Building Bridges for Wildlife:

Modeling the Richness of Human-Wildlife Encounters Over 15 Years Of Urban Growth in the Sky Islands

A Senior Capstone by

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Abstract: This study analyzes 15 years of wildlife tracking data across more than 40 transects in the Sky Islands surrounding landscape to investigate how human-wildlife encounters may respond to a decade of land development. The average detection of species per visit (ADPV), the quantification for human-wildlife encounters and indicator of species richness, was calculated for each transect across two sample periods 2001-2011 and 2011-2015. ArcMap was used to visualize the ADPV across sampling sites in the Sky Islands region. The p-value was then calculated to determine whether there was a significant difference between the ADPV of all species and of focal species before and after 2011. The results concluded there was no significant difference and the null hypothesis was accepted.

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Introduction

As urban land use further encroaches on undeveloped natural areas, planners are recognizing, more and more, the importance of mitigating habitat fragmentation and preserving landscape connectivity in order to preserve key wildlife species in natural areas. How does this play into the context of the diverse landscape in southern Arizona?

The mountain ranges in the Madrean Archipelago, also known as the Sky Islands, are hotspots for biodiversity for the wildlife species between southern U.S. and northern Mexico. Research on the wildlife within this region shows that the wildlife are not isolated to the mountains, and that connections between these ranges are crucial to preserve a healthy gene pool among species populations. What was previously an area that experienced little barriers to movement, now is threatened by heightened land development.-There is a gap in the knowledge on whether these landscape changes are impacting the diverse wildlife of this region. A major indicator of changes in wildlife populations would be the frequency of human-wildlife encounters. Previous studies have demonstrated that increases or decreases in human-wildlife encounters are symptomatic of disturbed habitats. Therefore, the goal of this study is to understand what human-wildlife encounters can tell us about the built environment's impact on the richness of the Sky Island's region.

The culmination of this research will produce a map of species persistence in the Sky Islands over the last 15 years combined with land use changes in the area. An interpretation of the results will determine areas vulnerable to fragmentation and provide a basis to suggest mitigation methods. Urban planners, land developers, and conservationists may use the analysis and recommendations to conserve biodiversity and enhance habitat connectivity in the Madrean Archipelago.

Lit Review

In order to fully comprehend the cross disciplines in this study, there are two objectives of this literary review: first, to investigate the known research between human land use and wildlife habitats; and secondly, to understand how to handle data from wildlife tracks to make inferences on the status of wildlife populations.

Human Land-Use Change in a Natural Landscape

Land-use change is the modification of the spatial configuration of a landscape for a new function (Verburg et al. 2013). These modifications come in a variety of forms such as deforestation, urban development, agriculture, etc. Increasing science has arisen to develop methods and models to understand the spatial and temporal dynamics of landscapes (Verburg et al. 2013). Landscapes are important because they provide space to produce food, inhabit, and extract natural resources. Increasing pressures from population growth, urbanization, commoditization, and climate change means that landscapes are increasingly changing (Verburg et al. 2013). In the analysis of land cover data over time, it is important to determine which of these factors may be driving the change in landscapes in the Madrean Archipelago Region.

The data used in this analysis comes from the U.S. Geological Survey's National Land Cover Database. This data is free and accessible to the public, while this is highly advantageous to this research it is important to assess the quality, strengths and limitations of this data (Gallant 2009). Careful assessment is especially important when simplifying the complex cover patterns of a landscape into clean, discrete categories (Gallant 2009). The land cover surveys will serve as a premise to understand any effects land cover change may have on the results of the study.

The Relation between Biodiversity and Habitat Fragmentation

Habitat fragmentation is the breaking up of habitat into separate, smaller pieces. Habitat fragmentation is generally understood to be a component of habitat loss by which fragmentation results from loss of habitat, but habitat loss does not always lead to fragmentation. Loss of habitat may lead to a smaller, single patch size without any fragmentation taking place (Andren 2015). One of the primary causes for the fragmentation of habitat is human development. The conversion of natural habitats for roads, agricultural, housing developments, and other industrial purposes can alter the landscape through loss of connectivity, increased fragmentation, and decrease in patch size (Andren 2015). This means that the gradual increase of habitat fragmentation may reach a threshold where afterwards small changes in the landscape will produce major consequences in the integrity of the ecosystem (Andren 2015). This principle coincides with the general assumption that habitat fragmentation has a large, negative effect on biodiversity (Fahrig 2003). The premise for this negative characterization stems from the fact that increased fragmentation leads to heightened isolation of the wildlife residing in the habitat fragments. The isolation of wildlife can lead to loss in genetic diversity and eventually lead to species extinction.

The Sky Islands are biodiversity hotspots in the Madrean region. They give residence to many wide-ranging animals including mountain lions, wolves, black bears, ocelots, and a jaguar. The natural landscapes in between the mountain ranges serve as linkages for these migrating species. It is critical that wildlife corridors are preserved and fragmentation is mitigated in order to sustain the natural connections between the Sky Islands and sustain the diverse wildlife populations in the region.

There are two aspects of biodiversity: (1) richness and (2) abundance. Abundance is difficult to determine from tracking surveys since the abundance of detected signs is not directly related to the abundance of wildlife (Long 2008). In order to produce meaningful conclusions from the tracking data, this study will focus on assessing the richness of species in the study area.

Tracking Wildlife in the Sky Island Region

Wildlife tracking is a non-invasive method for monitoring and assessing wildlife populations in their natural habitat. It can provide information on presence, relative abundance, occurrence, distribution and density of wildlife populations (Long 2008). Sky Island Alliance has used the practice as a tool to assess wildlife populations in the linkages of the Sky Island mountain ranges as well as a tool to engage citizen scientists in conservation efforts (Lamberton-Moreno, Avila-Villegas 2013). However, it is important to outline the limitations of wildlife tracking since the quality of the data is impacted by the skills of the user, distinguishability of the sign, quality of the terrain, and the subjectivity of interpretation (Lamberton-Moreno, Avila-Villegas 2013).

Track and sign identification at its basic form allows for occurrence-based measures which are a common mode of measurement for the monitoring and assessment of animal populations. The occurrence of an individual infers information on "population status, site occupancy, the proportion of area occupied, probability of occurrence, and a distribution of species" (Long 2008). By this method, sample units may be characterized as binary variables where each species is determined to be either present, 1, or absent, 0,. For the purpose of this study, a single detection is sufficient to assess species presence (Long 2008). Inferences based on observed occurrences can be ambiguous due to non-detection bias. In the following study, any detection of a species will equate the presence of the species in the survey area; but the non-detection of a species will not automatically equate the absence of the species. This measure is important because “in the presence of imperfect detection, an observed zero (i.e., putative absence) is ambiguous because it can result for one of two reasons: (1) the species was not present at the sample unit, or (2) the species was present but was undetected during sampling” (Long 2008).

The Wildlife Linkages Program of Sky Island Alliance (SIA) conducts data collection on wildlife presence across the interconnected landscape of the Madrean Archipelago Region. The program relies on citizen scientists to count tracks, scat, kills, live animal sightings, and other signs indicative of wildlife passing through over 40 sampling sites in the southern regions of Arizona and some parts of New Mexico (Lamberton-Moreno and Avila-Villegas 2013). Each sampling site consists of a mile long transect within the landscapes that link the Sky Island habitats. Though the Sky Island Region extends into New Mexico and Mexico, SIA’s data collection concentrates in southeast Arizona. A large-scale analysis of the entire Sky Island Region will likely show bias towards the southeast Arizona region. Reasons for this bias can be explained by 1) SIA is headquartered in Tucson, AZ, which means their resources and volunteers are much more available to projects conducted close to Tucson, AZ and 2) differences in policies across national borders restrict SIA’s conservation efforts beyond the United States.

Linear transects for ground-based surveys present may “impose substantial challenges regarding time, access, efficiency, safety, and sightability” (Long 2008). Therefore the selection of the sites was not completely random; in order to encourage regular sampling of each transect, sites were chosen for ease of access for citizen scientists. Thereby, the majority of sites are located within a 3 hour drive from the city of Tucson and have reliable access to paved roads and clear trails.

Focal species highlighted by Sky Island Alliance include: jaguar (*panther onca*), ocelot (*Leopardus pardalis*), bobcat (*Lynx rufus*), mountain lion (*Puma concolor*), Mexican gray wolf (*Canis lupus baileyi*), black bear (*Ursus americanus*), white-nosed coati (*Nasua narica*), and western ornate box turtle (*Terrapene ornata*). These focal species were chosen for their classification as a keystone, umbrella, indicator species, or habitat specialists (Lamberton-Moreno and Avila-Villegas 2013). These will also serve as the focal species for this study since the geographical region and characteristics of the habitat coincide with the study area of SIA's Wildlife Linkages Program.

Methodology

The aim of this study is to produce visual models of land use changes and wildlife presence in the area in order to interpret how land use change may affect the wildlife composition in the area of study. The study will follow a mixed methods approach that utilizes both quantitative and qualitative analyses of the data. The research is founded upon an assessment of land development and an understanding of wildlife populations in the Madrean Archipelago Region. Data on land use change is acquired from the U.S. Geological Survey's National Land Cover Database (NLCD) which provides spatial data on land cover and land cover change across the U.S. This data comprises of satellite images updated every 5 years. The land cover data will then be analyzed in conjunction with wildlife tracking data gathered by the citizen scientists of Sky Island Alliance (SIA), a non-profit organization, dedicated to the study and conservation of the Madrean Archipelago Region. SIA gathers wildlife tracking data on a monthly basis in designated transects throughout the Madrean Archipelago and includes location and characteristics of animal tracks.

The first phase of data analysis will examine SIA's tracking data, which consists of over 3,000 entries over 15 years. The quantitative analysis will calculate the average number of species detected per visit at each sampling site in order to determine the richness of human-wildlife encounters within the Sky Island landscape. The data will seek to determine whether there is a difference in the richness of human-wildlife encounters in surveys conducted before 2011 and after 2011. The null hypothesis assumes there is no difference in richness of species between the two sampling periods and the alternate hypothesis assumes there is a difference in the richness of species between the two sampling periods. A two-tailed t-test will be conducted to determine the p-value and conclude whether the difference is significant. The two-tailed t-test will allow for analysis in increases or decreases in the richness of human-wildlife encounters; significant changes in either direction end will call for further investigation. The significance level will be cut off at 0.05 to represent the conventional 5% chance of error.

One should note, there is no difference in the methods of collecting wildlife tracks and signs before and after 2011, the 2011 division between the sampling surveys allows for a 10-year difference between the start dates of each survey period and fits in congruence with the available data on land cover change from the National Land Cover Database. The resulting maps will provide a macro-scale look at species presence and the changes of land use over the past 15 years. If patterns present themselves this will require deeper investigation.

Data

The data focuses on the occurrence of species within the sampling sites derived from Sky Island Alliance's tracking surveys between 2001 and 2015. The objective of this analysis to understand the richness of human-wildlife encounters in the region. This means that the research will focus on one characteristic of the population status: richness of species as detected by humans.

In order to produce reliable conclusions from the wildlife tracks and sign surveys, several measures were taken to avoid bias and remove inconsistencies in the raw data. While the data includes surveys from over 40 transects across 15 years, the timelines for collection are not consistent. Some transects became active later in the program's duration, other transects became inactive. Therefore there are variations in the locations and the quantities of transects studied between 2001-2011 and 2011-2015. The data presents 40 active transects in 2001-2011 and 28 active transects in 2011-2015. The decrease in the quantity of sites studied is due to the greater number of years during 2001-2011, which allows for a longer window to sample across more sites. It is not necessarily an indication of reduced survey efforts over time. Additionally, some monthly collections were missed and contain no data. Thus the analysis of the data cannot be based upon a linear timeline.

Regarding the GPS coordinates of tracks and signs identified, the SIA database includes the exact coordinates for many of the signs recorded. However there is still a significant number of identifications without exact GPS locations. This proves to be an obstacle because the spatial data is fundamental to plotting wildlife presence onto a geographic map. Therefore, tracks and signs were reassigned their geographic coordinates based on the exact location of the transect itself. Since the research focuses on the presence/absence of species in an area, the exact location of each identification is not significant to the results. So long as it is known which transect the track or sign was found, the geographic information is sufficient to represent the richness of species in their respective sites.

To validate the research, it was important to conduct an analysis that was not dependent on spatial or temporal uniformity. The Average Detection per Visit value provides the solution to make inferences on the available data. This approach takes a look at the counts of species collected at each visit. By this method, a single occurrence of a species is sufficient to indicate the presence of the species in the area (Long 2008). This disregards the abundance of signs for individual species and takes note only on the presence of a species. Since some sites were visited more than others, a summary of counts was not enough to perform a comparison across the region. Therefore the data takes into consideration the average number of species detected per visit. The ADPV serves to represent the chances of encountering wildlife on a visit to the respective site. By using this number to compare detected species richness across all transects, one can infer which sites are more or less likely to present human-wildlife encounters. The analysis was performed on observations of all species. Since the presence of focal species are indicators of a healthy ecosystem, an additional analysis was performed exclusively on focal species. The species that presented themselves in the surveys include 5 out of 8 focal species: bobcat, mountain lion, black bear, coati, and box turtle.

The separation of samples into two sampling periods between 2001-2011 and 2011-2015 portrays results before and after the 2011 land cover collection from the National Land Cover Database. The calculated ADPV values between the two samples are then compared to determine whether there was a significant difference in the richness of human-wildlife encounters before and after 2011.

All Species Detected in Transects visited 2001-2011

TRANSECT NAME	LINKAGE STUDY AREA	TRANSECT ID	NUMBER OF VISITS	SPECIES COUNTS	ADVP
Amerind A	Whetstone/Dragoon	AMA	7	16	2
Apache Canyon	Cienega Corridor	AC	2	3	2
Black Draw	Peloncillos/Burro/Gila	BLK	5	16	3
Canoa Ranch Road	Canoa Ranch	CR	1	1	1
Cienega Creek A	Cienega Corridor	CCA	20	77	4
Clifford Wash	Whetstone/Dragoon	CW	33	114	3
Cottonwood Canyon	Santa Cruz/Tumacacori	CC	32	77	2
Cottonwood Flats	Santa Cruz/Tumacacori	CF	6	23	4
Doubtful Canyon	Peloncillos	DC	23	76	3
Fortynine West	Cienega Corridor	FNW	10	27	3
French Joe Canyon	Whetstone/Dragoon	FJC	2	7	4
Fresno Canyon	Cienega Corridor	FC	4	10	2
Gardner Canyon A	Cienega Corridor	GCA	31	136	4
Granite Gap	Peloncillos	GGP	27	134	5
Hay Hollow	Peloncillos/Burro/Gila	HAY	3	10	3
Las Chivas Wash	Santa Cruz/Tumacacori	LCW	57	248	4
Las Querencia	Santa Cruz/Tumacacori	LQ	40	137	3
Los Estrechos	Cienega Corridor	LOS	59	245	4
Marsh Station South	Cienega Corridor	MSS	1	7	7
Negro Canyon	Santa Cruz/Tumacacori	NC	20	54	3
North Canyon	Cienega Corridor	NCY	20	54	3
North Davidson Canyon	Cienega Corridor	NDC	69	341	5
North Railroad Loop	Cienega Corridor	NRL	58	214	4
Oracle Road A	Catalina/Tortolita	ORA	16	67	4
Rock Corral Canyon	Santa Cruz/Tumacacori	RCC	3	6	2
Sheehy Wash	Santa Cruz/Tumacacori	SHY	29	145	5
Slavin Gulch B	Whetstone/Dragoon	SGB	2	10	5
Slavin Wash A	Whetstone/Dragoon	SGA	25	85	3
Slavin Wash B	Whetstone/Dragoon	SGB	13	53	4
Smith Wash	Whetstone/Dragoon	SMW	36	162	4
South Davidson Canyon	Cienega Corridor	SDC	29	138	5
Stronghold West A	Whetstone/Dragoon	SWA	34	98	3
Stronghold West B	Whetstone/Dragoon	SWB	13	47	4
Tinker Canyon	Fort Huachuca	TCH	9	28	3
Toros Wash	Santa Cruz/Tumacacori	TW	10	28	3
Upper Davidson Canyon	Cienega Corridor	UDC	7	31	4
Utility Way A	Catalina/Tortolita	UWA	27	106	4
Utility Way B	Catalina/Tortolita	UWB	26	88	3
Vanar Wash	Catalina/Tortolita	VNR	7	20	3
Wakefield Canyon	Cienega Corridor	WFC	23	96	4

Table 1. Above shows the data collected across 40 sampling sites starting in 2001 until the start of 2011.

All Species Detected in Transects visited 2011-2015

TRANSECT NAME	LINKAGE STUDY AREA	TRANSECT ID	NUMBER OF VISITS	SPECIES COUNTS	ADVP
Canoa Ranch Road	CR	Canoa Ranch	8	59	7
Canoa Ranch Road	CR	Canoa Ranch	3	5	2
Cienega Creek A	CCA	Cienega Corridor	5	15	3
Finley-Adams Canyon	FAC	Patagonia/Huachuca/Sierra San Antonio	2	8	4
Fortynine East	FNE	Cienega Corridor	7	44	6
French Joe Canyon	FJC	Whetstone/Dragoon	10	41	4
Gardner Canyon A	GCA	Cienega Corridor	27	156	6
Granite Gap	GGP	Peloncillos	11	49	4
Hermosa Creek	HWC	Patagonia/Huachuca/Sierra San Antonio	2	10	5
Humboldt Canyon	HTC	Patagonia/Huachuca/Sierra San Antonio	2	10	5
Las Chivas Wash	LCW	Santa Cruz/Tumacacori	3	11	4
Las Querencia	LQ	Santa Cruz/Tumacacori	16	68	4
Los Estrechos	LOS	Cienega Corridor	5	21	4
Negro Canyon	NC	Santa Cruz/Tumacacori	1	4	4
North Canyon	NCY	Cienega Corridor	8	24	3
North Davidson Canyon	NDC	Cienega Corridor	13	55	4
North Railroad Loop	NRL	Cienega Corridor	3	5	2
Oracle Road A	ORA	Catalina/Tortolita	9	37	4
Santa Cruz River	SCR	Canoa Ranch	6	49	8
Santa Cruz River	SCR	Canoa Ranch	1	1	1
Slavin Wash A	SGA	Whetstone/Dragoon	1	9	9
Slavin Wash B	SGB	Whetstone/Dragoon	7	41	6
South Davidson Canyon	SDC	Cienega Corridor	10	41	4
Spring Canyon	SC	Peloncillos/Burro/Gila	1	1	1
Spring Canyon	SC	Peloncillos/Burro/Gila	10	57	6
Stronghold West A	SWA	Whetstone/Dragoon	1	5	5
Utility Way A	UWA	Catalina/Tortolita	8	34	4
Utility Way B	UWB	Catalina/Tortolita	1	1	1

Table 2. Data collected across 28 sampling sites between 2011 and 2015.

Results

P-values were calculated to determine whether there was a significant difference in the richness of human-wildlife encounters (ADPV) over 15 years of land cover change. A two-tailed t-test was performed between the samples during 2001-2011 and the samples 2011-2015 to determine whether there was a significant difference in the richness of human-wildlife encounters between the two time periods. The resulting p-values were 0.4884 and 0.0561 for all species and focal species surveys, respectively. The difference concludes to be insignificant. Therefore, the alternate hypothesis is rejected and the null hypothesis is considered to be true.

The following maps (figures 1-6) are screen shots from the resulting ArcMap and shows the resulting rates of human-wildlife encounters (ADPV) in the two sampling periods. The sizes of bubbles are useful in comparing the ADPV results of each site in relation to one another. The exact ADPV values are shown in the previous tables. The comparison of sampling periods demonstrate the changes in active and inactive sampling sites. Therefore the absence of circles does not negate the possibility of human-wildlife encounters in empty sites. The maps from NLCD show that there were indeed changes in impervious surfaces and land cover in the study area. However, since the data demonstrated no significance in ADPV values after a decade of changes, there was no basis for which to explore the impact of the built environment on the ADPV within the means of this study.

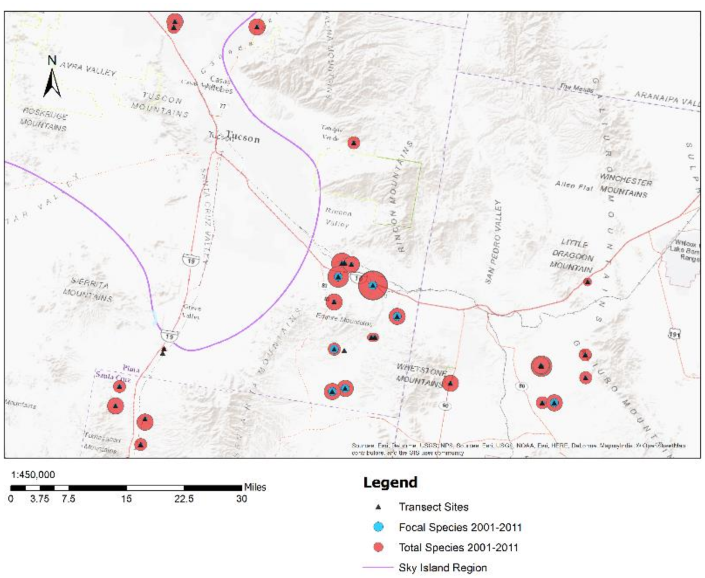

Figure 2. Richness of species detected in transects 2001-2011

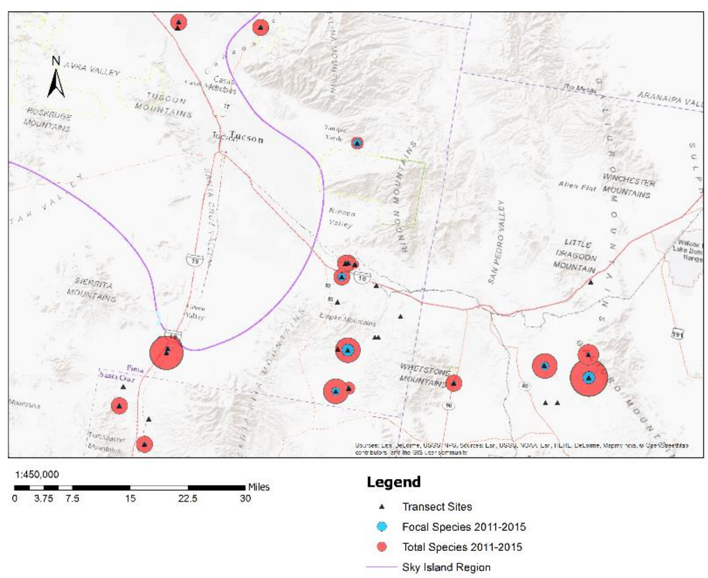

Figure 2. Richness of species detected in transects in 2011-2015

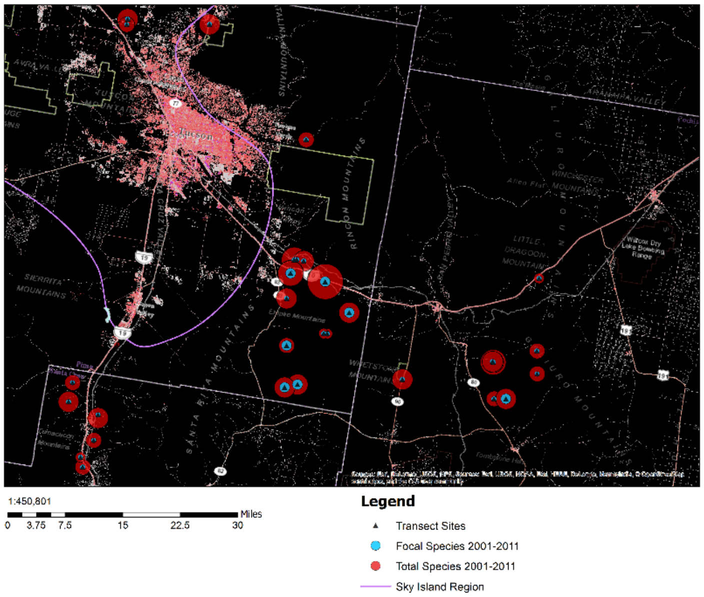

Figure 3. Impervious Surfaces 2001

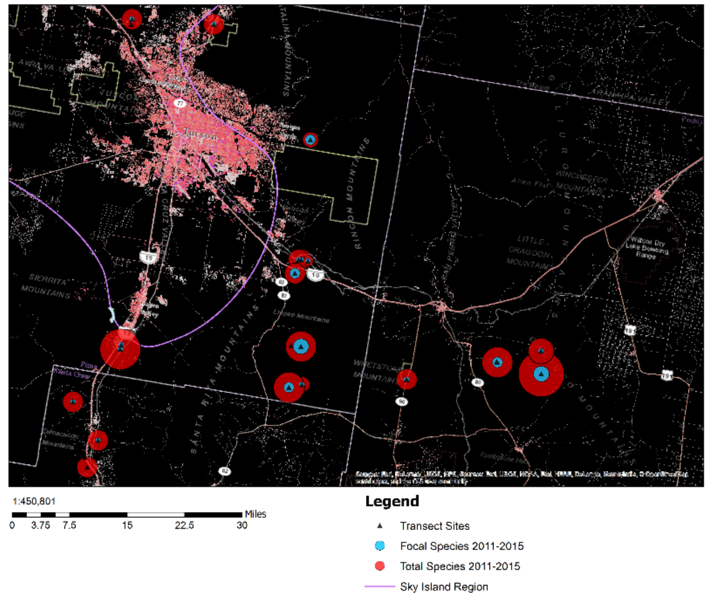

Figure 4. Impervious Surfaces 2011

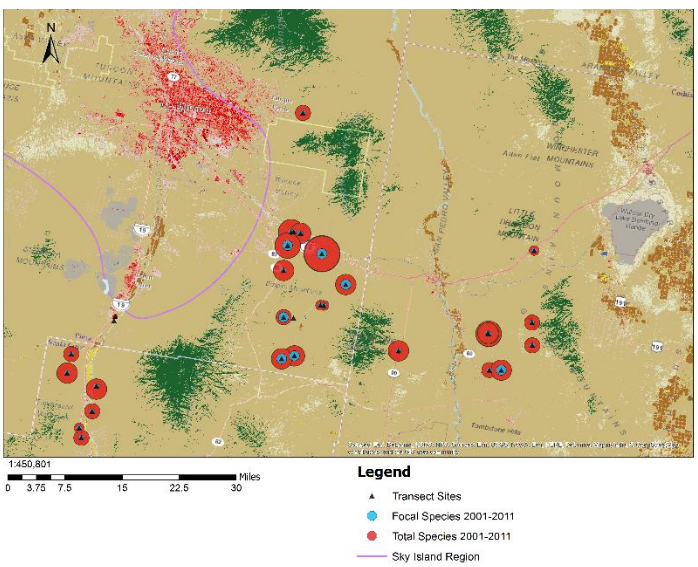

Figure 5. Land Cover 2001

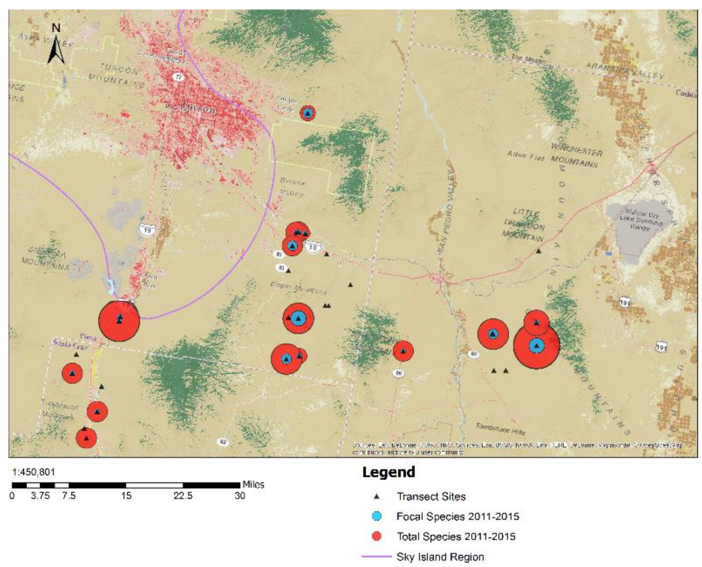

Figure 6. Land Cover 2011

Class\ Value	Classification Description
Water	
11	**Open Water** - areas of open water, generally with less than 25% cover of vegetation or soil.
12	**Perennial Ice/Snow** - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed	
21	**Developed, Open Space** - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	**Developed, Low Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	**Developed, Medium Intensity �** areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	**Developed High Intensity** -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren	
31	**Barren Land (Rock/Sand/Clay)** - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Forest	
41	**Deciduous Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42	**Evergreen Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
43	**Mixed Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Shrubland	
51	**Dwarf Scrub** - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52	**Shrub/Scrub** - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	
71	**Grassland/Herbaceous** - areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
72	**Sedge/Herbaceous** - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
73	**Lichens** - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
74	**Moss** - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
Planted/Cultivated	
81	**Pasture/Hay �** areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	**Cultivated Crops �** areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Wetlands	
90	**Woody Wetlands** - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95	**Emergent Herbaceous Wetlands** - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Figure 7. The legend above is taken from the National Land Cover Database and can be used to interpret the Land Cover maps in figures 5 & 6.

Discussion

The objective of the data analysis was to find the Average Detection per Visit at each sampling site in order to understand the richness of human-wildlife encounters in the Sky Island Region. This was done by analyzing data collected on all wildlife species encounters as well as on focal species encounters. The results concluded that over a decade of land development, there was no significant difference in the richness of human-wildlife encounters. However, the p-value for the ADPV of focal species was only .001 points away from the significance level which means additional data may prove to demonstrate a significant change in the richness of focal species before and after 2011.

An increase or decrease in human-wildlife encounters would mean that there has been a significant change in the diversity of the Sky Islands region. If a significant difference was found before and after 2011, this would infer a disturbance in natural habitats. In the end, the insignificant change in richness should be celebrated because it indicates that there is no significant harm on the wildlife richness in the linkages of the Sky Islands by the surrounding human development. The healthy diversity within the linkages that Sky Islands indicates a healthy biology within the mountain ranges as well. Nonetheless the results of the study should be further investigated in order to 1) confirm the results of the study with expanded data on the region and 2) to investigate what actions, if any, taken in urban development and conservation efforts in the region may have played a role in preserving the richness of the region.

Though the results conclude no significant difference in the richness of human-wildlife encounters, the fragility of the ecosystem processes and wildlife diversity should not be overlooked when developing in a rich biodiverse area like the Sky Island Region. Studies show that “the rapidity of change is intensifying faster than ever experienced in human history” with an expected increase to 79 percent urbanized land over the next two decades (Jochum et al. 2013). As urbanization and human populations continue to grow they encroach on natural habitats and threaten the vitality of the species within them.

Conclusion

Data from wildlife tracking surveys present many challenges due to inconsistencies in collection, variability in tracking skills, and identifiability from track and sign quality. Nonetheless the data collected by citizen scientists proves to offer valuable information on the detectability of wildlife in the landscapes where humans and wildlife converge. Though the results of this study concluded to be insignificant, further research should be conducted on human-wildlife encounters to understand whether the encroaching built environment leads to any impact. The study can do more to explore the implications of increased encounters between humans and wildlife. In hindsight it may prove useful to compare only the sites that were present in both sampling periods to get a more detailed understanding of specific sites.

Acknowledgements

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