Scenario Analysis: Evaluating Biodiversity Response to Forecasted Land-use Change in the San Pedro River Basin (U.S.-Mexico)

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A Community on Ecosystem Services
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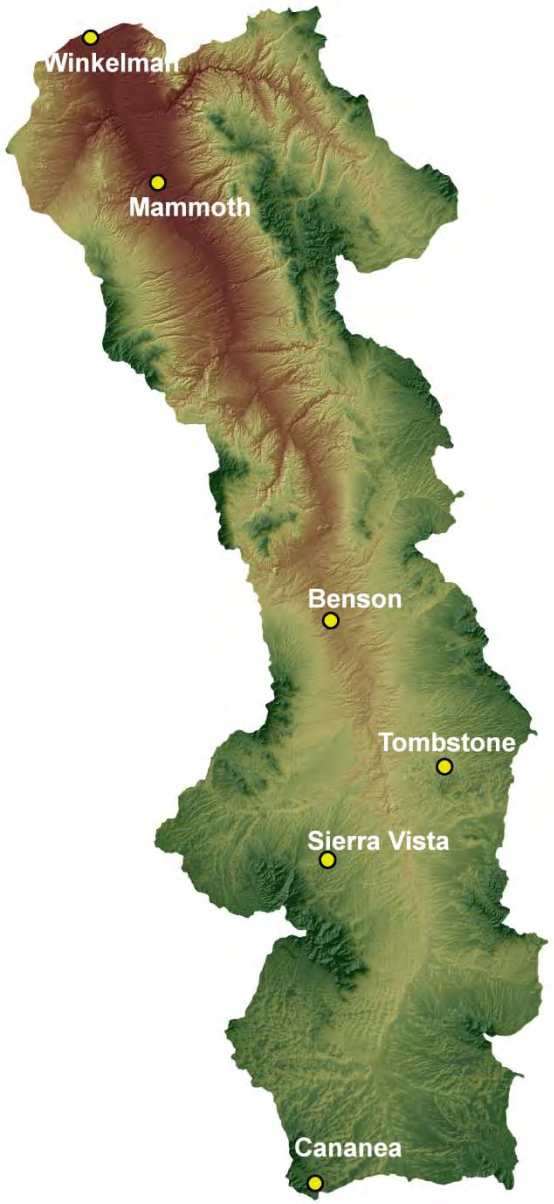
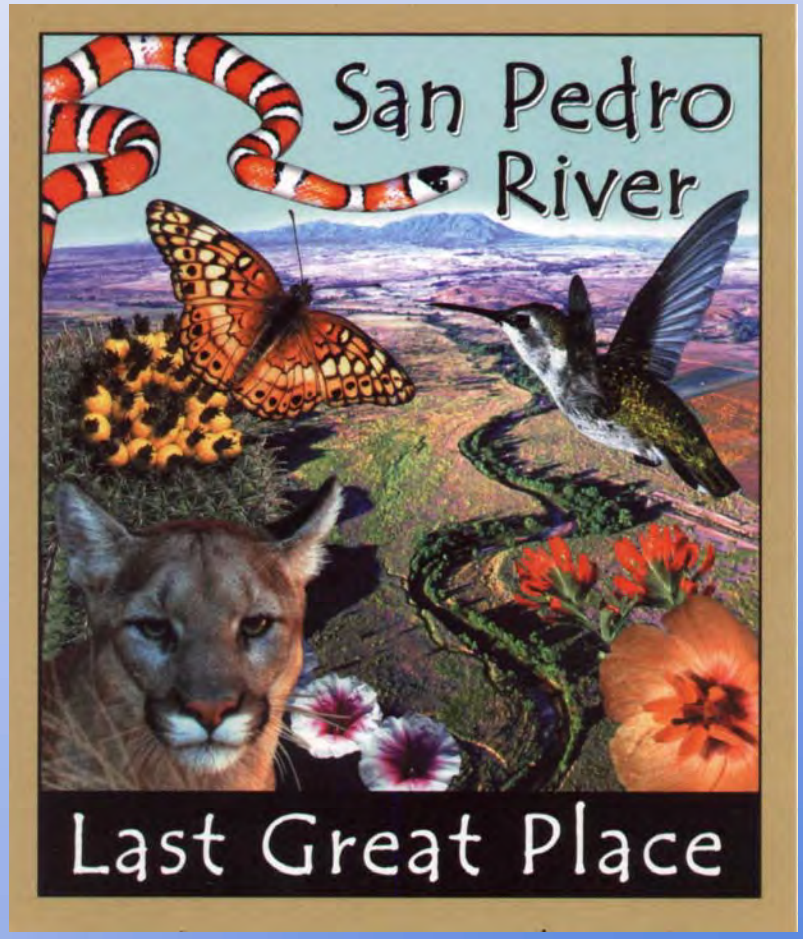
San Pedro River Basin

(U.S./Mexico, 9,800 km^2 and 1,800 km^2, respectively)



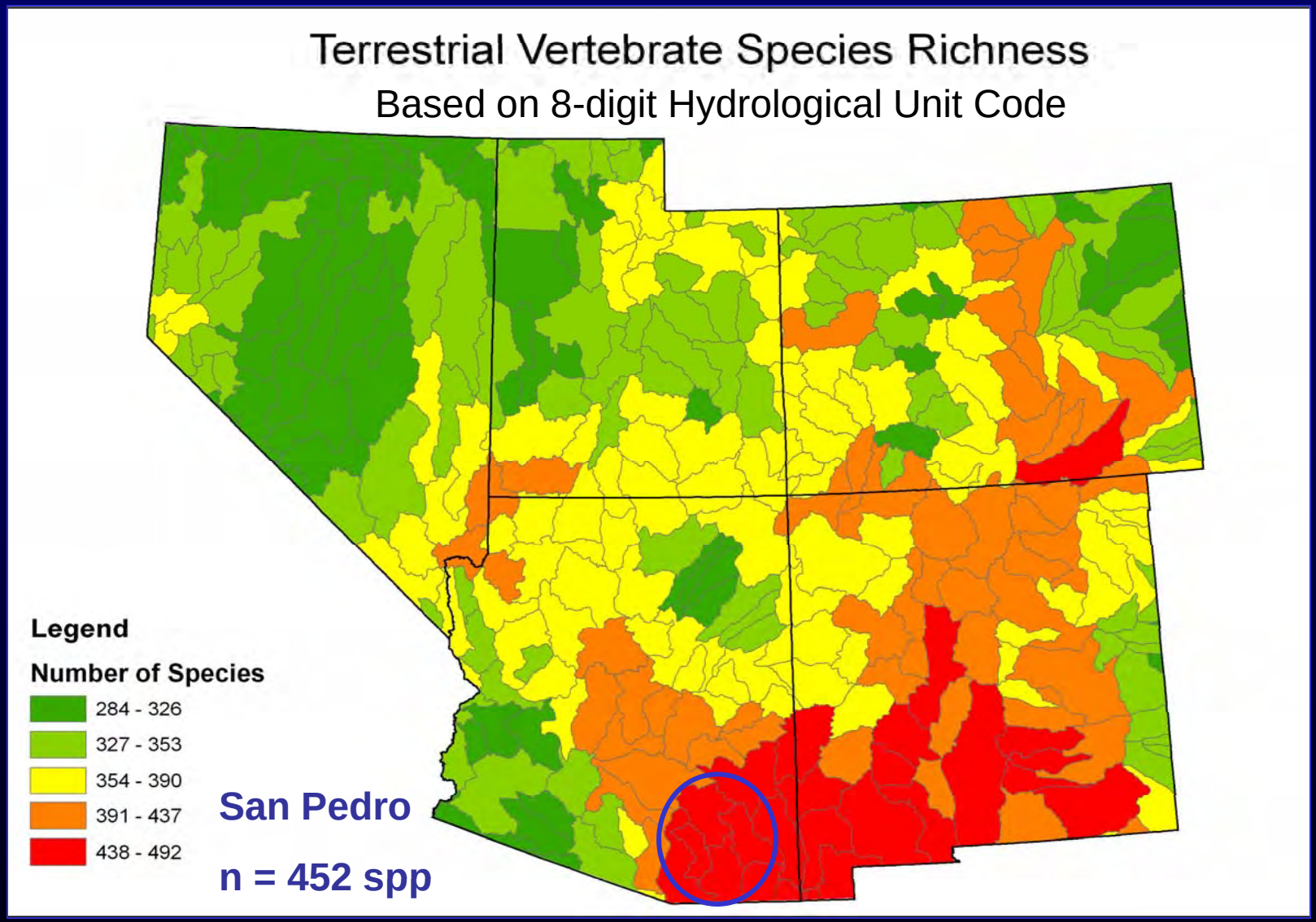
San Pedro River

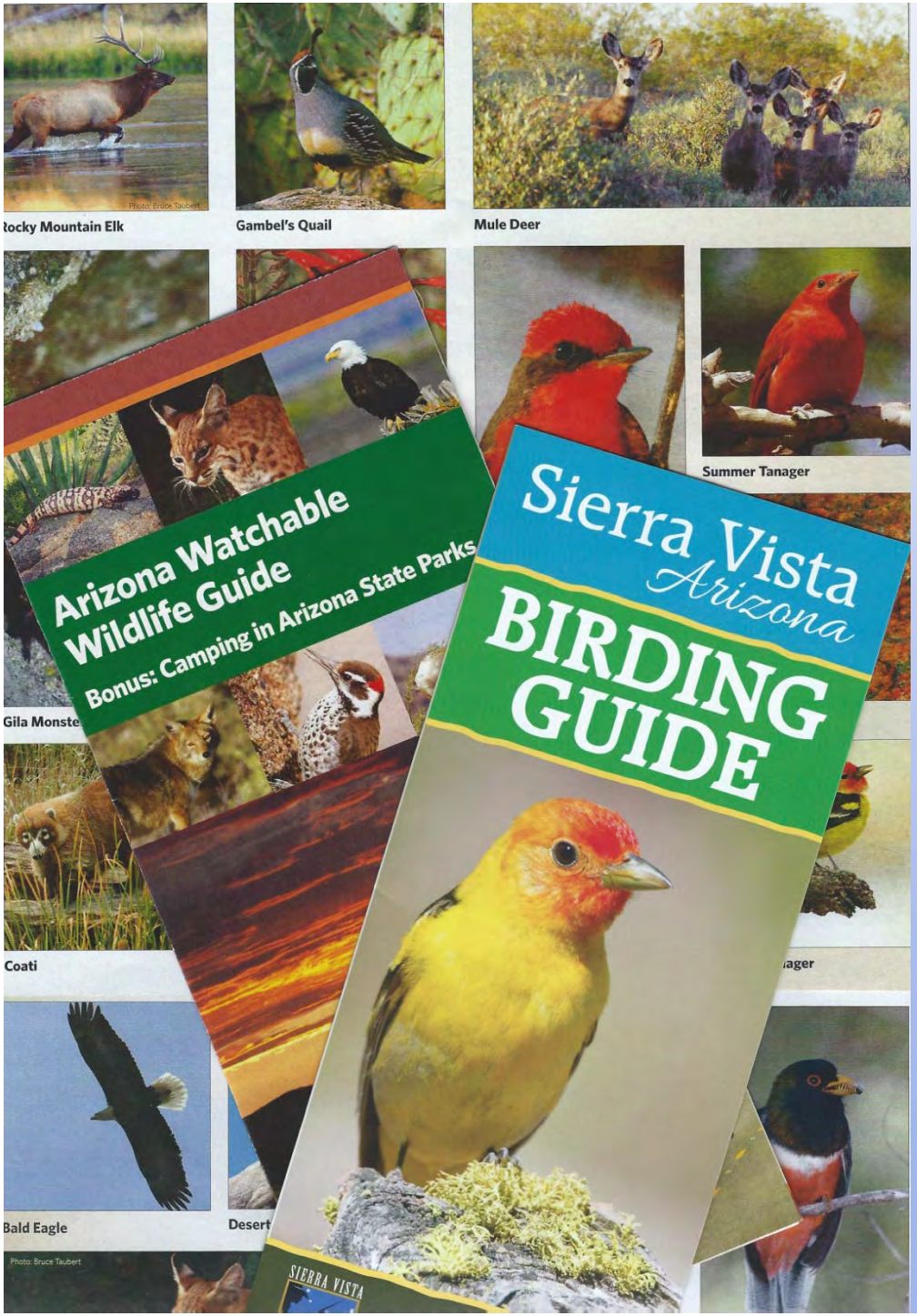
- **One of world's eight Last Great Places (TNC) – 6 preserves**
- **First designated National Riparian Conservation Area by Congress (1988)**
- **First designated Globally Important Bird Area in U.S. (American Bird Conservancy; 1996)**
- **Most Endangered River System (American Rivers)**



Terrestrial Vertebrate Species Richness

Based on 8-digit Hydrological Unit Code





Total Species = 452

Bird Spp = 287

Mammal Spp = 88

Reptile Spp = 61

Amphibian Spp = 16


W Kepner 1995

Analyzing Environmental Benefits & Consequences of Future Environments

PROBLEM:

How do changes in land use, and any subsequent change to land cover, affect ecological and what are the trade-offs between management decisions?

QUESTIONS:

Can growth patterns be managed to minimize environmental impacts?

How can impacts be assessed relative to the cumulative effect of past, proposed, or reasonably foreseeable future actions?

"Growth for the sake of growth is the ideology of the cancer cell." – Edward Abbey

Scenario:

Coherent, internally consistent, plausible description of a possible future state of the world; provide alternative views of future conditions considered likely to influence a given system or activity- IPCC

• Systematically explore implications of wide range of *alternative futures* related to key environmental stressors: **climate variation** *and* **land use** *or* endpoints: **habitat** *and* **water supply**

• Habitat used as a **surrogate measure of biodiversity**, an important societal value. Species richness can be an important indicator of ecosystem condition & it's ability to sustain ecosystem services in a number of categories, i.e. support function, regulating service, provisioning service, *and* cultural service.

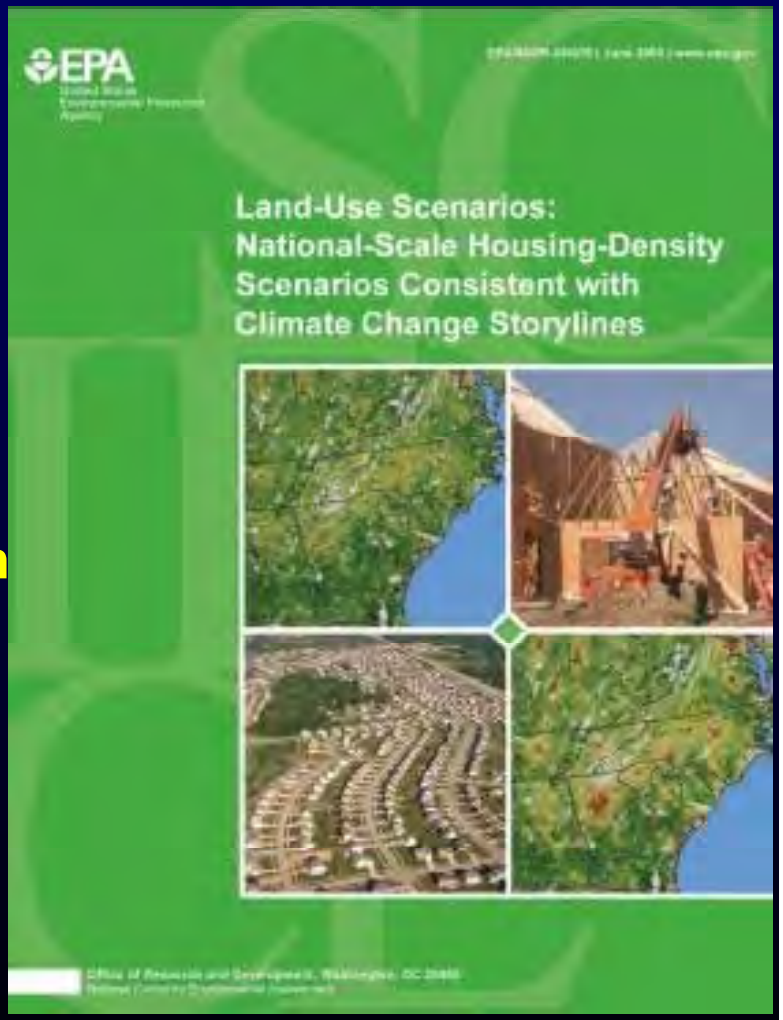
2. Land Use

1. Climate

3. Socially Relevant Endpoints, e.g. habitat

ICLUS: Integrated Climate and Land-Use Scenarios

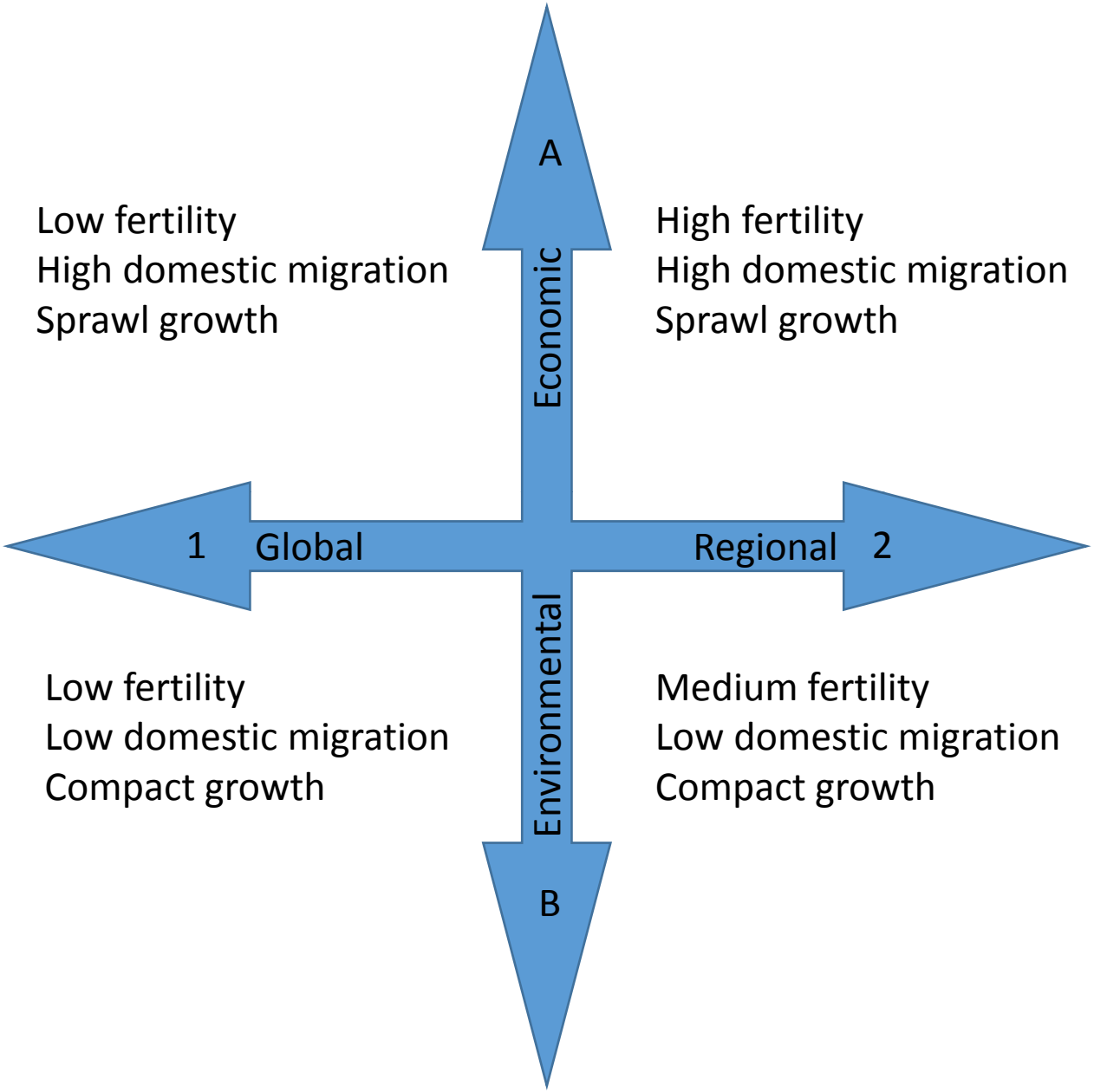
- Provides seamless land use scenarios for the **conterminous** United States consistent with IPCC emission storylines
- Demography and population at county level
- **Housing density allocated at 1 ha resolution**
- Estimated % impervious surface at 1 km^2 resolution



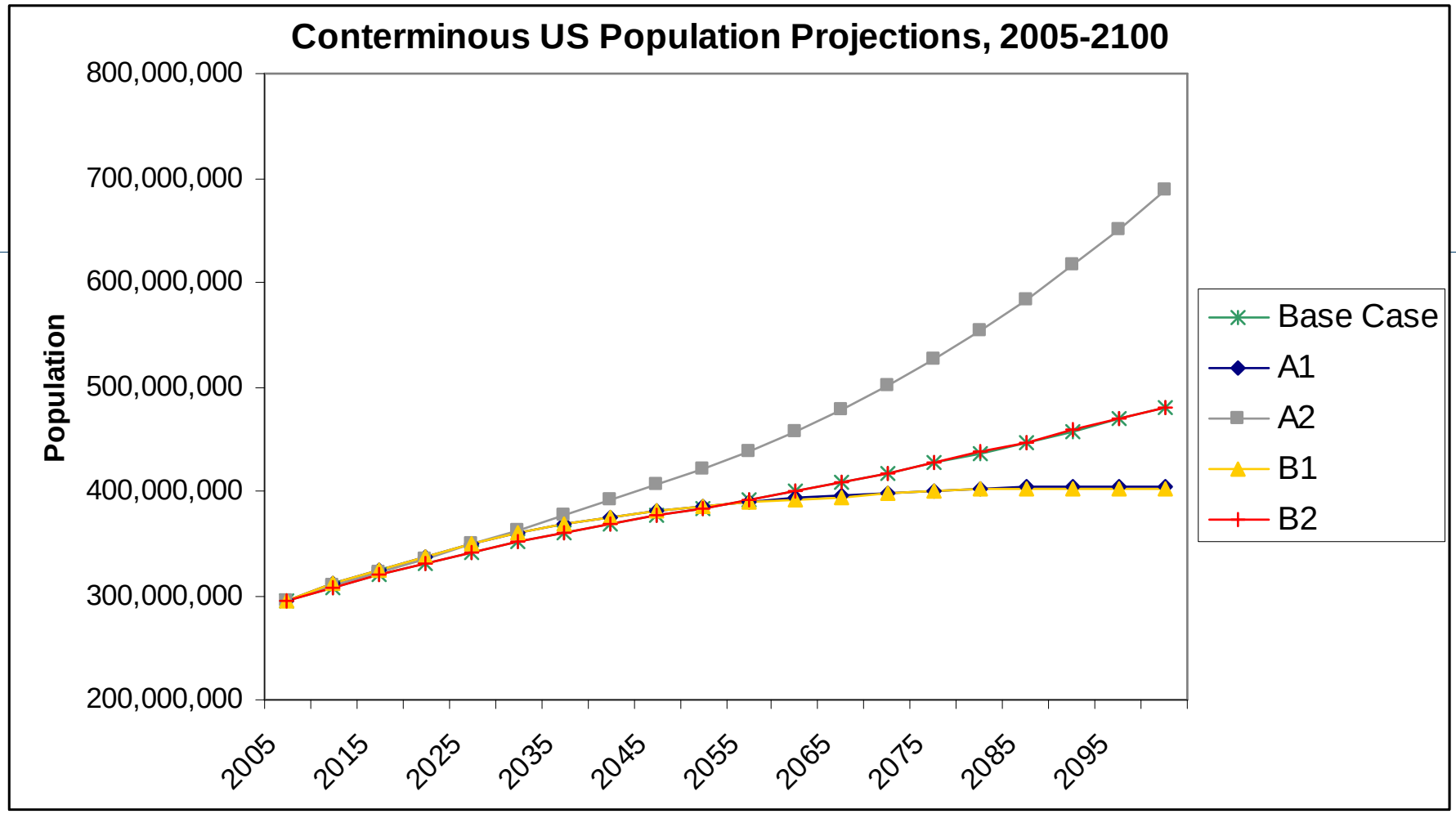
EPA Global Change Research Program
EPA/600/R-08/076F June 2009

Interpretation of Base Condition and Scenario Families for US

Global Scenario	Demographic Model			Spatial Allocation Model	
	Fertility	*Domestic migration*	*Net int'l migration*	*Household size*	*Urban Form*
A1: fast econ. dev.; med. pop growth; high global integration	Low	High	High	Smaller (-15%)	No change
B1: medium pop. growth rate; low dom. migration resulting in compact urban dev.	Low	Low	High	Smaller (-15%)	Slight compact
A2: high pop. growth rate, greatest land conversion, high dispersal (dom. migration) resulting in new pop. centers	High	High	Low	Larger (+15%)	No change
B2: moderate econ. dev.; med. pop growth; med int'l migr.	Medium	Low	Low	No change	Slight compact
Baseline (2000): US Census medium scenario	Medium	Medium	Medium	No change	No change


A
Economic
Low fertility
High domestic migration
Sprawl growth
High fertility
High domestic migration
Sprawl growth
1
Global
Regional
2
Environmental
B
Low fertility
Low domestic migration
Compact growth
Medium fertility
Low domestic migration
Compact growth

Population Projections for ICLUS Scenarios



Gap Analysis Products and Data Sources

(Southwest Region: AZ, NM, CO, UT, & NV)

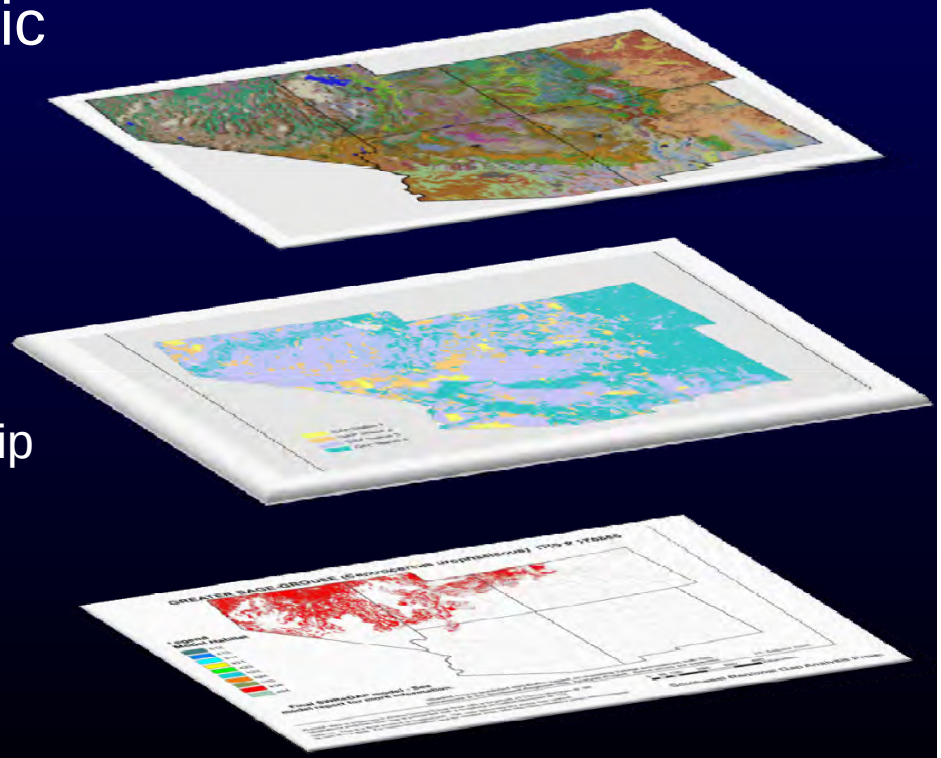
Deductive Habitat Models (817 spp)

- Knowledge based/expert based
- Wildlife Habitat Relationships
- Habitat based
- Top down - general to specific

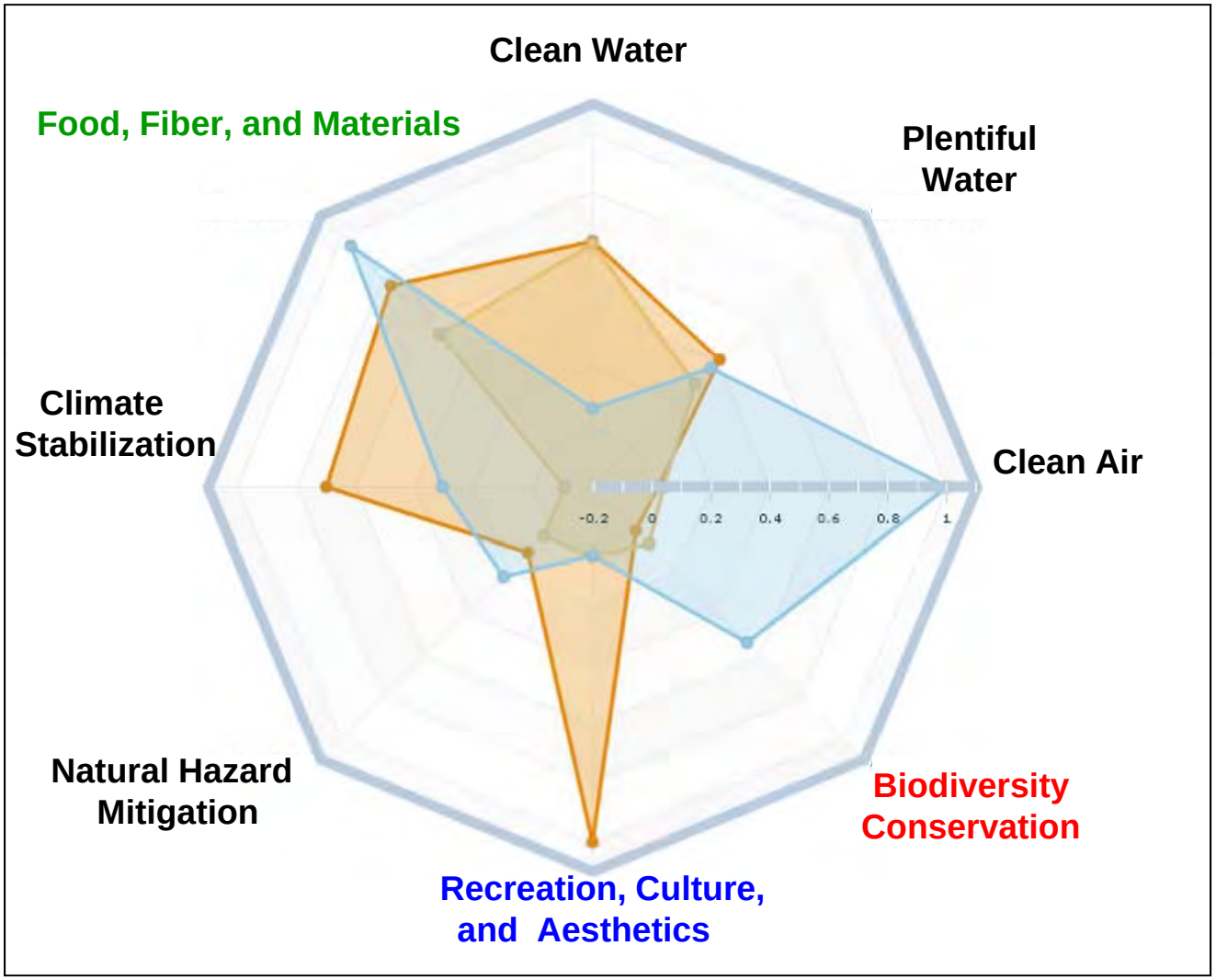
Land Cover (125 classes; Group 5 & 7 NVCS)

Land Ownership/Stewardship

Habitat Models



EnviroAtlas: Linking Ecosystems, People, and Well-being



* Total Species Richness

* Audubon Climate Threatened Species

* Total Harvestable Species

* Total Bird Species

Total Economic Effect =
$24,130,389/annum
Fish & Wildlife Economics and Statistics, Southwick Associates, 2013

Approach

Extracted

-Extracted all data for the San Pedro River Basin (AZ only) from the ICLUS seamless, national scale housing density dataset and the SWReGAP digital land cover and deductive habitat models for terrestrial vertebrates (n= 452 spp).

Reclassified

-The ICLUS Data was reclassified into 2 classes to represent Developed areas (urban, suburban, exurban) or Un-developed areas (rural & public lands).

Analyzed

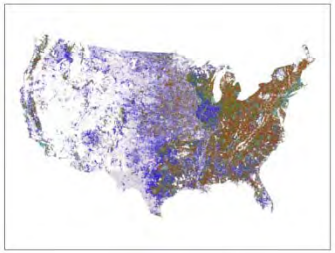
-The areas of each class for each biodiversity metric were then quantified for natural communities using the 5 ICLUS future development scenarios.

Compared

-The change in square kilometers and percent change in area of each biodiversity metric representing species habitat were compared between the baseline 2000 and all 5 future development scenarios for the year 2100.

Approach

National ICLUS Data Set

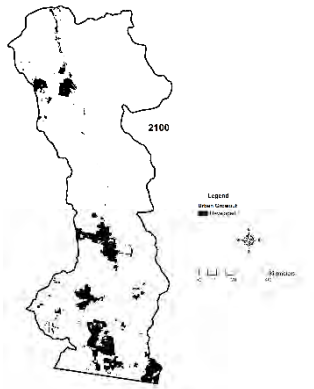


Extract

San Pedro River Study Area

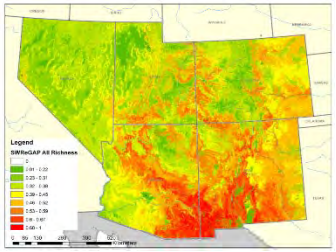
Reclassify

Urban Area (1)
Non Urban Area(0)



BC 2000- All 5 Scenarios 2100 @ 10-yr increments

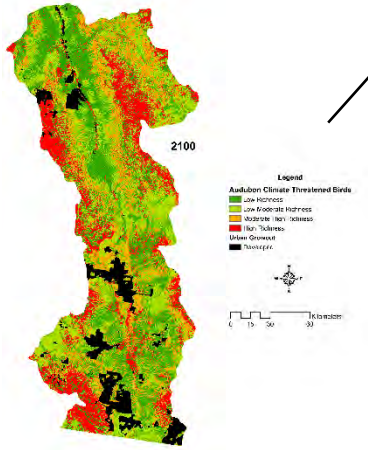
SWReGAP Data Set



Extract

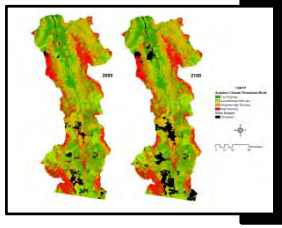
Biodiversity Metrics derived from GAP Deductive Habitat Models

Selected Metrics



Analyze-

areas of each class of each biodiversity metric by Non Urban areas using the five ICLUS future development scenarios.



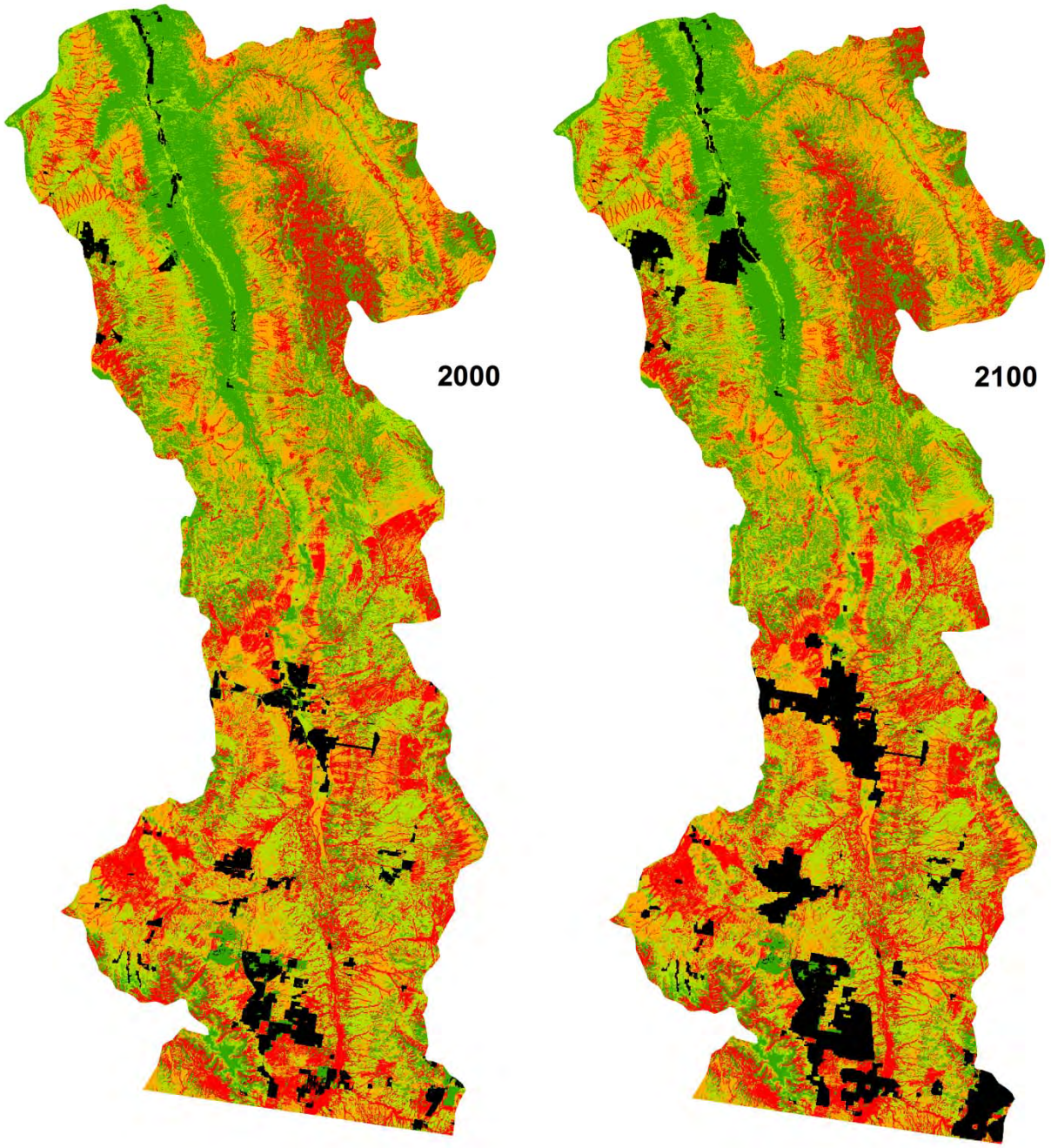
Compare-

Change in square km and percent change in area of each metric was compared between baseline and all 5 ICLUS Scenarios to year 2100

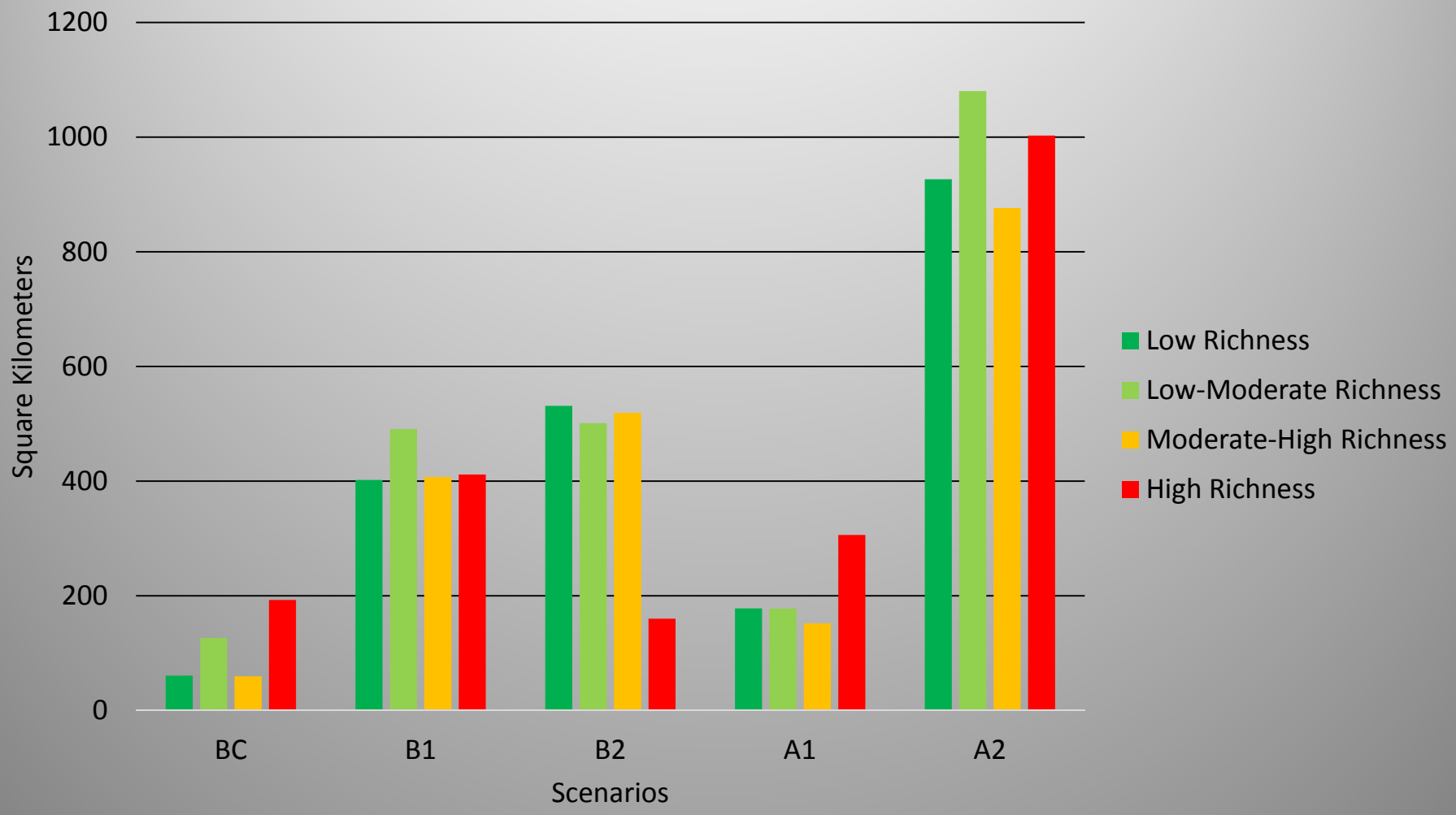
Un-developed (rural & public lands) *and* **Developed** (urban, suburban, and exurban) area (km^2) *and* % of total for **Baseline 2000** *and* **five future land-use change scenarios (A1, A2, B1, B2, & BC).**

	Un-developed		Developed	
	(km^2)	(%)	(km^2)	(%)
Baseline 2000	**93,532**	**96**	**3,698**	**4**
A1 2100	**92,844**	**95**	**4,386**	**5**
A2 2100	**89,648**	**92**	**7,582**	**8**
B1 2100	**91,821**	**94**	**5,410**	**6**
B2 2100	**91,065**	**94**	**6,165**	**6**
Baseline 2100	**93,092**	**96**	**4,138**	**4**

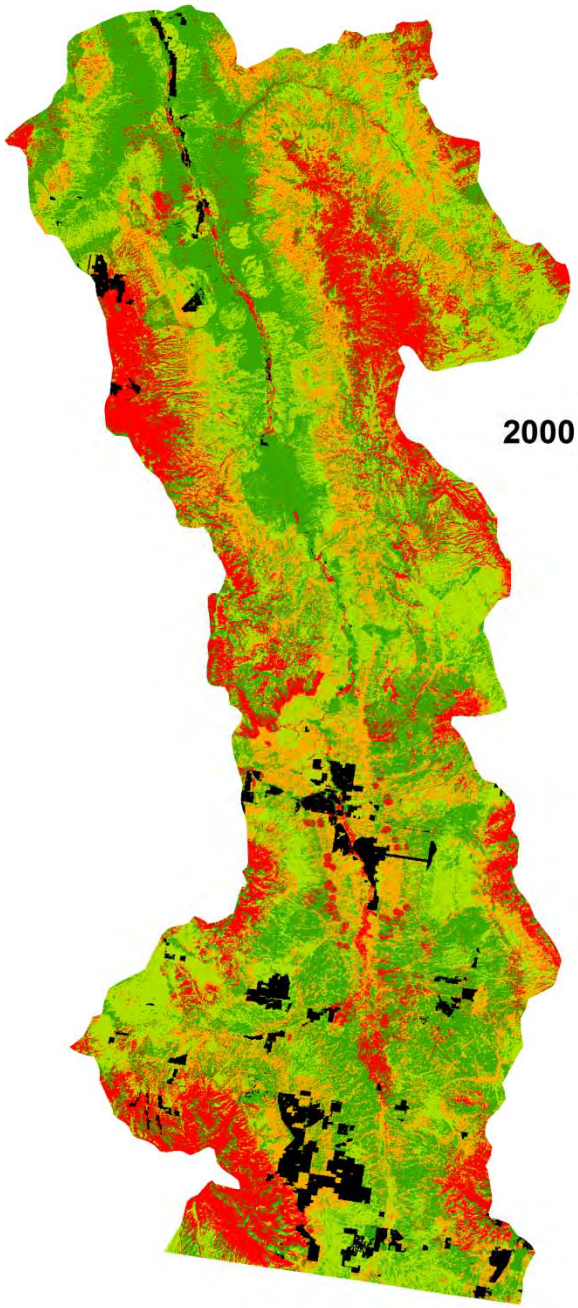
All Vertebrate Species Richness as Impacted by Scenario A2



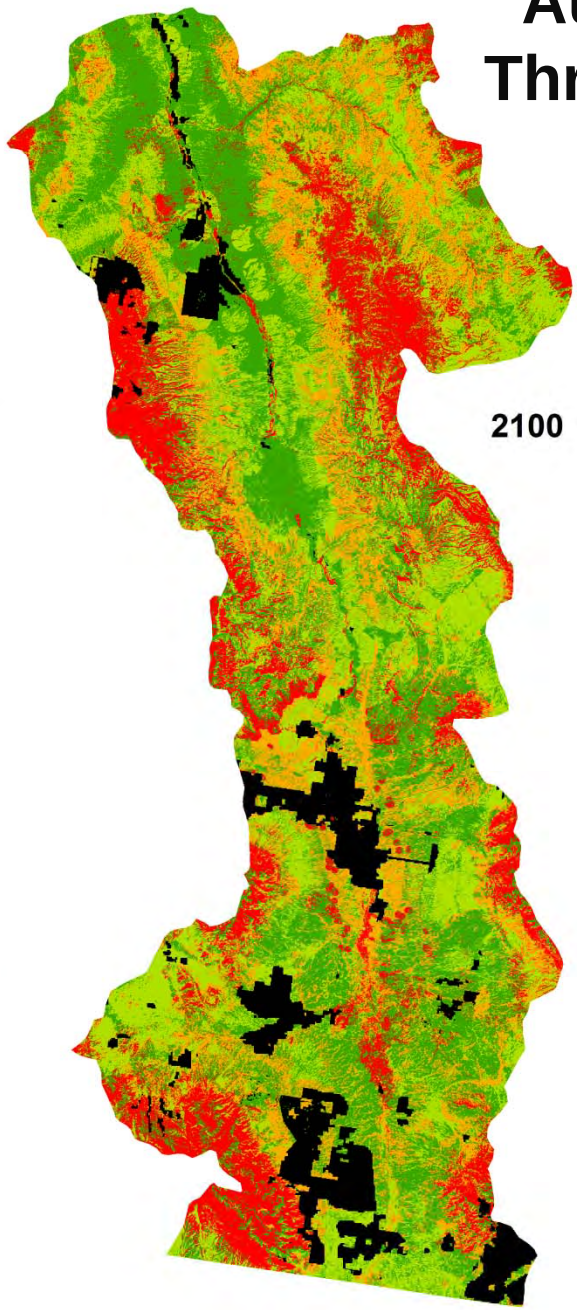
All Vertebrate Species



Audubon Climate Threatened Species Richness as Impacted by Scenario A2



2000



2100

Legend

Audubon Climate Threatened Birds

- Low Richness
- Low-Moderate Richness
- Moderate-High Richness
- High Richness

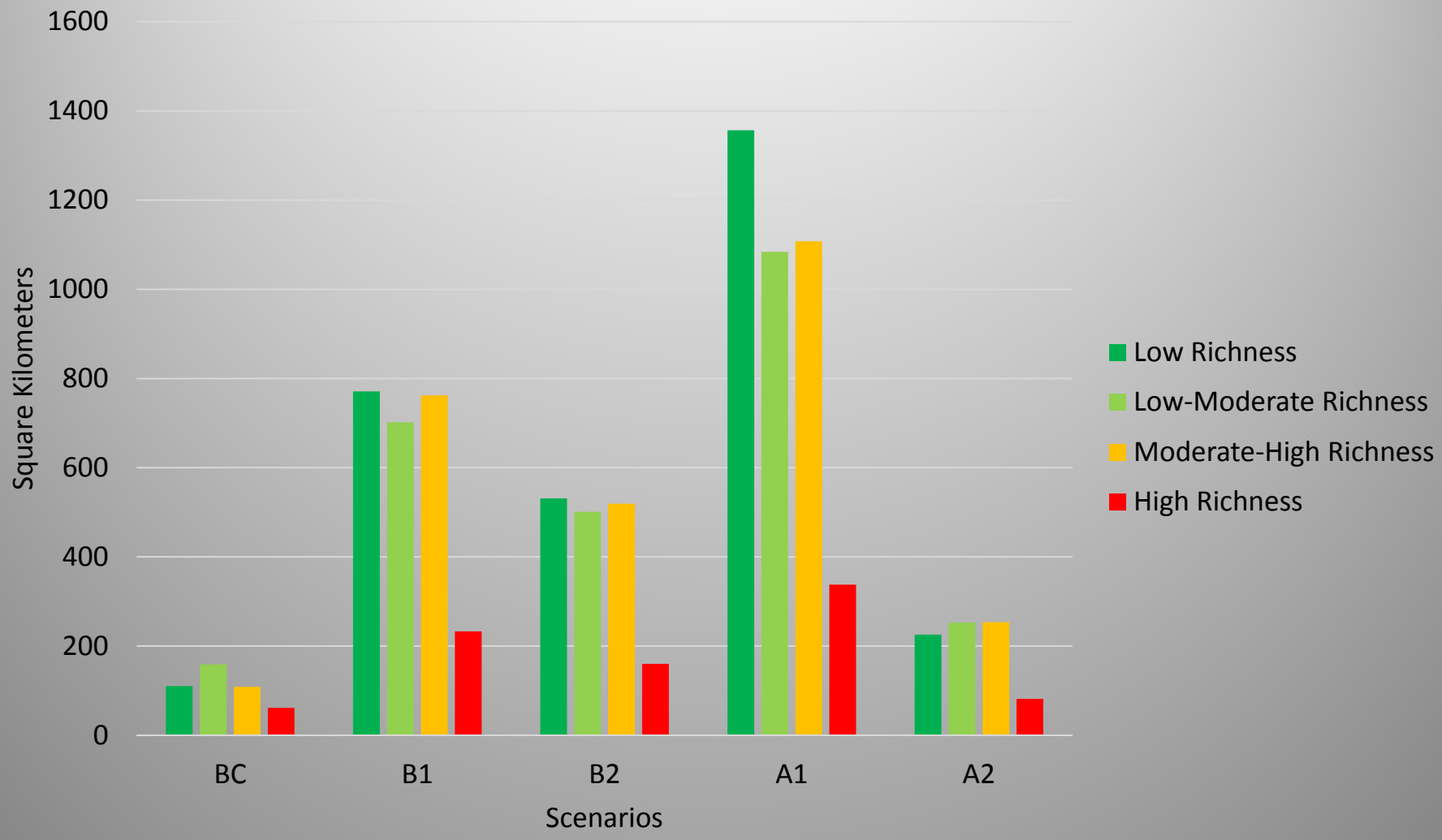
Urban Growout

- Developed

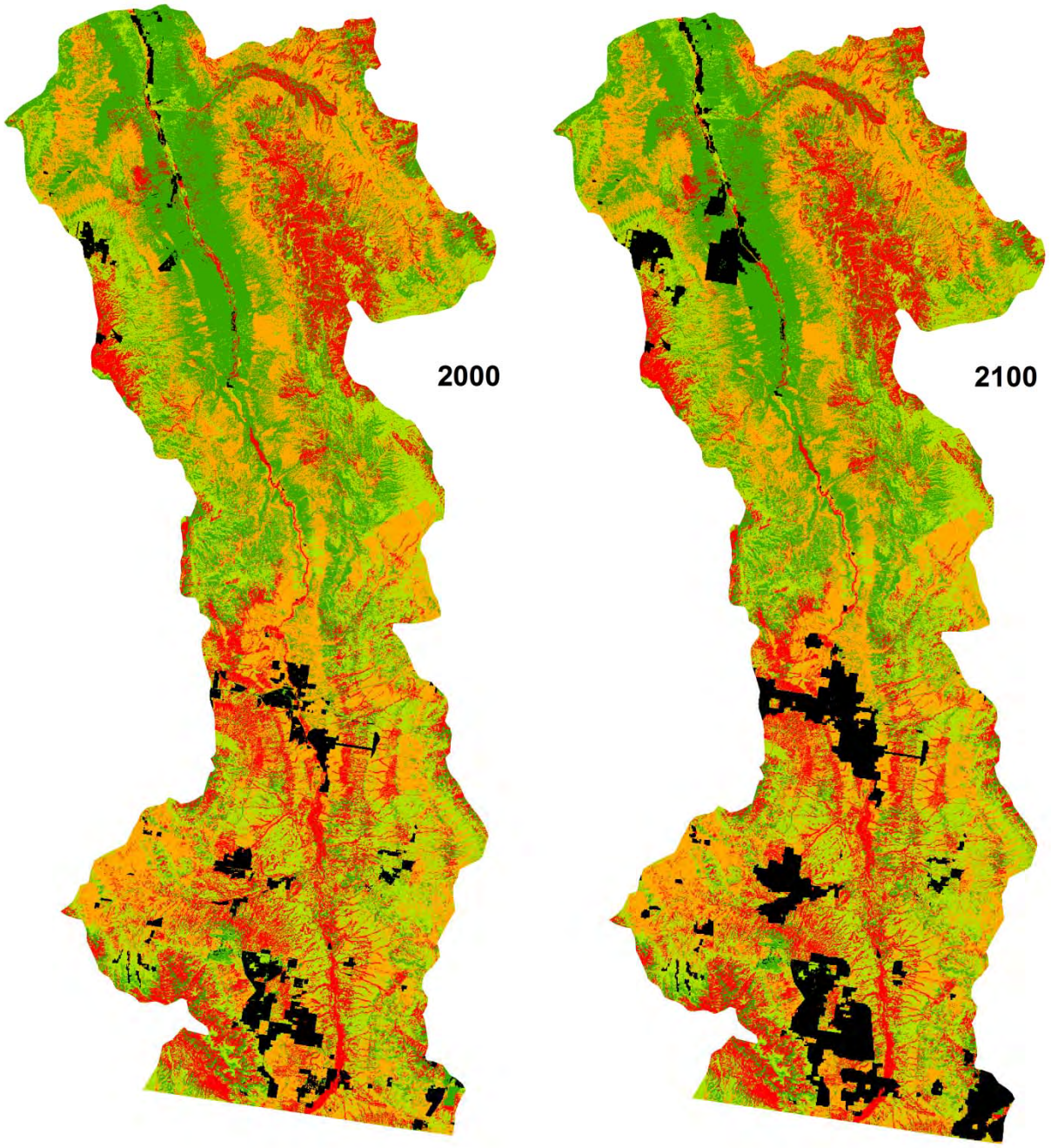
N
W E
S

0 15 30 60 Kilometers

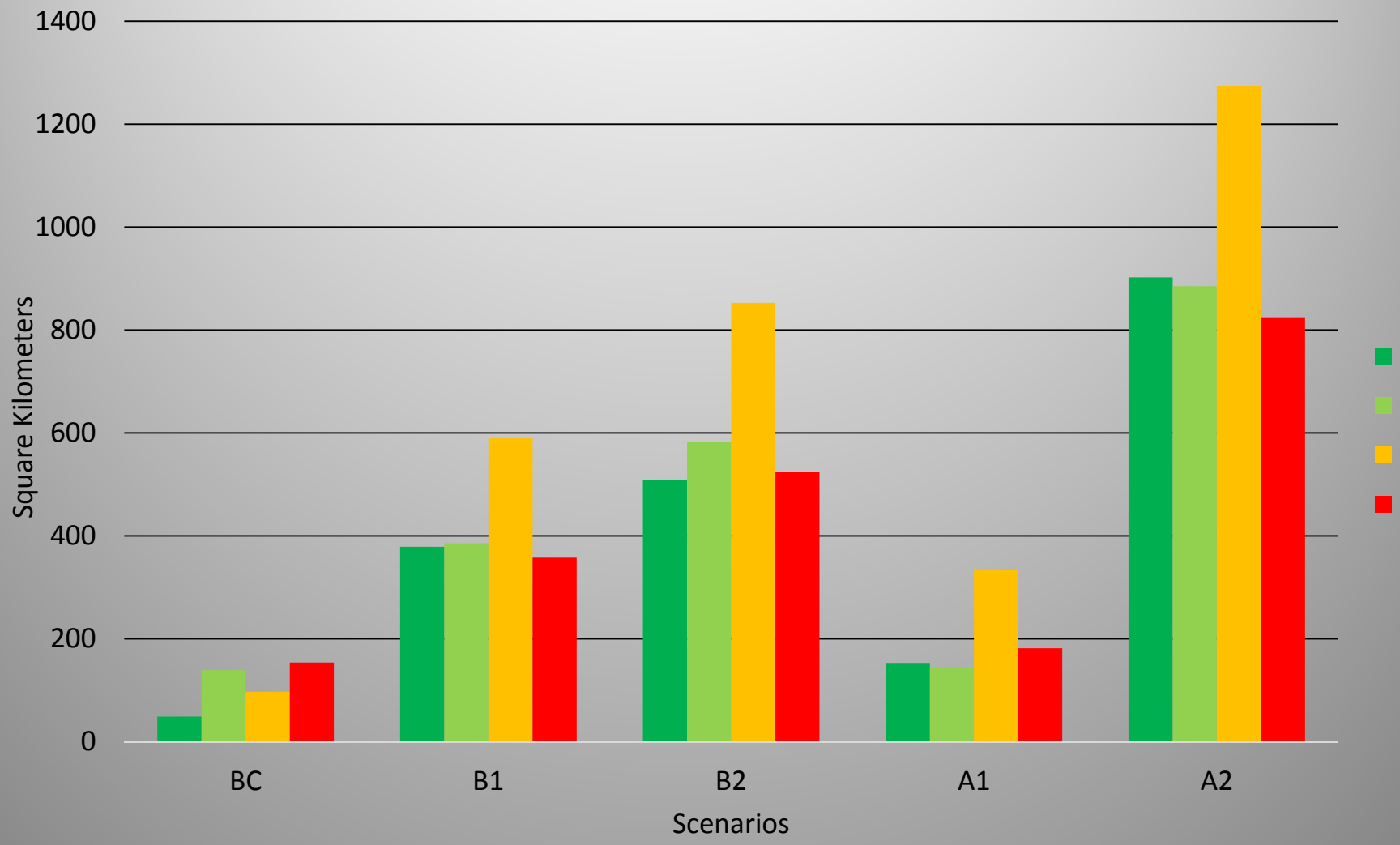
Audubon Climate Threatened Species
Relative Change in Species Richness



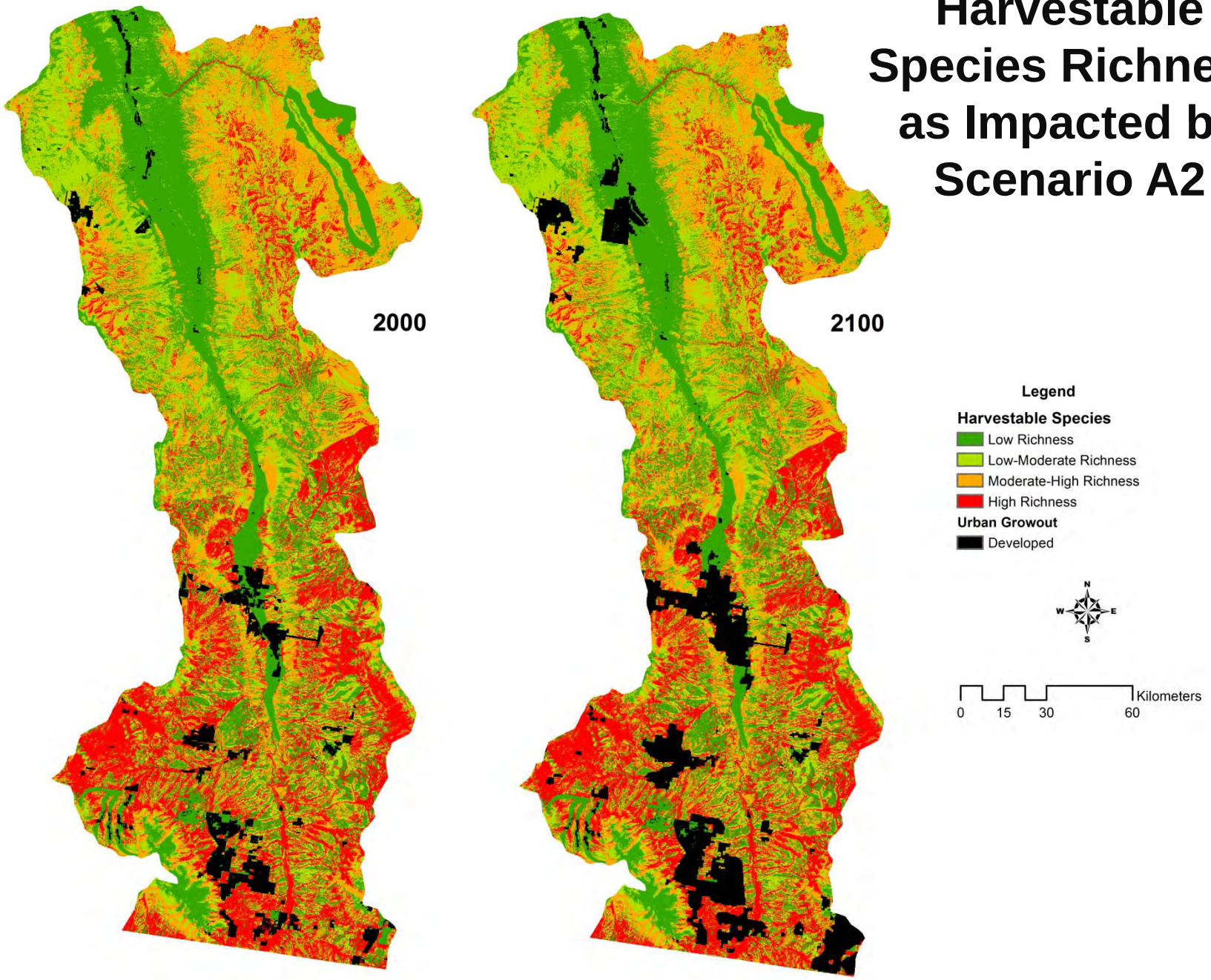
Bird Species Richness as Impacted by Scenario A2



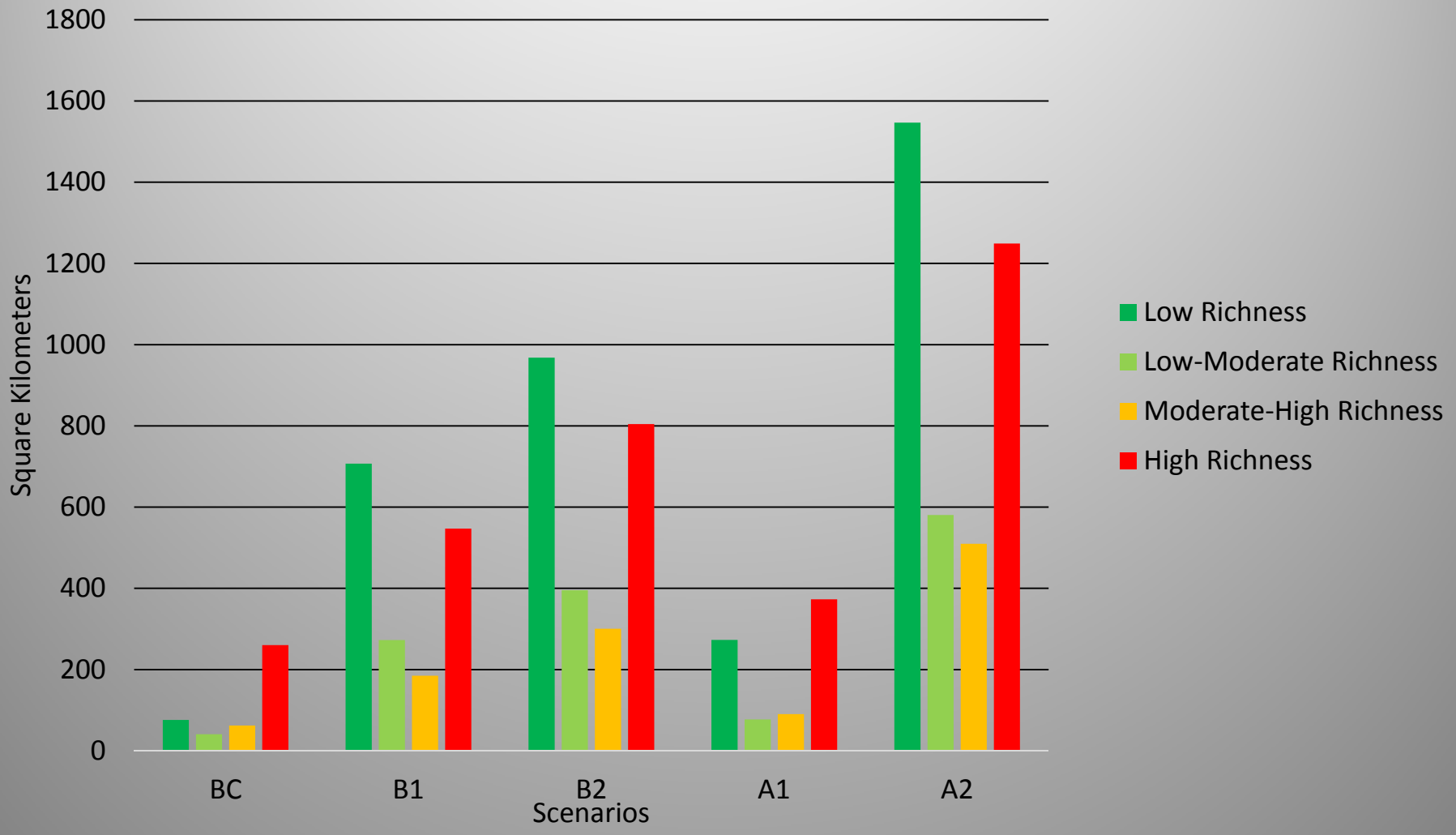
Total Bird Species
Change in Area for 4 Species Richness Categories



Harvestable Species Richness as Impacted by Scenario A2



Total Harvestable Species
Change in Area for 4 in Species Richness



General Conclusions

1) Deductive modeling provides a common sense approach for mapping and quantifying metrics of habitat provisioning, a surrogate for biodiversity, at watershed to national scales;
2) It provides reference condition and comparative analysis for future scenario analysis related to climate change and urbanization stressors;
3) Decreases in extent of area are projected for all species richness categories for the 4 metrics (of 22 tested) in the San Pedro over the next century;
4) Among the 5 scenarios examined, A2 (highest population growth, high fertility and domestic dispersal, and greatest land conversion to new population centers) presented the greatest increase in urban growth both in percent change & total area, and subsequently the greatest change in species richness for the 4 metrics;

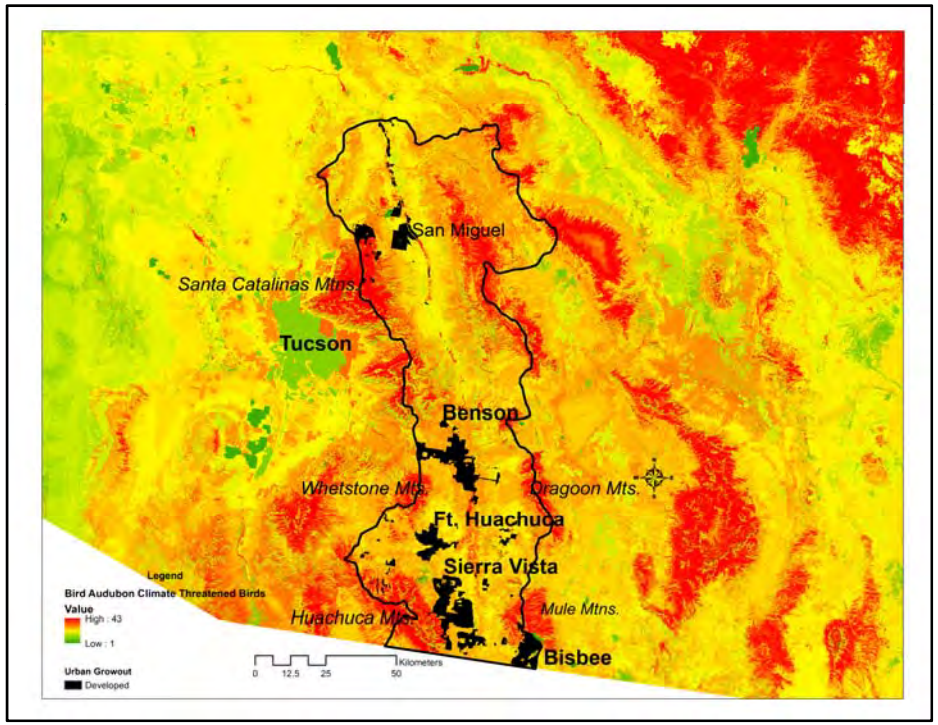
Biome Type	Total	Amphibians	Birds	Mammals	Reptiles
Barren Lands	107	3	35	43	26
Evergreen Forest	**263**	3	**146**	74	40
Deciduous Forest	104	0	68	32	4
Shrub/Scrub	206	6	96	**76**	**45**
Grassland	232	5	102	**80**	**45**
Woody Wetland	**301**	6	**202**	61	36
Emergent Wetland	149	3	108	35	3
Urban/Agriculture	170	1	131	33	7
Water	94	2	79	12	1

Evergreen Forest	**18.2 % Areal Extent**	**263 spp.**
Desert Scrub	**49.4 % Areal Extent**	**206 spp.**
Grassland	**27.8 % Areal Extent**	**232 spp.**
Woody Wetland (Riparian)	**1.3 % Areal Extent**	**301 spp.**

General Conclusions cont'd

5) Evergreen Forest, Desertscrub, Grassland, and Woody Wetland (riparian) appear to be the most specious Biome types;

6) Riparian woodland and Evergreen Forest are the least extant Biome types and the most specious and thus likely most vulnerable to changes in management practice or climate variation which could affect land cover extent (and species occurrence).



7) Initial testing with biodiversity/habitat metrics and ICLUS scenarios appears promising and transferable to other geographies and may prove to be an important decision-making tool for impact assessment.

Contact Information

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http://case.nmsu.edu/CASE/ES/
http://enviroatlas.epa.gov/enviroatlas/atlas.html