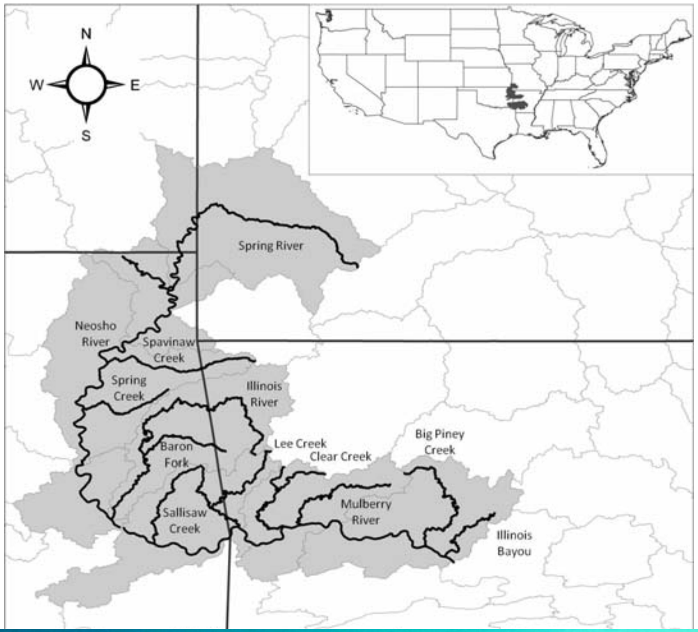
Conservation implications of shrinking distributions: An example using Arkansas River shiner

T. A. Worthington[1] and S.K. Brewer[2]

[1]Oklahoma Cooperative Fish and Wildlife Research Unit, Oklahoma State University
[2]U.S. Geological Survey, Oklahoma Cooperative Fish and Wildlife Research Unit, Oklahoma State University

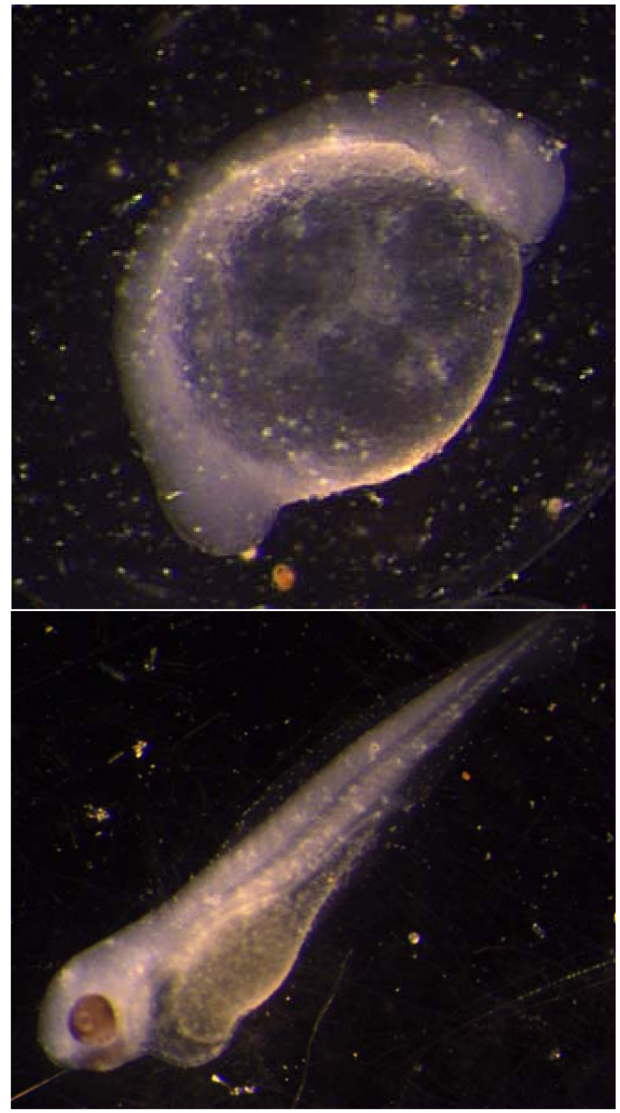
Distributions

- Predictable relations: Adaptive significance for the species
- Combination of controlling factors- biogeography, evolution, biotic, abiotic
- Significance of range: center versus edge
- Shrinking distributions: conditions are less favorable



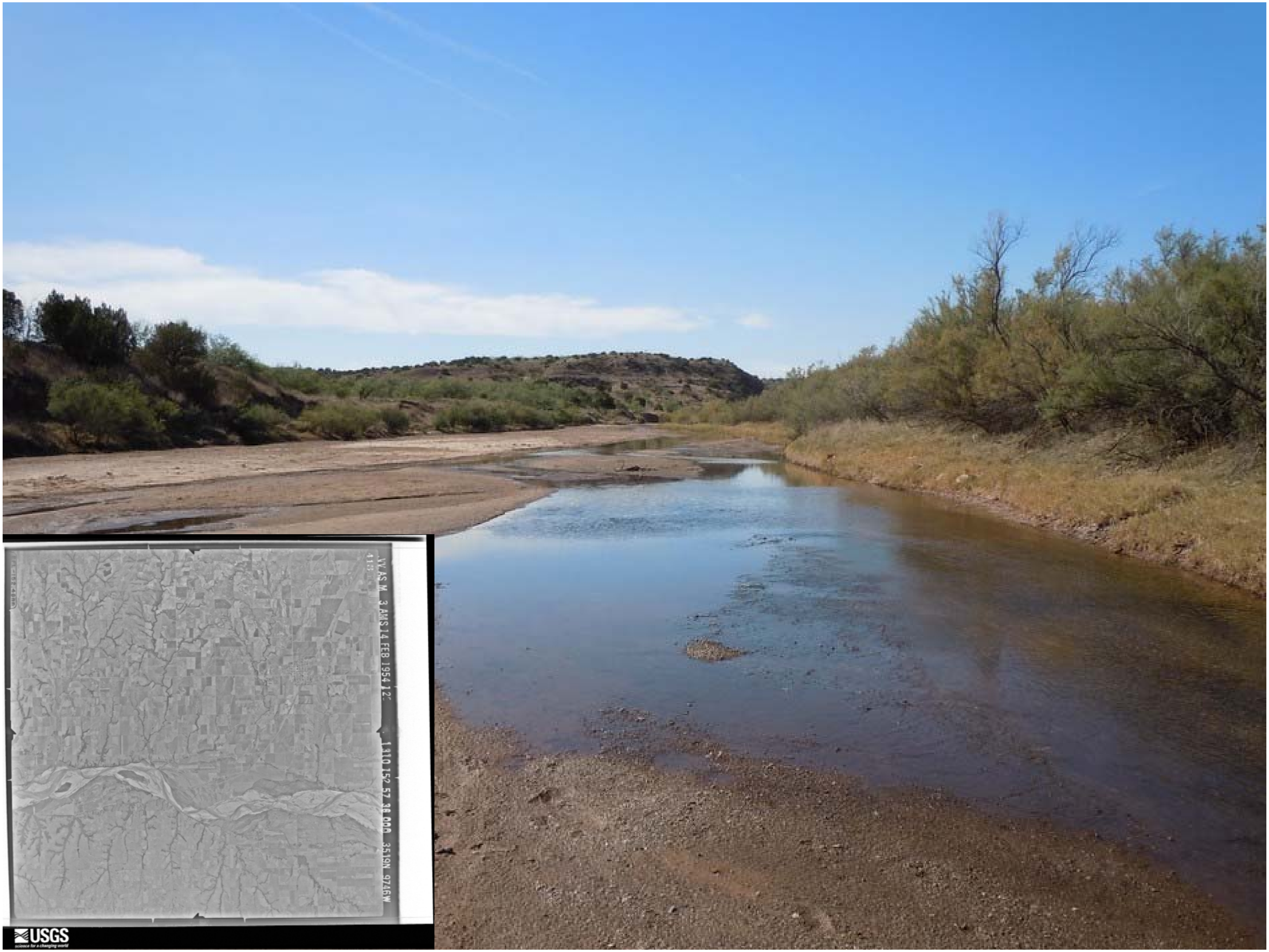
Reactive Management

- Conservation efforts for threatened or endangered species
  - Recovery plan
- What prevents our moving forward?
  - What factors are driving the decline?
  - How do species respond to changes in environmental conditions?

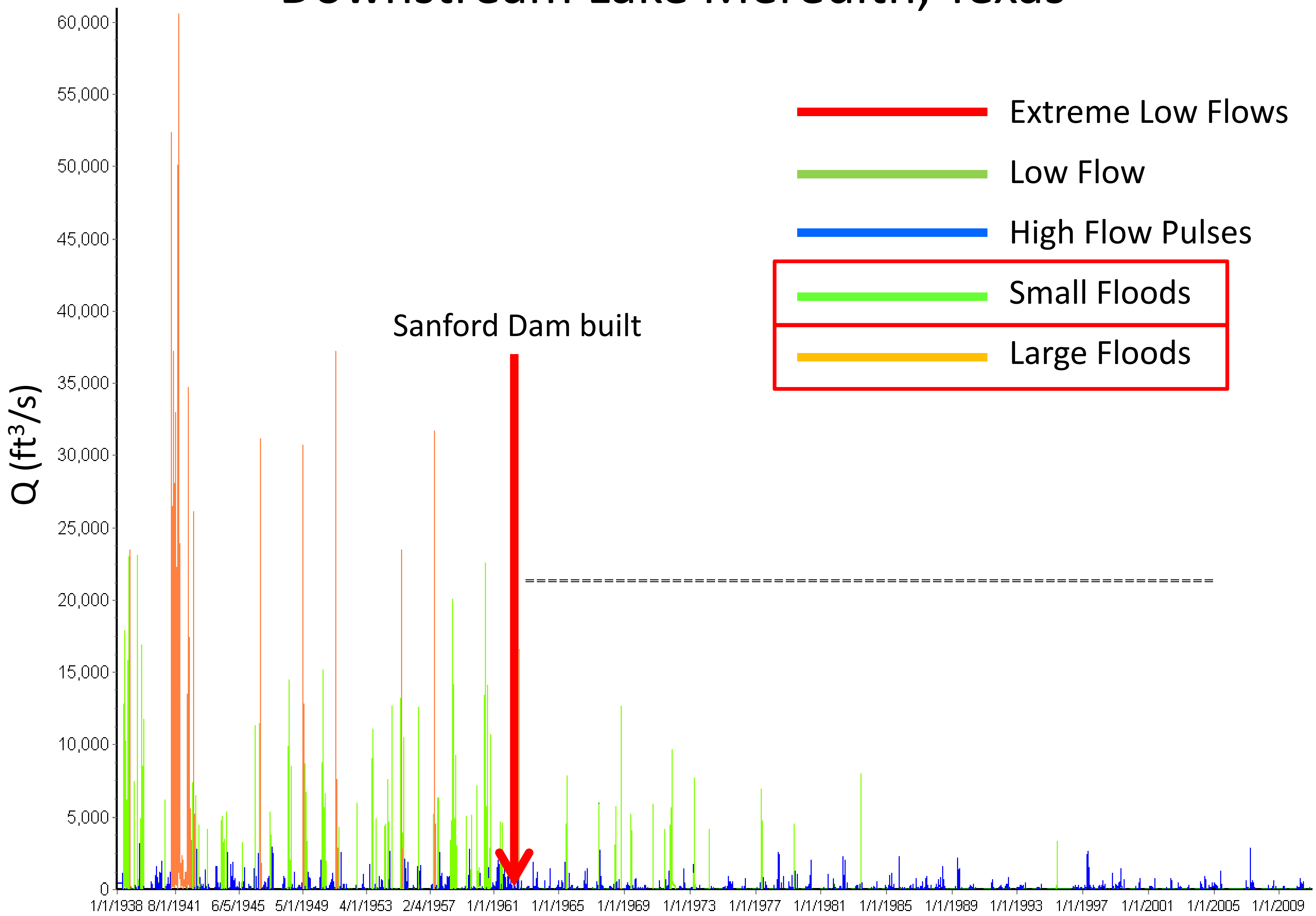


Changes in the Great Plains

- Characterized by wide, sand dominated, braided-intense floods and drought
  - Landuse
    - Eastern red cedar, salt cedar, ag
  - Fragmentation- reservoirs, water extraction, quality
  - Reductions in stream discharge and high flow events
    - Channel complexity
  - Elevated temperatures & salinity
  - Reduced turbidity, increased siltation
  - Introduced species (RRS)


USGS

Downstream Lake Meredith, Texas



Arkansas River shiner - *Notropis girardi*	Peppered chub - *Macrhybopsis tetranema*
Smalleye shiner – *N. buccula*	Speckled chub – *M. aestivalis*
Sharpenose shiner – *N. oxyrhynchus*	Sturgeon chub – *M. gelida*
Sabine shiner – *N. sabinae*	Shoal chub – *M. hyostoma*
Red River shiner – *N. bairdi*	Silver chub – *M. storeriana*
Rio Grande shiner – *N. jemezanus*	Prairie chub – *M. australis*
Pecos bluntnose shiner – *N. simus pecosensis*	Burrhead chub – *M. marconis*
	Sicklefin chub – *M. meeki*
Plains minnow - *Hybognathus placitus*	
Rio Grande silvery minnow - *H. amarus*	Flathead chub *Platygobio gracilis*
Western silvery minnow - *H. argyritis*	

Vulnerable

Threatened

Endangered

Extinct

Jelks, H. L., S. J. Walsh, N. M. Burkhead, S. Contreras-Balderas, E. Diaz-Pardo, D. A. Hendrickson, J. Lyons, N. E. Mandrak, F. Mccormick, J. S. Nelson, S. P. Platania, B. A. Porter, C. B. Renaud, J. J. Schmitter-Soto, E. B. Taylor and M. L. Warren. 2008. Conservation Status of Imperiled North American Freshwater and Diadromous Fishes. Fisheries 33:372-407.

Warren, M. L., B. M. Burr, S. J. Walsh, H. L. Bart, R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross and W. C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25:7-31.

Arkansas River shiner - *Notropis girardi*	Peppered chub - *Macrhybopsis tetranema*
Smalleye shiner – *N. buccula*	Speckled chub – *M. aestivalis*
Sharpenose shiner – *N. oxyrhynchus*	Sturgeon chub – *M. gelida*
Sabine shiner – *N. sabinae*	Shoal chub – *M. hyostoma*
Red River shiner – *N. bairdi*	Silver chub – *M. storeriana*
Rio Grande shiner – *N. jemezanus*	Prairie chub – *M. australis*
Pecos bluntnose shiner – *N. simus pecosensis*	Burrhead chub – *M. marconis*
	Sicklefin chub – *M. meeki*
Plains minnow - *Hybognathus placitus*	
Rio Grande silvery minnow - *H. amarus*	Flathead chub *Platygobio gracilis*
Western silvery minnow - *H. argyritis*	

Vulnerable

Threatened

Endangered

Extinct

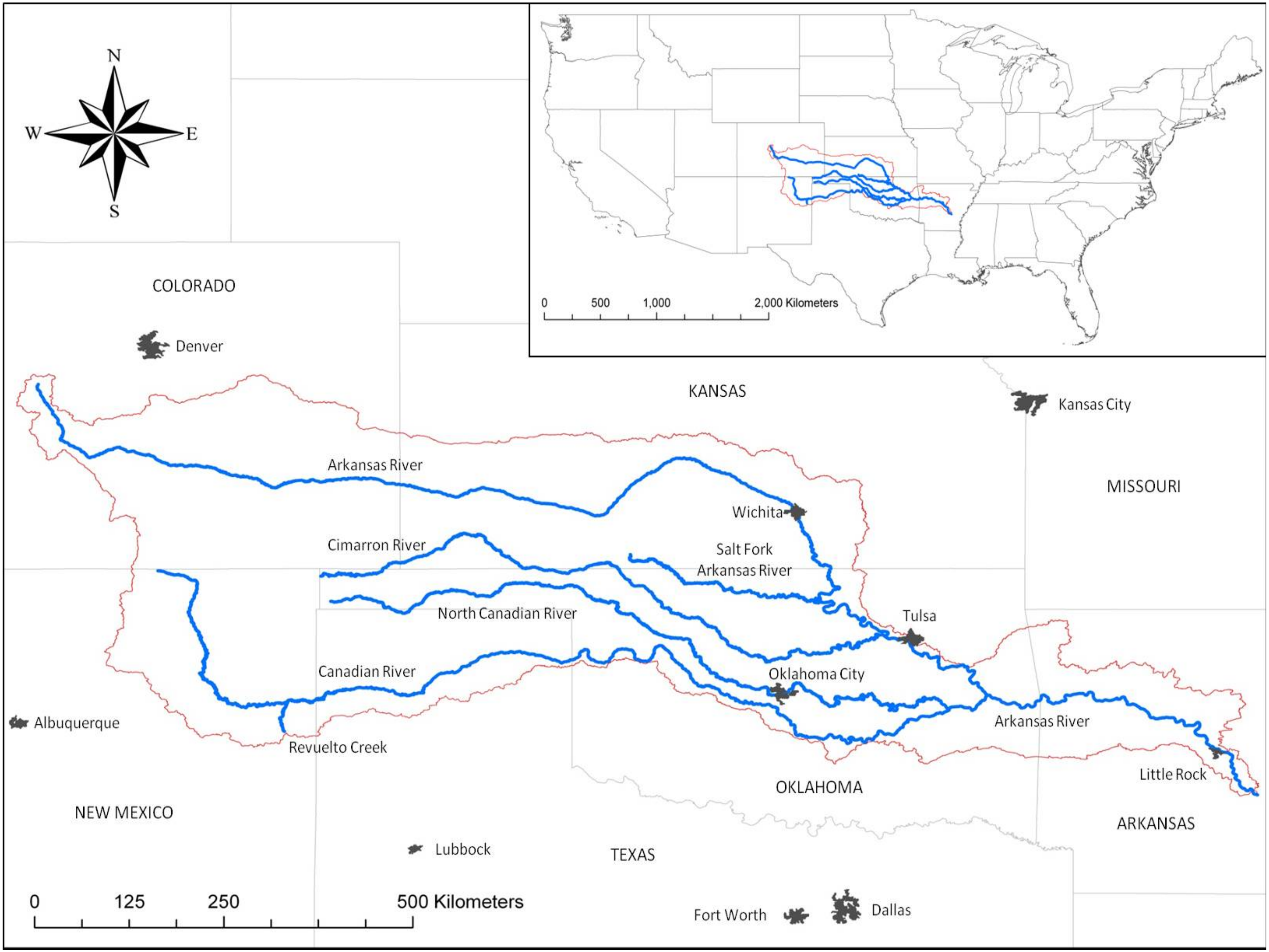
Jelks, H. L., S. J. Walsh, N. M. Burkhead, S. Contreras-Balderas, E. Diaz-Pardo, D. A. Hendrickson, J. Lyons, N. E. Mandrak, F. Mccormick, J. S. Nelson, S. P. Platania, B. A. Porter, C. B. Renaud, J. J. Schmitter-Soto, E. B. Taylor and M. L. Warren. 2008. Conservation Status of Imperiled North American Freshwater and Diadromous Fishes. Fisheries 33:372-407.

Warren, M. L., B. M. Burr, S. J. Walsh, H. L. Bart, R. C. Cashner, D. A. Etnier, B. J. Freeman, B. R. Kuhajda, R. L. Mayden, H. W. Robison, S. T. Ross and W. C. Starnes. 2000. Diversity, distribution, and conservation status of the native freshwater fishes of the southern United States. Fisheries 25:7-31.

Arkansas River shiner: model species

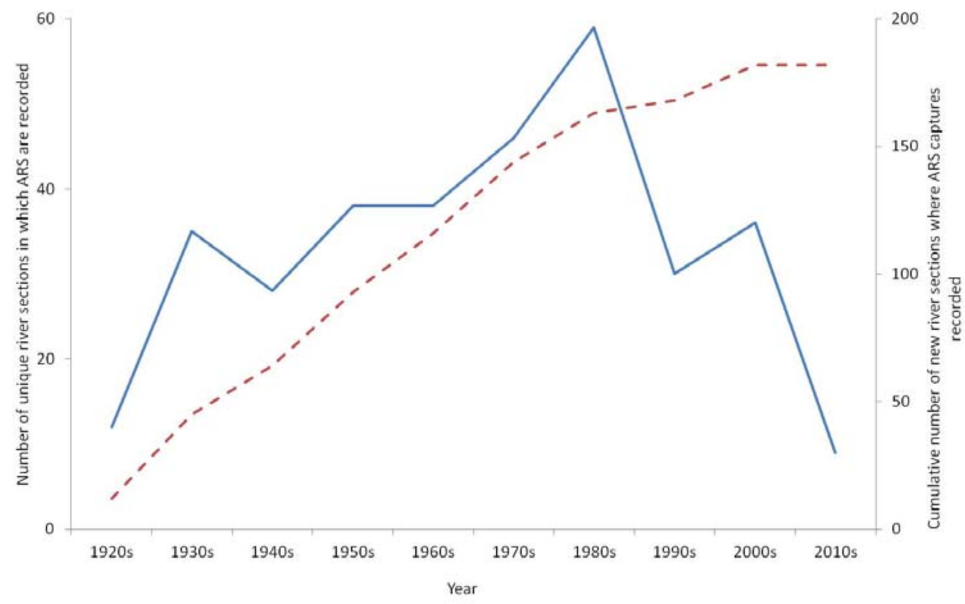
- Member of the pelagic broadcast spawning guild
- Adapted to tolerate harsh and variable conditions
  - Cutaneous sense organs and brain morphology
  - Fractional or extended spawning
  - Release semi-buoyant eggs
  - High thermal tolerance (>35°C)
- Thought to require substantial lengths of river

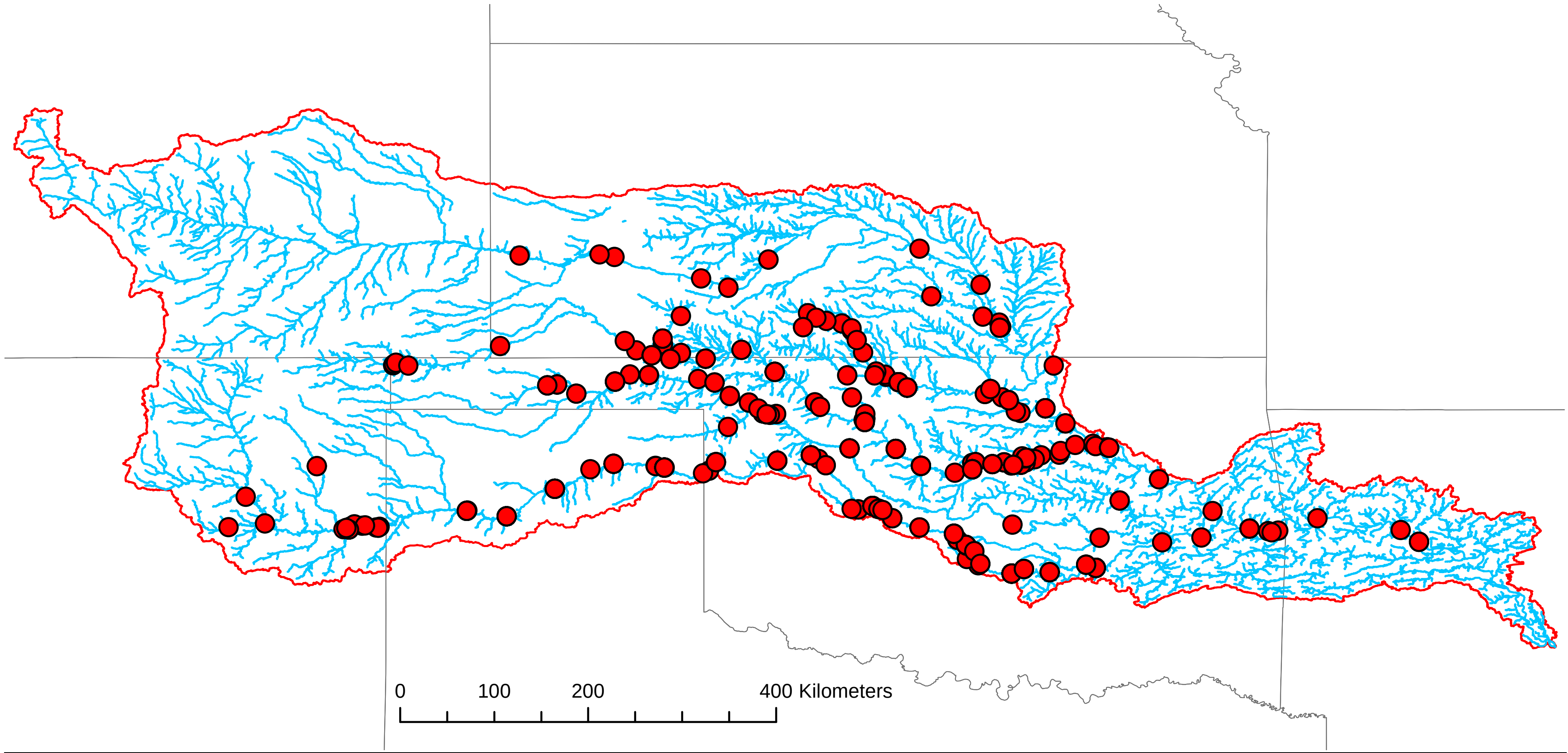
Objective- Assess how landscape change has altered the distribution of these fishes


N
W
E
S
COLORADO
Denver
KANSAS
Kansas City
MISSOURI
Arkansas River
Wichita
Cimarron River
Salt Fork
Arkansas River
North Canadian River
Tulsa
Canadian River
Oklahoma City
Arkansas River
Albuquerque
Revuelto Creek
Little Rock
OKLAHOMA
NEW MEXICO
ARKANSAS
Lubbock
TEXAS
0
125
250
500 Kilometers
Fort Worth
Dallas
0
500
1,000
2,000 Kilometers

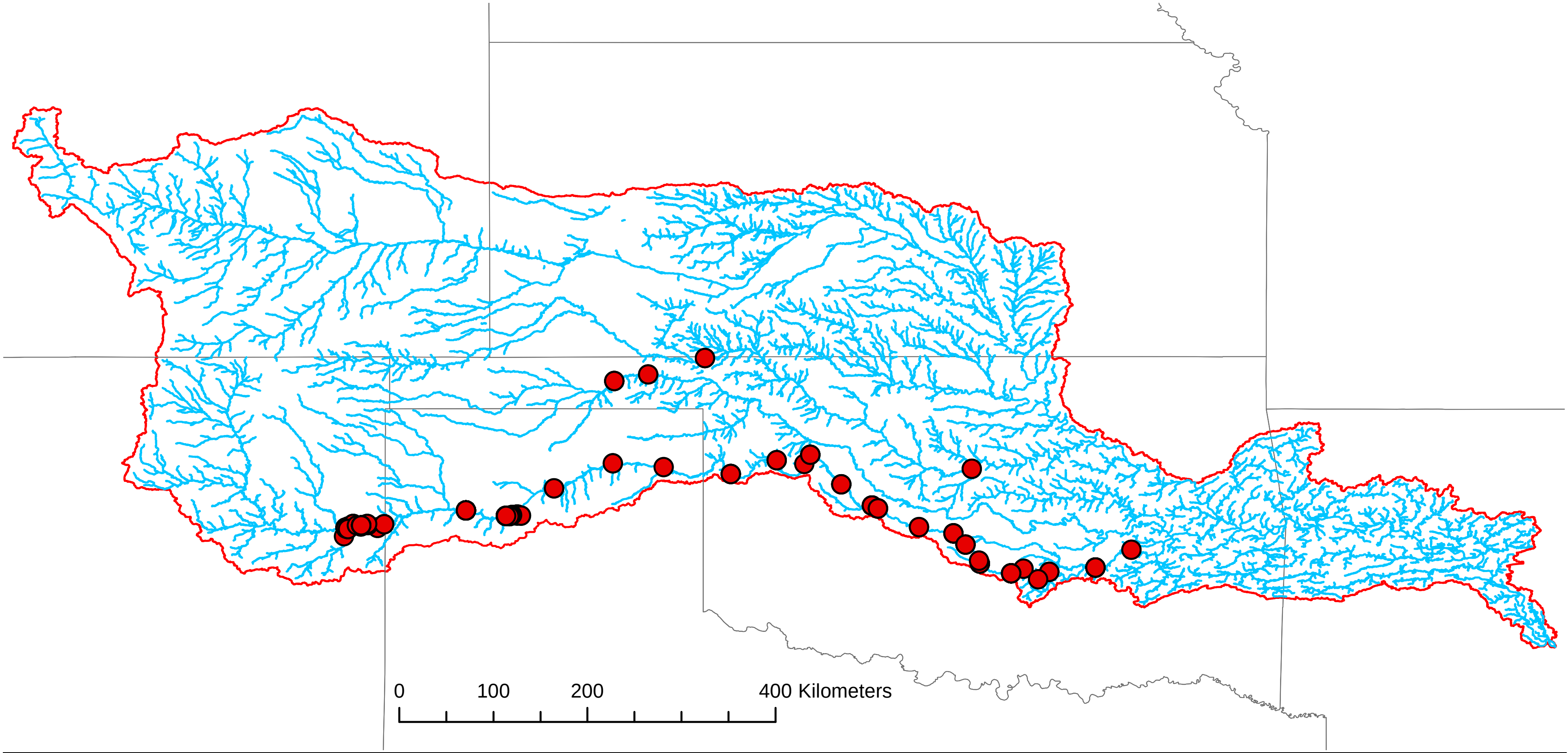
Methods: MaxEnt

- Construct SDMs for 2 time periods relevant to the decline of ARS
- Current model (1990 - 2010)
  - 47 locations
- Historic model (pre 1989)
  - 163 locations





- Arkansas River shiners captures 1926 – 1989
- Distributed throughout Arkansas River catchment



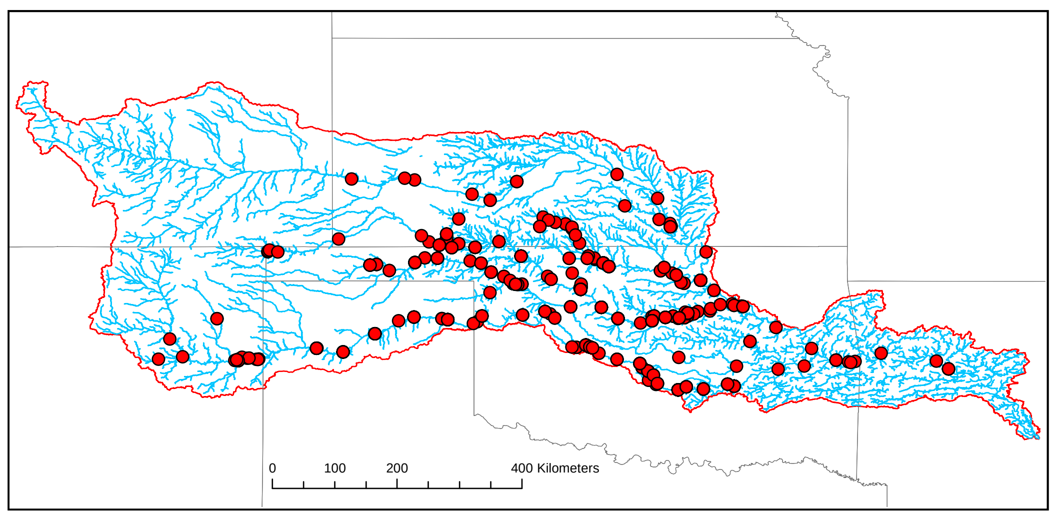
- Arkansas River shiners captures 1990 – 2010
- Recorded regularly in Canadian River
- Sporadic captures in Cimarron and N. Canadian

Methods: MaxEnt

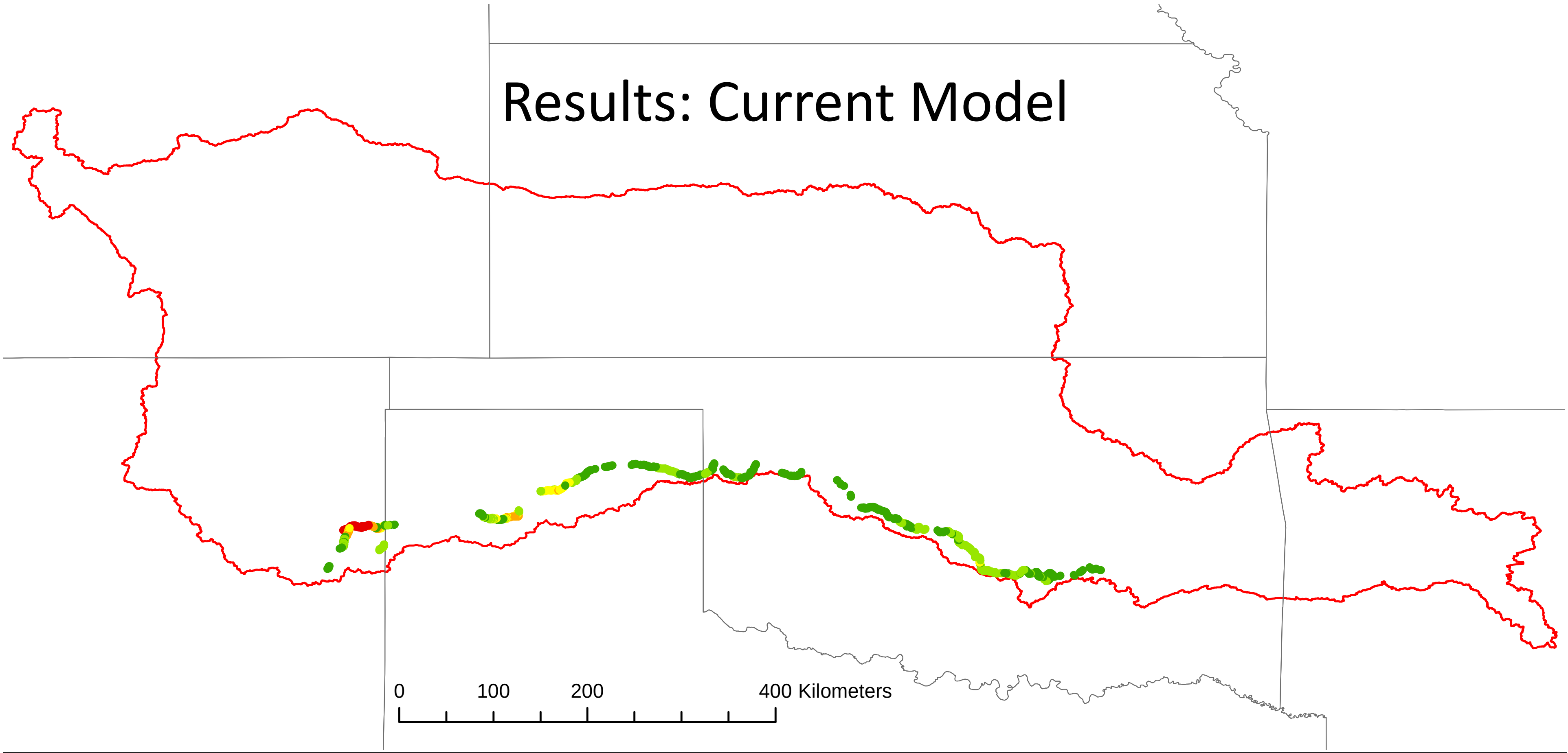
- 26 environmental variables
- 19 Bioclimatic predictors
  - Temperature and precipitation
- Geology
- Stream order
- Maximum elevation
- Slope
- Discharge
- Land use
- Downstream drift distance: NID (1096 barriers)

Methods: MaxEnt

- Samples with data (Vector) approach: 53,617 river segments (NHDPlus)
- Variable response curves- correlated data; contribution of environmental variables
- Model performance:
  - 10 x cross validation
  - AUC
  - Hindcast
  - Forecast



Results: Current Model

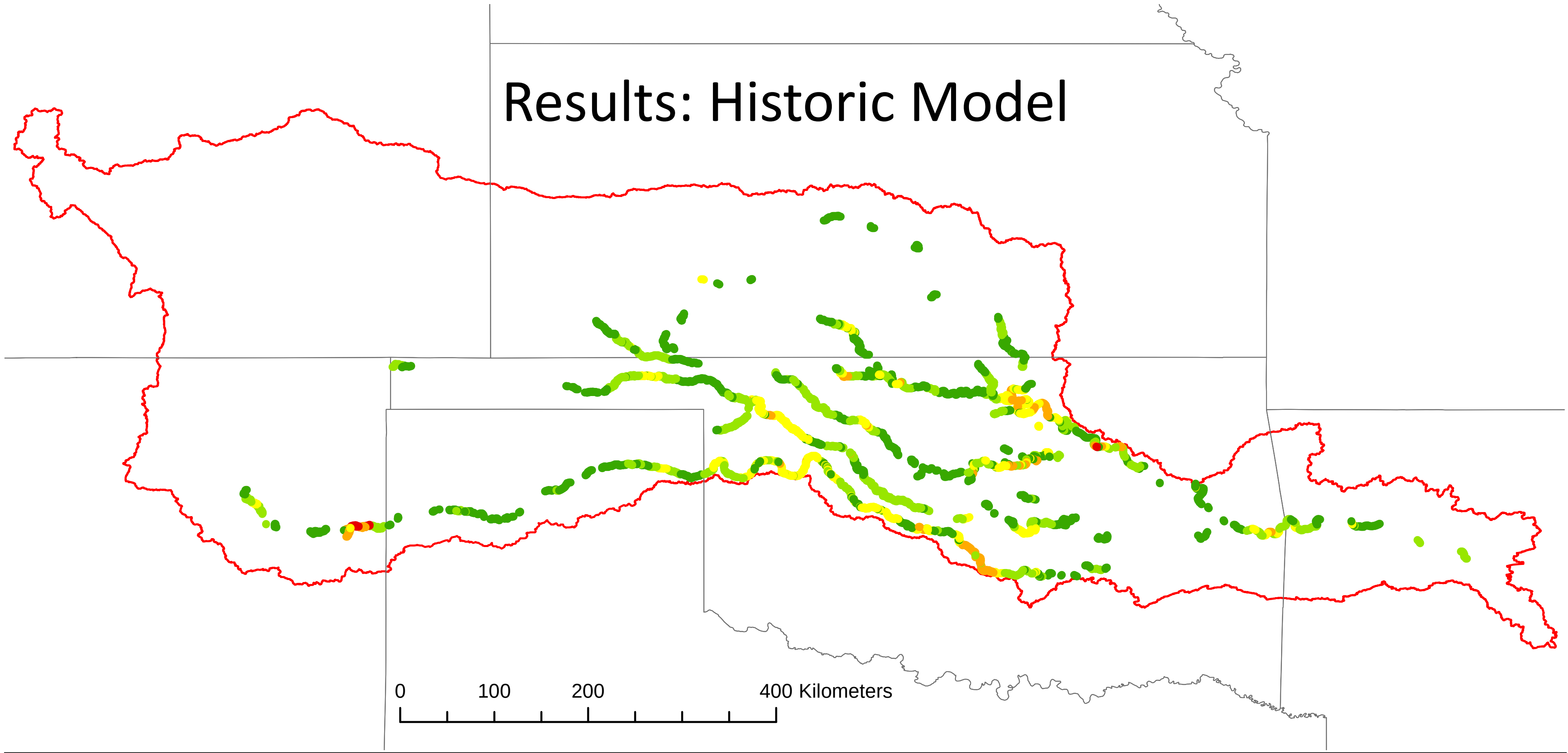


- AUC = 0.98 ± 0.03
- 343 segments in 3 rivers
- Canadian River
  - Ute Lake to Lake Eufaula

Probability of Presence

- 0.5 – 0.6
- 0.6 – 0.7
- 0.7 – 0.8
- 0.8 – 0.9
- 0.9 – 1.0

Results: Historic Model

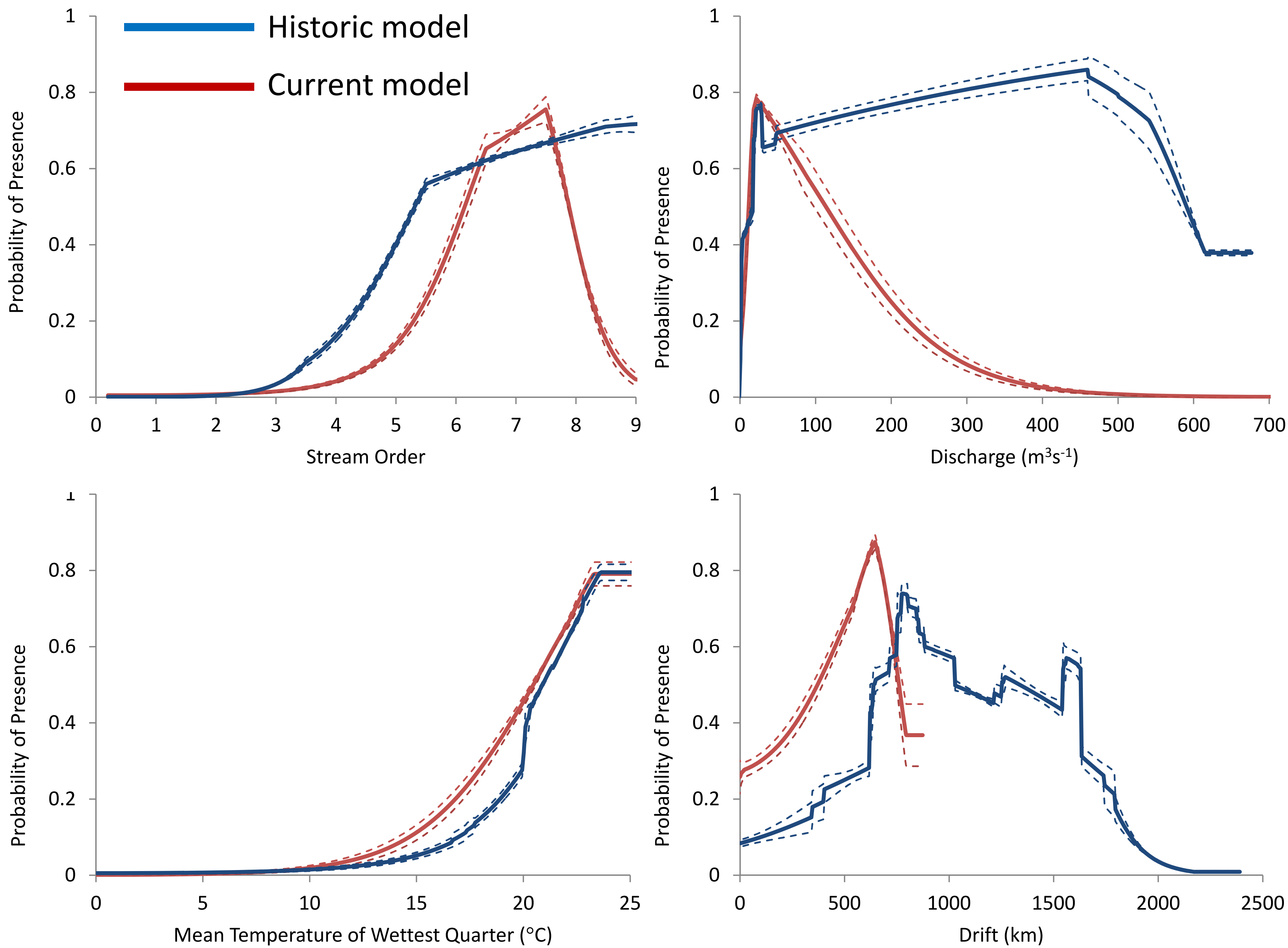


- AUC = 0.96 ± 0.01
- 1312 segments in 20 rivers
- Arkansas, Canadian, Cimarron, N. Canadian rivers

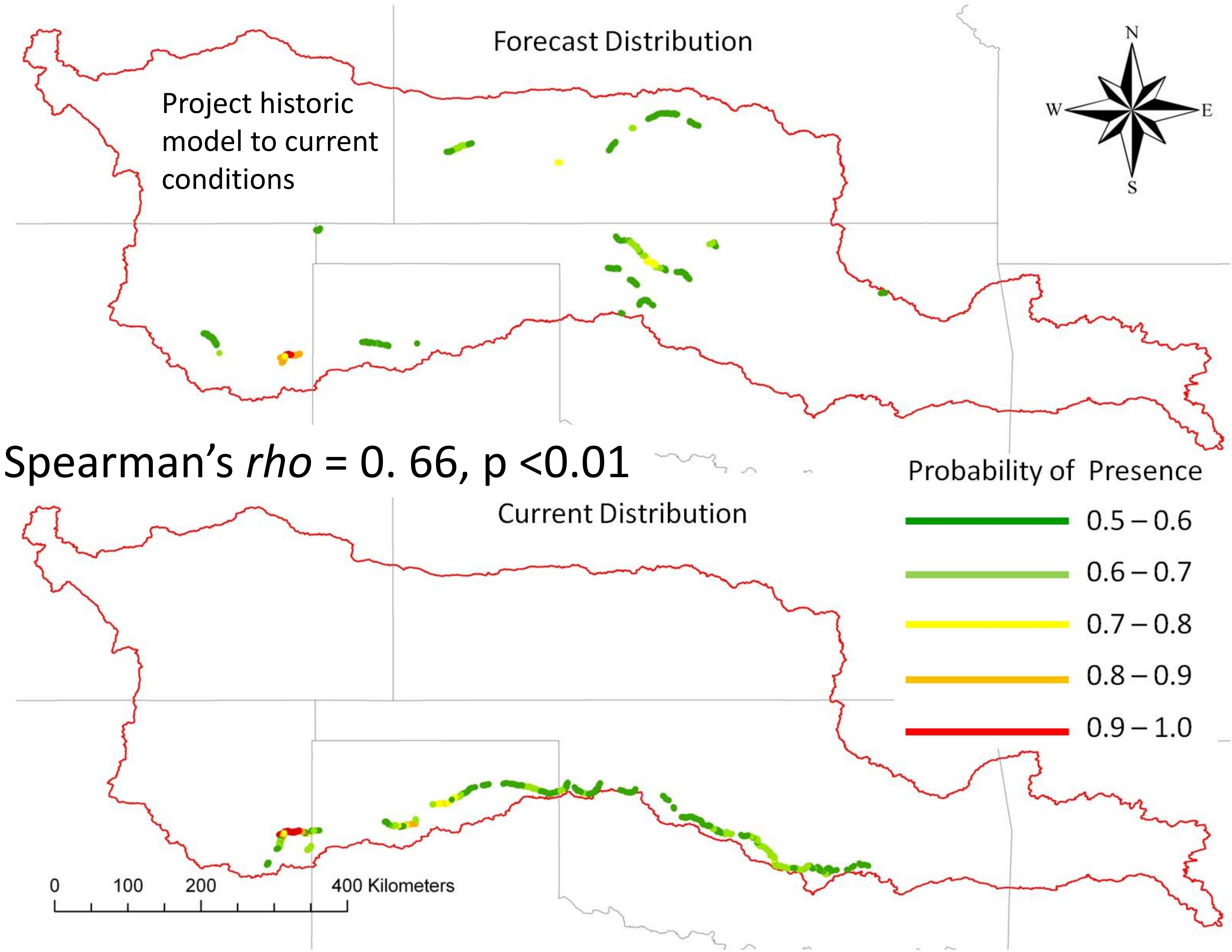
Probability of Presence

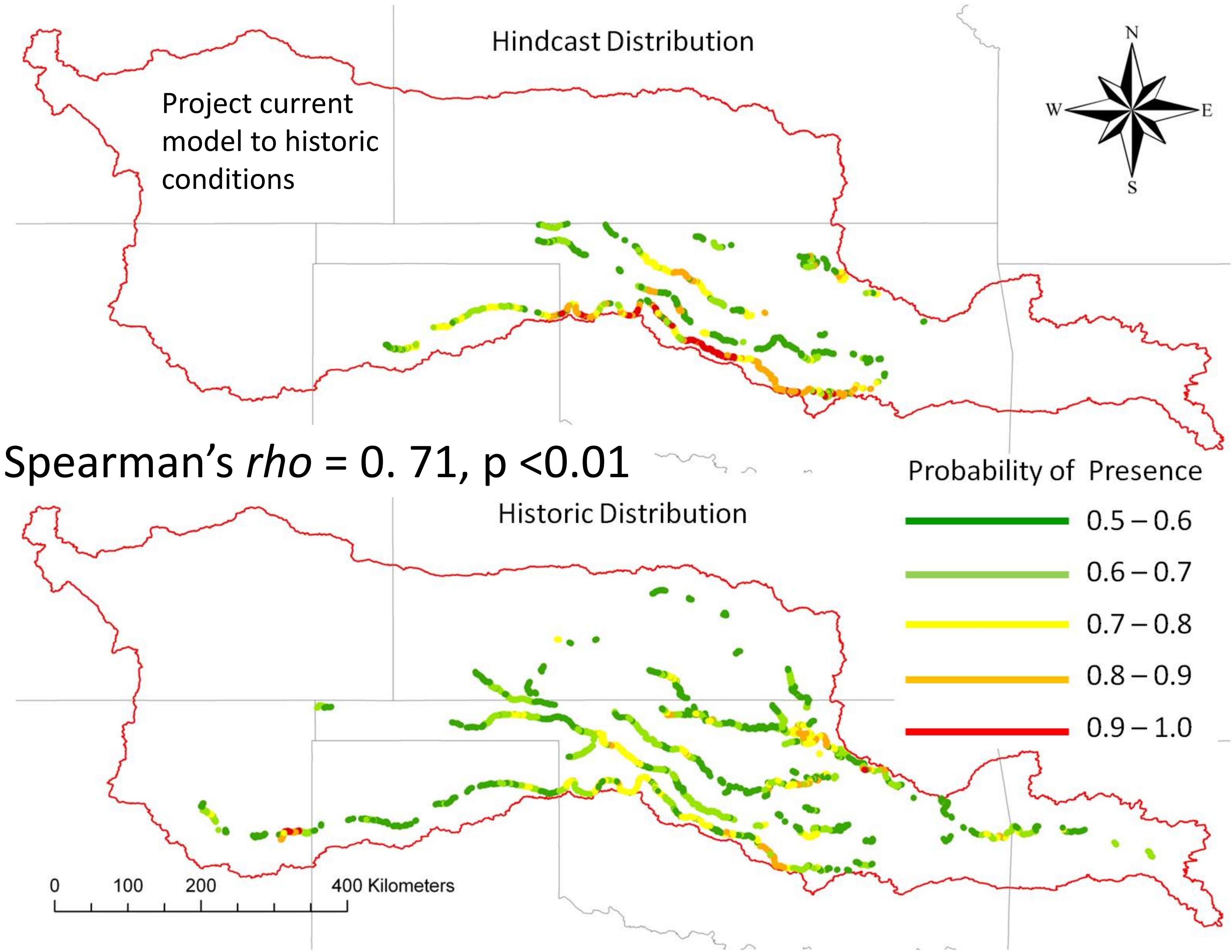
- 0.5 – 0.6
- 0.6 – 0.7
- 0.7 – 0.8
- 0.8 – 0.9
- 0.9 – 1.0

Variable	Current	Historic
Discharge	28.4	21.6
Stream order	25.2	41.7
Land use	12.4	1.0
Geology	11.2	3.3
Drift	4.6	_
Temperature seasonality	4.1	_
Maximum elevation	2.8	_
Precipitation of driest quarter	2.3	_
Precipitation seasonality	2.1	_
Slope	1.4	5.1
Mean temperature of wettest quarter	–	8.6
Mean temperature of coldest quarter	_	4.1
Maximum temperature of warmest month	–	2.2
Precipitation of wettest quarter	–	2.0



Historic model
Current model
Probability of Presence
Stream Order
Discharge (m^3s^{-1})
Mean Temperature of Wettest Quarter (°C)
Drift (km)


Forecast Distribution
Project historic model to current conditions
N
W
E
S
Spearman's *rho* = 0. 66, p <0.01
Probability of Presence
0.5 – 0.6
0.6 – 0.7
0.7 – 0.8
0.8 – 0.9
0.9 – 1.0
Current Distribution
0
100
200
400 Kilometers

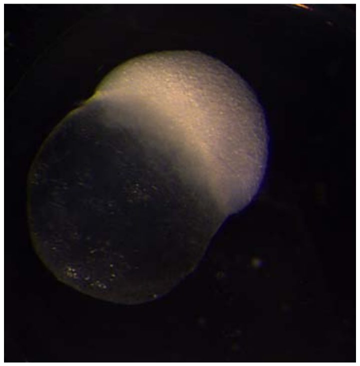

Hindcast Distribution
Project current model to historic conditions
N
W
E
S
Spearman's *rho* = 0. 71, p <0.01
Historic Distribution
Probability of Presence
0.5 – 0.6
0.6 – 0.7
0.7 – 0.8
0.8 – 0.9
0.9 – 1.0
0
100
200
400 Kilometers

Results: Predictive Power

- AUC suggests ‘excellent’ model performance
- Model not 100% accurate
- Projected distributions less accurate
    - Spatial variability in species/environmental relationship
    - Adaptation to changing environmental conditions

Conclusions

- Ute Lake - Lake Eufaula refuge for endemic plains fishes
  - plains minnow, peppered chub, plains sand shiner, and northern plains killifish
- Framework for reintroduction- focus on water!
- First to model interaction of factors across entire species range
- Add evidence linking decline to fragmentation and changes to natural flow regime
- Relevant to other threatened pelagic broadcast spawners



Limitations & Future Directions

- Limitations: species interactions (RRS), hydrologic metrics
- Future: climate and land-use change, water quality

Acknowledgements

- Great Plains Landscape Conservation Cooperative
- Mark Gregory
- Julia Mueller
- Daniel Fenner
- Dr. Bernard Kuhajda; Prof Anthony Echelle; Randy Parham; Dr. Edith Marsh-Matthews; Dr. Chris Taylor; Robert Robins; Melissa Mata; Dr. Nancy Glover McCartney; Dr. Darren Pollock; Dr. Dean Hendrickson; Dr. Aaron Place; Brian Wagner.