkage is identified in the Arizona Linkages Assessment conducted by the Arizona Department of Transportation (ADOT) and Arizona Game and Fish Department (AGFD) through which the proposed SunZia Aravaipa route would pass in the Aravaipa watershed.[227] In that document they outline several phases of impacts from road construction and presence that are detrimental to such linkages. The first phase has to do with the actual construction of the project.

Phase 1– Construction Impacts: Road construction generally takes place over short time frames and limited spatial scales. Impacts are largely direct and localized alterations to physical, chemical, and biological resources. Typical impacts could include fine sediment runoff, spillage of oil or other hazardous waste from machinery, channelization of rivers, changes to stream gradient and substrate that affect movement of aquatic organisms, and disruption of groundwater regimes.[228]

Ecosystem destruction from power line construction impacts tend to be permanent since lines are seldom removed and their maintenance continues the destructive processes.

Phase 2– Road Presence: Road presence includes impacts that are directly due to the existence of the road but that occur later in time than construction. Angermeier et al. (2004) considered roads within 0.6 miles (1 km) of a riparian area as potentially impacting riparian areas. Generally, the impacts are at similar spatial scales as construction but occur over longer time scales. These disturbances may include habitat alterations such as intermittent occurrence of road maintenance, long-term affects to hydrology, channel adjustment, and sediment regimes.[229]

Furthermore, the long-term and cumulative impacts of the roads and expected utility corridor expansion can only be surmised as extraordinarily significant in the presently largely unfragmented and intact landscape of the Aravaipa watershed.

Phase 3 – Urbanization/Cumulative Effects: By providing access to areas that are previously undisturbed, roads often lead to increased urbanization, which should be analyzed for impacts to riparian flora and fauna. The cumulative impact of multiple single road projects should be considered at large spatial and temporal scales within the watershed.[230]

Finally, the clearing of vegetation and associated soil compaction can only work in directions counter to revegetation and rangeland improvement by local ranchers and other conservation efforts such as described in the Aravaipa EMP.

Watersheds dominated by bare ground or that have been impacted in such a way that ground cover is reduced foster flash flooding which can destabilize riparian areas in associated drainages.[231]

The close connection between the uplands and riparian and other habitat linkages of the drainages is thus clearly implicated in the impacts from the clearing for roads and towers, as will be reviewed in greater detail in a following section (Section IV, D.). Here it is worth noting that it is intermittent and ephemeral drainages as well as perennial ones that are of concern with regard to the impacts of roads on connective linkages.

> *…a high level of protection for all perennial flowing waters is recommended. Furthermore, it is advocated that project proponents consider all water courses (perennial, intermittent, and ephemeral) as key habitats and potential linkages, and assess the potential impact of roads on organisms across multiple spatial and temporal scales.*[232]

In addition to the direct impacts of clearing for roads and tower pads are the long term impacts of clearing beneath power lines. The Energy Policy Act of 2005 designated North American Electric Reliability Corporation (NERC) to develop and enforce compliance with reliability standards that prevent power outages due to vegetation falling onto major power lines. NERC Standard FAC-003-1 was passed in the wake of several large-scale power outages caused by vegetation. Certain reportable outages can be subject to fines of up to $1 million a day. Power transmission lines operated at 200 kilovolts or higher are subject to the rule.[233]

> *Throughout Arizona, trees, shrubs and saguaros that exist below the power-lines are being felled, even where they are incapable of growing or falling into the power lines. In practice, the utilities are managing the hazard of electrical "flashovers" during fires by maintaining plenty of air space between the power line and the tops of trees. Saguaros are being cleared elsewhere for the same reason—the potential that electricity will arc downward through their watery bodies, causing fires that might jeopardize delivery of energy in a way that might be interpreted by NERC as a reportable outage.*
>
> *In short, more vegetation is being cleared as each utility begins implementing its plan. In practice, utilities remove far more vegetation that the minimum needed to meet NERC rules, to minimize the need for repeated mobilization of field crews. Inadequate field supervision of contractors contributes to the problems.*
>
> *…All trees, woody shrubs and saguaros may eventually be removed along power transmission lines rated at 200kV or higher, whether situated along public or private lands, along with impacts to plants and animals associated with repeated use of mechanical or herbicide treatments. Mechanical clearings may result in significant degradation of archeological resources. The cleared areas will alter fire behavior. In montane areas, the new clearings may serve as fire breaks. In some lower elevation areas, invasion of non-native grasses in the disturbed areas may actually increase the fire risk. In all locations, vegetation management will more or less permanently alter the characteristics of wildlife habitat under power lines.*[234]

Figure 6: Clearing beneath powerlines

Shown above is Landiscor aerial photograph of Cienega Creek, Pima County, Arizona, 2009, illustrating complete clearing of approximately three acres of cottonwood gallery forest and mesquite bosque on land owned by Tucson Electric Power (TEP). The power-line corridor crosses a perennial stream that provides habitat for the federally listed Gila topminnow.[235]

In advance of installation such practices are difficult to predict, but they are even more difficult to control once the corridor passes into ownership by utilities. With the prospect of such clearing practices in concert with SunZia's FERC request for a mile-wide study corridor for future expansion, the Aravaipa route passing between wilderness areas, Areas of Critical Environmental Concern and across the San Pedro River augurs for landscape fragmentation at a devastating scale.

3. EROSION

The impacts of fragmentation and edge effects from roads are exacerbated by erosion. Erosion is a matter of serious concern to conservationists, and particularly to Aravaipa watershed and Lower SPRV ranchers whose livelihoods depend upon good range conditions. It was a topic of particular concern in a watershed assessment performed by the Redington Natural Resource Conservation District (NRCD) under a grant from the Arizona Department of Environmental Quality, primarily led by Dr. Lamar Smith, a retired University of Arizona Assistant Professor of Range Management. Therein the bases of the issue were set forth:

> *Soil conservation is a basic objective for all natural resource management. Soil erosion on uplands can reduce soil depth and therefore reduce soil moisture holding capacity and rooting depth. Soil erosion can result in the loss of nutrients from the watershed, especially since these nutrients are most abundant in the surface soil. And soil erosion contributes to sediment accumulation and lower water quality in drainages and reservoirs.*[236]
>
> *Soil compaction can also reduce infiltration rates and soil moisture holding capacity, thus increasing runoff and erosion hazard.*[237]

As noted, studies indicate that for each kilometer of transmission line 25-40 hectares of land is compacted.[238] This becomes especially relevant as the watershed assessment indicated that roads were the major source of erosion in the Lower SPRV.

> *In the LSP watershed assessment, roads were considered to be the number one cause of human-related gully erosion. Most of the problems involve the unimproved roads on rangelands, but similar problems occur on the other categories as well. The main problem with unimproved roads is that they tend to intercept surface runoff and cause it to run down the road. This water builds up depth and erosive power and eventually starts to cut a gully in the tracks down the road. When these tracks develop into a deep rut or gully, the road is usually moved over to get out of the rut. Once started these gullies often tend to continue to erode, even if the road is moved. The severity of the problem is related to the slope of the road and the type of soil involved. Roads along ridges may have little problem because there is no source of water above them. Roads running down slopes act as channels for water.*[239]

This latter point is significant. Ranch roads tend to run along ridges, and observation indicates that decades old ranch roads show very little erosive action. However, powerline roads, because of their linear aspect, cut across drainages. Also, because transmission towers are usually sited on high points, roads to them tend to be very steep. A survey of many tens of miles of Tucson Electric Power high-voltage lines in Pima County (345-kV, 230-kV, 138-kV) on Google Earth showed service roads as close to the lines as possible and following them straight as an arrow except where necessary to detour around obstacles (rock outcrops, difficult terrain, wash crossings).[240]

In the upper Aravaipa watershed, the proposed twin 500-kV SunZia lines are generally traversing many drainages in an area of highly erodible soil as shown in Figure 7. Thus, the service roads can be expected to traverse these drainages as well, with impacts for aquatic species noted in Section IV D-2.

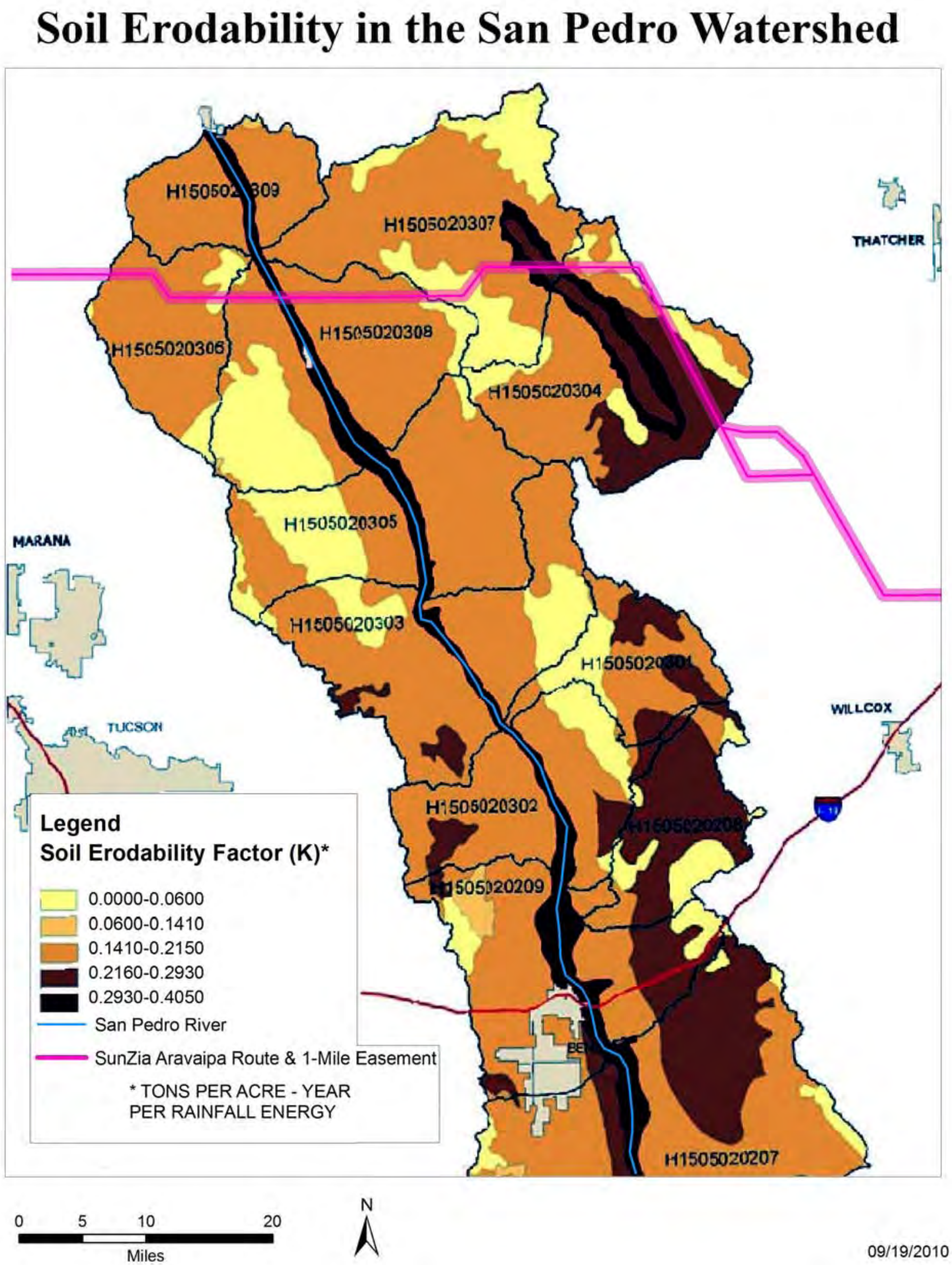

Figure 7: Map of Soil Erodibility

4. OFF-ROAD INCURSIONS

As outlined by Arizona's Wildlife Linkages Assessment, the final and most deleterious impact of roads that provide access to previously undisturbed areas is the threat of urbanization.[241] It is an oft-repeated story that "Roads become part of a 'foot in the door' principle, with developments sprawling alongside. They serve to open areas up to human expansion. This is especially noticeable in developing countries and undeveloped regions."[242]

In an undeveloped area like the Aravaipa watershed and Lower SPRV, these are common concerns voiced by conservationists. For the Sonoran Desert, "The major conservation threats are urbanization…. The urban and suburban areas of Phoenix and Tucson continue to expand rapidly."[243] For the Chihuahuan Desert "Degradation threats include increasing off-road vehicle use in some areas."[244] And for the Gila Freshwater Ecoregion which includes the San Pedro River and Aravaipa Creek, its Conservation Status is "Critical," i.e. the most severely threatened, for these same reasons.[245]

A powerline service road will not itself of course become a corridor for suburban sprawl. Rather it becomes the 'foot in the door' for the first wave of urban incursions, and in particular off-road vehicles. This has already been demonstrated as an issue in the Middle SPRV with the pipeline road.

> *In its present state, the pipeline road is eroding and allows for unregulated vehicle access to adjacent riparian area in Hot Springs Canyon. The Hot Springs Canyon riparian area includes sensitive and significant riparian resources which were recognized in designation of this area as the Hot Springs Watershed ACEC.*[246]

Indeed, shortly after its installation, the pipeline road was proposed as part of the Great Western Trail OHV system.[247] Such incursions are an even greater threat along the Lower SPRV portion of SunZia's proposed Aravaipa route due to its greater public access.

Off-road vehicle pressure continues to build in the Lower SPRV. Pinal County was the second fastest growing county in the U.S. between 2000 and 2009,[248] and is pressuring Arizona Game & Fish with the Northwest Galiuros Travel Management Plan to open the area to greater off-road access. Likewise the Coronado National Forest Plan Draft is proposing Redington Pass as a 'Motorized Recreation Area.' The Friends of Redington Pass, the Redington NRCD, the Cascabel Working Group and others are working to assure recreational access only at appropriate and approved points in the Lower SPRV.

Gating of power line roads is particularly difficult across the open range of Arizona State Land Department (ASLD) lands. Off-road vehicles presently trespass and follow washes up and down drainages. With cross-drainage roads this practice is bound to increase, especially with proximity to these burgeoning population centers. Policing of these roads and gates is virtually impossible in this remote area. Ranchers and private landowners have significant experience with the issue, as does The Nature Conservancy.

> *First, we are concerned about the construction and maintenance of access roads along the transmission line corridor. Access roads fragment the habitat for wildlife and frequently become open routes for recreational off-road vehicle drivers, from which they can venture away into unroaded*

landscapes. That prospect is particularly troubling for any route that crosses the Galiuro Mountains, a region where wildlife and the human experience of wilderness have benefitted from the almost total lack of through roads. Our experience with land management has shown that putting fences and gates across utility access roads is ineffective – replacing locks and rebuilding gates have become frequent events for our preserve managers.[249]

Off-road vehicle trespass is also addressed as a major concern in the Draft Aravaipa EMP. As was noted earlier (Section III, B. 3),

One of the major influences that shapes the character of the Aravaipa ecosystem has been its limited access. There are no useful through-roads connecting the east and west ends of Aravaipa Canyon, which has isolated much of the area from the large urban centers of Tucson and Phoenix.[250]

The Aravaipa EMP includes a number of prescriptions dealing with OHVs, but it is clearly already an issue. It notes that "There are no quantitative data on use levels of recreational OHV driving around Aravaipa. However, it is a growing form of recreation and areas within Aravaipa have received considerable use prior to roads being closed by recent private landowner actions."[251] It also asks "What measures are needed to protect cultural resources from vandalism, damage from OHV use…?"[252] and "How should we manage vehicle route proliferation caused by OHV trespass…?"[253]

Pima County, owner of the nearby A-7 Ranch through which a proposed SunZia route passes, has similar concerns and relevant experience regarding the roads.

Placement of a new transmission line inevitably results in increased public access across a landscape. No matter the steps taken, the lands become much more accessible and remain open because of the need to manage and repair the transmission lines and disturbances during construction that are never fully mitigated. All terrain vehicle impacts in this area are an increased concern when access points are created due to its proximity to Tucson. A prime example has been the Kinder-Morgan pipeline project's ongoing impacts to the County's Cienega Creek Natural Preserve and Bar V Ranch management and protection. Despite mitigation efforts by the company, impacts continue for the County to address with no long-term support or ability to reconfigure the impacts due to the constraints now placed by the location of the utility infrastructure corridor.[254]

Indeed, Pima County's Sonoran Desert Conservation Plan for the A-7 addressed this as a major stressor for the area:

Zone 2, Canyon Riparian and Wildlife Corridor; Stresses: Disruption of Wildlife Corridor; Sources: Growing recreational pressure from Tucson basin Dirt Bikes, Mountain Bikes, ATVs; Impacts: Destruction of habitat through construction of prospecting roads; Increase in sedimentation from disturbed soils in roads.

Zone 2, Canyon Riparian and Wildlife Corridor; Stresses: Degradation of Water Quality; Sources: Increase acreage of roads; Increased vehicular use by recreational users would increase release of VOCs and sedimentation from disturbed soils in roads; Impacts: Extirpation of aquatic dependent species such as longfin dace and lowland leopard frog would be likely. Insects with aquatic life stages would be reduced or extirpated with related impacts to insect feeding bats and birds.

Zone 3, Watershed Enhancement; Stresses: Incompatible recreational use; Sources: Network of roads permitting access; Impacts: Increase in surface runoff and sedimentation; Increased habitat destruction.[255]

As this review of stressors notes, the environmental impacts from off-road vehicles can be very significant, particularly in fragile desert areas like the Aravaipa watershed and Lower SPRV. Destruction of vegetation, compaction of soils and resultant erosive activity has already been mentioned. Some remote and isolated threatened and endangered species of plants may be threatened by off-road vehicle use.[256] The consequence of increased sediment load into streams from disturbed soils is also an extremely important issue that will be addressed in detail in the section on waters and fish (Section IV, D.).

Another obvious effect of roads is mortality from collisions with vehicles. It is a matter that is difficult to quantify, but in an area of such biodiversity as the Aravaipa watershed and Lower SPRV with such a wealth of mammalian, avian and reptilian species the cumulative impact must be considered significant. Off-road vehicles have been implicated in declines of desert tortoise populations, of which the Lower SPRV is significant habitat for the Sonoran variety.[257] Some studies in an equally rich area like Australia have found one bird killed every 13km and one mammal killed every 30 km traveled.[258]

There are also other impacts from off-road vehicles that may be less noticeable to humans but are deadly to smaller vertebrates and invertebrates. The increased release of Volatile Organic Compounds was alluded to above. "Pollutants are emitted by vehicles, including oil residues and heavy metals such as lead, zinc, copper, nickel and chromium (Broadbent and Cranwell 1979)."[259] Noise disturbance is also an issue. Fauna are more sensitive to sound than humans, and many depend on efficient hearing for survival.

> *Laboratory tests were performed on three desert species, used to the silence of high dune areas. A sand lizard Clma scoparia and kangaroo rat Dipodomys deserti were exposed to less than 10 minutes of recorded dune buggy sounds played intermittently at lower intensity than normal. This induced hearing loss in both species which lasted for weeks, leading to inability to respond to the recordings of predator sounds. A spade-foot toad Scaphiopus couchi was made to emerge prematurely from its burrow by playing 30 minutes of taped motorcycle sounds. These responses to off-road vehicles could cause death in the desert (Brattstrom and Bondello 1983*).[260]

Finally, as opposed to the subtle, there would be gross impacts as well. As noted by a California group opposed to a powerline through their area:

> *Areas with these types of power lines and new roads have seen increased illegal dumping and off-road desert trespass (by vehicles and OHVs). There would be an increased need for emergency responses to injuries and accidents and possibly for search-and-rescue operations as these roads open previously inaccessible areas. The costs associated with these new circumstances would be shouldered by our counties and local municipalities….*[261]

The direct and cumulative fragmentation impacts of the proposed SunZia transmission line project in an area as biodiverse and critical as the Aravaipa watershed and Lower SPRV must be considered substantial. Annabelle Andrews' excellent review of the literature associated with fragmentation of habitat by roads and utility corridors may give as good a summary as possible to the issue.

> *Ideally roads and other linear corridors should not be constructed through areas which are important to the survival of species, or remaining wilderness areas. National Parks and conservation areas should also be protected from these structures, which are best sited on land already disturbed.*

Siting of such projects is significant, and all possible alternatives should be investigated if wildlife values and viable habitats are to be sustained for future generations. Once wildlife suffers the most serious effect of fragmentation it is far more costly to maintain unviable areas, and to breed species back from near-extinction, than it is to leave viable areas of habitat undisturbed while we have the choice.[262]

C. BIRDS

Nearly all direct environmental impacts of the SunZia transmission project proposed routes through the Aravaipa watershed and Lower SPRV can be considered as a subset of fragmentation.

The prospective edge effects of SunZia service roads discussed in the previous section impact birds as well. For example, "Edges have been described as 'ecological traps' since studies have shown that birds may be attracted towards the vegetation on edges to breed, only to lose their offspring through nest predation (Yahner et *al.* 1989)."[263] Other impacts of roads on birds have also been documented.

In the Netherlands a long-distance effect on birds was noted by van der Zande et al. (1980), with specific species keeping particular distances from the roads, and lapwings Vanellus vanellus and godwits Limosa limosa as far as 1.8-2.1 km away. The study did not investigate the mechanism of disturbance, whether mechanical, acoustical or visual, but calculated a disturbance intensity which was the total population density loss suffered over the disturbance distance. An area became "psychologically unacceptable" to neotropical migratory birds in the USA after the construction of a nearby highway (Whitcombe et al. 1981). Cabin John Island near Washington was part of a continuous riparian forest and had always supported a large population of breeding birds. The nearby highway has not touched the island, yet edge species have increased and the rare interior species such as the neotropical migratory birds have declined.[264]

Species with excellent dispersal abilities, capable of invading and colonizing disturbed habitats, are attracted to edges, and move into the core of natural habitats if a road or utility corridor carries the edge into a previously undisturbed area.[265] These species are sometimes termed habitat generalists, and many of them are at least occasional nest predators.[266] One animal that thrives in fragmented habitats and poses significant hazard for neotropical breeding populations is the Brown-headed Cowbird. Cowbirds are obligate brood parasites that lay their eggs in the nests of other birds and then fly away, leaving their hosts to hatch and raise their young. More than 200 other species are affected.[267]

Grassland birds are much less area-sensitive, but they still prefer larger, more continuous tracts and show some evidence of greater nesting failure in fragmented parcels of land. Losses of grassland habitat in the southern U.S. may also be responsible for some of the declines of grassland species.[268] The fragmentation and areal impacts of the SunZia transmission service roads and clearing would thereby be significant, since the Semidesert Grasslands through which much of the routes would pass provide habitat for scaled quail, Gambel's quail, mourning dove, loggerhead shrike (former federal candidate), Botteri's sparrow, Baird's sparrow and others.[269]

Nonetheless, the much larger fragmentation impacts on birds have to do with the aerial barrier that the transmission towers and powerlines themselves would present.

Powerlines fragment bird flight paths, leading to collisions of birds with the lines, resulting in injury and death. …In the USA collisions with automobiles and powerlines were the most frequent cause of bird mortality (Stout and Cornell 1976).[270]

In the first section on indirect impacts, some of the generic information regarding avian fauna in the Lower SPRV was touched upon. First, that data will be summarized and presented in somewhat greater depth before proceeding to the direct and cumulative impacts that towers and transmission lines would present as fragmenting aerial barriers.

1. BIRDS OF THE SAN PEDRO - GENERAL

First, to recap some of the highlights with regard to birds, the San Pedro River Valley lies within ecoregions that have some of the highest avian diversity in North America. The Chihuahuan Desert is ranked first among North American ecoregions in bird richness with 279 resident species, and the Sonoran Desert is third on the continent with 261 species.[271] The Sonoran desert, together with its eastern neighbor the Chihuahuan desert, is the richest area in the United States for birds, particularly hummingbirds.[272] In total, more than 500 bird species migrate through, breed, or permanently reside in the Sonoran Ecoregion – nearly two-thirds of all species that occur in northern Mexico, the United States and Canada.[273] With regard to the Sky Island region, at least 468 bird species have been verified in southeastern Arizona during the past 50 years…."[274]

Narrowing that focus to our area in particular, the San Pedro River Valley (SPRV) has one of the highest bird diversities of any area its size in the United States.[275] "Nearly 390 bird species have been recorded within the SPRNCA boundaries, of which 250 are neotropical migrants."[276] It is this function as a major neotropical migratory corridor that has brought the greatest attention to the SPRV, as it "…supports one of the most important migratory bird habitats in North America; indeed, roughly half of the birds that breed in this arid region are dependent upon it."[277]

The data for migrating neotropicals through the SPRV is quite compelling.

The estimated densities of some species far exceed the breeding and migration densities reported elsewhere. The peak densities of Yellow Warblers (48.0 birds/ha) were much greater than reported breeding densities in southwestern riparian areas (San Pedro River, Arizona, peak of 5.7 birds/ha [Krueper 1992]; Rio Grande River, New Mexico, 3.3 birds/ha [Stahlecker et. al. 1989] and 0.6 birds/ha [V.C. Hink & R.D. Ohmart, unpublished manuscript]; and at 2500 m in Colorado, 2.5 birds/ha [Knopf et. al. 1988]), verifying that these stopover sites provide habitat for a great number of northbound migrants.[278]

As reported by the tri-national Commission for Environmental Cooperation, "Current estimates are that between one and four million landbirds migrate through the SPRNCA each spring. Densities of migrating songbirds average 40 birds/hectare, nearly ten times the breeding density. …These birds use not only the San Pedro but also other surrounding riparian areas."[279] However, as Dave Krueper points out, a BLM biologist involved in the Skagen surveys, "The 1-4 million number I feel is conservative and is only for the spring season. I feel that the total can easily be doubled when one takes into account the fall season. Especially considering that young of the year are involved and the migration season is so protracted."[280]

Such migration densities along the SPRV have raised it to prominence as the main migratory corridor in the West.

> *Peak densities of Yellow Warblers [48.0 birds/ha], Wilson's Warblers (33.7 birds/ha), and Yellow-rumped Warblers (30.1 birds/ha) in this study also surpass estimates of densities during spring and fall migration along the Rio Grande (Yellow Warblers, <0.5 birds/ha in spring; Wilson's Warblers, 1.3 birds/ha in spring and 2.5 birds/ha in fall; Yellow-rumped Warblers, 5.1 birds/ha in spring and 22.1 birds/ha in fall; V.C. Hink and R. D. Ohmart, unpublished manuscript) and in a variety of habitats in the Chiricahua Mountains of southeastern Arizona (Yellow Warblers 0.36 birds/ha in fall; Wilson's Warblers 0.5 birds/ha in spring and 2.0 birds/ha in fall; Yellow-rumped Warblers, 3.0 birds/ha in spring and 1.1 birds/ha in fall; Hutto 1985b).*[281]

Dave Krueper confirmed that these are much higher densities than the Colorado, Rio Grande, Pecos and Santa Cruz from available reports.[282] These major river systems may have been more dominant as migratory corridors historically, but no longer provide continuous habitat. This is testimony to the fact that North America's freshwater environments are among the most threatened, and that nearly every freshwater system suffers from some degree of degradation.[283] The San Pedro River's significance is clear when only 2 percent of the nation's 5.1 million kilometers of rivers and streams remain free flowing and undeveloped.[284] Jeff Price at a Commission for Economic Cooperation public meeting in Benson, Arizona noted that there is only one other migratory corridor in the Western United States of San Pedro significance, and that is the Kern Valley in California with about 250,000 migrants a year.[285]

Not all of these birds are just passing through however.

> *Breeding densities may be nearly as compelling an argument for preservation of the San Pedro. Here our numbers are probably much more accurate since we have week after week of data on territorial birds. Again extrapolating to the total of like-habitat, we've calculated approximately one quarter million Yellow Warblers breeding within the NCA. Adding in Lucy's Warbler, Common Yellowthroat and Yellow-breasted Chat, there are at least one-half million warblers alone breeding within the 44 miles of riparian corridor of the San Pedro RNCA.*[286]

Also lending credence to the avian significance of the San Pedro is the presence of notable species of special concern.

- *"Notably, 36 species of raptors, including the gray hawk (*Asturina nititda = Buteo nitidus*), Mississippi kite (*Ictinia mississippiensis*), common black hawk (*Buteogallus anthracinus*), and zone-tailed hawk (*Buteo albonotatus*) can be found within the San Pedro NCA.*

- *Regarding the gray hawk, the San Pedro RNCA is thought to support 40 percent of the nesting gray hawks in the United States."*[287]

- *"More than 15 percent of the world's population of western yellow-billed cuckoo breeds along the San Pedro,"*[288] *and a petition has been filed with the US Fish and Wildlife Service to investigate the possibility of listing.*[289]

- *Together the SPRNCA contains the densest breeding population of gray hawks and western yellow-billed cuckoos in the United States.*[290]
- *Peregrine falcons, formerly listed as endangered, inhabit the San Pedro watershed.*[291]
- *Critical habitat was designated for the southwestern willow flycatcher on the San Pedro in 1997.*[292]
- *"Twelve bird species found annually on the SPRNCA are classified as Wildlife of Special Concern in Arizona. This represents 41 percent of the birds found on that list." This includes Swainson's hawk, ferruginous hawk, western yellow-billed cuckoo, southwestern willow flycatcher.*[293]

"Partners in Flight" is a coalition of more than 150 federal, state, industry, academic and nongovernmental organizations. They developed a methodology for determining the relative conservation concern for different bird species which was translated into a WatchList.

> *Of the 107 species on the 1998 PIF WatchList, 52 have occurred in the SPRNCA at least once…. The 15 WatchList species found annually on the SPRNCA are Ross' goose, elf owl, gilded flicker, bridled titmouse, Bendire's thrasher, curve-billed thrasher, Bell's vireo, Lucy's warbler, Albert's towhee, Botteris's sparrow, Cassin's sparrow, Brewer's sparrow, sage sparrow, lark bunting and Baird's sparrow. Of the species migrating through the SPRNCA, the following PIF WatchList species are found there annually: willet, long-billed curlew, marbled godwit, stilt sandpiper, long-billed dowitcher, Franklin's gull, rufuous hummingbird, gray vireo, Virginia's warbler, hermit warbler, painted bunting and black-chinned sparrow.*
>
> *In Arizona, the local chapter of PIF has developed their own list of species of conservation concern. Of their top-scoring 45 species, 42 have occurred at least once in the SPRNCA. Of these 42, 25 occur annually with nine breeding, five wintering and 11 migrating through.*[294]

For these reasons, in 1995 the American Bird Conservancy, in partnership with Partners in Flight, the National Audubon Society and the Bureau of Land Management, named the San Pedro Riparian National Conservation Area (SPRNCA) a Globally Important Bird Area. This was the first designation of this kind in the Western Hemisphere.[295] Thus it has become noted as a habitat "of special continental importance."[296] It has in fact been recognized as having natural heritage values of global significance by several organizations, including The Nature Conservancy,[297] the Commission for Environmental Cooperation,[298] and the American Bird Conservancy.[299] Indeed, the Bureau of Land Management which is overseeing the SunZia project is itself among them.[300]

2. BIRDS OF THE LOWER SAN PEDRO RIVER VALLEY AND ARAVAIPA CANYON

Until recently the Lower San Pedro River Valley has not been the subject of the intensive avian research carried out on the river's upper reaches, for reasons likely having to do with its lack of designation as a National Conservation Area, lesser urban threats, a more intermittent flow regime, and access. However, its significance as avian habitat, which lends so much prominence to the San Pedro, is as great as that documented for the SPRNCA.

Early investigations conducted in the 1940s and 1970s had already documented between 95 and 111 bird species solely within the mesquite bosque currently owned by BHP-Billiton near San Manuel.[301] In 1995 "More than 100 species of birds were recorded on BLM properties in the Cascabel area (BLM 1995) upstream of the Pima County reach of the river. …Rare or declining species of riparian-nesting species include: northern gray hawk, zone-tailed hawk, common black hawk, Mississippi kite, cactus ferruginous pygmy-owl, western yellow-billed cuckoo, southwestern willow flycatcher, and northern beardless-tyrannulet."[302]

The Environmental Assessment for the Muleshoe Cooperative Management Area performed by the Bureau of Land Management in 1998 found "Substantial numbers of neotropical birds including summer tanagers, northern orioles, yellow-billed cuckoo, gray hawk, black hawk, and zone-tailed hawk nest in riparian habitats." The desert grasslands were found to provide habitat for scaled quail, Gambel's quail, mourning dove, loggerhead shrike (former federal candidate), Botteri's sparrow, and Baird's sparrow. And the then "endangered peregrine falcon inhabit the rugged cliffs and remote canyons that border and cross through the desert grassland."[303]

In 2000 The Nature Conservancy undertook a science-based approach to identify important Conservation Sites throughout the Sonoran Desert Ecoregion. They used the Natural Heritage Program ranking system to assist in selecting Fine Filter Targets. That system uses a five-category ranking to describe a species' rarity. A ranking of Global 1 (G1) characterizes the rarest species, while G5 characterizes the most common.[304] They selected nearly all G1 through G3 species for which data were available as Fine Filter Targets since those are the Ecoregion's rarest elements.[305] The [Lower] San Pedro River/Aravaipa Creek was selected as the fourth most prominent listing out of 100 Conservation Sites in the Sonoran Desert Ecoregion, and was in the top three of bird targets.[306] The Conservation Targets for birds, with their Natural Heritage Program ranking in parenthesis, were: Rufous-winged Sparrow (G4); Northern Gray Hawk (G3); Western Yellow-billed Cuckoo (G3); Gilded Flicker (G5); Yellow Warbler (G3); Southwestern Willow Flycatcher (G2); American Peregrine Falcon (G3); Cactus Ferruginous Pygmy-owl (G3); Abert's Towhee (G3).[307]

The Partners in Flight program, cited above in some of the earlier research on the San Pedro, has continued to evolve with substantial implications for the Lower SPRV. The Arizona Game and Fish Department and partners developed the Arizona Partners in Flight Bird Conservation Plan in June of 1999.[308] The Arizona Working Group of Partners in Flight (APIF) plan is part of the national Partners in Flight effort. APIF has since been incorporated under a larger umbrella known as the Arizona Bird Conservation Initiative (ABCI).[309] Since Jan. 2002, Arizona's Important Bird Areas (IBA) Program has been run as a partnership with Arizona Game and Fish Department, Arizona Bird Conservation Initiative (ABCI), Tucson Audubon Society and Audubon Arizona.[310]

The Arizona Important Bird Areas (IBA) Program, as part of their bird conservation plan, compiles and updates an Arizona WatchList. The latest iteration is the Arizona WatchList 2007, edited in 2009.[311] "The placement of a bird on or off the WatchList is based on the assessment of four factors: population size, range size, threats, and population trend (Panjabi et al. 2005). …Migrants and vagrants were not included in this list, which focuses on those species for which Arizona has a stewardship responsibility for either breeding or wintering habitats."[312]

Of the more than 280 breeding bird species in Arizona,[313] there are 47 WatchList Species in Arizona. Eleven of these are termed "Red Species," or globally threatened birds of Highest National Concern that occur in the United States. "Yellow Species" are rare and declining species that would join the red list should they begin to decline in population (or accelerate declines that have already begun) or decline for long enough to cause their populations or range sizes to fall below certain thresholds. There is also an appended list of 48 Arizona Bird Species of Greatest Conservation Need (SGCN) compiled by the Arizona Game and Fish Department as an appendix to Arizona's State Wildlife Action Plan or "Comprehensive Wildlife Conservation Strategy" (CWCS), April 2006. These tier 1a or 1b SGCN species have been identified for immediate conservation action.[314]

The San Pedro Riparian National Conservation Area (SPRNCA) is renowned for the number of species represented, recording over 370 species.[315] It is equally well represented with regard to the Arizona WatchList. Of the 11 "Red Species," or globally threatened birds of Highest National Concern, 6 have been recorded in the SPRNCA. Of the 36 rare and declining "Yellow Species" on the WatchList, 29 have been recorded in the SPRNCA. Of the 48 Arizona Bird Species of Greatest Conservation Need (SGCN), 36 have been recorded in the SPRNCA.

As noted, the Lower SPRV does not enjoy the renown of a National Conservation Area, nor the years of intensive research and thousands of yearly birding visitors. Still, some significant bird species documentation has been maintained for various sites throughout the Lower SPRV and Aravaipa Canyon. For the purposes of this project, that documentation was compiled into a "Birds of the Lower San Pedro River Valley" list by Bob Evans, an experienced and well-regarded bird enthusiast.[316] The list is appended to this document and was compiled from the following sources (See Appendix).

- Aravipa Canyon Preserve (TNC)
- BHP Billiton Riparian Corridor (Tucson Audubon)
- Saguaro-Juniper Corporation (private)
- Three Links Farm (TNC)
- Bingham Cienega (Pima County/TNC)
- Cook's Lake (Bureau of Reclamation)
- Muleshoe Ranch Preserve (TNC)
- Saguaro National Park (East)

Among those eight sites, four are in various elevations of the valley uplands (Aravaipa, Saguaro-Juniper, Muleshoe, Saguaro NP), and on both the east and west sides of the valley. The other four are riverine sites (BHP, Three-Links, Bingham and Cook's Lake). Also the Saguaro NP and Three-Links sites are at the southernmost portion of the Lower SPRV; BHP, Aravaipa and Cook's Lake are at the northernmost portion; and Saguaro-Juniper, Muleshoe and Bingham are at various intermediate points. Thus the full extent of the Lower SPRV is fairly well represented, which as will be seen is an important point with regard to bird habitat and the SunZia route.

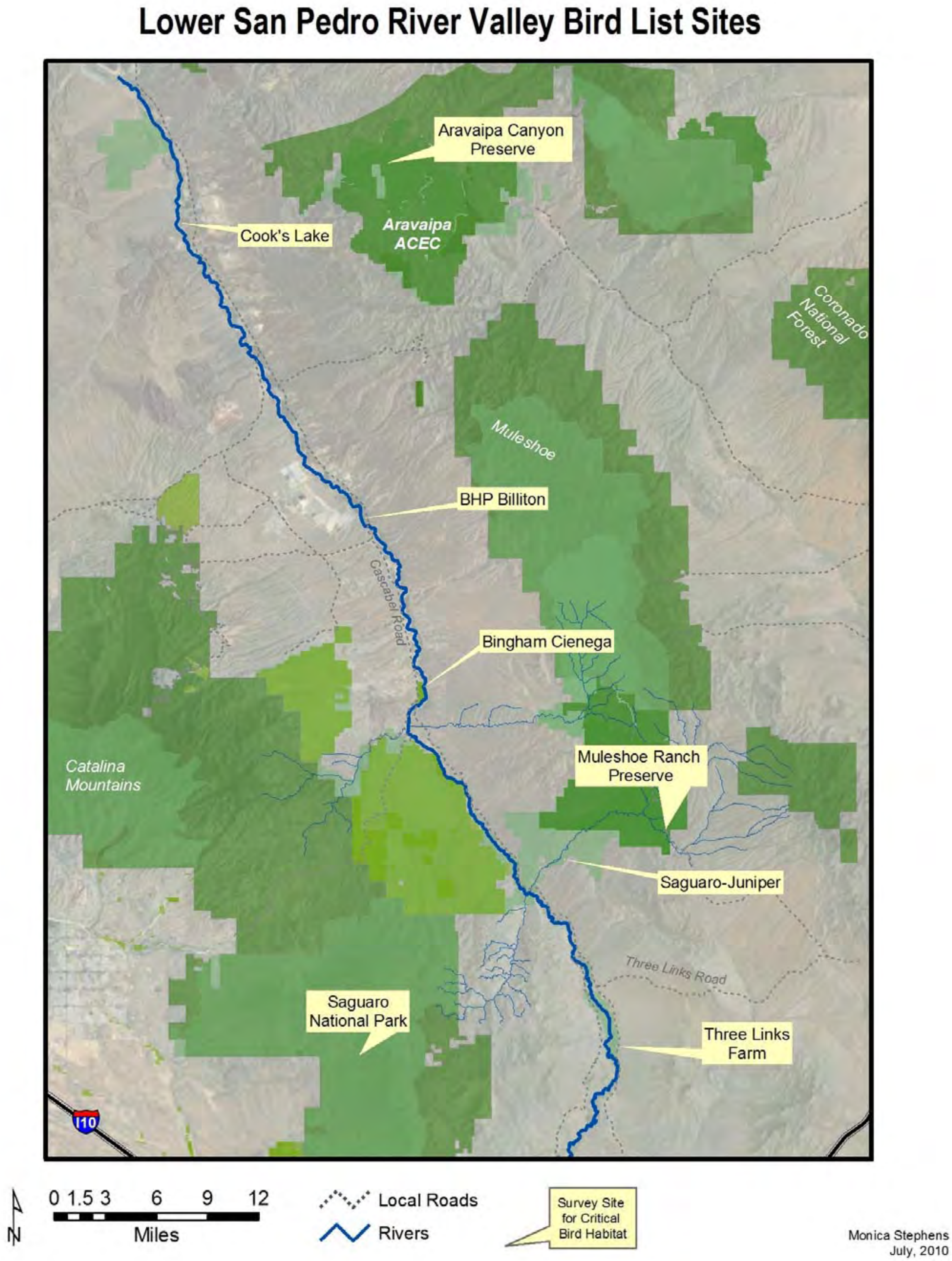

Figure 8: Map of Lower San Pedro River Valley Bird List sites.

The compiled "Birds of the Lower San Pedro River Valley" list represents an impressive 307 species. Also 31 species have been recorded in the Lower SPRV not represented on the SPRNCA list, so that a total of 404 species have been recorded on these bird lists for the SPRV. That represents around half the bird species known in the continental U.S., and an extraordinary number for an inland area.

The Lower SPRV is also well represented with regard to the Arizona WatchList. Of the 11 "Red Species," or globally threatened birds of Highest National Concern, 6 have been recorded in the Lower SPRV, and with SPRNCA a total of 8 for the SPRV. Of the 36 rare and declining "Yellow Species" on the WatchList, 26 have been recorded in the Lower SPRV, and with SPRNCA a total of 30 for the SPRV. Of the 48 Arizona Bird Species of Greatest Conservation Need (SGCN), 30 have been recorded in the in the Lower SPRV, and with SPRNCA a total of 39 in the SPRV. In other words, roughly 75-80% of all Arizona WatchList species are found on the Upper and Lower SPRV.

	SPECIES	RED LIST - 11	YELLOW LIST - 36	SGCN - 48
SPRNCA	**373**	**6**	**29**	**36**
THREE-LINKS	168	2	12	16
SAGUARO-JUNIPER	131	3	10	8
MULESHOE	187	4	16	14
ARAVAIPA	232	4	17	22
BHP	94	2	5	8
COOK'S LAKE	198	3	11	17
BINGHAM	145	1	5	8
SAGUARO NP	198	4	23	9
LOWER	**307**	**6**	**26**	**30**
TOTAL	**404**	**8**	**30**	**39**

Figure 9: San Pedro River Valley comparative bird list chart

These results continue to substantiate the extraordinary importance of the SPRV as an avian corridor and habitat and its significance as a Globally Important Bird Area. It also supports the significance of the Lower San Pedro component of the SPRV, so much so that it has now been designated as one of Arizona's Important Bird Areas (IBA). There are currently 35 IBA sites identified in Arizona, and the Lower San Pedro River is one of two that have received global recognition.[317] "The Lower San Pedro River was identified by Audubon's Important Bird Areas Program as an Arizona Important Bird Area (IBA) in January 2007 (AZ IBA Science Committee) and a Global Important Bird Area in January 2008 (National Audubon IBA Technical Committee).[318] Among the IBA Programs goals nationwide are to identify, document, and publicly recognize a state's most important areas for birds, and facilitate long-term conservation of these most important avian habitats and their avian communities.[319]

Paul Green, Executive Director of Tucson Audubon, explained the extent and significance of the IBA designation:

> *The reach of the San Pedro River from just north of Benson, Arizona (i.e., "the Narrows") north to the San Pedro-Gila River confluence at Winkelman, Arizona, has been identified as both a State and Global "Important Bird Area." The Lower San Pedro River Important Bird Area was recognized for the very dense populations of certain species of conservation concern or status it supports, including the federally Endangered Southwestern Willow Flycatcher (the densest population in Arizona), and also the highly ranked species populations of Bell's Vireo, Lucy's Warbler, Yellow-billed Cuckoo (proposed Candidate for federal Endangered/Threatened status), and Gray Hawk.*[320]

This of course describes the area through which the SunZia Aravaipa route proposes to run. Avian surveys at BHP Billiton near San Manuel, only a few miles south of where the Aravaipa route proposes to cross the San Pedro River, have further established the importance and equality of the Lower San Pedro relative to the Upper San Pedro Riparian National Conservation Area (SPRNCA),

> *The riparian avian species diversity at BHP (94 species) is apparently similar to the Upper San Pedro River within the San Pedro Riparian National Conservation Area (SPRNCA), accounting for the presence of grassland species with the SPRNCA. Thirteen species of concern are present within the BHP riparian corridor lands, and seven of these are notably abundant.*[321]
>
> *Exceptional for riparian areas in Arizona and nationally, is the great number of avian species of conservation status/concern supported along this reach of river within BHP lands. Populations of (breeding) Gray Hawk, Yellow-billed Cuckoo, Southwestern Willow Flycatcher (EAS listed), Bell's Vireo, Lucy's Warbler, and a suite of other riparian-obligate birds are in outstanding abundance within this riparian corridor along the lower San Pedro River.*[322]

Among those critical species of concern, the Southwestern Willow Flycatcher has received the greatest attention in the Lower San Pedro Valley. "Riparian habitat along the San Pedro River is becoming increasingly important to [southwest willow] flycatcher conservation as other known nesting locations within Arizona become degraded (SRP 2002, Munzer et al. 2005)." Reportedly more than 10 million dollars has been spent on research and monitoring of flycatcher populations on the lower San Pedro and at Roosevelt Lake.[323]

> *…the lower reaches of the San Pedro River are currently subject to intensive survey efforts, largely conducted by Arizona Game and Fish Department biologists, for the endangered southwestern willow flycatcher (Empidonax extimus traillii).*
>
> *The aforementioned survey effort has shown the reach between Three Links and the Gila River confluence to be densely occupied by southwestern willow flycatchers. Indeed, in 2005, the most-recent year for which complete survey data have been summarized, the reach thus described contained 164 southwestern willow flycatcher territories consisting of 308 adult birds. These lower reaches thus contain over 99 percent of the southwestern willow flycatcher territories on the San Pedro River within the United States. The San Pedro RNCA hosts the remaining < 1 percent of the territories and adults.*[324]

The significance of the San Pedro River Valley and of the Lower San Pedro as a Globally Important Bird Area through which the SunZia routes are proposed to travel is incontrovertible. It is established as the main neotropical migratory corridor in the West and of exceptional significance both for the number of species and species of critical concern. Most important is that,

> *…long-term conservation of species such as the flycatcher will depend upon landscape-scale protection of the processes that create and sustain suitable habitat. In this river setting, endangered species protection mandated by the Endangered Species Act hinges on protection of physical ecosystem processes.*[325]

3. DECLINING AVIAN POPULATIONS IN DECLINING HABITATS

That the San Pedro is "one river" and continuous from the Mexican border to the Gila should make extrapolations of avian importance from Upper to Lower segments common sense. As indicated above, it has been reasonably established scientifically as well that the Lower SPRV is every bit the equal of the Upper SPRNCA with regard to avian species and densities, all due consideration given for some differences in habitat and availability of data. Now that both areas have been awarded the official imprimatur of Globally Important Bird Areas their significance is unassailable.

That the SunZia Aravaipa route should propose to transect an area of such recognized continental and global importance is suspect on the face of it. But several points remain to further question the judgment of such a proposition. First is the very rarity and vulnerability of the avian species and their associated habitats under consideration. Second is to once again make the case with regards to birds, as with the ecosystem, that it is the whole valley watershed that is threatened and implicated by the SunZia proposal, not just a "ribbon through the desert" and a few isolated habitat patches that can be neatly avoided.

The San Pedro River, as noted above, is often cited as the last major free-flowing river in the desert Southwest. This report then made the case that the Lower SPRV is part of the largest unfragmented and intact landscape in the desert Southwest through which courses a major free-flowing river. In the immediately preceding sections it was documented that the SPRV has one of the highest bird diversities of any area its size in the United States, and that it is by quite a distance the main neotropical migratory corridor in the Western United States. Finally it contains a very high proportion and density of species of concern.

As praiseworthy as such accolades are for the SPRV, any attribute that contains the word "last" is worrisome. The San Pedro holds its position among rivers more by virtue of attrition than obvious grandeur. The reaction of visitors that "Is this it?!" is a common one,[326] and it pales by comparison to other western river systems such as the Rio Grande, Pecos, Colorado and Kern Rivers whose priority as a migration route it has usurped. Until the establishment of the Upper San Pedro Partnership it was listed as one of America's "most endangered rivers,"[327] even as its viability continues under assault by development and groundwater overdrafts. The natural landscape of the Lower San Pedro has suffered its second major threat within a handful of years after the I-10 bypass and now the SunZia proposals.

Further, the avian "species of concern" so notable in the SPRV are precisely that because they are rare and/or declining. Take the Bell's vireo for example.

> *Our [Bells' vireo] detection rates of 4.3 to 10.3 birds per linear kilometer (7/11/09), is extremely high (2.7 mean for SPRNCA, 1990), and was the qualifying criteria for the advancement of this State IBA to Global IBA status by the National IBA Technical Committee in January 2008.*[328]

With a "bird's eye view" that is good news for the Bell's vireo and the Lower San Pedro, but not necessarily overall. The trend line is quite the opposite:

> *Bell's Vireo is an Audubon WatchList (Red) listed species because of long-term declines in the Breeding Bird Survey (-60%, 1965-2004 in Arizona, trend line -2.67, p=0.002 Continentally, Butcher and Niven 2007).*[329]

The Lucy's Warbler is a WatchList (Yellow) listed species and is "extremely abundant" locally and found on all of the local bird lists (see Appendix) even while it has shown a 12% decline over the past 40 years (albeit statistically non-significant).[330] Others of these WatchList species are found in considerable densities on the San Pedro and throughout the SPRV, such as the Gray Hawk, Yellow-billed Cuckoo, Abert's Towhee, Tropical Kingbirds and others, even while their populations overall are low and their occurrence rare. Indeed, even the Southwestern Willow Flycatcher was found "in abundance" in the 2009 Audubon BHP survey while it has been a federally listed Endangered species since 1995.[331]

The point of these species of concern listings is not to tout the preciousness of rarity, but rather to serve as a warning system. Bird populations serve as comprehensive "ecological indicators" as they reflect the broader health of a habitat or an ecosystem,[332] true canaries in the coal mine. Indeed, Partners in Flight, an originator of the WatchList program, was created as an international coalition dedicated to "keeping common birds common."[333] All such programs have as their *raison d'être* to provide management guidelines so that extinction of species and their attendant habitats does not become a reality.

> *From the standpoint of biodiversity conservation, it is economically and strategically prudent to understand where and how to manage for conservation purposes well before species and ecosystems become 'endangered.' Recovering species that have declined to low numbers or ecosystems that have been heavily degraded is far more expensive and problematic than maintaining our extant biodiversity. The Ecoregion's increasing population growth, coupled with continued depletion of water and land resources, suggest the future costs of not acting now will be high.*[334]

Thus it is not just rare species that are the focus of conservation efforts, but rather to keep species from becoming rare. "Because it protects common as well as rare species, this [ecoregional assessment] strategy has greater potential to be proactive and to sustain entire assemblages before individual species become so rare as to warrant protection under endangered species laws."[335] Unfortunately, some of those "entire assemblages" are under threat as well, and it so happens that one of those assemblages is the neotropical migrant birds for which the SPRV is so renowned.

In the 1970s and 1980s there was widespread publicity over the drop in numbers of neotropical migrant birds as counted in over 30 years of the Breeding Birds Survey census.

> *Analyses of trends during the late 1970s and the 1980s suggested that populations of many species were indeed beginning to drop steeply. These declines, coupled with concurrent reports of a diminishing number of migratory flocks seen on weather radar as migrant songbirds crossed the Gulf of Mexico, helped create the mood of urgency that led to the formation of Partners in Flight.*[336]

Those early trends have continued to be substantiated in the biological literature.

> *Populations of neotropical migrant birds have experienced significant declines in recent years.*[337]

> *Our results also imply that current concern by conservationists and wildlife managers (see Finch, 1991; Hagan & Johnston, 1992) over populations of neotropical migrant birds is justified. …These factors combined suggest that neotropical migrants may be more sensitive to environmental changes induced by human activities than are resident species.*[338]

That national concern became localized in the West, and in particular Arizona and the SPRV as its importance as the main Western neotropical migratory corridor became evident. The Bureau of Land Management, which manages the San Pedro Riparian National Conservation Area (SPRNCA), noted that:

> *Concerns have increased over population declines of migrant bird species which breed in North American and winter south of the United States (Neotropical Migratory Birds). The Bureau of Land Management recognized this problem and has prepared management plans to monitor and enhance populations of bird species which utilize Bureau lands throughout North America.*[339]

In 1998 NAFTA established a tri-national Commission for Environmental Cooperation (CEC) which prepared a study intended to promote cooperative efforts to recognize and protect habitats of special continental importance…,"[340] in particular that of the San Pedro Riparian National Conservation Area (SPRNCA). It recognized that "The loss of habitat would have an impact on migrating songbirds. This would likely lead to population declines in Wilson's warbler and yellow warbler on their breeding grounds in the United States and Canada."[341]

Those concerns were also taken up by the Arizona Game and Fish Department (AGFD).

> *Arizona's neotropical migrants, which breed in the United States and/or Canada and winter to the south, from Mexico to South America, total 237 species, of which 163 nest here regularly or irregularly. Research across the United States suggests that populations of many of these species are declining, due to loss or alteration of habitat, cowbird nest parasitism, and predation.*[342]

The AGFD also cooperated with the Partners in Flight program, now under the auspices of the Arizona Bird Conservation Initiative (ABCI), which also noted that "Declines in many bird populations here in Arizona and across the nation have led to concern about the future of migratory and resident birds."[343]

Conservation efforts in the Lower SPRV also seized on the issue as germane to many of their local projects, as was the case in the Muleshoe Ranch Cooperative Management Area between BLM, USFS and TNC:

> *Neotropical migratory birds which depend upon riparian vegetation have been shown to be declining in population or distribution throughout the western United States in recent years. Management of riparian breeding habitat is critical to recover populations of listed species or to prevent listing of these and other avian species.*[344]

The decline of neotropical bird populations is thus widely acknowledged, and the concern about it is usually reflected in the need to protect their riparian habitat, as noted in several of the above quotes. The association and importance of riparian areas for birds is well established, as is also their relative rarity in the desert Southwest.

> *Low-elevation riparian woodlands (henceforth "riparian woodlands"; Fig. 1) in the desert southwest currently make up a small fraction of the desert landscape. For example, only 0.5% of the land area in Arizona is riparian woodland (Johnson et al. 1977). Despite the rarity of this vegetation community, riparian woodlands provide valuable wildlife habitat (Knopf and Samson 1994). Over 50% of breeding bird species in the southwestern U.S. are considered to be dependent upon riparian woodlands (Johnson et al. 1977). In addition, riparian woodlands provide critical stopover habitat*

> *for many species of long-distance, migratory birds. The high species richness of birds in riparian woodlands relative to surrounding vegetative communities is commonly attributed to the structural complexity of the vegetation (Anderson and Ohmart 1977, Bull and Skovlin 1982, Knopf and Samson 1994).*[345]

In the SPRV, that riparian habitat is most often associated with the river itself, the basis for much of its reputation. "The riparian area along the San Pedro is a lifeline for a great variety of birds that winter in Mexico and breed during the summer months in the United States and Canada."[346] The San Pedro River riparian area is also the habitat for many species of concern, and likewise the area for many avian surveys, such as Tucson Audubon conducts at BHP Billiton.[347]

> *Indeed, the Arizona Partners in Flight (PIF) conservation plan has identified low-elevation riparian habitat as the top priority habitat in Arizona in need of conservation because it contains immense biological importance and is severely threatened within Arizona (Latta et al. 1999). Three species that inhabit low-elevation riparian woodland are considered Arizona PIF priority species: Southwestern Willow Flycatcher (Empidonax traillii extremus), Western Yellow-billed Cuckoo (Coccyzus americanus occidentalis), and Lucy's Warbler (Vermivora luciae). The Southwestern Willow Flycatcher and the Western Yellow-billed Cuckoo are considered wildlife of special concern in Arizona (Arizona Game and Fish Department 1996) and are federally listed as endangered and candidate species, respectively (Federal Register 1996).*
>
> *An additional 8 species that inhabit low-elevation riparian woodland are considered Arizona PIF preliminary priority species: Brown-crested Flycatcher (Myiarchus tyrannulus), Northern Beardless-tyrannulet (Camptostoma imberbe), Bell's Vireo (Vireo bellii), Yellow Warbler (Dendroica petechia), Rufous-winged Sparrow (Aimophila carpalis), Abert's Towhee (Pipilo aberti), and Summer Tanager (Piranga rubra).*[348]

Thus the regard for the San Pedro River's habitat is well deserved. "Naturally functioning riparian floodplain systems are extremely rare and endangered in the Southwest, and long-term conservation is critical to maintain these systems."[349] Indeed, the Lower San Pedro River riparian area includes two G2 plant communities, Fremont Cottonwood-Gooding Willow (*Populus fremontii-Salix goodingii Riparian Forest*) and Mesquite Bosque (*Prosopic velutina woodland*), and a G1 plant community at Bingham Cienega (*Scirpus spp./Eleacharis spp./Juncus spp. Marshland*).[350] This is based on the Natural Heritage Program ranking system which uses a five-category ranking to describe a species' rarity, Global 1 (G1) characterizing the rarest species and G5 characterizing the most common.[351]

However, it would be a mistake, sadly often made, to presume that it is only the San Pedro River riparian areas and its "ribbon of green" that share this critical avian breeding and migratory corridor function. The study most responsible for the San Pedro's renown as a migratory corridor for millions of birds had a broader assessment as to the stopover sites for the migrants.

> *The relative importance of cottonwood-willow riparian corridors and isolated oases to land birds migrating across southeastern Arizona was evaluated during four spring migrations, 1989 to 1994, based on patterns of species richness, relative abundance, density, and body condition of birds. …The continuous band of riparian vegetation along the San Pedro River does not appear to be functioning as a corridor for many migrating species, although it may for a few… which account for fewer than 10% of the individuals migrating through the area. Small, isolated oases hosted more avian species than the corridor sites, and the relative abundance of most migrating birds did not*

> *differ between sites relative to size-connectivity. There were few differences in between-year variability in the relative abundance of migrating birds between corridor and oases sites.*[352]

These oases are also generally riparian in character, but often reflect another rare plant community (G3), the Mixed Deciduous Broadleaf Riparian Forest (*Platanus racemosa/mixed spp. Riparian Forest*).[353] Skagen goes on to explain that "Continuous extensive bands of riparian vegetation may attract more en route migrants… because the larger patches are easier to find (Simberloff & Cox 1987). …On the other hand, small, isolated oases may facilitate migration by providing a 'stepping stone' (MacArthur & Wilson 1967:123) arrangement of stopover areas."[354]

This function of upland oases sites in the Lower SPRV is corroborated by species bird lists from Hot Springs Canyon, Aravaipa Canyon, Saguaro National Park (East) and the Muleshoe Ranch (see Appendix). Indeed, as many of the WatchList species of concern are recorded from these sites as on the San Pedro, though with some of the variability that would be expected from differences in habitat. Of the 13 sites surveyed in the Skagan study, two were on the Muleshoe Ranch, and "The isolated oases sites hosted more species (101-109) than corridor sites (84-102)…."[355]

The association of migrating birds with upland and even relatively xeric habitats has been corroborated in other studies. "In the desert Southwest, migrating birds have been documented using upland habitat and xeroriparian washes as well as riparian areas."[356] Even a study focused on the presence of surface water (which of course is often present in oases) found exceptions to that more common association:

> *In contrast, results from our spatial analysis showed negative associations with increased extent of surface water for 2 common riparian breeding bird species, the Bell's Vireo and Yellow-breasted Chat. Yellow-breasted Chats typically inhabit cottonwood/willow riparian woodlands with a dense understory of mesquite, tamarisk, and other shrubs in Arizona (Corman and Wise-Gervais 2005). Bell's Vireos inhabit riparian woodlands along perennial and intermittent streams with a dense understory of mesquite and shrubs, but they also inhabit drier thickets and mesquite bosques in Arizona (Corman and Wise-Gervais 2005). Indeed, we found that Bell's Vireos and Yellow-breasted Chats were both positively associated with dense understory growth.*[357]

Skagen too noted that "Oasis sites were higher in elevation and had less vegetation than riparian sites. In spite of these confounding factors, the patterns of species presence and abundance relative to size-connectivity were clear. More species occurred in oases even though shrub and canopy foliage volumes were smaller there…."[358] This differentiation for many species is also substantiated by the analysis of habitat preferences. The 186 species recorded during 230 surveys over four years of the Skagen study were grouped into "Macrohabitat guilds." 35 species were in guild 1: "Especially or generally near water." 67 species were in guild 2: "Riparian or water mentioned in habitat accounts." 84 species were in guild 3: "Woodlands, chaparral-scrub, grasslands, savannah, desert, no mention of water in habitat accounts."[359]

Thus the avian richness of the SPRV is widely scattered. The attribution of "continental importance" applies primarily to the birds of the San Pedro River *Valley*, not just to the river itself. As the Skagen study affirms, the riparian oases of the SPRV are as important as the mainstem river, if not more so. Though the San Pedro River is the arterial heart, it is the whole, continuous San Pedro River Valley that forms the body of the flyway.

The importance of both the riverine and upland riparian habitats for these birds makes their conservation even more critical. Any further habitat fragmentation by virtue of roads and associated impacts could only exacerbate an already dire situation.

> *Evidence of such high densities and limited habitat availability during migration accentuates the interdependence of geographic and political regions in providing resource requirements for birds throughout their life cycles. Many western North American migrants pass through or over Arizona. Arizona provides a critical link between breeding and wintering habitats of species that are highly dependent on the presence and condition of stopover sites along their migration routes. Riparian habitats in the southwestern United States have undergone extensive deterioration (Minckley & Brown 1982)….*
>
> *Further elimination or degradation of riparian stopover sites could adversely affect the breeding success of northern bird populations. In light of potential habitat limitation during migration and the specific results of this study, the protection of both small, disjunct riparian patches and extensive riverine tracts in western landscapes is imperative.*[360]

It is not only fragmentation on the ground that is relevant with birds. 80% of the species surveyed in the Skagan study had at least portions of their population migrating to and through the SPRV, enough to account for millions annually. Even those that are entirely resident may make altitudinal movements.[361] The canyons act as corridors for birds too: "The riparian corridors are important migration and movement corridors for wildlife such as black bear, coati, and neotropical bird species."[362] Birds are also routinely flying between uplands and riparian areas: "Moreover, our results indicate that the presence of riparian areas positively influences avian species richness and relative abundance in upland areas adjacent to riparian woodlands."[363]

The San Pedro River Valley, from river to uplands, is an area of extraordinary bird richness and diversity and populated with many avian species of concern. It is the main migratory corridor in the Western United States for an assemblage of species that is declining and the focus of exceptional conservation effort. Fragmentation of the landscape would impact their rare and declining habitats. Any direct impacts to their populations would be more than significant.

4. POWERLINE FRAGMENTATION OF AVIAN AERIAL SPACE

The SunZia transmission line project entails dual towers that stand up to 16 stories high that carry 500Kv of powerlines in addition to accompanying service roads within a 1000 foot easement and a study corridor of a mile in width to accommodate future expansion. The proposed Aravaipa route would traverse approximately 15 miles across the uplands and bottom of the Lower San Pedro Valley, part of the largest unfragmented and intact landscape with a major free-flowing river in the desert Southwest – and that supports exceptional avian populations, diversity and the main neotropical migrant corridor in the Western United States. The on-the-ground fragmenting impact of the project on threatened and declining bird populations and habitat have been discussed. But what if any impact would the towers and transmission lines themselves have on the birds for which the SPRV is so renowned?

Wing morphology studies have been done on birds indicating that some classes of birds are particularly vulnerable to electrocution. "Generally …electrocution victims were birds of prey, ravens and thermal soarers."[364] The SPRV is a major habitat and migration route for many birds in this class, including 28 raptors on the SPRNCA bird list, which includes WatchList species such as Swainson's Hawk, Northern Aplomado Falcon, Bald Eagle, Northern Goshawk, Northern Gray Hawk, Ferruginous Hawk, Common Black Hawk, Crested Caracara, American Peregrine Falcon, Mississippi Kite and Osprey.[365] Also included in the class of birds of prey susceptible to electrocution would be owls (Strigiformes), of which 14 species occur on the Lower SPRV bird list, which include WatchList species such as Flammulated Owl, Spotted Owl, Ferruginous Pygmy-Owl, Elf Owl, and Short-eared Owl (See Appendix).

Smaller birds have a reduced chance of becoming electrocuted because the conductors and grounded components 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)."[366]

Perhaps such concerns can be eliminated by engineering. Still, it is worthy of note that that studies show Passeriformes (perching birds) to be significant victims of electrocution, though those were primarily crows and allies.[367] One such indicator is that "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)."[368]

Also, counting of these smaller birds is difficult. In one major study, "All birds smaller than a turtle dove (*Streptopelia turtur*) were omitted from analysis. These were likely to be underestimated, as small dead birds are difficult to detect under a power line and have a higher disappearance rate (e.g. Renssen et al., 1975)."[369] Further, "Unfortunately, few reports addressing electrocution mortality have included complete lists of the victim species and the numbers of casualties. …records, even from biologists, frequently fail to distinguish between death caused by collision or electrocution.[370]

It seems clear that SunZia engineers are cognizant of these kinds of electrocution impacts that transmission lines can have on birds. Some engineering alternatives have been developed that apparently significantly mitigate this threat. "[T]here is good evidence that the design of power lines and pylons are important in determining the risk of death from electrocution."[371] Whether or not the evidence is conclusive in entirely eliminating the threat of electrocution to Falconiformes, Strigiformes and Passeriformes in an area of such avian significance and vulnerable species would be incumbent upon SunZia engineers and EPG biologists to demonstrate.

However, another threat looms much larger, which is avian mortality from collision with powerlines and towers, and as Bervander notes, it is a significantly more complex problem than electrocution.[372] In keeping with the argument of this report that all impacts of the SunZia proposal in the Lower SPRV are iterations of landscape and habitat fragmentation, Andrews documents that:

> *Powerlines fragment bird flight paths, leading to collisions of birds with the lines, resulting in injury and death. …In the USA collisions with automobiles and powerlines were the most frequent cause of bird mortality (Stout and Cornell 1976).*[373]

…the fragmentation by power-lines of the area flown between resting and feeding create the situations in which the greatest number of deaths occur in the USA (Anderson 1978; Malcolm 1982; Rusz et al. 1986).[374]

That toll of avian mortality by transmission lines is not minor:

Bird kills as a result of collisions with electrical transmission lines range from hundreds of thousands to perhaps 175 million (Koops, 1987 cited in Manville, 2002; Erickson et al., 2001).[375]

It is not only collision with transmission lines at issue, the impacts of sixteen-story towers should not be discounted either. "Towers and the windows of taller buildings are also the cause of death of hundreds of millions of migrating songbirds each year."[376] Communication towers have been found to be major causes of avian mortality. "Ninety-two percent of birds killed at towers in the studies were migratory. The majority of these (57% of the total) are known to migrate predominantly or frequently at night (as classified by the Birds of North America - Poole et al, eds. 1992 -). These include warblers, sparrows (the two largest groups by species), thrushes, flycatchers and vireos."[377] In general communication towers are much taller than the powerline towers here referenced, and nighttime lighting appears to be a confusing issue for birds. However, these issues of height and lighting are not well distinguished in the relevant studies: "It is therefore not possible to make correlations between lit and unlit towers or short and tall towers."[378] At the least it is significant that tall structures are significant mortality issues for nocturnal migrating passerines which are so predominate in the Lower SPRV.

The same wing morphology studies alluded to above have been applied to birds involved in powerline collisions.

Three categories were identified: species with a high risk of collision, species with a high risk of electrocution and a third mixed group, susceptible to both these causes of death. The variables, weight, wing length, total length and tail length classified 88.6% of the species correctly in these three categories when used in a discriminant analysis. The classification can be used in a predictive model to identify species susceptible to power line mortality.

General descriptions given to potential collision casualties are 'poor fliers' (such as ducks), 'heavy birds' (such as swans and cranes), and flock-formers (Bevanger, 1994).[379]

It is apparently for reasons such as these that SunZia was persuaded to alter its routes away from the vicinity of the Bosque del Apache National Wildlife Refuge in New Mexico, which has a significant contingent of waterfowl. However, significant diversities of those "poor flier" and water bird species also inhabit and migrate through the SPRV. Bevanger identified these classes of more common victims of collisions with power lines in 16 different investigations: 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).[380] The SPRNCA bird list tallies the following number of species for these classes: Podicipedidae (grebes) 6; Anatidae (wildfowl – ducks, geese and swans) 28; Phasianidae (partridges, quails, pheasants and allies) 4; Rallidae/Gruidae (rails, coots, cranes) 7; Charadriformes - Charadriidae (plovers, lapwings), Scolopacidae (snipes, sandpipers and allies), and Laridae (gulls) 41;

and Ciconiiformes (herons and allies) 12. That represents nearly 100 species, or around a fourth of all species identified on the San Pedro.[381]

However, as noted, the issue is considerably more complex than just focusing on these "poor fliers." First, smaller birds were entirely omitted from the Janss study: "All birds smaller than a turtle dove (*Streptopelia turtur*) were omitted from analysis."[382] Contrariwise, the Bevanger study of common victims of collisions with power lines from the above noted 16 different investigations found significant collision incidence for these smaller Passeriformes: Tyrannidae (tyrant flycatchers) 6, Alaudidae (larks) 68, Hirundinidae (swallows) 9, Motacillidae (pipits, wagtails) 34, Troglodytidae (wrens) 3, Turdidae (chats, thrushes) 420, Sylviidae (warblers and allies) 117, Muscicapidae (flycatchers) 3, Ernberizidae (buntings and allies) 86, Parulidae (wood-warblers) 7, Icteridae (blackbirds, orioles and allies) 87, Fringillidae (finches) 25, Ploceidae (weavers and allies) 46, Sturnidae (starlings) 590, Corvidae (crows and allies) 18.[383] Many have low incidence, but others as noted are considerable, and that despite difficulties in counting smaller species, since "…small dead birds are difficult to detect under a power line and have a higher disappearance rate (e.g. Renssen et al., 1975)."[384]

As with electrocution, various engineering techniques have also been tried to reduce collisions, and in one localized study in Ontario, Canada with some success.

> *The effectiveness of different types of wire marker devices and different installation techniques are well documented in APLIC (1994). Markers have been shown to reduce the mortality at transmission lines by 50-80% (Brown and Drewein, 1995; Savereno et al., 1996; Janss and Ferrer, 1998; Alonso and Alonso, 1999*).[385]
>
> *Bird deaths appear to have declined since bird flight diverters were placed on the lines above Burlington beach, however, more rigorous surveys will be necessary to determine if bird mortality has truly decreased at marked versus unmarked transmission lines.*[386]

Nonetheless, the overall results of engineering fixes in broader studies are mixed, inconclusive, and decidedly do not eliminate the problem.

> *Power line designs have been suggested to be related to the possibility of collision accidents, but there are no data available to support this hypothesis. For example, Janss and Ferrer (1998) did not find differences in collision mortality between three power lines with different designs.*[387]
>
> *Power line collisions can be reduced, although not eradicated (e.g. APLIC, 1994; Alonso et al, 1994; Brown and Drewien, 1995; Janss and Ferrer, 1998). The most frequently used measure is wire-marking, which alerts birds to the presence of power lines and provides them with more time to avoid the collision. …The influence of the power line design on collision rates, however, is little studied. The use of raptor models to scare off birds from power lines has not produced encouraging results (Janss et al., 1999). Because mitigation measures only reduce collision mortality, but do not solve it, adequate route planning of power lines is especially important in this case.*[388]

The reasons for these mixed results are varied.

> *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.[389]

Particularly relevant to the SPRV are issues having to do with its geographical location as a migratory corridor and relating to migratory behaviors. Those factors and issues are varied and detailed in a number of different studies:

Most long-distance migrants travel at night and follow paths that are strongly influenced by variable wind patterns. The use of the oases and intermediate sites as well as the river corridor by many migrating birds is consistent with the passage of migrants in broad fronts rather than along north-south corridors.[390]

An analysis of collision studies reveal patterns in mortality. Poor visibility, bad weather, mass migrations, dispersal of juveniles and the fragmentation by power-lines of the area flown between resting and feeding create the situations in which the greatest number of deaths occur in the USA (Anderson 1978; Malcolm 1982; Rusz et al. 1986).[391]

Other local factors, not related to species, might also explain differences in mortality rates. Bad weather conditions and poor visibility increase the possibility of collision and electrocution accidents (Renssen et al., 1975; APLIC, 1994, 1996). This could result in different mortality rates for populations of the same species inhabiting different areas. Furthermore differences can exist between individuals. For example, young birds have relatively little flight experience and weakened birds might have reduced reaction capability (Mathiasson, 1993; APLIC, 1994, 1996; Henderson et al., 1996), while familiarity with the area could reduce collision mortality (Anderson, 1978; Bevanger, 1994).[392]

Flying in flocks… increases the possibility of collision because those birds at the rear of the flock are relatively unaware of obstacles (APLIC, 1994). … Cranes, ground breeders and feeders… are often exposed to risk by daily flock movements between feeding, breeding and roosting areas.

Overall, this "mixed" group [of collision and electrocution] warrants special attention from a conservation perspective, as they all seem to be at risk of collision. The extent to which this is a problem depends, for each species, on the number of hours in flight near power lines, social behaviour of the species (e.g. flock forming), and local factors (such as local weather).[393]

In sum, engineering fixes such as line markers are not going to be effective in the nighttime and low light travel conditions most often utilized by migrants. Weather conditions that are often especially extreme during spring migrations can inhibit vision and drive flocks into towers and lines. Flocks also reduce the aversion ability of some individuals. Migrants are not familiar with the area, and young birds returning in the Fall migration are not experienced fliers. Stress and weakness induced by long migrations can also be a factor. They are also not just traveling in straight north-south fronts, but between oases and across broad fronts.

Further, "No investigation was found that was specifically designed to judge effects of power lines on bird mortality at the population level….,"[394] whether that applies to mass migrations or to rare and declining species of concern. Indeed there is evidence that there are impacts among these dwindling populations where loss of just a few individuals can have a significant effect.

> *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. … 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.*[395]

Interestingly, since Bervanger's study, a U.S. Forest Service study has extrapolated some population impacts. Based on three studies from the Netherlands they find that,

> *Estimates in all three studies were in the same order of magnitude. The latter study estimated (unadjusted for scavenging and searcher efficiency) 113 fatalities per km of high tension line in grasslands, 58 fatalities per km of high tension line in agricultural lands, and 489 fatalities per km of high tension line near river crossings. We use the mean estimate (adjusted for scavenging and searcher efficiency bias) of 750,000/2,875 = 261/mile of high tension line.*[396]

At 261 fatalities per mile over the 45 mile length of the SunZia Aravaipa route, that works out to over 10,000 avian fatalities per year. In a major migratory corridor such as the SPRV that figure can only be considered conservative. Such impacts, whether to species of concern or entire assemblages of declining species such as neotropical migrants, can be particularly devastating when factored as a cumulative effect over time, season after season.

> *The cumulative toll of bird collisions with power lines has the potential to have serious conservation impacts for some threatened bird populations (Faanes, 1987; Lewis, 1993; Bevanger, 1994; 1998).*[397]

5. SUMMARY

It has been demonstrated that the installation, clearings and attendant service roads for a project of SunZia's size, scope and potential expansion in the Aravaipa watershed and Lower SPRV would significantly fragment its rare, largely unfragmented and relatively intact landscape. That would certainly be the case for the upland Semidesert grasslands, which are declining as are many of the bird species dependent upon them. Further, the rare riparian habitat most favored by the great diversity of avian populations would also be impacted by the nexus of processes connecting uplands and watercourses. Since biogeography has demonstrated that fragmentation of habitat threatens the long-term survival of species, and especially vulnerable ones such as these rare and declining species of concern, it can be said to be degrading habitat upon which those species depend and thus their survival.

Further, the transmission lines and towers themselves would fragment aerial space of the whole class of declining neotropical migrants of which the SPRV is the preeminent route in the West, along with a cadre of species of concern that stand to have their limited populations further degraded by collisions. That aerial space is not just the San Pedro River, but demonstrably the entire Valley, including the uplands and montane areas. Significantly, 187 bird species have been recorded on the Muleshoe Preverve at elevations similar to those of the upland traverse of SunZia's Aravaipa route in the LSPRV. The cumulative impacts of collision mortality on these rare and declining populations, season after season over decades would have to be regarded as significant.

> *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.*[398]

The importance of this issue of threats to avian populations and their habitats is not just to scientists and birders, though the economic importance to an area as popular for ecotourism and scientific study as the San Pedro River Valley is certainly significant. "Millions of people watch birds as a hobby and many of them flock to areas where birds concentrate, where they spend millions of dollars on ecotourism."[399]

Much more important, by orders of magnitude, is the significance of avian populations for entire ecosystems, which relates to the reason for the Upper and Lower SPRV being named Globally Important Bird Areas and of "continental importance." That latter quote comes from the tri-national Committee for Environmental Cooperation that was called to address habitat and avian species threats at the San Pedro Riparian National Conservation Area.[400] It should be obvious that as a trade agreement NAFTA's concerns are primarily economic, and secondarily environmental. Though it was only a rarely spoken subtext, Mexico, the United States and Canada were involved together in this rare international cooperation because they were all suffering economic impacts from declines in neotropical migrants. In particular the neotropical migrants that subsist on the insects that predate these countries forests were no longer in sufficient abundance to do the job; the forests and their lumber products were declining as an economic resource for all three countries.

> *Migratory songbirds play a major role in the health and functioning of ecosystems, as consumers of insects (especially those that defoliate trees), dispersers of seeds, and pollinators of flowers. They are also of considerable value to regional economies. When forest birds eat insects, the result is greater tree growth and a longer period between insect outbreaks -- services that may be worth as much as $5000 per year for each square mile of forest land.*[401]

It should not require an environmental disaster such as the Gulf of Mexico oil spill to appreciate the relationship between natural ecosystems and human economies and to persuade us to take prudent precautions.

Not only are there economic factors involved with the proposed SunZia installation, but there are significant legal issues as well. With many species of concern, and the SPRV being the established main migratory corridor in the West, not only are NEPA statutes at issue, but also:

…the Migratory Bird Treaty Act (MBTA) of 1918, one of the oldest conservation statutes in existence… states that no migratory bird may be killed unless it is specifically exempted under a permit. The MBTA is a strict liability statute, making the 'take' of migratory birds without a permit illegal, even if unintentional, incidental or inadvertent. The Endangered Species Act (ESA) gives further, wide-reaching protection to birds on the Endangered Species List.[402]

As Bevanger notes,

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.[403]

Fortunately we are not in that unfortunate situation. Here in the SPRV it is well documented as to the extraordinary richness and diversity of avian populations, as well as the many vulnerable species of concern. Further, the whole valley clearly serves as the main neotropical migratory corridor in the West, serving a whole assemblage of a critical and declining population of birds. As it so happens, that same assemblage is especially vulnerable to collisions with towers and powerlines. The legal statutes are in place, and the conservation management action plans are in place. It is only required to act on them.

Global changes brought about by human activities affect all living creatures, and songbirds have become the most visible indicators of the consequences of these changes. Songbirds serve as a kind of barometer of the general state of the environment and a ready reminder of the underlying need for conservation and biodiversity.[404]

D. WATERS, FISH AND AMPHIBIANS:

This section will first build and elaborate on the Lower SPRV and Aravaipa components of the Gila freshwater ecoregion (Section III, C. 6), and then the potential direct and cumulative impacts of erosion from transmission line installations and service roads (Section IV, B. 3). Further derivative impacts on intermittent and ephemeral waters and springs will follow.

1. GENERAL

The importance of the San Pedro River has been discussed in generic terms (Section III, B. 1), and with regard to its place in the Gila Freshwater Ecoregion (Section III, C. 6). To recapitulate, its Biological Distinctiveness is "Continentally Outstanding", the class just below "Globally Outstanding," and its Conservation Status is "Critical" i.e. the most severely threatened.[405] The San Pedro River and Aravaipa Creek, within the Gila freshwater ecoregion, is Site Number 102 of 146 North American sites listed in the World Wildlife Federation ecoregional assessment as "Important Sites for the Conservation of Freshwater Biodiversity in North America."[406]

In The Nature Conservancy's ecoregional assessment of the Sonoran Desert Ecoregion, the "San Pedro River/Aravaipa Creek Conservation Site" was listed fourth out of the 100 Conservation Sites identified.[407]

All assessments emphasize the extremely critical nature of these systems.

> *It is difficult to overstate the importance of Arizona's freshwater systems. The status of these resources – their quantity, quality, distribution, and the biological diversity they harbor, is the single most important issue to both the sustainability of biodiversity and human communities in Arizona.*[408]

The reasons for that importance are twofold. First is because of the primacy of water and associated riparian habitats in desert regions. The previous section on birds detailed the significance of riparian habitat for resident and migrating species. That also holds true for the vast majority of desert fauna. "In the desert Southwest it is estimated that nearly 80% of all terrestrial wildlife species use riparian habitats at one or more stages of their lives."[409]

That is of course 100% the case with the associated waters for aquatic fauna, which in the case of the Gila Freshwater Ecoregion "contains one of the most unique fish assemblages in North America."[410] Indeed, "As many as seven fish species that are not found in the Colorado ecoregion's waters can be considered endemic to the Gila ecoregion; given a total of nineteen native species found in the Gila, this is an impressive number of endemics."[411]

The second reason for this overarching importance is because these freshwater systems and the associated aquatic fauna are so degraded and imperiled. The litany of attestations to this fact substantiates the concern about the issue. That is the case nationally…

> *The cumulative impact of all forms of disturbance to aquatic systems is staggering. Within the United States alone, 67 percent of freshwater mussels and 65 percent of crayfish species are rare or imperiled; 37 percent of freshwater fish species are at risk of extinction; and 35 percent of amphibians that depend on aquatic habitats are rare or imperiled (The Nature Conservancy 1996c). These numbers do not include the twenty-seven species of freshwater fish and ten species of mussels that are known to have gone extinct in North America in the last 100 years (Miller et al. 1989; The Nature Conservancy 1996c).*[412]

It is even more the case in the Southwest and Arizona. In an AGFD and USGS ecological assessment of Arizona's streams and rivers, "Most of Arizona's stream length was assessed to be in most-disturbed ecological condition: 70% was in most-disturbed condition…."[413] Furthermore,

> *Native fish populations have declined throughout the southwest. Of 36 fish species historically native to Arizona, 21 are listed as threatened or endangered, and one species has gone extinct. Primary causes of species decline are habitat loss and negative interactions, such as predation and competition, with non-native aquatic species.*[414]

And TNC's assessment of the situation locally is similar.

> *Experts concluded that the native fish fauna, as a whole, had been degraded to the point where further losses would only result in diminished viability or functional extinction, and that, in some cases, without significant restoration some Conservation Targets would not be restored to viability.*[415]

Nonetheless, within that bleak picture some of the best native fish habitat available in the Southwest exists in the Lower SPRV and Aravaipa watershed. Indeed, Conservation Sites such as those chosen by the WWF and TNC are selected not only for their biodiversity, but for the viability of their intact habitat. "Sites were selected on the presence of important biodiversity targets. For example, some priority sites were selected because they are places where rare habitats remain intact or where important species assemblages could be restored."[416]

Water quality and aquatic habitat in the Lower SPRV is to date apparently a relative exception to the rule of degradation. A water quality assessment found that "Tributary washes appear to be sources of high quality groundwater to the San Pedro River."[417]

> *Arizona has 18 watercourses that have been classified as "Unique Waters" (Table 8-1, Figure 8-7). …A waterway is deemed a "unique water" and is legislatively defined as "outstanding state resource water" by the director of ADEQ. The determination and finding is based upon the decision criteria for designation including whether the waterway is perennial, free-flowing, unimpaired, and either has "exceptional recreational or ecological significance" or is found to be essential for the continued existence of threatened and endangered species as well as possibly providing critical habitat (Arizona Administrative Code [AAC] R18-11-112).*
>
> *Unique waters are granted supplemental water quality protection through an anti-degradation requirement (AAC R18-11-107 [D]). Any new or additional discharge to a "unique water", including its tributaries, is prohibited if that discharge would degrade existing water quality. Sitespecific water quality standards can also be applied to unique waters for an added level of protection (AAC R18-11-112).*[418]

Aravaipa Creek was investigated and designated as one of "Arizona's Designated Unique Waters" by the Arizona Department of Environmental Quality, which provides for a high standard of protection of quality.[419] Aravaipa Creek and the San Pedro River are also both "Arizona Waters Potential Candidates for Wild and Scenic River Designations."[420] Aravaipa Creek has been analyzed as to eligibility for the National Wild and Scenic Rivers System, found to be suitable, and BLM recommended to Congress that portions be designated as wild.[421]

Of special significance is that these tributary canyons are predominantly absent exotic species since "Statewide, non-native aquatic vertebrate species were the predominant stressor…."[422]

> *Although native fish still occur in most river drainages in Arizona, few streams support fish communities that have no non-native species. Communities of as many as ten native species probably occurred historically at several sites in the Gila River Basin. Today, the single richest site known is Aravaipa Creek, which still supports seven kinds of native fish in the virtual absence of non-native species. The next largest purely native fish faunas are in a few streams that support five species. Streams with even four native species are rare and rapidly becoming even more so, especially those that have only native species.*[423]

Native fish species in Aravaipa Creek include loach minnow, spikedace, roundtail chub, speckled dace, longfin dace, desert sucker and Sonoran Sucker. All of these species have suffered reductions in their distribution, especially at lower elevations, and the loach minnow and spikedace are federally listed as threatened under the Endangered Species Act.[424] Spikedace are now common only in Aravaipa Creek, Arizona, and portions of the Gila River, New Mexico.[425] Two more native species, Gila topminnow and desert pupfish, were recently reestablished into three sites on the South Rim. Both are listed as endangered species, and both may have been present in the Aravaipa watershed but lost prior to the first fish sampling efforts.[426]

Highlighting the importance of Aravaipa Creek as critical habitat for declining native fish species is its #3 ranking among 32 streams in Arizona containing native fish species.[427]

Also, an amphibian, the Lowland Leopard Frog (*Rana Yavapaiensis*) is a "Wildlife of Special Concern in Arizona" that occurs throughout the Lower SPRV.

> *Rosen (pers. comm.) reported that all perennial reaches from the Narrows to Dudleyville contain lowland leopard frogs and often in abundance. He strongly supports the conservation approach of protecting the side canyons as a means of protecting metapopulations of lowland leopard frogs.*[428]

It is also present in the Aravaipa watershed, but like many of the rare native fish, population declines and threats to habitat are of significant concern.

> *Lowland leopard frogs in the Aravaipa watershed occupy the perennial stream through the canyon and wet reaches of several tributary canyons. We have a nearly-continuous record since 1977 of frog monitoring data collected by Klondyke biologist Jay Schnell and TNC staff. It suggests the population is relatively stable at a fairly low density, roughly ten times less than that seen during 1979-1981. It remains unclear whether there was a severe population crash or those were extraordinarily good years.*[429]

2. SEDIMENTATION

The prospective indirect impacts of habitat fragmentation have been discussed with regard to the SunZia Aravaipa route and its attendant clearings, roads and forecast expansion (Section IV, B). Those impacts are demonstrable by virtue of the science of biogeography: breaking up habitats into islands that create barriers and edge effects reduces species viability over the long-term. Those long-term, cumulative, indirect impacts are sufficient to strongly argue against such a project in the midst of such critical habitats and species of concern.

Transmission line clearings and their service roads may also have direct impacts on native fish and their habitat which are even more immediate. One unfortunate byproduct of roads would be the opening of the back country to off-road vehicles, such as was discussed above (Section IV, B.4). Roads and access in these areas will increase the risk of unauthorized stocking of non-native fishes, which as noted is the main stressor of native fish.

Another direct impact can be just as damaging to the perennial and intermittent aquatic habitats of these species, and that is erosion. The issue of erosion was examined above (Section IV, B.3) primarily with regard to land-based impacts. To recapitulate that discussion, in the local Redington NRCD generated Lower San Pedro Watershed Assessment Project, roads were found to be "the number one cause of human-related gully erosion."[430] That was demonstrably the case especially with powerline roads, due to their steep access to high points for tower siting and cutting across drainages.[431]

Erosion carries sediment loads, which is a natural process. However, "Excessive erosion can overwhelm a rivers' capacity to process sediment…."[432] Roads in particular are notorious for their excessive production of sediment, particularly in highly erosive soils and steep areas.

> *Increased delivery of sediment to streams has long been recognized as one of the major environmental impacts of human development of land. Roads are an inevitable adjunct to land development for any*

> *purpose, and are often by far a greater source of sediment to watercourses than all other land-uses combined.*[433]

> *Broadbent and Cranwell (1979) reviewed studies on erosion and sedimentation caused by road construction, and found that, in the United States, highway construction in 11 % of a catchment area contributed 85% of the sediment leaving the catchment.*[434]

That would particularly be the case with linear roads cutting across drainages of the Aravaipa watershed. As noted in the section on connectivity (Section III, D), that would have consequences throughout the watershed.

> *One complicating aspect of river and riparian ecosystem conservation is the strong linkage between watersheds and the rivers that drain them. That is, watershed conditions influence important hydrologic and geomorphic processes such as the volume of surface runoff and the amount of sediment delivered to streams.*[435]

> *Because rivers are products of their watersheds, riparian preserves can be affected by off-site activities that alter the hydrologic cycle (Pringle 2000, 2001).*[436]

The high sediment load impacts of 30 miles of erosive trans-watershed transmission line roads could be very significant for Aravaipa Creek.

> *This sediment is delivered to streams mainly at stream crossings (Shaw and Thompson 1986, Case et al. 1994, Clarke and Scruton 1997), making stream crossings a potentially useful and easily-measured predictor of sediment delivery to watercourses (Case et al., 1994, Eaglin and Hubert 1993, BC Forest Service 1995a, 1995b). Because roads are an inevitable adjunct to land development for any purpose, measures of the frequency of stream crossings might also serve as an easily-measured indicator of the overall impact of human development on watercourses within a watershed.*[437]

Other factors are relevant as well, all of which are applicable here:

> *…stream crossing density is one of five indicators of the potential for surface erosion. The others are road density, road density on erodible soil, road density within 100 m of a stream, and road density on erodible soil within 100 m of a stream. Each of these indicators is scored according to its potential to contribute to surface erosion.*[438]

A major impact of the SunZia roads would be to the Aravaipa Creek's water quality. In a recent ecological assessment of Arizona's streams and rivers by AGFD, excess sediments were identified as one of the major stressors affecting stream condition, and noted as a greater problem in Xeric than in Mountain streams.[439]

Such water quality concerns would be especially important for waterways like Aravaipa Creek that have been designated "Unique Waters." The legality of such sediment load discharges may even be at issue.

> *Unique waters are granted supplemental water quality protection through an anti-degradation requirement (AAC R18-11-107 [D]). Any new or additional discharge to a "unique water", including its tributaries, is prohibited if that discharge would degrade existing water quality. Site-*

specific water quality standards can also be applied to unique waters for an added level of protection (AAC R18-11-112).[440]

As noted in Figure 7, the high K factor (erodibility factor) of soil types in the upper Aravaipa watershed, through which power line service roads would traverse would drain directly into Aravaipa Creek affecting the richest assemblage of native fish in Arizona.

Of special concern are the impacts such sedimentation would have on the native fish species and their habitats in these canyon tributaries. The potential impacts are manifold and serious for an assemblage of species that are already so threatened:

- *Suspended sediment decreases the penetration of light into the water. This affects fish feeding and schooling practices, and can lead to reduced survival.*
- *Sediment reduces the amount of light penetrating the water, depriving the plants of light needed for photosynthesis.*
- *Sediment particles absorb warmth from the sun and thus increase water temperature. This can stress some species of fish.*
- *Settling sediment can bury and suffocate fish eggs and bury the gravel nests they rest in.*
- *Suspended sediment in high concentrations can dislodge plants, invertebrates, and insects in the stream bed. This affects the food source of fish, and can result in smaller and fewer fish.*
- *Excess sediment from eroding soils contains organic matter that contributes to oxygen depletion in the water as it is decomposed.*
- *Eroding soils also contribute the nutrients nitrogen, and especially phosphorus. In low nutrient streams and recovering waters… these can contribute to algal growth and oxygen depletion.*
- *Suspended sediment in high concentrations irritates the gills of fish, and can cause death.*
- *Sediment can destroy the protective mucous covering the eyes and scales of fish, making them more susceptible to infection and disease.*
- *Sediment loads in… waterways often result in further increased erosion and instability of stream banks, causing stream channels to become wider and shallower, which leads to warmer water temperature.*[441]

These issues are well documented in a number of studies:

Increased delivery of sediment to streams has long been recognized as one of the major environmental impacts of human development of land (Waters 1995). Among many other things, high suspended sediment loads… damage fish food supplies and habitat, and can injure fish directly, depending on the duration and concentration (Newcombe and MacDonald 1991, Waters 1995, Newcombe and Jensen 1996). Increased bedloads of sand and gravel can fill in the channel, causing bank erosion, widening, flooding and losses of critical fish habitat in pools and the interstices of the streambed (Swanston 1991, Hicks et al. 1991).[442]

Excessive erosion can overwhelm a rivers' capacity to process sediment, which results in the depth of pools being reduced, coarser substrates being covered and filled with fine sediments, and lateral *channel erosion being increased (D. Wood et al. 1990), causing a reduction in abundance, biomass, and biodiversity of native fish assemblages (Shields et al. 1994*).[443]

Of particular concern with the smaller desert fish endemic to this area is the importance of pools and riffles which can be diminished by excessive sediment-loading from erosion.

Watersheds dominated by bare ground or that have been impacted in such a way that ground cover is reduced foster flash flooding which can destabilize riparian areas in associated drainages. Excess sediment from these unstable watersheds can fill in important fish habitat features such as pools and riffles with fine sediment.[444]

Fish habitats are controlled primarily by sediment input and transport, which are functions of the volume and pattern of precipitation and runoff. …When sediment input is excessive, pools may become rare due to sediment filling (Swantson 1991).[445]

Several of these impacts have been shown to be species specific, for example, the oxygen depletion caused by excess sediment. "Lowe et al. (1967) showed that desert sucker had the lowest survivorship at reduced oxygen levels when sharing habitat with speckled dace, longfin dace, and desert pupfish."[446] Others impacts extend to broader classes of species, for example severe sedimentation is a negative indicator for lowland leopard frogs.[447] Indeed, a summary of potential stressors listed for Pima County's nearby A7 Ranch indicate that the impacts range across the spectrum in the most critical riparian habitats.

Zone 2, Canyon Riparian and Wildlife Corridor; Stresses: Degradation of Water Quality; Sources: Increased acreage of roads… and sedimentation from disturbed soils in roads; Impacts: Extirpation of aquatic dependent species such as longfin dace and lowland leopard frog would be likely. Insects with aquatic life stages would be reduced or extirpated with related impacts to insect feeding bats and birds.[448]

These issues are already of concern in the Aravaipa watershed.

Within Aravaipa Creek, monitoring data show excessive sediment deposition with the greatest effects at the canyon's upstream (eastern) end. The result is reduced aquatic habitat diversity – pools are filled in and cobbly runs and riffles are replaced by shallow sandy runs.[449]

The management prescription in the Aravaipa watershed is the same as have been detailed for other nearby ecosystems:

Ecosystem management involves trying to understand the connections between what happens on different parts of the landscape. Management of upland vegetation affects watershed functions, which then affect the riparian and aquatic communities.[450]

Due to the rarity and sensitivity of this habitat, an installation of the size and scope of the SunZia project across the Aravaipa watershed portends potentially catastrophic consequences for some of the Southwest's most pristine waters and species of critical concern.

3. INTERMITTENT AND EPHEMERAL WATERS AND SPRINGS

The impacts of erosion and sedimentation to the riparian habitat and resident aquatic species of Aravaipa creek and the Lower San Pedro River (SPR) that the SunZia project clearings and roads would entail are established. Nonetheless, the seemingly outdated ecological assumptions evidenced by SunZia threading of routes around protected status lands cautions that connections need to be made explicit rather than left implicit.

Roads to service transmission towers would inevitably contribute to erosion and sedimentation into Aravaipa Creek tributary drainages and ultimately the creek itself. Powerline routes may be generally configured to cut above the perennial or intermittent portions of tributaries and thus presumably obviate native fish and other aquatic species concerns in the canyons. However, since ecosystems do not stop at traditional boundary lines, though the former part of that statement may generally hold true, the latter part does not.

In storm events when erosion and sedimentation would be most prevalent, the creeks are running as well. During wet seasons such as this past 2009-10 winter, creeks that are otherwise intermittent or ephemeral can run for weeks or even months at a time. Their reach and sediment loads can in any event become much greater, and thus the aquatic habitat is considerably expanded and potentially impacted. As Zimmerman noted,

> *In reality there may not be much difference in duration between perennial and semiperennial flows because many of the streams designated as perennial in southeastern Arizona dry up for 2 months or more prior to the summer rains. In arid region rivers even the term 'perennial' can be rather imprecise.*[451]

Many of those habitats along reaches not considered perennial would be termed xeroriparian, still an important habitat for many species.[452] The Arizona Wildlife Linkages Assessment makes it clear that

> *…a high level of protection for all perennial flowing waters is recommended. Furthermore, it is advocated that project proponents consider all water courses (perennial, intermittent, and ephemeral) as key habitats and potential linkages, and assess the potential impact of roads on organisms across multiple spatial and temporal scales.*[453]

In this regard, it is also important to consider SunZia's FERC expansionist model that proposes a mile-wide EIS evaluation. Not only would impacts be exponentially aggravated, but the reach of the infrastructure corridor would expand outward from the core route, presumably up to a half-mile in either direction. Further, with the prospect of clearing trees and vegetation beneath powerlines, especially in the uplands and montane areas, the erosive impacts could be exponentially greater.

Sedimentation would not only be impacting semi-perennial and intermittent aquatic reaches, it could be inhibiting and compromising the expansion of those habitats. Such expansion is not an abstraction, but a demonstrable factor in the recovering altered habitats of the Lower SPRV and Aravaipa watershed. This is particularly an issue when considering the long-term impacts of the project. Conditions, particularly in stream reaches, are considerably dynamic and can change relatively rapidly. This is a strategy that conservationists have recently been keener to exploit.

> *Initially, much of the land acquisition in the lower basin was directed toward the protection of existing wetland and riparian forest habitats. …Over time, a growing understanding of the relationship between hydrologic processes and riparian habitat characteristics led TNC to expand its perspective on conservation opportunities in the lower basin. In 1997, TNC initiated a planning effort for the central basin in which consideration of riparian potential, rather than existing condition alone, became an important criterion driving land conservation projects. Current conservation planning emphasizes the importance of hydrologic evaluation as a basis for acquisition. An important aspect of this approach is assessment of the feasibility of improving hydrologic conditions in*

the river to benefit native fish and riparian habitat over the long term. As such, the conservation approach has expanded to include ecosystem restoration.[454]

Though the acquisition strategy may have altered, the concept of ecosystem restoration is nothing new. For example, the Aravaipa Ecosystem Management Plan (EMP) extensively references the experience of the nearby Muleshoe EMP.

> *The relationships between watershed vegetation, watershed hydrological processes, stream hydrology, and riparian condition have been studied at the Muleshoe Cooperative Management Area about 25 miles south of the Aravaipa ecosystem. …That plan featured a conceptual model which links conditions of the watershed vegetation to those of the aquatic and riparian habitat through the mechanisms of sediment transport and runoff characteristics that affect flood magnitude and water storage (Figure 3-5). A key goal was to increase the land area dominated by perennial grasses while reducing the dominance of shrubs.*
>
> *Implementation of the Muleshoe Plan included an aggressive program of prescribed burning. During the period 1998-2000, nearly 17,000 acres were treated with fire in three large burns. These caused immediate reductions of shrub cover by 77-83%, though some regrowth from rootstock showed the need for periodic burns to maintain reduced shrub cover. In most cases, the fires also resulted in increased ground cover, with increases in both annual and perennial grasses (Brunson et al. 2001). Since 1994, stream vegetative cover and the amount of undercut bank have increased dramatically in Hot Springs Creek, the major stream in the area being intensively managed. In addition, the mean maximum depth of aquatic habitats has increased as has the number of deep pools. Associated with these aquatic habitat changes, the population density of native fish increased significantly. These improvements occurred despite decreased base flows due to persistent drought (Gori and Backer 2005).*[455]

Prescribed burning to improve watershed conditions has already occurred at the Aravaipa Canyon Preserve.[456] Since prescribed burns are one of the management prescriptions for the Aravaipa watershed,[457] such improvements in watershed conditions can only be anticipated to continue. Additionally, area ranches have participated in these burns and other range improvement efforts. Indeed, improving grasslands and watershed conditions is the concern of all ranchers who seek to procure a sustainable living from their rangeland. As the local Redington NRCD driven Lower San Pedro Watershed Assessment Project noted,

> *…there is general agreement that overall range and watershed condition has improved greatly since the early 1900s and especially since the 1950s. Numbers of livestock have declined dramatically and management (pasture rotation, distribution of grazing) has greatly improved. …Other than roads, there is probably less human impact on the vegetation of the watersheds now than at any other time since settlement.*[458]

The consequences of these improved management practices are evident. Due to conservation and management efforts, "Passive benefits have included riparian restoration and amelioration of detrimental human activities…."[459] Indeed, some flow regimes are still improving in the Aravaipa watershed contradicting expectations under drought conditions.

> *Following the extended drought in the watershed, we would expect reduced flows in the tributary canyons. The reduction of flow in Turkey Creek fits this, but the ten-fold increase in Oak Grove Canyon does not match that expectation. The presence of riparian-obligate trees along Oak Grove*

suggests that the observed flows were accurately identified, and were likely associated with improved watershed conditions.[460]

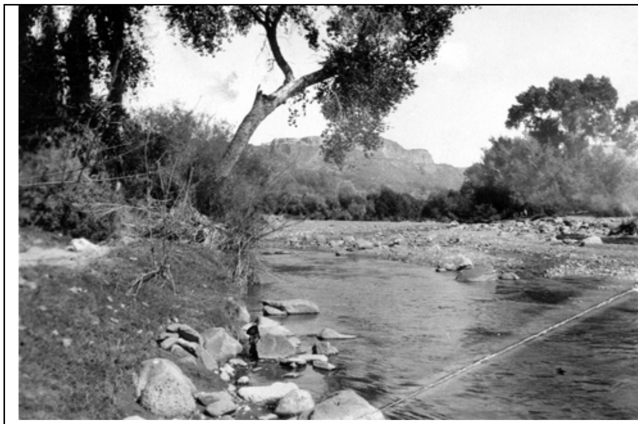

Photo by Harold V. Brown	Stake 3236, 11-8-2003, Raymond M. Turner, couresy of the UGGS Desert Laboratory Repeat Photography Collection

Figure 10: Aravaipa Creek repeat photo stations, left 1906, right, 2003

Riparian vegetation and habitat improvement in the tributaries generally holds throughout the Lower SPRV. Improvements in the vegetative and stream condition of Aravaipa Creek are demonstrated by sophisticated repeat photography sequences, as shown in Figure 10.[461]

As these sequences clearly indicate, riparian vegetation and aquatic habitat is improving and expanding. Indeed, the documentation of Webb, Leake and Turner indicate substantial increases in riparian vegetation throughout Aravaipa Creek and its tributaries.[462]

With improving management throughout the valley this is not surprising.

> *Dryland rivers have some of the most variable flow regimes in the world…. However, the very unpredictability of streamflows in dry regions, over time, has produced ecosystems with high resilience.*[463]

Furthermore, management prescriptions of the new Aravaipa EMP, such as those following, can be expected to continue the trend in a positive direction:

- Restore historic wetlands, including those in Oak Grove, Parsons, Wire Corral, Virgus, Spring, Deer, upper Deer Creek, and Black canyons, through proper manipulation of vegetation and soil.[464]
- Maintain and enhance the diversity of native fish and wildlife species and native habitats of the Aravaipa ecosystem.[465]
- Retain, maintain and/or enhance all habitat essential to the recovery or survival of any threatened or endangered species including habitat historically used by the species.[466]

That these presently intermittent stream segments should become perennial or semi-perennial aquatic habitat in the foreseeable future and intercept the sediment deposits of upland roads should not be surprising either. Sadly, the impacts from a project of the size and extent of SunZia and its attendant expansion would likely preclude such healing from continuing and more likely return the momentum in the opposite direction.

Springs are also isolated but important riparian patches that would be impacted by excess sedimentation from steep backcountry roads. In some areas they are the only oases for whole biotas.

> *With desertification, aquatic habitats shrink and springs soon become isolated archipelagos in seas of aridity, continuing to flow long after perennial lakes and streams are gone. Ultimately they may become the only natural refuges for whole biotas. A substantial proportion of aquatic life in deserts as well as of terrestrial organisms reliant on perennial water is intimately associated with springs and spring-fed systems.*[467]

Indeed, the total number of springs, regardless of discharge, identified by USGS in the Lower San Pedro Water Atlas was between 203 and 209.[468] The complement of species within and surrounding these springs are often rare as well as extraordinary contributors to the region's biodiversity.

> *Unlike fishes, many other spring-dwelling organisms tend to be restricted to headsprings and the uppermost outflows. Hydrobiid snails are abundant and display tremendous diversity. For example, fifty-eight new species of a single genus were described in 1998 from spring in the Great Basin (Hershler 1998).*[469]

> *Because springs are so small and isolated, their absolute numbers of species are small; nonetheless they contain and support a disproportionate amount of biodiversity, as they often represent the only existing surface water. Thus, habitat loss and alteration are highly destructive of both local and regional biodiversity on a relative scale.*[470]

Once again, not only indirect, but direct and cumulative impacts of a project of SunZia's size, scope and potential for expansion would threaten one of North America's rarest habitats and assemblage of species. It is indefensible on scientifically demonstrable grounds that such a project should be permitted to proceed.

E. MAMMALS

The San Pedro River Valley is "internationally renowned for its native biodiversity," containing "one of the richest assemblages of species of any region in the United States (Simpson 1964 in Friedman and Zube, 1992)."[471] Mammals unquestionably make up a conspicuous portion of that diversity, and in various venues it is even advertized that the San Pedro supports the greatest diversity of mammal species in North America.

There are several explanations for the great diversity and richness of mammal species in this region.

> *Several of the factors described above combine to produce the high mammal species richness of the San Pedro watershed. These factors include region size, biogeographic location, climate, water availability, primary productivity, habitat heterogeneity, disturbance, and edge habitat use. The factors can be summarized into three broad categories: geography, environmental gradients, and non-equilibrium processes.*[472]

It should be noted that "habitat heterogeneity" refers to the connectivity and unfragmented character of the landscape, and "edge habitat use" references the natural edges created by the merging of biotic ecotones, not the artificial edges created by roads and structures. "Distinct communities and habitats occur naturally with intergradation of different environments, often called ecotones. The edge is a human artifact where two contrasting habitats suddenly converge without the natural gradations."[473] These categories favorable to local mammal species richness are congruent with larger mammalian studies in North America.

> *This survey shows that species density and the ecological structure of mammalian faunas change along environmental gradients of climate and physiography. Five environmental variables, representing seasonal extremes of temperature, annual energy and moisture, and topography predict 88% of the variation in species density across North America (Table 4a).*[474]

> *Biogeographical factors: Changes in mammalian species density do not simply involve an increase or decrease in species from all size and trophic categories in concert. … This result is not surprising from the standpoint of earlier literature about the zoogeography of North American mammals. For example, Hagmeier & Stults (1964) and Jones & Birney (1988) documented the affiliation of particular mammals for regions that are distinctive in physiography, vegetation and macroclimate.*[475]

All of these factors converge in this region. As described above (Section III, C), a major reason for the diversity of mammal species can be attributed to the convergence of four terrestrial ecoregions.

> *The San Pedro watershed is a large area (ca. 12,000 km2), well connected to other species-rich regions, and has a warm temperate climate. The watershed lies at the intersection of four biogeographic zones (the Sonoran Desert to the west, the Chihuahuan Desert to the east, the Rocky Mountains to the north, and the Sierra Madres to the south) and includes species from each zone. Long summers and relatively mild winters allow mammals with tropical affinities, such as peccaries, coatis, opossums, and various bats, to extend their range northward into the San Pedro watershed (Hoffmeister 1986). Although precipitation is modest, rainfall peaks during late summer, maximizing biological production. Thus, regional conditions resemble those that correlate with high species richness. In sum, the San Pedro watershed is a large, well-connected region with a favorable climate.*[476]

That estimation certainly fits with appraisals of the Southwest region in general: "There are approximately 643 species of mammals in temperate North America, and according to one USGS report (Mac et al. 1998), the American Southwest region probably has the greatest diversity of mammal species in the country."[477] It is also supported by the mammalian richness of the involved ecoregions. The Chihuahuan Desert Ecoregion is first in mammal species richness in North America with 109 identified species, and the Sonoran Desert Ecoregion is fourth with 82 species.[478] Furthermore, the Madrean "Sky Islands" are equally as diverse.

> *The mountains of the Apache Highlands are unique on Earth, for they represent the only sky island complex that extends from the sub-tropical to the temperate latitudes (Warshall 1995). The result of these geographic and geologic phenomena is an unusually rich fauna and flora…." More than 4000 vascular plant species have been identified, as have 110 mammals (Felger et al. 1997, Simpson 1964).*[479]

Species diversity references the total number of species weighted by their relative abundance, and species richness refers to the total number of species in a community.[480] With such mammalian diversity and richness in the coalescing ecoregions of the SPRV, in concert with the presence of good waters and a largely unfragmented landscape and intact habitat, it is little wonder that the Lower SPRV and its major tributary, Aravaipa Creek, should also be exceptionally rich in mammal species.

Stromberg and Tellman devote a detailed chapter to mammals in their book on the San Pedro River. The figure they cite is the one most often quoted for mammal richness in the SPRV:

> *The number of mammal species that occur in the San Pedro watershed – estimated using indirect observations (e.g. sign and scat), captures, or field observations (Woolsey 1987, Duncan 1988, Hass 2001), as well as overlapping range maps (Cockrum 1960, Hall 1981, Davis 1982, Hoffmeister 1986) – may be as high as 87 species.*[481]

Their attribution is that "The San Pedro watershed is an internationally recognized 'hotspot' for mammals, hosting one of the riches assemblages of mammal species in the United States (Simpson 1964, Hall 1981, Duncan 1988)."[482] Any question beyond that accolade as to whether "the San Pedro supports the greatest diversity of mammal species in North America" is probably, at least presently, irresolvable academic quibbling. Nonetheless, for the sake of argument for the uniqueness of this area, a few points are worthy of note.

First, all of the "field observations" cited by Stromberg and Tellman for the San Pedro are for the Upper San Pedro, and predominantly for the San Pedro Riparian National Conservation Area (SPRNCA).

- Duncan, Douglas K., Mammal inventory of the San Pedro Riparian National Conservation Area, Cochise County, Arizona. U.S. Bureau of Land Management, San Pedro Project Office, 1988.
- Woolsy, N., Furbearing animals of the San Pedro Preserve. Unpublished report for U.S. Bureau of Land Management, San Pedro Project Office, 1987.
- Hass, C.C. 2001 Landscape fragmentation and connectivity for carnivores in the Upper San Pedro Basin, Fort Huachuca Wildlife Office.

The Lower SPRV and Aravaipa watershed partake of three of the four biotic communities in the Upper SPRV as outlined by Brown and Lowe[483]: Petran Montane Conifer Forest (122.3); Madrean Evergreen Woodland (123.3); and Semidesert Grassland (143.1). Differentiating the Lower SPRV and Aravaipa watershed from the Upper SPRV however, they also partake of the Sonoran Desertscrub (154.12) in the Lower SPRV, and the Great Basin Conifer Woodland (122.4) and Interior Chaparral (133.3) in the Aravaipa Valley, with their attendant rich assemblage of species. There is also only north of Interstate-10 an immediately proximate biotic community not present further south – the Petran Sublapine Conifer Forest (121.3) in the highest reaches of the Pinaleno Mountains.

Thus four distinct biotic communities and their complement of unique species are represented within or immediately proximate to the Aravaipa watershed and Lower SPRV which are not represented in the Upper SPRV. Here it is presumed that "overlapping range maps" for mammal species are consulted to fill out the area. While that is a scientifically respectable approach, it does have its limitations. For example, within just one of those represented biotic communities, it is noted that,

> *Although a considerable amount of biological inventory and ecological analysis has been conducted in the Sonoran Desert Ecoregion, surprisingly little of this information has made it into the databases. We suspect that the identified network of Conservation sites actually captures many more occurrences of conservation targets than is suggested by the data obtained for this analysis.*"[484]

Perhaps even more to the point:

> *From almost any perspective, many nongame mammals in Arizona are poorly known. Entire species complexes, such as the voles, gophers, and several genera of mice have yet to be definitely analyzed with modern biochemical taxonomic techniques. The ecology and distribution of some of these species, and many other small mammals, is also poorly known.*[485]

This is particularly significant since rodents make up such a significant portion of mammalian species.

> *Species density is higher in western North America than in the eastern part at a given latitude, despite harsher climates in the west. Western North America is fragmented into many basins and mountain ranges. There, numerous species of congeneric rodents (e.g. Spermophilus and Dipodomys) occur with their closest relatives in adjacent mountain ranges or deserts, and there is high spatial turnover among rodent species.*[486]

> *Much of the variation in species density across North America results from changes in the number of species of Rodentia (rodents) or Chiroptera (bats)-an observation of no great surprise because together they comprise over half of all living species of mammals (Wilson & Reeder, 1993). …From east to west, the most striking changes in species density occur in rodents.*[487]

The importance and variation in rodent species are thus especially significant with regard to mammal diversity and richness in the Aravaipa watershed and Lower SPRV, especially when these additional biotic communities have not been intensely surveyed as they have in the Upper San Pedro.

Bats are also of particular note since they represent such a large complement of the mammalian species in the region. "Of the 27 species of bats known to occur in Arizona, 23 species are expected to occur in the Lower San Pedro River Basin due to the elevational gradient and diversity of riparian and xeric communities (Ronnie Sidner, pers. comm.)."[488]

With these notations in mind, it is significant that the Badgley and Fox map based upon "predictive modeling that is correlated with observed species density" shows southwest New Mexico and southeast Arizona to be the highest mammal species density area (120 species) in the United States.[489] The contour map of mammalian species density (number of species/quadrat) is based on a grid system with a contour interval of 10 species. "Strong latitudinal, longitudinal and elevational gradients are present, as documented in Fig. 1 from Simpson (1964)."[490] The "Observed species density" is documented at 109 species.[491]

Thus at a minimum the Aravaipa Canyon and Lower SPRV can be said to be "an internationally recognized 'hotspot' for mammals," and further that it is *within the region of* the greatest richness and diversity of mammal species in the United States. While the unparalleled eight biotic communities and their attendant species represented within and immediately adjacent to the Lower SPRV would argue for some of the highest mammalian richness and diversity in the region, and thus the U.S., claims beyond these well established acknowledgments would require further studies and assessments.

As it stands, that attribution is more than sufficient to establish the backdrop for impacts to mammals that can be associated with the SunZia Aravaipa route proposal. Fragmentation of the as yet largely unfragmented and intact habitat of the Aravaipa watershed and Lower SPRV, as discussed above (Section IV, B), would doubtless be the overarching threat to this rich assemblage of mammal species. As noted, "habitat heterogeneity," or connectivity and lack of fragmentation, is a key factor in predicting mammal diversity and richness. Stromberg and Tellman recapitulate some of this science in so far as it relates to mammals.

> *As described by MacArthur and Wilson (1967), species richness on islands depends on a balance between colonization and extinction, both of which relate to island size and distance to the mainland. …The theory of metapopulation dynamics extends this thinking to different habitat types in a terrestrial landscape (Hanski 1999). …Increasing patch size results in larger populations that are more resistant to extinction. Patch location relative to other patches influences dispersal and the probability of recolonization following extinction events. Together, these two geographic factors play an important role in determining species richness patterns for a given region (Brown 1971, Tonn and Magnuson 1982, Rosenzweig 1995).*[492]

The effects of fragmentation have been discussed at some length, but the impacts are often indirect and long-term. In fact, the impacts are often within such a timeframe that by the time the effect is documented it is too late for species of concern and the habitat no longer exists for the kind of diversity and richness formerly resident. That would especially be the case in an environment such as the Lower SPRV, which is demonstrably *part of the largest relatively intact and largely unfragmented extended landscape in the desert Southwest through which courses a major free-flowing river.* That of course is the rationale for ecoregional assessments, to identify such "hotspots" of biodiversity as exist in this region, and hopefully to apply the managerial recommendations such that these habitats and rich assemblages of species can be maintained.

> *From the standpoint of biodiversity conservation, it is economically and strategically prudent to understand where and how to manage for conservation purposes well before species and ecosystems become 'endangered.' Recovering species that have declined to low numbers or ecosystems that have been heavily degraded is far more expensive and problematic than maintaining our extant biodiversity.*[493]

Acknowledging the long-term and cumulative impacts of fragmentation does not imply however that there would not be direct and immediate impacts. It may appear that roads and clearings, such as those that would support SunZia's installation and maintenance, would create no physical barriers and that animals can cross with impunity. But that is not the situation, particularly for a class of mammals which is among those most responsible for the extraordinary richness and diversity of the region.

> *A barrier need not be an impenetrable structure. There is nothing to prevent fauna crossing most roads, especially minor dirt roads which are also less used by vehicles. However, there is evidence that*

edges act as barriers (Yahner 1988), and a number of studies support the Canadian study by Oxiey et al. (1974), who found that total clearance of 30 m or more was the main factor inhibiting the movement of small mammals across roads.[494]

Rodents play a key role in the SPRV ecosystem, especially in the Semidesert Grasslands and Desertscrub that are the dominant biomes along the SunZia Aravaipa route. They are major contributors to grassland seed dispersal: "Seed-catching rodents such as pocket mice, kangaroo rats, and deer mice also disperse seeds (Vander Wall 1997).[495] They are also a dominant prey of the many diverse and critical raptor species that inhabit the region.

There are a plethora of studies documenting this negative interaction of small mammals and roads. Here follow some of those studies reported in a comprehensive review of the fragmentation of habitat by roads and utility corridors.

These patterns [of edge effects] have been described for small mammals along powerline corridors in forests in the USA (Johnson et al. 1979)….[496]

Road studies have examined roads of different widths, surfaces and traffic volumes (Oxiey etal. 1974; Garland and Bradley 1984; Swihart and Slade 1984; Mader 1984; Bakowski and Kozakiewicz 1988; Baur and Baur 1990). Even a road in Kansas which was less than 3 m wide consisting of two dirt strips worn by the tyres of 10-20 vehicles a day, with vegetation on it, strongly inhibited crossing by prairie voles Microtus ochrogaster and cotton rats Sigmodon hispidus (Swihart and Slade 1984).[497]

It is worth noting that a related species, the Yellow-nosed cotton rat, *Sigmodon ochrognathus*, a species tracked by the Arizona Heritage Data Management System, and a former Candidate 2 for Federal listing, has been documented in the Aravaipa watershed.[498]

In Germany a five-year study comparing the crossing by forest mice Apodemus flavicollis of road widths from 3 m to 6 m found that they did not cross, and if translocated very few returned (Mader 1984). A Polish study found the same species of forest mouse did cross a 5 m gravel road and concluded that lower traffic intensity than the roads in the German study may have contributed to the result; however, the road was a barrier to the bank voles Clethrionomys glareolus (Bakowski and Kozakiewicz 1988).[499]

Studies examining the use of structural or landscape features have discovered a barrier effect of roads on some species. In northern New South Wales Barnett et al. (1978) discovered that the mosaic-tailed rat Melomys cervinipes would not cross an overgrown, unused fire-trail 3 m wide, and that few brown antechinus Antechinus stuartii and bush rats Rattus fuscipes were trapped on both sides of the 4.5 m and 3.25 m unsealed low-usage roads.[500]

In the USA, mowed grass strips 10-15 m wide have acted as barriers to dispersal of small mammals (Joule and Cameron 1975; Cole 1978). Schreiber and Graves (1977) found that powerline corridors with young trees and shrubs (maintained by removal of woody vegetation every 3-5 years) acted as a barrier to two small forest mammals, a mouse Peromyscus leucopus and a shrew Biarina brevicauda, even though other small mammals lived in the established understorey of the corridor.[501]

Many of these studies come from very different ecosystems and conditions. But as the author notes, some basic patterns emerge and can be extrapolated. "Although it is difficult to draw conclusions from a comparison of studies covering different countries, species and habitats, areas of concern for wildlife conservation and management emerge, including increased mortality, divided populations and invasions of common species."[502]

Some of the above studies implicate road width as a factor in fragmenting edge effects, but the 45 mile linear length of the transmission route through this area may be even more at issue.

> *Harris (1988) and Yahner (1988) warn that edges can have negative consequences for wildlife, especially those species dependent on large undisturbed areas. It is difficult to delineate the edge dimensions and to quantify the effect of the edge, but edge effects may be more a function of length than width, and the structural variation at the edge can act as a barrier to dispersal of some species (Yahner 1988). … In assessing the risk of extinction associated with fragmentation, edge effects must be considered (Wilcox and Murphy 1985).*[503]

In consideration of the expansion of the utility corridor as forecast by the SunZia FERC application, at a certain point even larger mammals become implicated.

> *Observations have shown that roads disturb large mammals, even if the road is not a barrier. Faecal pellets were counted along different types of roads in Colorado and it was discovered that mule deer Odocoileus hemionus and elk Cervus canadensis avoid roads to a distance of 200 m, with avoidance greatest near heavily-travelled roads (Rost and Bailey 1979). Mountain lions Felis concolor select home areas with low road densities (van Dyke et al. 1986a), and avoid making homes in areas near improved dirt or paved roads, which they also cross less frequently (van Dyke et al. 1986b).*[504]

Also, as detailed above (Section IV, B.4), off-road incursions in the back-country of the Aravaipa watershed and Lower SPRV would be particularly destructive and virtually impossible to control and contain. This could especially become an issue with the desert bighorn sheep for which the Aravaipa watershed has become renowned:

> *Desert bighorn sheep have become the highest profile species in the ecosystem, and the species most associated with the ecosystem. The herd is historic, being the first desert bighorn sheep reintroduction attempted in the state. The success of this reintroduced species into its former range is remarkable. The population has grown and expanded, and now provides what most hunters consider to be the premier trophy desert bighorn population in the state. Desert bighorn sheep can suffer when in close association with domestic livestock and pet or feral dogs, and they can also suffer from excessive human interactions.*[505]
>
> *The world record (horn size) hunted desert bighorn sheep has come from this population. AZGFD says that the population is in two parts, about 75% along Aravaipa Creek and about 25% in the Galiuros and that individuals go back and forth between these two areas. These two parts of the population are connected by a north-south corridor between these two areas which would be cut by the proposed transmission lines. In fact, AZGFD thinks of the whole population, Aravaipa and Galiuros, as one when determining the number of permits and issuing them.*[506]

Then, along with expansion and increased off-road incursions, even road-kill of mammals becomes an issue.

The most obvious effect of roads is the mortality caused by collisions with vehicles. The data from road-kills can be useful for establishing the distribution and population trends of wildlife (Case 1978; Bennett, in press). The numbers lost in Australia are considerable, approximately one bird every 13 km, and one mammal every 30 km (Vestjens 1973; Disney and Fullagar 1978).[507]

Again, as with the case of neotropical migrant birds and native fish, an entire rich and diverse assemblage of species, in this case mammals, would be subjected to direct, cumulative and long-term impacts from the proposed SunZia installation. In an area of such rich biodiversity it seems imprudent to presume that it could be otherwise. And in a landscape that is so rare as to have the imprimatur "last" attached to it, it would seem unconscionable to risk it.

Ideally roads and other linear corridors should not be constructed through areas which are important to the survival of species, or remaining wilderness areas. National Parks and conservation areas should also be protected from these structures, which are best sited on land already disturbed.

Siting of such projects is significant, and all possible alternatives should be investigated if wildlife values and viable habitats are to be sustained for future generations. Once wildlife suffers the most serious effect of fragmentation it is far more costly to maintain unviable areas, and to breed species back from near-extinction, than it is to leave viable areas of habitat undisturbed while we have the choice.[508]

F. REPTILES

In an area "internationally renowned for its biodiversity," wherein two deserts also meet as they do in the Lower SPRV, it is not surprising that reptilian diversity should also be exceedingly high. "Reptiles show a maximum for species richness in the Chihuahuan Desert (103 species)…. Only the Great Sandy Desert of Australia supports a richer desert reptile fauna than the Chihuahuan Desert (Cogger 1992; Flannery 1994)."[509] The Sonoran Desert is also rich in species, and TNC's ecoregional assessment of the Apache Highlands Ecoregion finds "More than 75 reptile species, making it one of the most diverse reptile regions in North America."[510]

The Muleshoe Ranch Environmental Assessment found that "The desert grassland provides habitat for desert kingsnake, desert grassland whiptail, southwestern earless lizard, desert box turtle, [and] Gila monster….."[511] "The area also supports a large population of Sonoran desert tortoise and has been designated as Category 2 Tortoise Habitat."[512] The Arizona Game and Fish Department lists the Sonoran population of the desert tortoise among the Threatened Native Wildlife in Arizona. They note that its habitat "occurs primarily on rocky slopes and bajadas of Mojave and Sonoran desertscrub (see references in AIDTT 2000). Caliche caves in incised, cut banks of washes (arroyos) are also used for shelter sites…."[513]

The SemiDesert grassland and Sonoran Desertscrub habitats of these and many other reptiles are the same biotic communities through which the SunZia Aravaipa route and its service roads would principally pass.

Not surprisingly, "Desert tortoises and other herpetofauna are adversely impacted by habitat fragmentation due to roads."[514] Much as is the case with small mammals:

The ecological impacts roads have on herpetofauna across temporal and spatial scales are profound, beginning during the early states of construction and progressing through to completion and daily use. Herpetofauna have the potential to be negatively influenced from roads as a consequence of urbanization, either directly from on-road mortality or indirectly as a result of a variety of ecological impacts and enabled human accessibility. The quality and the potential severity of indirect impacts of roads and urban development on amphibians and reptiles far exceed those incurred from direct mortality and wildlife although our understanding of these indirect consequences is premature.[515]

Many of the impacts on reptiles with regard to habitat fragmentation are very similar to those referenced above with small mammals (Section IV, E.).[516]

Unlike natural corridors, roads frequently cross topographic and environmental contours, thereby fragmenting a range of habitat types (Bennett 1991) and affecting many wildlife groups that possess a diversity of ecological and life history strategies. The transformation of physical conditions on and adjacent to roads eliminates areas of continuous habitat while simultaneously creating long-lasting edge effects (Forman and Alexander 1998). When discussing indirect road effects on herpetofauna, the information base becomes sparse because indirect effects are more pervasive and more difficult to quantify than direct effects, and documenting indirect effects due to roads often requires extensive and long-term monitoring.[517]

The direct and indirect impacts of 45 miles of a linear dirt road through the Aravaipa watershed and Lower SPRV may be difficult to quantify, but again the issue may be more one of length than width.

It is difficult to delineate the edge dimensions and to quantify the effect of the edge, but edge effects may be more a function of length than width, and the structural variation at the edge can act as a barrier to dispersal of some species (Yahner 1988). …In assessing the risk of extinction associated with fragmentation, edge effects must be considered (Wilcox and Murphy 1985).[518]

With regard to threatened herpetofaunal species, in addition to the Desert tortoise, the Aravaipa Ecosystem Management Plan also identified the Giant spotted whiptail (*Aspidoscelis burti strictogrammus*) and Bezy's right lizard (*Xantusia bezyi*) as species tracked by the Arizona Heritage Data Management System which occur in the Aravaipa Creek watershed, as well as the Lowland leopard frog (*Rana yavapaiensis*) discussed above (Section V, D.).[519] Whatever the case with regard to species of concern, there are certainly many factors involved in fragmentation and edge effects from roads that would impact all herpetofaunal species.

The combined environmental effects generated by roads (e.g., thermal, hydrological, pollutants, noise, light, invasive species, human access), referred to as the "road-effect zone" (Forman 2000), extend outward from 100 m to 800 m beyond the road edge (e.g., Reijnen et al. 1995). Considered independently, each factor influences the surrounding ecosystem to varying extents and is further augmented by road type and environmental processes, including wind, water, and behavior (Forman et al. 2003).[520]

Among those factors, water is a particular issue with the severely erosive soils in that steep powerline roads can make them impassable to many smaller species (Section IV, B.3).

With regard to direct impacts on herpetofauna, mortality from road-kill is the most obvious. Apart from construction and routine maintenance, vehicle collisions with reptiles along these roads would be most severe with off-road vehicle incursions. As discussed above (Section IV, B.4), these incursions are nearly impossible to contain in the backcountry of the Aravaipa watershed and Lower SPRV. The SunZia Aravaipa route would create irresistible opportunities for enthusiasts who often travel in troupes of half-dozen to a dozen vehicles or more. Road-kill of snakes is a well-documented phenomenon.

> *The most thorough, long-term records of direct road mortality have been provided for snakes. Since the 1930s, herpetologists have driven U.S. roads to document snake occurrence and collect specimens (e.g., Klauber 1931; Scott 1938); therefore, documentation of traffic fatalities with this taxa are not novel. Reports in which the majority of specimens are already dead are not uncommon. The highest road mortality of snakes to our knowledge has been documented along U.S. Highway 441 in Paynes Prairie State Preserve in Florida (1.854 individuals/km surveyed, 623 snakes killed, 336 km surveyed, Smith and Dodd 2003).*[521]

The evidence is not so clear with lizards.

> *Lack of evidence for high mortality of lizards could be a detection issue due to small size and rapid deterioration of road-killed specimens of many species (e.g., Kline and Swann 1998), or a lower mortality rate due to their ability to cross roads faster than other reptiles (but see Kline et al. 2001). Also, most species of lizards do not migrate seasonally and exhibit high site-fidelity within small home ranges, potentially limiting their encounters with roads (Rutherford and Gregory 2003).*[522]

However, those very factors of small home range for lizards have equally adverse impacts from another aspect of habitat fragmentation.

> *Species most vulnerable to roads and utility corridors are those with poor dispersal abilities, sedentary habitats, specialized needs and those endemic to an area.*[523]
>
> *A barrier to dispersal of species can disrupt social organization. It can lead to local extinctions if an area is affected by fire or drought, can reduce the immigration of species to areas which may need replenishment, and also limit gene-flow, with subsequent "bottle-neck" effects. "For species with poor dispersal or dispersal-related problems ... fragmentation may prove more critical than area as a determinant of extinction probabilities" (Shaffer and Samson 1985).*[524]

A similar phenomenon can also occur with some species of snakes, especially smaller ones.

> *A variety of researchers have noted road avoidance by snakes (e.g., Weatherhead and Prior 1992; Fitch 1999; Goode and Wall 2002; Sealy 2002; Laidig and Golden 2004; Shine et al. 2004; Plummer and Mills 2006). …Andrews and Gibbons (2005) performed experiments that revealed significant levels of variation among species in road avoidance rates where a positive correlation was found between crossing frequency and body length, likely due to natural behaviors of smaller snakes to avoid open spaces (e.g., Klauber 1931; Dodd et al. 1989; Fitch 1999; Enge and Wood 2002). The propensity to cross roads can also vary within a species where juveniles and adults do not cross proportionately to ratios in the surrounding environment (Seigel and Pilgrim 2002) Some snakes attempt to cross, but deter and retreat (Andrews and Gibbons 2005), ultimately not crossing, a behavior that has been observed in the field (Holman and Hill 1961; Franz and Scudder 1977). Individuals that enter a road but do not cross are exposed to both direct mortality and road fragmentation.*[525]

Again, the steep character of powerline roads in these erosive soils can lead to virtual ditches such that they became impassible to these smaller fauna.

There are other effects of off-road activity impacting herpetofauna that range from the subtle to the gross. In the former category, noise has been shown to be a serious impact on these more sensitive animals.

> *Laboratory tests were performed on three desert species, used to the silence of high dune areas. A sand lizard Clma scoparia and kangaroo rat Dipodomys deserti were exposed to less than 10 minutes of recorded dune buggy sounds played intermittently at lower intensity than normal. This induced hearing loss in both species which lasted for weeks, leading to inability to respond to the recordings of predator sounds. A spade-foot toad Scaphiopus couchi was made to emerge prematurely from its burrow by playing 30 minutes of taped motorcycle sounds. These responses to off-road vehicles could cause death in the desert (Brattstrom and Bondello 1983*).[526]

On a grosser scale is the well known propensity of off-road vehicles to go off-road in new and unpatrolled areas creating new roads and even larger impacts. "Activities such as recreational off-highway vehicle use (Webb & Wilshire 1983)… may lead to destruction in a confined area or degradation over a larger area. [O]ff-highway vehicle activity (Luckenbach & Bury 1983)… [has] been demonstrated to negatively impact reptile and amphibian abundance.[527] Indeed,

> *Ample evidence suggests that road mortality of herpetofauna results in significant loss of individuals and in some situations threatens the sustainability of populations. Reed et al. (2004) concluded that road mortality is substantial, exceeding the damage incurred by other anthropogenic sources such as illegal collection for trade.*[528]

The illegal collection of herpetofauna for trade is however another impact that can be foreseen to follow from the opening of the backcountry that the SunZia service roads would provide. Illegal collecting is a well recognized impact in desert areas and increasing. "While collecting methods that destroy microhabitats have been employed for decades (Klauber 1935), reptile collection for the burgeoning pet trade has led to accelerated microhabitat loss and degradation in recent years (Grismer & Edwards 1988; Mellink 1995)."[529] "Collecting of herpetofauna, cacti, and ironwood is increasing to a level that could threaten native wildlife and plant populations."[530] That could become a significant local issue if the Aravaipa watershed and Lower SPRV backcountry becomes accessible by powerline roads as the Phoenix and Tucson metropolitan areas continue expanding. The possibilities are various.

> *With growing human populations and increasing urbanization, interest in reptiles as food, pets, or raw materials for clothing and curios has increased (Dodd 1986). The effects of this increased use on reptile and amphibian populations are largely unknown. Several studies have called attention to the effects of rattlesnake roundups on rattlesnake populations and habitats (Campbell et al. 1989; Reinert 1990; Warwick 1990; Weir 1992) and on non-target species (Speake & Mount 1973). Harvest of gopher tortoises has negative impacts not only on tortoises, but on other species (e.g. Crotalus adamanteus) inhabiting their burrows (Landers & Speake 1980; Diemer 1986, 1987; Spillers & Speake 1988). Direct take of animals or eggs, whether intentional or incidental, has been implicated as a source of population declines and/or endangerment for some species, such as red-legged frogs (Rana aurora, Jennings & Hayes 1985), loggerhead sea turtles (Caretta caretta, Crouse et al. 1987; Crowder et al. 1994), timber rattlesnakes (Crotalus horridus, Brown 1993;*

Brown et al. 1994), and New Mexico ridgenose rattlesnakes (C. willardi obscurus, Baltosser & Hubbard 1985).[531]

The effects of collecting on reptilian habitat and abundance have been investigated in southern Arizona and found to be significant and extensive.

To assess the extent of collector-caused habitat destruction in Arizona, we photo-documented habitat damage throughout the state, within the habitats of several reptiles, including night lizards (Xantusia vigilis), chuckwallas (S. obesus), rosy boas (Lichanura trivirgata), Arizona mountain kingsnakes (Lampropeltis pyromelana), Gila monsters (Heloderma suspectum), and three species of montane rattlesnakes (Crotalus willardi, C. lepidus, and C. pricei). Numerous reported collecting localities in a total of 11 mountain ranges were visited in order to gain an understanding of the nature and extent of the type of habitat destruction with which we were concerned. Although we did not survey randomly selected sites or mountain ranges, it is still interesting that we found habitat damage, often extensive, at every known or suspected reptile collecting site visited.[532]

Habitat damage by reptile collectors and others is extensive and ongoing in deserts of the southwestern United States. In Arizona, we have found damaged rock outcrops, within short distances of roads, in virtually every mountain range we have visited.[533]

It is that characterization of "within short distances of roads" that is most pertinent. This is also not an isolated phenomenon, as the Arizona Game and Fish Department has documented.

During the 2003-04-reptile collection season, "Operation Madrean Arch" was launched. This operation recorded over 200 pieces of intelligence information related to the illegal take of protected rattlesnake species. Several cases prosecuted related to the illegal take and commercialization of Gila monsters, massasaguas, and ridge-nosed rattlesnakes and resulted in 15 years of license revocations and possible fines.[534]

The notation of Gila Monsters (*Heloderma suspectum)* is significant since their core range in the United States is in Arizona, and the Lower SPRV is prime habitat.

In southern Arizona, the Gila Monster is more abundant in wetter and rockier palo verde-sahuaro desert than in drier and sandier creosote-bursage desert, where it occurs mainly in or near rocky buttes or mountains (Lowe et al. 1986).[535]

Even though collection of Gila Monsters is prohibited by laws and regulations throughout the range in the United States, the aforementioned collecting and habitat destruction is taking its toll.

Populations have been exploited (illegally) by commercial and private collectors, and they have suffered from habitat destruction due to urbanization and agricultural development (New Mexico Department of Fish and Game 1985). Concrete-lined canals are barriers to movement (Brown and Carmony 1999), as are busy highways. Mortality on roads likely is increasing as traffic volume increases on established highways and new roads are built. The most important reason for the decline is habitat loss resulting from development (Campbell and Lamar 2004).[536]

In fact, the populations of this iconic desert species have dropped to such a degree that they are now ranked as "Near Threatened," with a real possibility of dropping into the even more critical category of "Vulnerable."

Listed as Near Threatened because this species is probably in significant decline (but probably at a rate of less than 30% over three generations), especially because of habitat loss throughout much of its range, thus making the species close to qualifying for Vulnerable under criteria A2, A3 and A4.[537]

Another iconic desert species, the Sonoran population of the Desert tortoise mentioned above, is threatening to join the ranks of its Mojave cousin. Some of its decline is also attributed to off-road vehicle activity and directly to utility corridors.

Declines [in Desert tortoise populations] are due to habitat loss associated with urban development, utility corridors, highway mortality, off-road vehicle use and recreational activities. Also, populations of predators like coyotes and ravens have grown exponentially, subsidized by human food sources. Power lines provide artificial nesting perches for ravens, and invasive plant species compete for scarce resources and fuel fires that destroy the habitat. …Data are also being used to create habitat suitability models, which give a range-wide sense of tortoise habitat and are a valuable tool in the effort to wisely site new green energy projects.' The challenge is finding the right balance to be able to achieve our alternative energy goals while not sacrificing the native landscape and our natural heritage at the same time,' said Roy Averill-Murray, U.S. Fish and Wildlife Service desert tortoise recovery coordinator. 'The tortoise tells us so much about the health of the desert,' said Kristin Berry, USGS research wildlife biologist in "The Heat is On." 'It's a symbol of the wellbeing of our environment, and for that reason alone we should be concerned about its wellbeing and that it thrives.'[538]

It is not surprising that the Aravaipa Ecosystem Management Plan specifically addresses many of the same threats and concerns about these very species within the watershed:

Slow-moving upland species, primarily Gila monsters and Sonoran desert tortoises, are susceptible to human impact such as shooting and collection; they are also vulnerable to road mortality and unnatural fires. These impacts can be significant in depressing populations as a whole.[539]

With even these species that are so representational of the desert in decline, it would be most perspicacious to avoid the Lower SPRV and Aravaipa watershed which is so rich in biodiversity and reptilian species. Southern Arizona is clearly going to see more growth. But both are factors of development which will continue to put pressure on habitat and species populations. The few and increasingly rare (if not the last) areas that can support such fauna should not be subjected to fragmentation by roads and utility corridors. Species like the Desert tortoise and Gila monster need not go the way other iconic species such as the Bald eagle did, resulting in more expensive efforts at recovery in ever declining habitats.

G. PLANTS

Plants and plant communities are referenced throughout this document. Wherever fragmentation caused by the proposed SunZia routes would impact fauna or their habitats, plants and plant communities are implicated at every turn. Most of those impacts, direct and indirect, have been discussed in the relevant preceding sections. Here there will only be a brief recapitulation of biotic and plant communities of the Aravaipa watershed and Lower SPRV, and then some mention of particularly threatened plant species.

As has been noted, there are eight biotic communities within the Aravaipa watershed and Lower SPRV: Six of these are crossed by the proposed SunZia Aravaipa route. Using Brown and Lowe's descriptors and catalog numbers in the Aravaipa watershed and Lower SPRV, the Forest Formation is represented by the Petran Sublapine Conifer Forest (121.3) and Petran Montane Conifer Forest (122.3) in the mountain ranges' highest portions. The Woodland Formation is represented by the Madrean Evergreen Woodland (123.3) and the Great Basin Conifer Woodland (122.4) at the north end of the Galiuro Mountains. The Scrub Formation is represented by the Interior Chaparral (133.3) in a lower transition zone. The Grassland Formation is represented by the Semidesert Grassland (143.1) covering a large portion of the upper Aravaipa watershed. The Desertscrub Formation is represented by the Arizona Upland Subdivision of the Sonoran Desertscrub (154.12) in the northern SPRV valley basin.[540]

Those biotic formations or biomes "are not provinces *per se*, which are biotic, faunistic, or floristic in structure, function or other aspects."[541] Nonetheless, they do either roughly correlate to or fit within four great terrestrial ecoregions within the Aravaipa watershed and Lower San Pedro River Valley. The World Wildlife Fund (WWF) distinguishes those ecoregions as Sonoran Desert, Chihuahuan Desert, Madrean and Arizona Mountains. The Nature Conservancy (TNC) amalgamates some of those ecoregions together into what they call the Apache Highlands. The WWF divisions, they explain, are more suited for large scale framing.[542]

The vascular plant richness of these ecoregions is extraordinary. Nabhan & Plotkin (1994) repute the Sonoran Desert to have the greatest diversity of vegetative growth of any desert in the world.[543] Approximately 3,500 plant species live in the Chihuahuan desert.[544] TNC notes that "The mountains of the Apache Highlands are unique on Earth, for they represent the only sky island complex that extends from the sub-tropical to the temperate latitudes (Warshall 1995). The result of these geographic and geologic phenomena is an unusually rich fauna and flora…. More than 4000 vascular plant species have been identified, as have 110 mammals (Felger et al. 1997, Simpson 1964)."[545] How the rich biotic diversity of these merging ecoregions and biotic communities translates into the Lower SPRV plant richness can only be speculated since "…thorough floristic inventories remain to be conducted in those parts of the river."[546]

It is the contention of modern biogeography, and of this paper, that fragmentation of this otherwise largely unfragmented and intact landscape would impact every biotic component. The chapters on Connectivity (Section III, D) and Fragmentation (Section IV, B) discuss this issue.

With regard to the proposed SunZia Aravaipa route, the biotic community most directly impacted would likely be the Semidesert grasslands (See Figure 3). Gori and Enquist documented a substantial decline in the area of grasslands throughout the Apache Highlands, which require restoration and fire management against invasive shrubs.

> *Approximately 43% of the region, historically, was comprised of grasslands (Gori, Enquist 2003). Today that figure has been reduced to 22%, highlighting the fact that the basins of this region have experienced the heaviest human impacts. Among those impacts is the absence of fire, which has contributed to an increase in shrubs at the expense of grasses. …the greatest areas of grassland with restoration potential are found on federal and state lands.*[547]

The areal impact of service roads and tower pads alone could be significant, not to mention the consequences of expansion, off-road vehicle access and hindrance to prescribed burns. For these Chihuahuan Semidesert grasslands, "Degradation threats include increasing off-road vehicle use in some areas, invasions of non-native species, [and] increasing dominance of native shrub species in areas historically characterized by open grasslands…."[548]

The Aravaipa route would also transect many tributary washes of Aravaipa Creek along its length. Often the canyons are riparian in character and reflect a rare plant community (G3), the Mixed Deciduous Broadleaf Riparian Forest (Platanus racemosa/mixed spp. Riparian Forest).[549]

> *The riparian forest within Aravaipa Canyon is part of the attraction for recreational users of the area and provides habitat for a wide array of wildlife. Smaller but similar riparian communities grow in many of the tributary canyons, forming ecological corridors through the more arid uplands.*
>
> *In the Aravaipa ecosystem, riparian zones up to about 5,200 feet elevation are vegetated by Sonoran riparian deciduous forest species (Fremont cottonwood, Goodding willow, velvet mesquite) and by those characteristic of interior riparian deciduous forests (netleaf hackberry, velvet ash, sycamore and Arizona walnut).*[550]

This plant community has often been referenced throughout this paper, for

> *[T]he riparian communities along these streams provide migratory birds and pollinating insects and bats with critical trans-hemispheric travel corridors. …It is difficult to overstate the importance of Arizona's freshwater systems. The status of these resources – their quantity, quality, distribution, and the biological diversity they harbor, is the single most important issue to both the sustainability of biodiversity and human communities in Arizona.*[551]

The impacts that sedimentation from the erosion of the powerline roads could have on these habitats was discussed above (Section IV, D). "Riparian habitats throughout the [Sonoran Desert] ecoregion are severely degraded…. Riparian woodlands in the region are now one of the rarest habitat types in North America because of widespread destruction."[552]

There are also three globally imperiled plant communities within the Aravaipa watershed and Lower SPRV.

- Fremont Cottonwood-Gooding Willow (Populus fremontii-Salix goodingii Riparian Forest (G2)
- Mesquite Bosque (Prosopic velutina woodland) (G2)
- Cienega Marshland (Scirpus spp./Eleacharis spp./Juncus spp. Marshland) (G1).[553]

The impacts of fragmentation of the Aravaipa watershed and Lower SPRV ecosystem hold for these rare plant communities as well. Island biogeography demonstrates that the risk of extinction decreases as habitat size increases.[554] "The theory of metapopulation dynamics extends this thinking to different habitat types in a terrestrial landscape (Hanski 1999). …Increasing patch size results in larger populations that are more resistant to extinction."[555] Of course the corollary is that reducing patch size by fragmentation results in smaller populations that are more vulnerable to extirpation.

There are also a number of individual plant species of concern within the Lower SPRV and Aravaipa watershed for which these same impacts of fragmentation would apply.

- San Carlos Wild Buckwheat (*Eriogonum Capillare*): [Reichenbacher, F. W., R. J. Shmalzel, and S.J. Bainbridge. 1993. Status report, Eriogonum capillare. Prepared for U.S. Fish and Wildlife Service, Ecological Services, Phoenix, Arizona.]

  "This species is an annual that is found only in Arizona in Pinal, Gila, Graham, Cochise, and Pima counties. Habitat is generally sandy and gravelly alluvium or weathered limestone gravels along washes and riverbeds and up lower slopes of adjacent hills."

  "Threats may include… off-road vehicle use."

- Aravaipa sage (*Salvia Amissa):* A perennial herb restricted in range to south central Arizona. Habitat is shady canyon bottom on alluvial benches in the understory of deciduous broadleaf riparian forest. Elevational range from 1,500 to 5,000 ft. "…erosion of floodplain terraces… and sedimentation of plant sites in canyon bottoms due to degradation of adjacent uplands are potential threats."[556]

Also listed as species tracked by the Arizona Heritage Data Management System which occur in the Aravaipa Creek watershed are:[557]

- Aravaipa wood fern (*Thelypteris puberula* var. *sonorensis*)
- Arizona giant sedge (*Carex spissa* var. *ultra*)
- Catalina beardtongue (*Penstemon discolor*)
- Baboquivari giant hyssop (*Agastache rupestris*)
- Toumey agave (*Agave toumeyana* var. *bella*)
- Fish creek fleabane (*Erigeron piscaticus*)
- Superb beardtongue (*Penstemon superbus*)
- Mexican gama grass (*Tripsacum lanceolatum*)

The SunZia service roads would also open the area to two additional threats to these plants and plant communities: off-road vehicles and the introduction of exotic species. "Introduction of exotic plants and animals" and "recreation" were identified as the top two stressors in the Sonoran Desert Ecoregion.[558] With this new access to formerly undisturbed areas, plants are easily introduced into the core of an area along a road, partly because the edge effect favors species with generalized requirements.[559]

> *Roads can serve as dispersal corridors, facilitating species expansion, an occurrence that is particularly problematic with invasive species. … Lastly, roads can enable the spread of exotic plant species that subsequently eliminate native flora and fauna (Wester and Juvik 1983; Parendes and Jones 2000) and compromise the quality and availability of habitat and prey bases (e.g., Zink et al. 1995; Maerz et al. 2005*).[560]

Nabhan and Holdsworth provide a detailed account of the current threats to the Sonoran Ecoregion's biodiversity, all of which have been mentioned above, including widespread habitat loss, loss of natural hydrologic regimes, increasing recreational use, and exotic and invasive plants among others.[561] For the largely unfragmented and intact landscape of the Aravaipa watershed and Lower

SPRV, these associated impacts of fragmentation from the SunZia powerline installation and service roads would be significantly deleterious to these rare and important plants and plant communities.

V. CONCLUSION

1. INDIRECT IMPACTS:

The first main section of this document dealt with "Indirect Impacts," which were summarized above (Section III, E). There the parameters of the Aravaipa watershed and San Pedro River Valley (SPRV) landscape were laid out. Here in this conclusion a brief recapitulation of that section will be followed by a summary of the "Direct Impacts" documented in Section IV, A-G. Some discussion will follow regarding larger or extrapolated points. Since adequate documentation exists throughout the body of this document, footnotes will by and large be dispensed with except as occasionally necessitated to support a point or make a new one.

The Aravaipa watershed and Lower SPRV watershed includes eight biotic communities, six of which the proposed SunZia Aravaipa route is to pass through. Those eight biomes are in turn parts of four great ecoregions extant in the Aravaipa watershed and Lower SPRV Chihuahuan, Sonoran, Madrean and Arizona Mountain. Each one of those has been identified as among the World Wildlife Federation (WWF) Global 200 most ecologically significant terrestrial ecoregions on Earth due to their biological diversity and richness. In turn, they are tied together in this watershed by the Gila Freshwater Ecoregion, that is, the canyon tributaries and the San Pedro River, which are of "Continental Importance" and of "Critical" conservation status.

All of these ecoregions merge together into an ecological and interdependent whole. Further, the ecological integrity of the Aravaipa watershed and Lower SPRV is confirmed by its largely unfragmented landscape and relatively intact habitat. Landscape connectivity has been identified as a major feature of the Aravaipa watershed and Lower SPRV by ADOT and AGFD's Arizona Wildlife Linkages Assessment, and conservation NGOs that have identified connecting cross-valley canyons as "Imperiled Movement Corridors." Indeed, it was posited in this paper that the Lower SPRV is part of the most extensive unfragmented and intact landscape through which runs a major free-flowing river in the desert Southwest.

The sustainability interests of valley stakeholders have been reflected in rancher's "best practices," as well as managerial recommendations derived from ecoregional assessments – now the preferred model for both environmental NGOs and agencies. Many of these recommendations have been discussed throughout this document and especially in the chapter on Connectivity (Section III, D.). It is particularly noteworthy that the BLM, which is facilitating the SunZia Project process, admits that it has been late to ecoregional assessment science with regard to coordinated land use strategies. It also admits to some unfortunate outcomes from its former outdated approach, and is just now coordinating with The Nature Conservancy (TNC) in "rapid ecoregional assessments" in California and throughout the Southwest.[562]

While BLM is catching up, TNC has already done in-depth ecoregional assessments for the Sonoran Desert and Apache Highlands. Two major Conservation Sites within those assessments, together include the extent of the Lower SPRV and Aravaipa watershed. The entire Lower SPRV and Aravaipa watershed which the SunZia route would traverse for over 45 miles reflects extraordinary biological richness and diversity. The Nature Conservancy, in its Apache Highlands Ecoregional assessment, identified three additional Conservation Sites in the Aravaipa watershed, all either crossed by or in proximity to the proposed SunZia Aravaipa route. The recommendations for such sites have uniformly been to maintain and enhance the connections between the waters and uplands and to not fragment them with erosive and artificial barriers that negatively impact species, habitats and water quality.

It has also been shown throughout how the implementation of those recommendations by land managers has led to range, water and habitat improvements throughout the Aravaipa watershed. The nearby Redington NRCD/ADEQ watershed assessment found similarly significant improvement of rangeland quality and practices throughout the Lower SPRV. Repeat photo station monitoring by USGS and private parties have documented similar improvements in grassland and riparian habitats.

The summary of the first main section regarding Indirect Impacts was that the Aravaipa watershed and Lower SPRV is of such extraordinary natural diversity and richness that the proposal of a major utility corridor and its forecast expansion through the area is Environmentally Objectionable on the face of it. Further, that richness and diversity serves as a metric from which to measure any Direct Impacts. That is, the severity of any impact is exacerbated by the exceptional context of the proposed action.

2. DIRECT IMPACTS:

The second main section (Section IV) addresses in detail the richness and diversity of the valley biological inventory, and what the direct and cumulative impacts of such an installation would be to those entities. The overarching issue of these impacts is that of fragmentation.

As was noted in the text, the science of island biogeography has resulted in a rapid and substantial paradigm shift in conservation studies and programs, much of which has been evidenced by the ecoregional approach discussed above and throughout. The essential understanding is that floral and faunal species and communities have been demonstrated to be more viable in larger connected areas. The smaller and more dissected into islands that geographical areas become, the more vulnerable those species and communities are to decline and ultimate extinction. As species decline and are extirpated, ecological functions of a system deteriorate ultimately to the point of collapse, such that services offered to plant, animal and human communities cease to function effectively.

With regard to the SunZia powerline corridor and its forecast expansion, the greatest direct terrestrial fragmentation impacts would be from the service roads, tower pads and vegetation clearing beneath powerlines. That extent is a forty-five mile linear swath and some 360 towers across the Aravaipa watershed and Lower SPRV. The proposed routes are primarily across uplands that would require either steep roads across numerous canyons and drainages to the high points for towers, or many spur roads from lower elevation access points, or both. The dual towers would be large 16-story structures requiring unknown road size and width for installation and maintenance. Particularly unknown are what other roads or clearing might be required within the mile-wide corridor to be studied for future expansion.

These roads are of particular concern to ranchers and land managers on two principal counts. First is soil erosion caused by powerline roads. This is demonstrated by the powerline roads already extant in the San Pedro Valley, shown by the nearby Redington NRCD watershed assessment to be the worst erosive impacts throughout the valley – which impacts would be dwarfed by the size and extent of the upland routes proposed by SunZia. Such erosive features would be a major degrading factor to grass and rangeland quality.

The second concern is the access permitted to the backcountry by off-road vehicles. Ranchers and land managers from every quarter agree as to the unfeasibility of preventing these incursions. It is a remote, unmonitored area on the one hand, while being so proximate to the large and ever-expanding urban, suburban and exurban areas of Phoenix and Tucson as to invite off-road enthusiasts. The natural gas pipeline road located south of the proposed Aravaipa route was immediately solicited as part of the Great Western Trail OHV system, and such pressures are already mounting for the Lower SPRV from Pinal and Pima Counties.

The impacts of off-road vehicles to desert vegetation and habitat are well documented, and valley ranchers are as familiar with and opposed to them as federal agencies, county governments and environmental NGOs. The extent of roads and road impacts can be magnified many times over, along with direct impacts to flora and fauna.

TERRESTRIAL FRAGMENTATION:

The biological impact to terrestrial species has been documented throughout. These impacts are manifested through direct areal impacts, edge effects, and spatial barriers. Again, these have especially to do with fragmentation of habitat into smaller components which impacts the whole ecosystem, though those impacts may occur cumulatively and over considerable differentials of time.

The floral communities most directly impacted by the SunZia roads would be the Semidesert grassland. It is not only well-represented in the Aravaipa Valley, but is also a declining plant community throughout the Southwest. Whereas it historically comprised about 43% of the region, it has been reduced to about half that figure now. A number of avian and other faunal species are declining along with the habitat, as well as several endangered plants that could be threatened directly by the road and tower pads or off-road vehicle excursions.

The two classes of animals most directly vulnerable to road impacts are mammals and reptiles. The SPRV is not only a “hotspot” of mammal richness and diversity, it is within the region of the greatest of those aspects in North America. Further, the Aravaipa watershed and Lower SPRV, though not fully inventoried, due to its unfragmented and intact landscape as well as its unusual concentration of biotic communities, representing every biotic formation in the Southwest, along with their characteristic complement of species, likely ranks among the highest. This is particularly possible since bats and rodents compose fully half of mammal species.

About two dozen bat species have been identified in the area, as high a concentration as anywhere in the U.S., and several of those are listed species. Several of those species are nectar feeding, and the areal clearing involved for the roads and tower pads would reduce habitat as the routes pass through Semidesert grasslands and Desertscrub, and the agaves and other flora which serve them would be diminished.

The area is also rich in rodents, both from the Chihuahuan and Sonoran ecoregions, which are a keystone fauna of the grasslands. They play an important role in grass seed dispersal, and are a major food for snakes, raptors and owls. Roads have been shown to have edge effects, that is, they produce changes in mircoclimate and attract generalist species which alter floristic and faunistic structure. Vulnerable species tend to recede from these edges, thereby reducing core habitat area and creating islands which further reduce their viability. This is especially an issue for species with localized habitats and poor dispersal ability.

Roads, even relatively narrow dirt ones, can serve as barriers to rodents which negatively impact their movement and populations. They can be instinctively reluctant to cross an open area which makes them susceptible to predation. Roads in these severely erosive soils, especially steep grades to towers, can become ditches further impeding movement, even for some other mammalian orders. The section on Landscape Fragmentation (Section IV, B) documents many of these impacts, and notes that the length of a road can be even more significant than its with, certainly a factor with the forty-five mile transect proposed by the SunZia Aravaipa route.

The Lower SPRV and Aravaipa watershed is also a hotspot for reptilian richness and diversity as the Chihuahuan desert, with the highest number of reptile species in North America, merges with the Sonoran desert, also exceedingly rich. Many of the same edge and barrier effects impacting rodents are at issue with the snakes, lizards and desert tortoises that are such a rich and vital component of the Semidesert grasslands and Desertscrub through which this route is projected to pass.

Road-kill can become a significant issue with these reptiles, especially as these roads open up the backcountry to off-road vehicle incursion. Noise and toxicity are other consequent impacts to some sensitive species. It also opens the backcountry to illegal collecting of reptile species which has been shown to be a significant issue in destroying habitat and even impacting populations. Even the Gila monster, of which the Lower SPRV's Saguaro–Palo Verde plant community is prime habitat, is becoming so vulnerable as to be in significant decline. Power lines also become roosting and nesting areas for ravens which prey on Desert tortoises, also a species of concern. That these iconic species of the Southwest could be pushed into similar status as the Bald Eagle, representative of so much of our national heritage, is especially concerning.

AQUATIC AND RIPARIAN FRAGMENTATION:

The riparian and aquatic habitats of Aravaipa Creek and San Pedro River make up some of the most critical habitats of the Southwest deserts. The Gila Freshwater Ecoregion, of which the San Pedro River and Araviapa Creek and its canyon tributaries are a component, is ranked as "Continentally Outstanding" by the World Wildlife Federation (WWF), and its Conservation Status is "Critical." The San Pedro River and Aravaipa Creek is one of the North American sites listed in the WWF ecoregional assessment as "Important Sites for the Conservation of Freshwater Biodiversity in North America."

The waters and associated habitats in the Southwest are exceedingly degraded, so that an Arizona Game and Fish Department and U.S. Geological Survey ecological assessment of Arizona's streams and rivers found that 70% of Arizona's stream length was assessed to be in "most-disturbed" ecological condition. As a consequence, native fish are the most endangered class of animals in the region, with 21 of 36 native species listed as threatened or endangered.

It is not coincidental that the Aravaipa Creek and Lower SPRV's unique unfragmented and intact landscape contains some of the best waters and native fish habitat in the Southwest. The San Pedro River is among only 2% of the nation's rivers that remain free-flowing and undeveloped. Further, Aravaipa Canyon has been listed by ADEQ as a Unique Water. Aravaipa Creek is the single richest site for native fish in Arizona. It still supports seven kinds of native fish in the virtual absence of non-native species. It is also prime habitat for the Lowland leopard frog, a species of concern, as are so many amphibians.

Of particular concern to these waters and habitats is soil erosion caused by powerline roads along the forty-five miles of Aravaipa watershed and Lower SPRV transected by SunZia's proposed Aravaipa route (Figures 6, 7, 10). These steep roads that must cross multiple drainages to high point tower placements all drain into washes and canyons carrying heavy sediment loads.   These in turn drain into Aravaipa Creek which is amongst the few steams still hospitable to native fish. Excessive sedimentation is a major concern for native fish habitat in particular, as it fills in and chokes their pools and riffles. Increased sediment loads also leads to increased scouring in flood events, eroding stream banks and vegetation that make up so much of these critical aquatic and riparian habitats.

The greatest impacts of sedimentation occur during events when streams are flowing and fish habitat is most in flux. Further, due to improved management by ranchers and various status lands, these riparian habitats are significantly improving, building banks, increasing in vegetation and flow regimes.

The aquatic and riparian fragmentation impacts of the SunZia roads would also occur throughout the ecosystem, since it is all connected, and particularly so with regard to water courses. Sedimentation impacts have been shown to be magnified by the number of drainages crossed by a road. In the Aravaipa watershed, where the linear transect would cross an abundance of drainages, the impacts to riparian areas are compounded, especially in the Aravaipa Creek.

Many who point to the abundance of open space in the Southwest deserts do not account that these aquatic and riparian areas comprise less than one percent of the geographic area, and yet 80% of animal species that inhabit that open space are reliant on them during at least some phase of their life cycle.   Riparian woodlands in the region are now one of the rarest habitat types in North America. The Mixed Broadleaf Deciduous Riparian Forests, Fremont Cottonwood-Gooding Willow, and Mesquite Bosque that compose the riparian woodlands of the Aravaipa watershed and Lower SPRV are all rare and threatened plant communities, several of them globally so.

These riparian and aquatic habitats also serve as major connective corridors between uplands and Aravaipa Creek, with a tremendous variety of the rich diversity of mammal and avian species utilizing them for seasonal migration and dispersal. Springs, of which there are over 200 in the Lower SPRV, are also isolated but important riparian patches that would be impacted by excess sedimentation from steep backcountry roads.

An entire assemblage of native fish species, as well as the critical riparian habitats which are the arterial bloodflow of this unfragmented and intact landscape, would be significantly and directly impacted by the SunZia installation. That does not account for the immeasurable cumulative impacts that would attend expansion of the utility corridor and the likely development that would attend it.

AERIAL FRAGMENTATION:

Possibly the greatest direct impacts of a SunZia powerline installation would be to the resident and migratory avian populations of the San Pedro River Valley. The SPRV is internationally renowned as having one of the highest bird diversities of any area its size in the United States. Both the Upper and the Lower SPRV have been declared Globally Important Bird Areas. NAFTA's tri-national Commission for Environmental Cooperation was assembled due to the SPRV's critical importance for Mexico, the United States and Canada.

Over 400 bird species have been identified in the SPRV, fully half the species known in North America, which is a phenomenal number for an inland area where shore birds, which make up such a large component of species, are only rarely seen. Also, many species of concern, some federally listed, are known in the SPRV. Between 75 and 80% of the Audubon WatchList for bird species of national concern breeding or wintering in Arizona are found along its length.

The attribute for which the SPRV is best known, in conjunction with its being the last major free flowing river in the desert Southwest, is that it serves as the main migratory corridor for neotropical birds in the West, with migration densities up to ten times that known elsewhere. Further, it has been well documented that those migrants utilize the entire valley – river, tributary canyons and uplands – as flight corridor and habitat stopovers. This document confirmed that by the compilation of bird lists from a variety of sites throughout the Lower SPRV showing a wide diversity of species distribution (see Section IV, C.2 and Appendix).

Powerlines and towers have been shown to be significant factors in avian mortality, somewhat by electrocution, but especially because of collisions. Certain classes of birds, either by virtue of wing morphology, or of aerial habits, have been shown to be particularly vulnerable. That is especially the case for waterfowl near wetlands, and raptors in uplands. Both classes of birds and both habitats are well represented in the SPRV. But the neotropical migrants, for which the SPRV is so renowned, are especially at risk. Due to their propensity to migrate at night, in flocks, in extremes of weather, flying between oases and across broad fronts rather than direct north-south lines, along with exhaustion, young and inexperienced birds in the fall, and unfamiliarity with the area, these migrants are particularly vulnerable to powerline and tower collision fatalities.

Based upon studies, the USFS estimates more than 10,000 fatalities per year for 40 miles of powerline (the approximate length of the proposed SunZia route through the Aravaipa watershed to the San Pedro River) on average, for anywhere. In a major flight corridor like the SPRV, where migratory densities are demonstrably ten times that of other migratory corridors in the West, that figure would be expected to be compounded by orders of magnitude.

These migrant birds are demonstrably declining in population, which is of major concern not only for species viability, but for the major role they play in forest health as consumers of woodland predating insects. Mexican, American and Canadian forests are suffering as a result of their decline. In concert with the many rare or declining species of national concern that utilize the SPRV, this assemblage of species cannot afford fragmentation of its flight path and further depredation to its populations.

3. Discussion

The Aravaipa watershed and Lower San Pedro River Valley, through which SunZia's proposed Aravaipa route would pass, is part of the largest unfragmented and intact landscape with a major free flowing river in the desert Southwest. As a result of its merging of four globally significant terrestrial ecoregions and a continentally important freshwater ecoregion, along with eight biotic communities, it contains extraordinary biodiversity. It serves as the main neotropical migratory bird corridor in the Western United States, is one of the last major refugia for threatened and endangered native fish, and is within the region of, if not containing, the greatest diversity of mammal species in North America. It is also home to a half dozen rare or declining plant communities along with an extraordinary richness of reptiles and other classes of flora and fauna.

The proposed SunZia powerline installation, along with its service roads, has been shown to be a potentially major factor in fragmentation. Island biogeography, the paradigm of modern ecological science, has demonstrated that floral and faunal species and communities are vulnerable to decline and eventual extinction and collapse by creating edge effects, barriers and disjunction into smaller core habitats. This paper has documented that the powerlines, towers and service roads would fragment the terrestrial, aquatic and aerial habitats and accompanying floral and faunal species to their significant detriment.

The Aravaipa watershed and Lower SPRV is also demonstrably an unfragmented and intact cultural landscape rich in western history and lore, and continues as one of the rare places in the desert Southwest where ranching and its traditional lifestyle can sustainably steward lands in the midst of an unfragmented landscape of remarkable biodiversity. It is also home to a remarkable amalgam of conservation status lands held by a great assortment of federal, state, and county agencies and NGOs. The cultural diversity of the area reflects that of its biology.

What the fragmentation of the area would do to that cultural diversity, particularly with regard to the projected expansion of the utility corridor, access to off-road vehicles, and opening the door to exurban and suburban development, is speculative only in terms of time-frame and severity. It would certainly implicate direct financial impacts to the local ranching economy. The environmental service values provided by the Lower SPRV migratory bird habitat for the forests of North America magnify those economic impacts many times over.

The managerial recommendations for this area are consistent throughout: avoid fragmentation. That is the recommendation of the World Wildlife Federation global ecoregional analyses, and of The Nature Conservancy's local and more in-depth assessments. Every conservation organization that has weighed in on the issue has uniformly protested SunZia's proposed Aravaipa route. Various federal, state and county agencies and political representatives have voiced the same concerns. Finally, but not least, so have local institutions like the Redington and Winkelman Natural Resource Conservation Districts and, of course, the community-led Friends of the Aravaipa Region and Cascabel Working Group, all of these being associations of local agriculturalists and residents who know the area best.

Beyond managerial recommendations, there are legal statutes that are applicable in an area of the Aravaipa watershed and Lower SPRV's environmental significance. The Arizona Department of Environmental Quality has statutes protecting any degradation to designated Unique Waters, of which Aravaipa Canyon is one. Excessive sediment loads from the SunZia roads would be a water quality issue in the erosive soils of the area. Opening up access to the introduction of exotic species in the native fish habitats of backcountry streams could also be an issue.

One of the oldest conservation statutes in existence, the Migratory Bird Treaty Act (MBTA) of 1918, states that no migratory bird may be killed unless it is specifically exempted under a permit. The

MBTA is a strict liability statute, making the 'take' of migratory birds without a permit illegal, even if unintentional, incidental or inadvertent. That such an old statute should be in existence demonstrates the longstanding understanding of the environmental and economic importance of migratory birds. It seems certainly applicable in the main neotropical migratory corridor in the American West.

The Endangered Species Act (ESA) must of course come into consideration as one of the main environmental laws of the United States. Throughout this paper threatened and endangered species and species of concern have been documented. It is especially applicable to some bird species, native fish, some mammals and reptiles as well as plants. The direct impacts of terrestrial, aquatic and aerial fragmentation by the proposed SunZia installations are of sufficient severity to be implicated in ESA laws.

In the Upper SPRV, even indirect impacts have become considerations with regard to ground water withdrawals that are threatening the habitat upon which threatened and endangered species depend. There the argument is with regard to subterranean impacts. Here in the Lower SPRV and Aravaipa watershed where the landscape is largely unfragmented and intact, similar arguments could be made with regard to terrestrial, aquatic and aerial fragmentation impacts on the habitats of vulnerable species.

The ESA is important in documenting vulnerable species, which are certainly valuable in their own right, but also as "canaries in the coal mine" and bellwethers of ecosystem dysfunction. On the other hand, the ESA was crafted on older biological models before the broader understandings of biogeography and ecoregional science lent better insights into the connectivity and interdependence of ecological systems. As a result it can isolate species concerns from their wider communities, and divide much of the human community as well.

That can be especially the case in the West where ranchers have had private property intrusions and been vilified over individual species concerns. That is both because of and despite the fact that very often ranches have been demonstrated to contain equal and sometimes better biodiversity than nature preserves.[563] Sometimes that demonstrated biodiversity has to do with the optimal lowland locations of ranches. But it is likely also testimony to the fact that ranches in the West tend to be inclusive of several different plant communities and habitats, and in that regard less fragmented than some nature preserves that focus on a single rich but isolated habitat.

The ESA can thus be a two-edged sword, and that may indeed be the case with the proposed SunZia Aravaipa route. Because the ESA focuses so greatly on individual species and their habitats, environmental consultants have become adept at the legalistic maneuvering that skirts protected status lands and species, which abides by the letter but affronts the spirit of the law.

Such maneuvering controverts everything learned from modern biological science, and the weight of all the evidence of the importance of connectivity demonstrated throughout this paper. It is also an affront to the conservation work performed by area ranchers, as though their lands adjoining protected ones are of less biological importance. It also disrespects the importance of our Arizona State Lands, as though financial costs are the ultimate measure of importance. It is even a slight to the considerable work of the Bureau of Land Management (BLM), facilitating the SunZia process, which has been so active in the Aravaipa watershed and Lower SPRV and invested tens of thousands of taxpayer dollars to protect lands adjacent to this proposed installation. It indicates the outdated perspectives that BLM has admitted as being short-sighted and counterproductive, and is just now engaging in Rapid Ecoregional Assessments with particular focus on the appropriate siting of renewable energy and conservation areas in cooperation with The Nature Conservancy[564].

The NEPA statutes seem the most well-rounded and applicable to this situation. The context as well as the intensity and severity of direct, indirect and cumulative impacts on ecological, aesthetic, historic, cultural, economic, and social functions, as well as cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, and ecologically critical areas of the Aravaipa watershed and Lower SPRV by the SunZia proposals appear beyond question. Any fair and reasonable application of these laws should lead to a judgment of Environmental Objection.

The Aravaipa watershed and Lower San Pedro River Valley is clearly environmentally unique and important. The valley residents and its supporters are united within their diversity far beyond any "Not-In-My-Back-Yard" concerns. In the midst of growing urban pressures in the region, an area of this significance needs to be conserved for its local, state, regional, national, continental, hemispheric and global importance.

BIRDS OF THE LOWER SAN PEDRO RIVER VALLEY

Scientific Name	Common Name	Attribution
Grebes		
Podilymbus podiceps	Pied-billed Grebe	1, 5, 6, 7
Podiceps nigricollis	Eared Grebe	1, 6, 7
Herons and Allies		
Ardea herodias	Great Blue Heron	1, 2, 3, 4, 5, 6, 7
Ardea alba	# Great Egret	4, 6
Egretta tricolor	Tricolored Heron	1
Egretta thula	# Snowy Egret	1, 4, 6, 7
Bubulcus ibis	Cattle Egret	3, 4
Butorides virescens	Green Heron	1, 5, 6, 7
Nycticorax nycticorax	Black-crowned Night Heron	1, 4, 5, 6
Ixyobrychus exilis	Least Bittern	6
Ibises and Spoonbills		
Plegadis chihi	White-faced Ibis	1, 5, 6
Swans, Geese, and Ducks		
Dendrocygna bicolor	Fulvous Whistling-Duck	4
Dendrocygna autumnalis	# Black-bellied Whistling-Duck	1, 5, 6
Chen caerulescens	Snow Goose	1
Chen rossii	Ross's Goose	1, 6
Branta canadensis	Canada Goose	1, 6, 8
Aix sponsa	Wood Duck	1, 6
Anas americana	American Wigeon	1, 4, 5, 6, 7
Anas strepera	Gadwall	1, 5, 6, 7
Anas crecca	Green-winged Teal	1, 4, 5, 6, 7
Anas platyrhynchos	Mallard	1, 2, 4, 5, 6, 7

Scientific Name	Common Name	Attribution
Anas platyrhynchos	Mexican Duck	1
Anas acuta	Northern Pintail	1, 4, 5, 6, 7
Anas discors	Blue-winged Teal	1, 6
Anas cyanoptera	Cinnamon Teal	1, 4, 5, 6, 7
Anas clypeata	Northern Shoveler	1, 6, 7
Aythya valisineria	Canvasback	1, 6
Aythya americana	Redhead	1, 6, 7
Aythya collaris	Ring-necked Duck	1, 6, 7
Aythya affinis	Lesser Scaup	1, 6, 7
Bucephala clangula	Common Goldeneye	6
Bucephala albeola	Bufflehead	1, 6, 7
Mergus merganser	Common Merganser	6, 7
Oxyura jamaicensis	Ruddy Duck	1, 6
Osprey		
Pandion haliaetus	# Osprey	1, 3, 4, 6, 7
New World Vultures		
Coragyps atratus	Black Vulture	4, 7, 8
Cathartes aura	Turkey Vulture	1, 2, 3, 4, 5, 6, 7, 8
Hawks, Eagles and Kites		
Ictinia mississippiensis	# Mississippi Kite	4, 6
Haliaeetus leucocephalus	# Bald Eagle	1, 4, 7
Circus cyaneus	Northern Harrier	1, 3, 4, 5, 6, 7, 8
Accipiter striatus	Sharp-shinned Hawk	1, 3, 4, 5, 6, 7, 8
Accipiter cooperii	Cooper's Hawk	1, 2, 3, 4, 6, 7, 8
Accipiter gentilis	# Northern Goshawk	1, 4, 7
Buteogallus anthracinus	# Common Blawk-Hawk	1, 2, 3, 4, 6, 7, 8
Parabuteo unicinctus	Harris's Hawk	3, 5, 6, 7, 8
Buteo lineatus	Red-shouldered Hawk	6
Buteo platypterus	Broad-winged Hawk	4
Buteo nitidus	# Gray Hawk	1, 2, 3, 4, 5, 6, 7
Buteo swainsoni	* Swainson's hawk	1, 2, 4, 6, 7, 8

Scientific Name	Common Name	Attribution
Buteo albonotatus	Zone-tailed Hawk	1, 2, 3, 4, 5, 6, 7, 8
Buteo jamaicensis	Red-tailed Hawk	1, 2, 3, 4, 5, 6, 7, 8
Buteo regalis	# Ferruginous Hawk	4, 5, 6, 7, 8
Aquila chrysaetos	Golden Eagle	1, 3, 4, 5, 7, 8
Falcons and Caracaras		
Caracara cheriway	# Crested Caracara	1
Falco sparverius	American Kestrel	1, 3, 4, 5, 6, 7, 8
Falco columbarius	Merlin	4, 6, 7, 8
Falco mexicanus	Prairie Falcon	1, 2, 4, 6, 7, 8
Falco peregrinus	# Peregrine Falcon	1, 3, 4, 6, 7, 8
Turkeys		
Meleagris gallopavo	Wild Turkey	1, 2, 8
New World Quail		
Callipepla squamata	* Scaled Quail	3, 7, 8
Callipepla gambelii	Gambel's Quail	1, 2, 3, 4, 5, 6, 7, 8
Colinus virginianus ridgwayi	# Masked Bobwhite	1
Cyrtonyx montezumae	* Montezuma Quail	1, 7, 8
Pheasants and Partridges		
Alectoris chukar	Chuckar	1
Cranes		
Grus canadensis	Sandhill Crane	1, 4
Rails		
Rallus limicola	Virginia Rail	5, 6
Prozana Carolina	Sora	5, 6
Porphyrio martinica	Purple Gallinule	6
Gallinula chloropus	Common Moorhen	5, 6
Fulica Americana	American Coot	1, 5, 6, 7

Scientific Name	Common Name	Attribution
Avocets and Stilts		
Recurvirostra americana	American Avocet	1
Plovers		
Charadrius vociferus	Killdeer	1, 3, 4, 5, 6, 7, 8
Sandpipers and Allies		
Gallinago delicata	Wilson's Snipe	1, 4, 5, 6, 7, 8
Limnodromus scolopaceus	Long-billed Dowitcher	1
Actitis macularia	Spotted Sandpiper	1, 4, 6, 7, 8
Tringa solitaria	Solitary Sandpiper	1, 3, 6
Tringa melanoleuca	Greater Yellowlegs	1, 6
Tringa flavipes	Lesser Yellowlegs	1, 4
Calidris bairdii	Baird's Sandpiper	1
Calidris minutilla	Least Sandpiper	1, 6, 7
Calidris mauri	Western Sandpiper	1
Phalaropus tricolor	Wilson's Phalarope	1
Pigeons and Doves		
Columba livia	Rock Dove	1, 3, 4, 6, 8
Patagioenas fasciata	Band-tailed Pigeon	1, 8
Streptopelia bitorquata	Eurasian Collared-Dove	3, 4
Zenaida macroura	Mourning Dove	1, 2, 3, 4, 5, 6, 7, 8
Zenaida asiatica	White-winged Dove	1, 2, 3, 4, 5, 6, 7, 8
Columbina passerina	Common Ground-Dove	1, 2, 3, 4, 5, 6, 7, 8
Columbina inca	Inca Dove	1, 2, 3, 5, 6, 7, 8
Cuckoos and Allies		
Coccyzus americanus	# Yellow-billed Cuckoo	1, 2, 3, 4, 5, 6, 7, 8
Geococcyx californianus	Greater Roadrunner	1, 2, 3, 4, 5, 6, 7, 8
Owls		
Tyto alba	Barn Owl	1, 2, 4, 5, 6, 7, 8
Otus flammeolus	* Flammulated Owl	7, 8

Scientific Name	Common Name	Attribution
Megascops kennicottii	Western Screech-Owl	1, 3, 4, 5, 6, 7, 8
Megascops trichopsis	Whiskered Screech-Owl	5, 8
Bubo virginianus	Great Horned Owl	1, 3, 4, 5, 6, 7, 8
Strix occidentalis	! # Spotted Owl	1
Strix varia	Barred Owl	1
Glaucidium gnorma	Northern Pygmy Owl	1, 8
Glaucidium brasilianum	# Ferruginous Pygmy-Owl	1, 7
Micrathene whitneyi	* Elf Owl	1, 3, 4, 7, 8
Athene cunicularia	Burrowing Owl	1, 4, 8
Aegolius acadicus	Northern Saw-whet Owl	7, 8
Asio otus	Northern Long-eared Owl	7, 8
Asio flammeus	* Short-eared Owl	7, 8
Nightjars and Allies		
Chordeiles acutipennis	Lesser Nighthawk	1, 2, 3, 4, 5, 6, 7, 8
Chordeiles minor	Common Nighthawk	4
Phalaenoptilus nuttallii	Common Poorwill	1, 3, 4, 7, 8
Caprimulgus ridgwayi	Buff-collared Nightjar	1, 6
Caprimulgus vociferus	Whip-poor-will	4, 8
Swifts		
Chaetura vauxi	Vaux's Swift	1, 7, 8
Aeronautes saxatalis	White-throated swift	1, 2, 3, 4, 5, 6, 7, 8
Hummingbirds		
Cynathus latirostris	Broad-billed Hummingbird	1, 3, 4, 6, 7, 8
Eugenes fulgens	Magnificent Hummingbird	3, 8
Archilochus alexandri	Black-chinned Hummingbird	1, 2, 3, 4, 5, 7, 8
Calypte anna	Anna's Hummingbird	1, 2, 3, 4, 5, 6, 7, 8
Calypte costae	* Costa's Hummingbird	1, 3, 6, 7, 8
Stellula calliope	Calliope Hummingbird	3, 4, 8
Selasphorus platycercus	Broad-tailed Hummingbird	1, 3, 4, 7, 8
Selasphorus rufus	Rufous Hummingbird	1, 3, 4, 6, 7, 8
Selasphorus sasin	Allen's Hummingbird	4

Scientific Name	Common Name	Attribution
Kingfishers		
Megaceryle alcyon	# Belted Kingfisher	1, 2, 4, 6, 7, 8
Woodpeckers		
Melanerpes lewis	! Lewis's Woodpecker	1, 4, 6, 7, 8
Melanerpes formicivorus	Acorn Woodpecker	1, 6, 7, 8
Melanerpes uropygialis	Gila Woodpecker	1, 2, 3, 4, 5, 6, 7, 8
Sphyrapicus varius	Yellow-bellied Sapsucker	1, 8
Sphyrapicus nuchalis	# Red-naped Sapsucker	4, 5, 6, 7
Sphyrapicus thyroideus	* Williamson's Sapsucker	1, 8
Picoides scalaris	Ladder-backed Woodpecker	1, 2, 3, 4, 5, 6, 7, 8
Picoides arizonae	* Arizona Woodpecker	1, 7, 8
Picoides villosus	Hairy Woodpecker	8
Colaptes auratus	Northern Flicker	1, 2, 3, 4, 5, 6, 7, 8
Colaptes chrysoides	! Gilded Flicker	2, 3
Tyrant Flycatchers		
Camptostoma imberbe	Northern Beardless Tyrannulet	1, 2, 4, 5, 6, 7, 8
Empidonx traillii	* # Willow Flycatcher	1, 2, 4, 5, 6, 8
Empidonax hammondii	Hammond's Flycatcher	1, 3, 6, 7, 8
Empidonax wrightii	Gray Flycatcher	1, 2, 3, 4, 5, 6, 7, 8
Empidonax oberholseri	Dusky Flycatcher	1, 2, 6, 7, 8
Empidonax difficilis	Pacific Slope Flycatcher	5
Empidonax occidentalis	Cordilleran Flycatcher	2, 4, 6
Empidonax fulvifrons	# Buff-breasted Flycatcher	1
Contopus cooperi	* # Olive-sided Flycatcher	1, 4, 5, 6, 8
Cantopus pertinax	Greater Pewee	8
Contopus sordidulus	Western Wood-Pewee	1, 2, 3, 4, 5, 6, 7, 8
Sayornis nigricans	Black Phoebe	1, 2, 3, 4, 5, 6, 7, 8
Sayornis phoebe	Eastern Phoebe	1, 6
Sayornis saya	Say's Phoebe	1, 2, 3, 4, 5, 6, 7, 8
Pyrocephalus rubinus	Vermilion Flycatcher	1, 2, 3, 4, 5, 6, 7, 8
Tyrannus melancholicus	# Tropical Kingbird	2, 6

Scientific Name	Common Name	Attribution
Tyrannus vociferans	Cassin's Kingbird	1, 2, 3, 4, 5, 6, 7, 8
Tyrannus crassirostris	* # Thick-billed Kingbird	2, 6
Tyrannus verticalis	Western Kingbird	1, 2, 3, 4, 5, 6, 7, 8
Tyrannus forficatus	Scissor-tailed Flycatcher	3, 4
Myiarchus tuberculifer	Dusky-capped Flycatcher	5, 7
Myiarchus cinerascens	Ash-throated Flycatcher	1, 2, 3, 4, 5, 6, 7, 8
Myiarchus tyrannulus	Brown-crested Flycatcher	2, 3, 4, 5, 6, 7, 8
Deltarhynchus flammulatus	Flammulated Flycatcher	4
Pachyramphus aglaiae	# Rose-throated Becard	1
Larks		
Eremophila alpestris	Horned Lark	1, 7, 8
Swallows		
Riparia riparia	Bank Swallow	1, 6
Tachycineta bicolor	Tree Swallow	1, 4, 5, 6, 8
Tchycineta thalassina	Violet-green Swallow	1, 2, 4, 5, 6, 7, 8
Progne subis	# Purple Martin	1, 2, 3, 4, 5, 6, 7, 8
Stelgidopteryx serripennis	Northern Rough-winged Swallow	1, 2, 4, 5, 6, 7, 8
Hirundo rustica	Barn Swallow	1, 3, 4, 6, 7, 8
Petrochelidon pyrrohonota	Cliff Swallow	1, 4, 5, 6, 7, 8
Pipits		
Anthus rubescens	American Pipit	1, 3, 4, 5, 6, 7
Kinglets		
Regulus satrapa	Golden-crowned Kinglet	1, 8
Regulus calendula	Ruby-crowned Kinglet	1, 2, 3, 4, 5, 6, 7, 8
Silky-flycatchers		
Phainopepla nitens	Phainopepla	1, 2, 3, 4, 5, 6, 7, 8
Waxwings		
Bombycilla cedrorum	Cedar Waxwing	1, 4, 5, 6, 7, 8

Scientific Name	Common Name	Attribution
Dippers		
Cinclus mexicanus	American Dipper	1, 7
Wrens		
Campylorhynchus brunneicapillus	Cactus Wren	1, 3, 5, 6, 7, 8
Salpinctes obsoletus	Rock Wren	1, 3, 4, 6, 7, 8
Catherpes mexicanus	Canyon Wren	1, 3, 7, 8
Thryomanes bewickii	Bewick's Wren	1, 2, 3, 4, 5, 6, 7, 8
Troglodytes troglodytes	Winter wren	7
Troglodytes aedon	House Wren	1, 2, 4, 5, 6, 7, 8
Cistothorus palustris	Marsh Wren	2, 5, 6
Mockingbirds and Thrashers		
Mimus polyglottos	Northern Mockingbird	1, 2, 3, 4, 5, 6, 7, 8
Oreoscoptes montanus	# Sage thrasher	1, 3, 5, 8
Toxostoma bendirei	! Bendire's Thrasher	3, 7, 8
Toxostoma curvirostre	Curve-billed Thrasher	1, 3, 4, 5, 6, 7, 8
Toxostoma crissale	Crissal Thrasher	1, 3, 4, 6, 7, 8
Thrushes and Allies		
Sialia sialis	# Eastern Bluebird	1, 8
Sialia mexicana	Western Bluebird	1, 3, 6, 7, 8
Sialia currucoides	Mountain Bluebird	1, 3, 4, 8
Myadestes townsendi	Townsend's Solitaire	1, 7, 8
Catharus ustulatus	# Swainson's Thrush	1, 7
Catharus guttatus	Hermit Thrush	1, 3, 4, 5, 6, 7, 8
Turdus migratorius	American Robin	1, 3, 4, 5, 6, 7, 8
Gnatcatchers		
Polioptila caerulea	Blue-gray Gnatcatcher	1, 3, 4, 6, 7
Polioptila melanura	Black-tailed Gnatcatcher	1, 2, 3, 5, 6, 7, 8
Long-tailed Tits		

Scientific Name	Common Name	Attribution
Psaltriparus minimus	Bushtit	1, 2, 5, 7, 8
Chickadees and Tits		
Poecile gambeli	Mountain Chickadee	8
Baeolophus wollweberi	Bridled Titmouse	1, 2, 3, 4, 5, 6, 7, 8
Baeolophus ridgwayi	Juniper Titmouse	1, 7
Nuthatches		
Sitta pygmaea	Pygmy Nuthatch	8
Sitta canadensis	Red-breasted Nuthatch	1, 6, 8
Sitta carolinensis	White-breasted Nuthatch	1, 4, 6, 7, 8
Creepers		
Certhia americana	Brown Creeper	5, 6, 7, 8
Penduline Tits		
Auriparus flaviceps	Verdin	1, 2, 3, 4, 5, 6, 7, 8
Shrikes		
Lanius ludovicianus	Loggerhead Shrike	1, 3, 4, 5, 6, 7, 8
Crows and Jays		
Cyanocitta stelleri	Steller's Jay	1, 4, 5, 8
Aphelocoma californica	Western Scrub-Jay	1, 3, 4, 5, 6, 7, 8
Aphelocoma ultramarina	Mexican jay	1, 7, 8
Gymnorhinus cyanocephalus	* Pinyon Jay	3, 8
Nucifraga columbiana	Clark's Nutcracker	8
Corvus cryptoleucus	Chihuahuan Raven	1, 4, 5, 6, 7
Corvus corax	Common Raven	1, 2, 3, 4, 5, 6, 7, 8
Starilings		
Sturnus vulgaris	European Starling	1, 2, 4, 5, 6, 7, 8
Old World Sparrows		

Scientific Name	Common Name	Attribution
Passer domesticus	House Sparrow	1, 3, 4, 5, 7, 8
Vireos		
Vireo bellii	! Bell's Vireo	1, 2, 3, 4, 5, 6, 7, 8
Vireo vicinior	* Gray Vireo	1, 7, 8
Vireo flavifrons	Yellow-throated Vireo	6
Vireo plumbeous	Plumbeous Vireo	1, 2, 5, 6, 7, 8
Vireo cassinii	Cassins Vireo	1, 2
Vireo huttoni	Hutton's Vireo	1, 2, 4, 5, 6, 7, 8
Vireo gilvus	Warbling Vireo	1, 2, 4, 5, 6, 7, 8
Vireo flavoviridis	Yellow-green Vireo	6
Siskins, Crossbills and Allies		
Carpodacus cassinii	Cassin's Finch	1, 8
Carpodacus purpureus	Purple Finch	6, 7
Carpodacus mexicanus	House Finch	1, 2, 3, 4, 5, 6, 7, 8
Loxia curvirostra	Red Crossbill	8
Carduelis pinus	Pine Siskin	1, 3, 5, 7, 8
Carduelis psaltria	Lesser goldfinch	1, 2, 3, 4, 5, 6, 7, 8
Carduelis lawrencei	* Lawrence's Goldfinch	1, 4, 6, 8
Carduelis tristis	American Goldfinch	1, 3, 5, 6, 8
Coccothraustes vespertinus	Evening Grosbeak	8
Olive Warbler		
Peucedramus taeniatus	Olive Warbler	8
New World Warblers		
Vermivora peregrina	Tennesse Warbler	1
Vermivora celata	Orange-crowned Warbler	1, 2, 3, 5, 6, 7, 8
Vermivora ruficapilla	Nashville Warbler	1, 5, 6, 8
Vermivora virginiae	* Virginia's Warbler	1, 3, 4, 7, 8
Vermivora luciae	* Lucy's Warbler	1, 2, 3, 4, 5, 6, 7, 8
Dendroica petechia	Yellow Warbler	1, 2, 3, 4, 5, 6, 7, 8
Dendroica coronata	Yellow-rumped Warbler	1, 2, 3, 4, 5, 6, 7, 8

Scientific Name	Common Name	Attribution
Dendroica nigrescens	Black-throated Gray Warbler	1, 2, 3, 4, 5, 6, 7, 8
Dendroica townsendi	Townsend's Warbler	1, 2, 3, 4, 5, 6, 8
Dendroica occidentalis	Hermit Warbler	1, 4, 8
Dendroica fusca	Blackburnian Warbler	3
Dendroica graciae	* Grace's Warbler	4, 8
Mniotilta varia	Black-and-white Warbler	6
Setophaga ruticilla	American Redstart	1, 5, 6
Helmitheros vermivorum	Worm-eating Warbler	6
Seiurus noveboracensis	Northern Waterthrush	1, 6
Oporornis tolmiei	MacGillivray's Warbler	1, 2, 3, 4, 5, 6, 7, 8
Geothlypis trichas	Common Yellowthroat	1, 2, 3, 4, 5, 6, 7
Wilsonia pusilla	Hooded Warbler	6
Wilsonia pusilla	Wilson's Warbler	1, 2, 3, 4, 5, 6, 7, 8
Cardellina rubrifrons	* Red-faced Warbler	8
Myioborus pictus	Painted Redstart	4, 7, 8
Icteria virens	Yellow-breasted Chat	1, 2, 3, 4, 5, 6, 7, 8
Tanagers		
Piranga flava	Hepatic Tanager	1, 4, 7, 8
Piranga rubra	Summer Tanager	1, 2, 3, 4, 5, 6, 7, 8
Piranga ludoviciana	Western Tanager	1, 2, 3, 4, 5, 6, 7, 8
Buntings, Sparrows and Allies		
Pipilo chlorurus	Green-tailed Towhee	1, 2, 3, 4, 5, 6, 7, 8
Pipilo maculatus	Spotted Towhee	1, 5, 6, 7, 8
Pipilo fuscus	Canyon Towhee	1, 3, 4, 5, 6, 7, 8
Pipilo aberti	* Abert's Towhee	1, 2, 3, 4, 5, 6, 7, 8
Aimophilia botterii	# Botteri's Sparrow	3
Aimophila cassinii	Cassin's Sparrow	1, 4, 8
Aimophila ruficeps	Rufous-crowned Sparrow	1, 3, 7, 8
Aimophila carpalis	* Rufous-winged Sparrow	2, 3, 4, 6, 7, 8
Spizella passerina	Chipping Sparrow	1, 2, 3, 4, 5, 6, 7, 8
Spizella pallida	Clay-colored Sparrow	1
Spizella breweri	* Brewer's Sparrow	1, 3, 4, 5, 6, 7, 8

Scientific Name	Common Name	Attribution
Spizella atrogularis	! Black-chinned Sparrow	1, 7, 8
Pooecetes gramineus	Vesper Sparrow	1, 3, 4, 6, 7, 8
Chondestes grammacus	Lark Sparrow	1, 2, 4, 5, 6, 7, 8
Amphispiza bilineata	Black-throated Sparrow	1, 2, 3, 4, 5, 6, 7, 8
Amphispiza belli	* Sage Sparrow	7, 8
Calamospiza melanocorys	* Lark Bunting	1, 3, 4, 6, 7, 8
Passerculus sandwichensis	Savannah Sparrow	1, 5, 6, 7, 8
Ammodramus savannarum	# Grasshopper Sparrow	1
Passerella iliaca	Fox Sparrow	5, 8
Melospiza melodia	Song Sparrow	1, 2, 4, 5, 6, 8
Melospiza lincolnii	Lincoln's Sparrow	1, 2, 3, 4, 5, 6, 7, 8
Melospiza georgiana	Swamp Sparrow	6
Zonotrichia leucophrys	White-crowned Sparrow	1, 3, 4, 5, 6, 7, 8
Zonotrichia albicollis	White-throated Sparrow	1, 6, 8
Zonotrichia atricapilla	Golden-crowned Sparrow	8
Junco hyemalis	Dark-eyed Junco	1, 3, 4, 5, 6, 7, 8
Junco phaeonotus	Yellow-eyed Junco	8
Calcarius ornatus	* Chestnut collared Longspur	1
Cardinals and Allies		
Cardinalis cardinalis	Northern Cardinal	1, 2, 3, 4, 5, 6, 7, 8
Cardinalis sinuatus	Pyrrhuloxia	1, 2, 3, 4, 5, 6, 7, 8
Pheucticus ludovicianus	Rose-breasted Grosbeak	1, 8
Pheucticus melanocephalus	Black-headed Grosbeak	1, 2, 3, 4, 5, 6, 7, 8
Guiraca caerulea	Blue Grosbeak	1, 2, 3, 4, 5, 6, 7
Passerina amoena	Lazuli Bunting	1, 2, 3, 4, 5, 6, 7, 8
Passerina cyanea	Indigo Bunting	1, 4, 6, 7
Passerina versicolor	* Varied Bunting	1, 3, 8
Blackbirds and Orioles		
Agelaius phoeniceus	Red-winged Blackbird	1, 3, 4, 5, 6, 8
Sturnella magna	Eastern Meadowlark	3, 4, 5, 8
Sturnella neglecta	Western Meadowlark	4, 5, 6, 7, 8
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	4, 5, 6, 8

Scientific Name	Common Name	Attribution
Euphagus carolinus	Rusty Blackbird	6
Euphagus cyanocephalus	Brewer's Blackbird	1, 3, 6, 7, 8
Quiscalus quiscula	Common Grackle	4
Quiscalus mexicanus	Great-tailed grackle	1, 2, 3, 4, 5, 6, 7
Molothrus aeneus	Bronzed Cowbird	1, 4, 6, 7, 8
Molothrus ater	Brown-headed Cowbird	1, 2, 3, 4, 5, 6, 7, 8
Icterus pustulatus	Streak-backed Oriole	6
Icterus cucullatus	Hooded Oriole	1, 2, 3, 4, 5, 6, 7, 8
Icterus bullockii	Bullock's Oriole	1, 2, 3, 4, 5, 6, 7, 8
Icterus parisorum	Scott's Oriole	1, 3, 4, 5, 7, 8

Figure 11: Lower San Pedro River Valley Bird List

This list is a compilation of data included in the bird lists for the following entities:

1) Aravipa Canyon Preserve (TNC)
2) BHP Billiton Riparian Corridor (Tucson Audubon)
3) Saguaro-Juniper Corporation (private)
4) Three Links Farm (TNC)
5) Bingham Cienega (Pima Co./TNC)
6) Cook's Lake (Bureau of Reclamation)
7) Muleshoe Ranch Preserve (TNC)
8) Saguaro National Park (East)

Common names preceded by the symbol '!' are listed in the Arizona Audubon Society WatchList as Red species, those species which are globally threatened and are considered Birds of Highest National Concern that occur within the United States.

Common names preceded by the symbol '*' are birds designated as Yellow species, those which are rare and declining in population to the extent that they will be designated Red species if their decline accelerates, or continues for long enough to cause their populations or range sizes to fall below predetermined limits.

Common names preceded by the symbol '#' are considered Species of Greatest Conservation Need (SCGN) by the Arizona Game and Fish Department. A list of SCGN species was compiled as an appendix to Arizona's State Wildlife Acton Plan prepared in April, 2006.

	SPECIES	RED LIST - 11	YELLOW LIST - 36	SGCN - 48
SPRNCA	**373**	**6**	**29**	**36**
THREE-LINKS	168	2	12	16
SAGUARO-JUNIPER	131	3	10	8
MULESHOE	187	4	16	14
ARAVAIPA	232	4	17	22
BHP	94	2	5	8
COOK'S LAKE	198	3	11	17
BINGHAM	145	1	5	8
SAGUARO NP	198	4	23	9
LOWER	**307**	**6**	**26**	**30**
TOTAL	**404**	**8**	**30**	**39**

Figure 12: Bird List Comparative Chart

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