Watershed valuation - understanding spatial variation in value derived from fish diversity

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Informing decisions in a changing world

- Freshwater fauna are among the most imperiled worldwide
- Quantifying value important when making decisions that influence freshwater habitats
- Considering biodiversity value problematic
  - Geographic mismatch between economic and ecological data
  - Political / admin. boundaries versus species relevant environment
  - Biodiversity: decisions about water and land
- Watersheds as appropriate spatial resolution for valuation

Freshwater ecosystems and biodiversity

- Ecosystem goods and ecosystem services
- Provide societal benefits
  - Value recognized where and when infrastructure allows access: coincidence in space and time sets context
- Freshwater biodiversity
  - History / biogeography
  - Water quality and quantity
  - Land cover / land use
  - Resource management decisions
- Hedonic modeling to estimate recreational use for fish species richness

Research questions

What is the role of fish diversity in supporting fishing activity?

→ expect high diversity to support more fishing activity

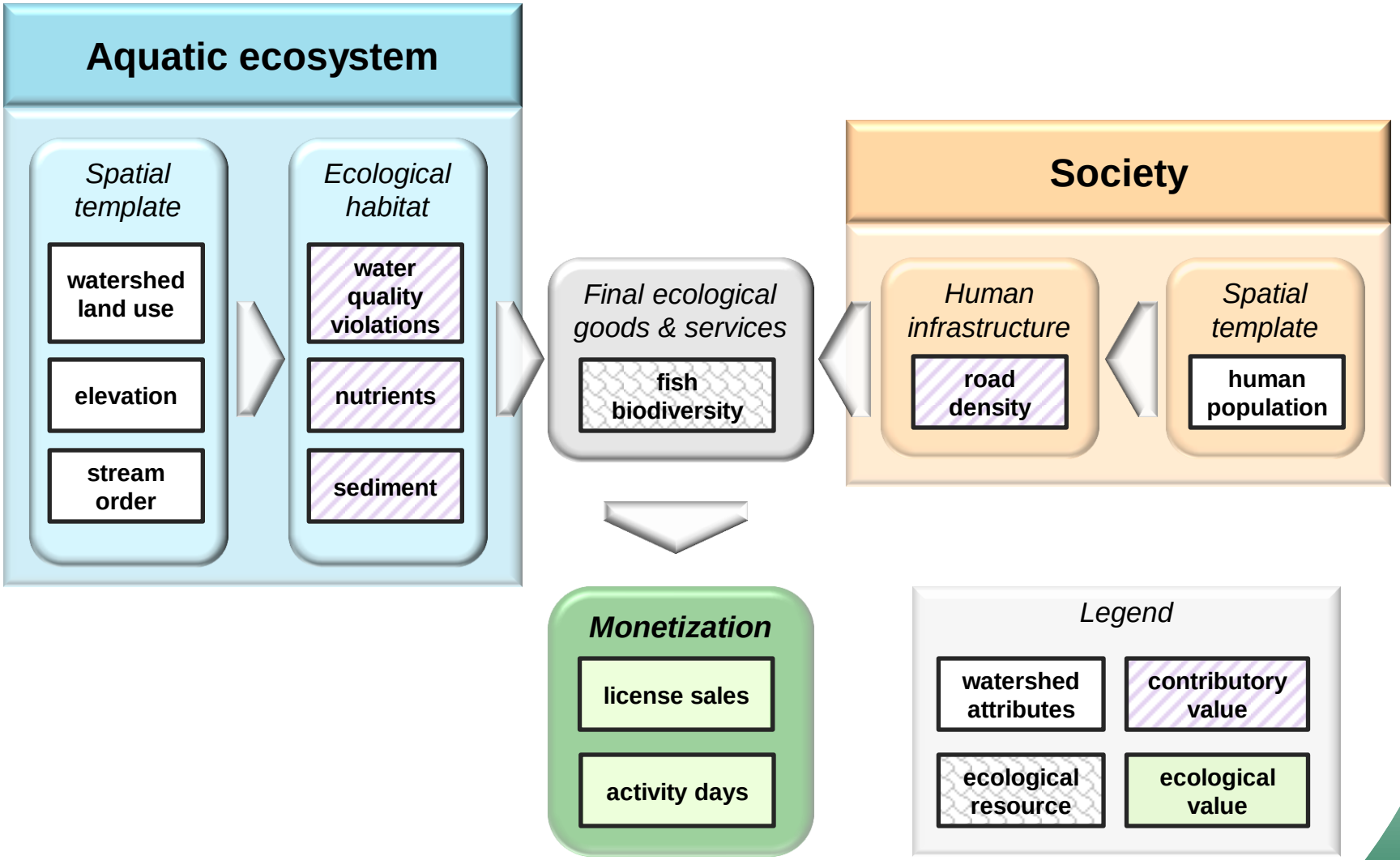
Do non-game fishes contribute to use value?
→ assume direct and indirect linkages

Relative role of variables in overlap between biota and humans?

Objective: a regional map of use value

→ inform decisions in resource stewardship
→ contribution towards total ecosystem valuation

Spatial valuation framework



Methods

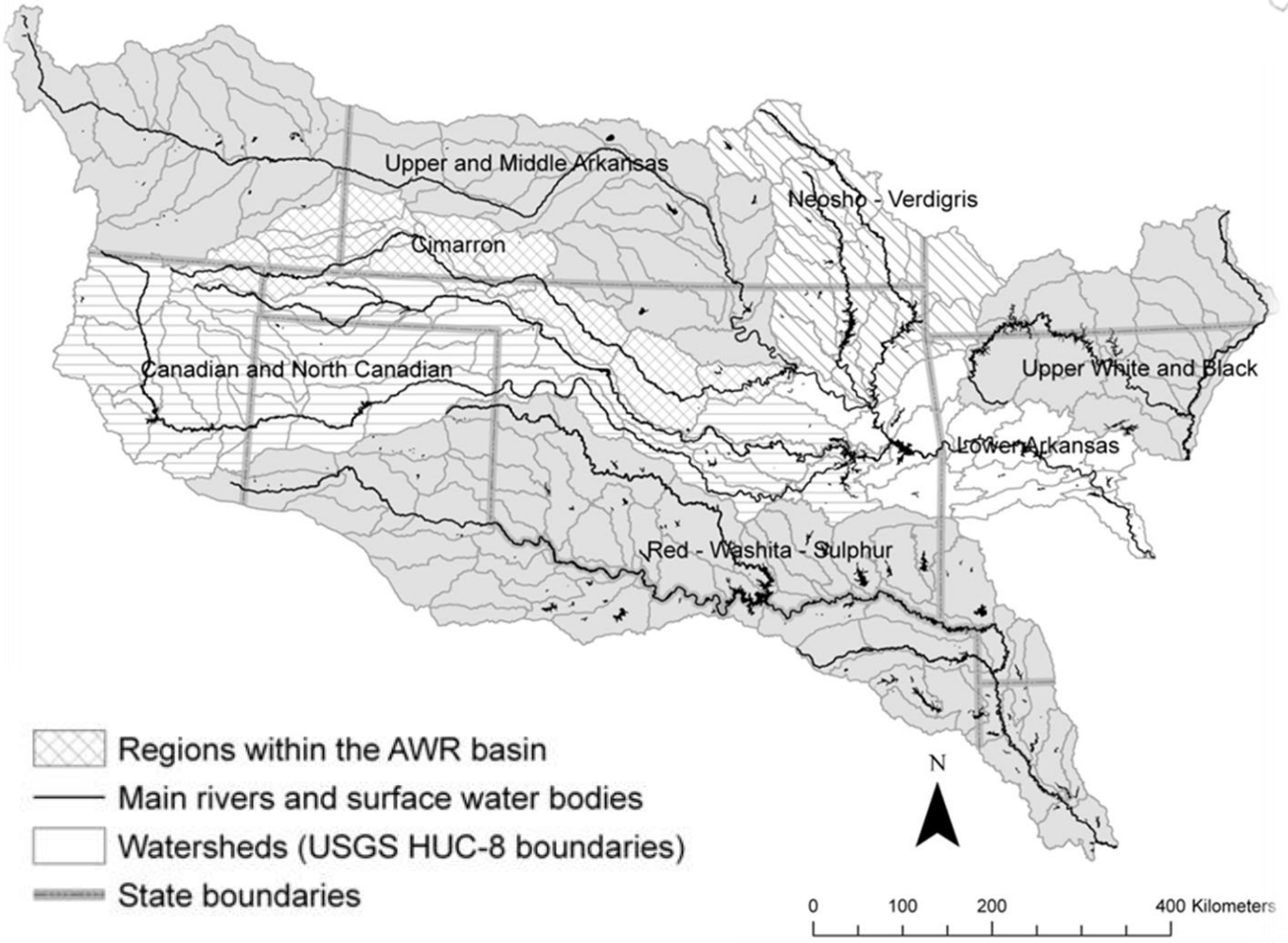
- Study area and data sources

- Regression modeling
  - Poisson regression to predict Total Activity Days (TAD)
  - Relative role of predictor variables in explaining fishing activity

- Hedonic model
  - Use value for fish species richness by watershed

Study area

Arkansas – White – Red River basin



642,000 km^2

8 states

7 subregions

173 watersheds

322 counties

1353 census tracts

7783 block groups

Data sources and method

- US. Census Bureau population data (2000)
- Fish richness data from NatureServe.org
- County-level license sales (2008-9)
- National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (2006)
- Net Economic Values of Wildlife-Related Recreation in 2006 (2009)

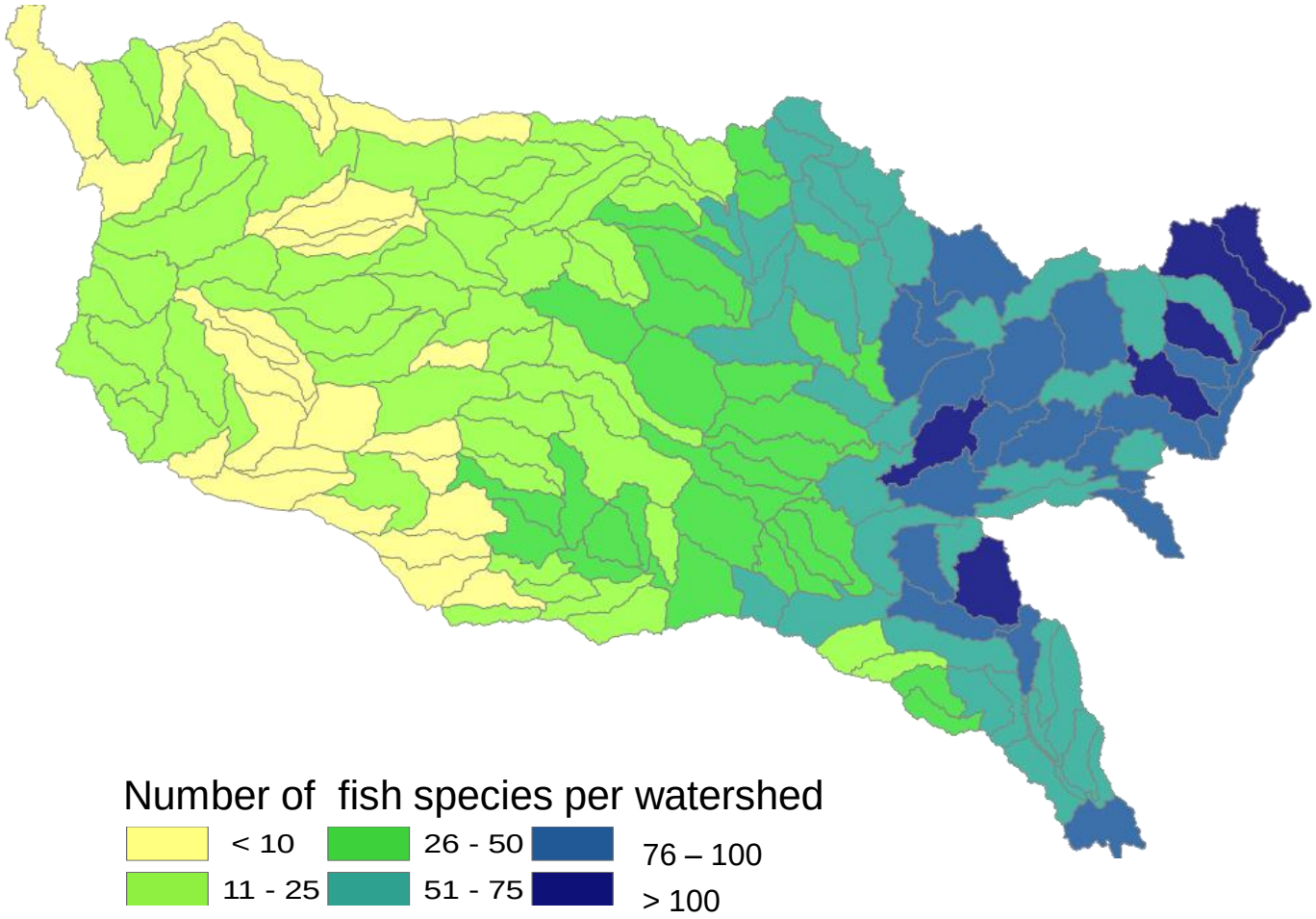
Revealed Behavior → Fishing Privilege

Resident and Nonresident Activity

Average Activity Days | Average Annual Expenditure | Average Daily Trip Expenditure | Total variable expenditures

- Total Privilege
  - Population with fishing rights
    - Temporary (6 classes,1 day - 2 weeks)
    - Annual (2 classes, annual fishing and combo)
- Activity days: allowed combining temporal and annual privileges

Fish species richness in the AWR



Fish data: NatureServe.org (2009)

~ 215 fish species native or naturalized

26 taxonomic families

Regional biodiversity

Precipitation gradient

Elevation gradient

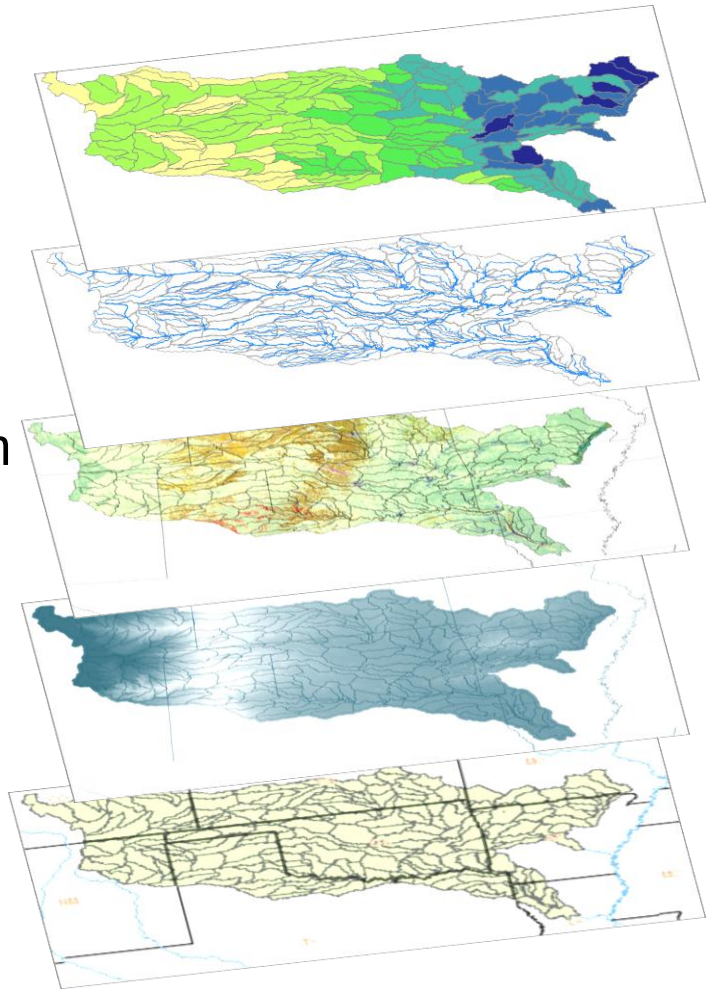
Quantify predictor variables at the scale of watersheds

Total fish richness (by watershed)
Lists of game fish from state agencies
- Compile by watershed

Extract environmental data

Water quality data (TMDL) by state from US. EPA, compile by watershed

US. Census Bureau population data
- dissolve by census block group
- based on block group centroids accumulate by watershed



Regression modeling total activity days (TAD)

$$Ln(TAD_i) = b_0 + b_1 PopT + b_2 Rch + b_3 Sed + b_4 RkmA + b_5 \%Wa + b_6 ElDr + b_7 TMDLw + b_8 St2 + b_9 St3p + \varepsilon$$

PopT	population (1000) by watershed
Rch	fish species richness (total richness, game fish richness)
Sed	Sediment load (from SWAT watershed modeling)
RkmA	Road density by watershed
%Wa	proportion surface water by watershed
ElDr	Elevation of watershed
TMDLw	Total Maximum Daily Load / water quality indicator
St2	Length of headwater 1st and 2nd order streams
St3p	Length of 3rd and higher order streams and rivers

Monetization

- General hedonic model (Hanley et al. 2001)

$$Use\ value = f\ (biodiversity,\ habitat,\ societal\ access)$$

- Variation of the general hedonic model
  - Assuming uniform distribution of fishing licenses within population
- Monetary use value, V_i, for fish species richness in watershed *i* is the sum of average daily fishing trip expenditures by holders of resident and non-resident licenses.
- By watershed, multiply number of resident and non-resident licenses by the corresponding number of average activity days per year and average trip expenditure per fishing day.

Monetization

(2006 US $)

$$V_i = \sum_j Pc_{ij} \left(AD_i^R \; R_i \; TE_j^R + AD_i^{NR} \; NR_i \; TE_j^{NR}\right)$$

V_i	Monetary use value for fish species richness in watershed$_i$
Pc_{ij}	Proportion of population in state $_j$ within watershed$_i$
R_i and NR_i	number of resident and non-resident fishing licenses* in watershed$_i$, respectively
AD^R and AD^{NR}	number of activity days per year per resident and non-resident license, respectively
TE	average trip related expenditure

*assume uniform distribution of privilege (license) within population

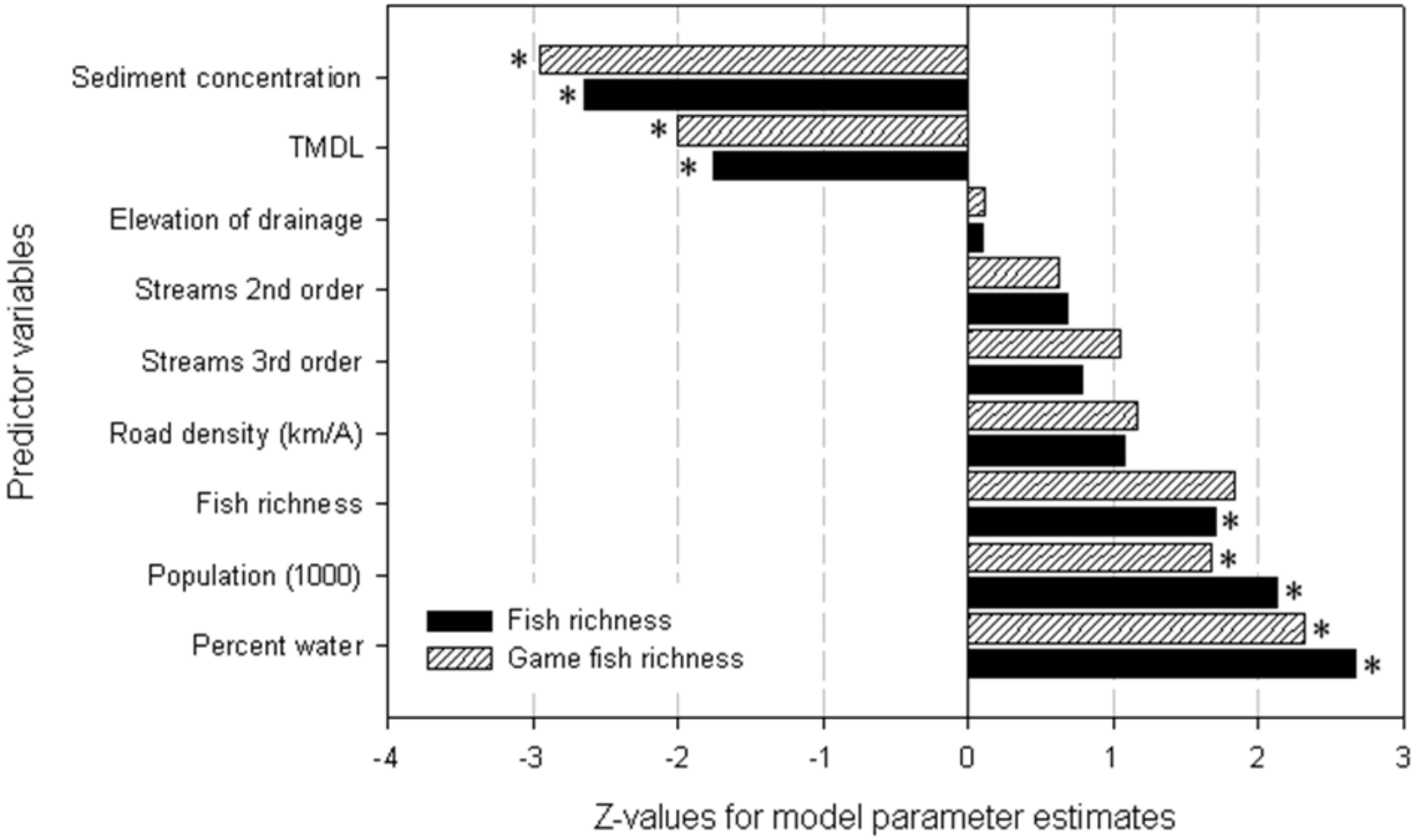
Results

Pearson correlation coefficients for correlation among selected variables of interest

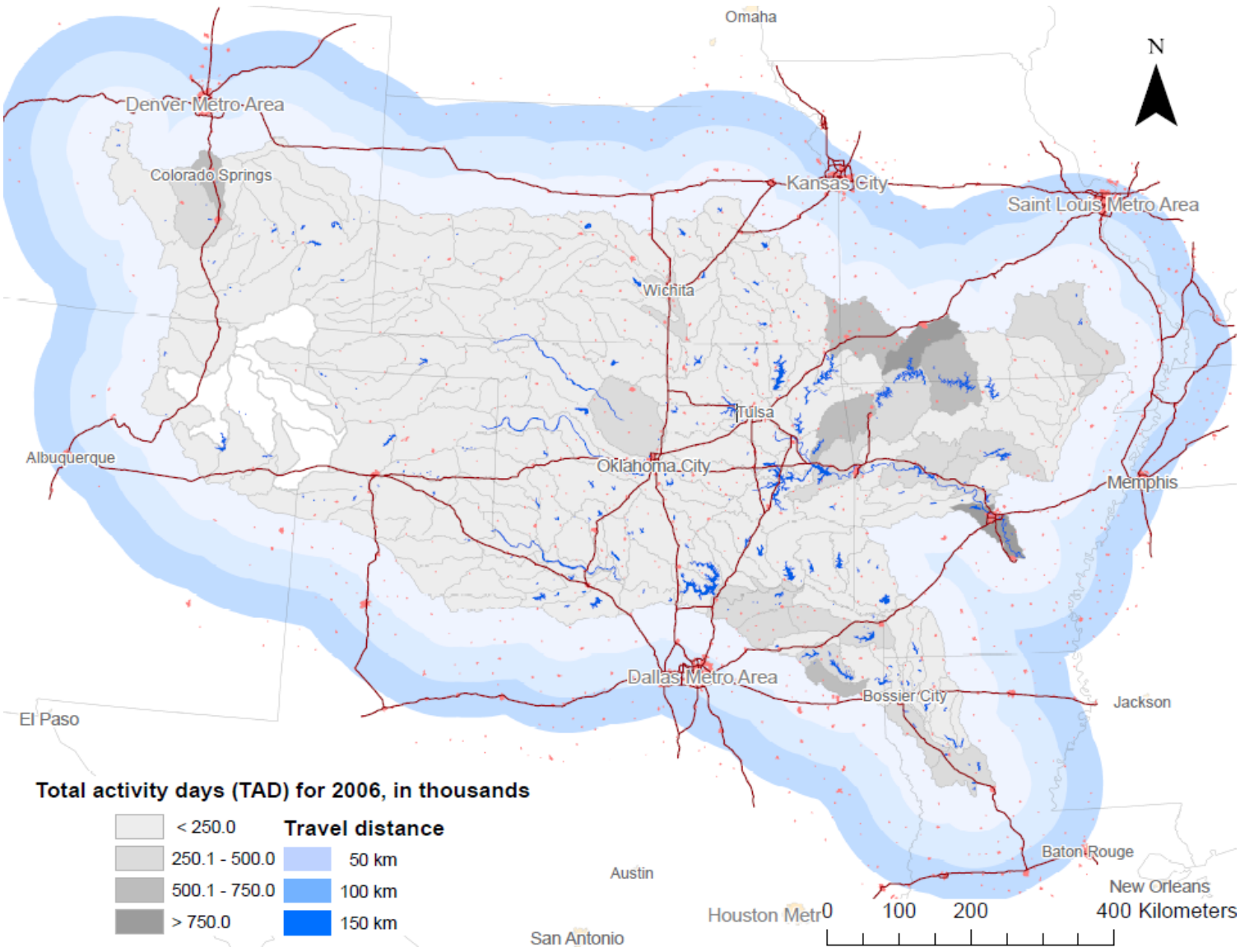
	Total Activity Days	Resident privilege	Total privilege	Non-resident privilege	Fish richness	Game fish richness
	TAD	Rpriv	Tpriv	Nrpriv	Sf	Gf
TAD	1.0					
Rpriv	0.94	1.0				
Tpriv	0.73	0.68	1.0			
Nrpriv	0.60	0.53	0.98	1.0		
Sf	**0.55**	0.44	0.35	0.29	1.0	
Gf	0.53	0.39	0.37	0.33	***0.94***	1.0

Results: Total Activity Days - regression model

– Strong positive correlation between game fish and total fish richness



Results: Total Activity Days - mapped



Fish richness

Full model
adj. $R^2 = 0.69$

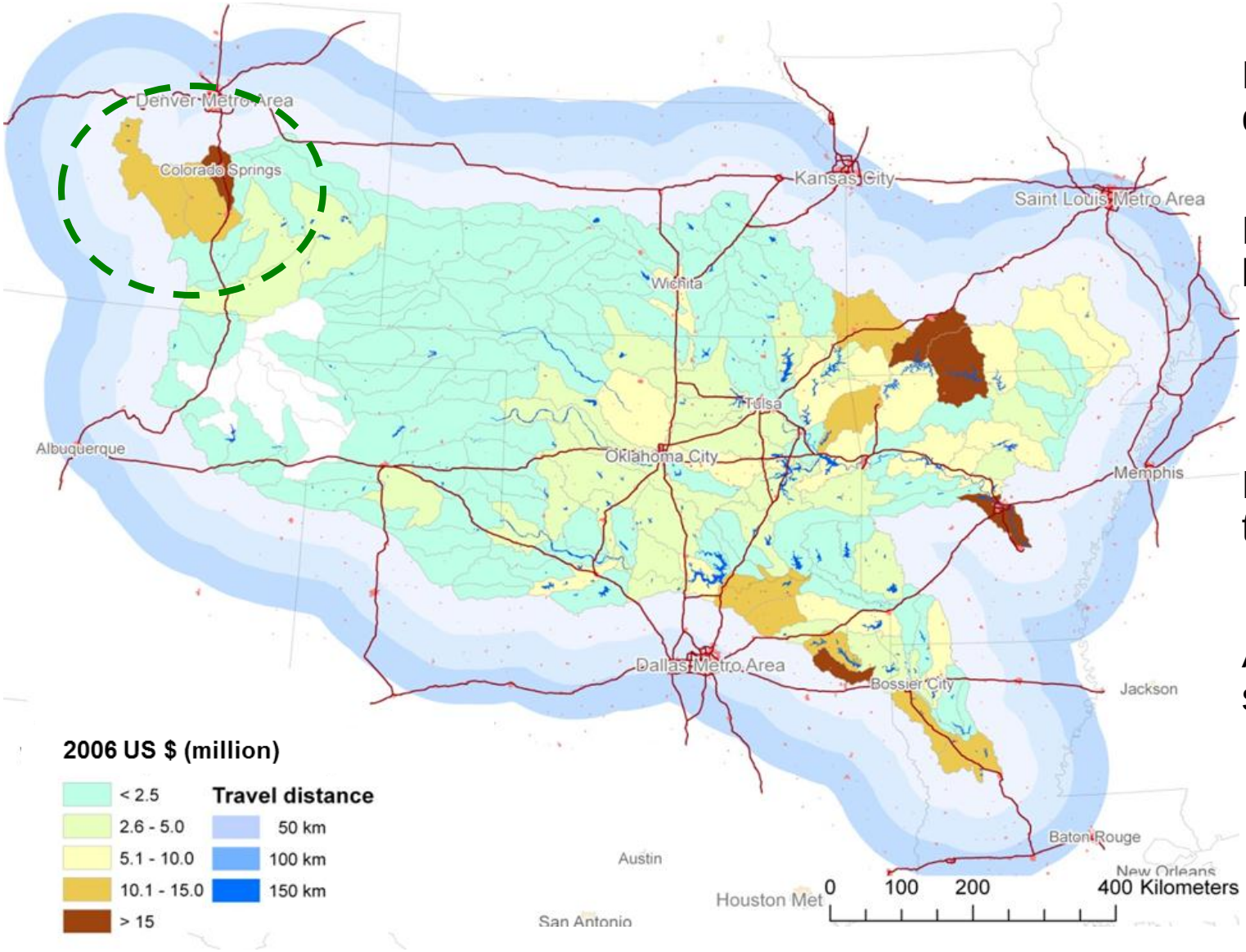
Reduced model
adj. $R^2 = 0.68$

Game fish

Full model
adj. $R^2 = 0.62$

Reduced model
adj. $R^2 = 0.61$

Results: Total trip-related expenditure



Regional differences

High diversity larger use value

Exception: trout fisheries

Allocate $ for site studies

Summary

- Framework for valuation of freshwater biodiversity
  - Watershed as the appropriate spatial unit in valuation
- Fish richness
  - Proxy to derive use value for biodiversity
  - Identified relative contributions of ecosystem and societal predictor variables
- Approach should prove helpful to resource management
  - Analysis over large region
  - identify areas / candidate sites for allocation of more resources

    → (i.e.: survey or site / location specific study)
- Caution: derived use values are minimum values at best
  - Non-use values not represented
- Contribution towards total ecosystem valuation

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