Central Great Plains Ecoregion Headwaters Assessment EPA Region 7

National Monitoring Conference

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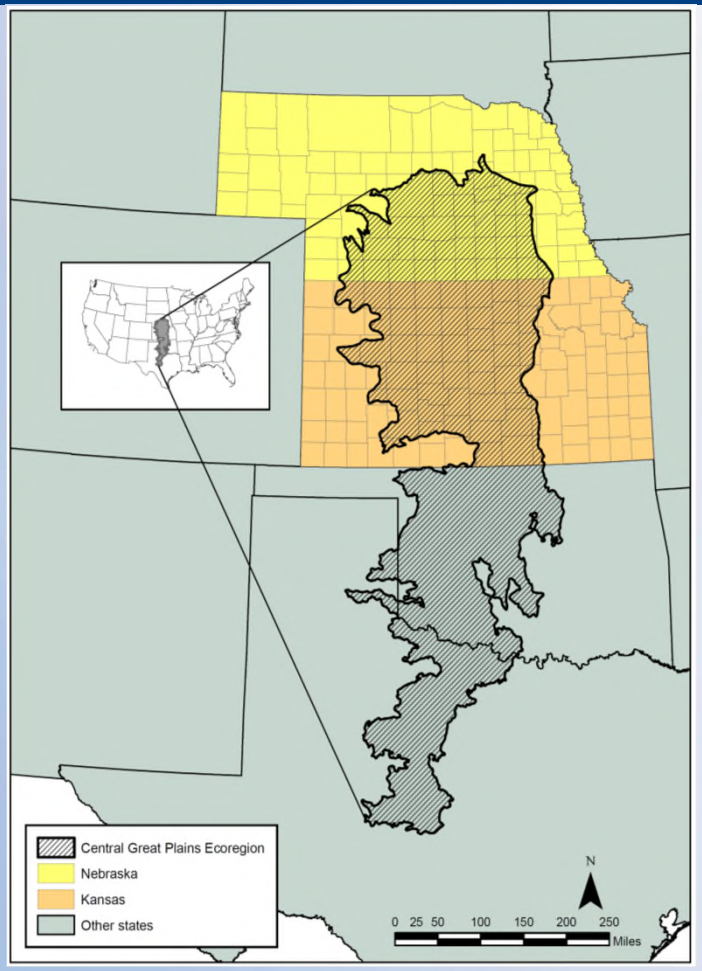
Project Purpose

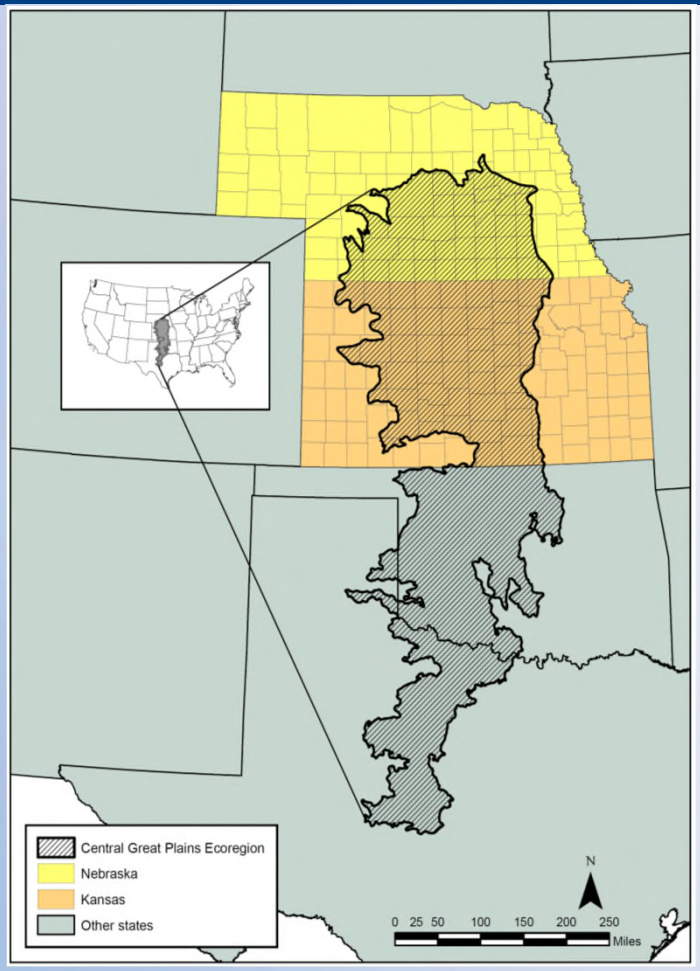
- Purpose: to identify potential pollutants contributing to biological impairment in headwater streams of the Central Great Plain Ecoregion
- Focus on Headwater Streams
  - Kansas – Biological impairment at stream segments means the entire upstream watershed is impaired.
  - Nebraska – Biological impairment is stream segment only.
- Headwater streams are defined as those with a watershed area < 80 sq. miles



Central Great Plains Ecoregion

Project Overview

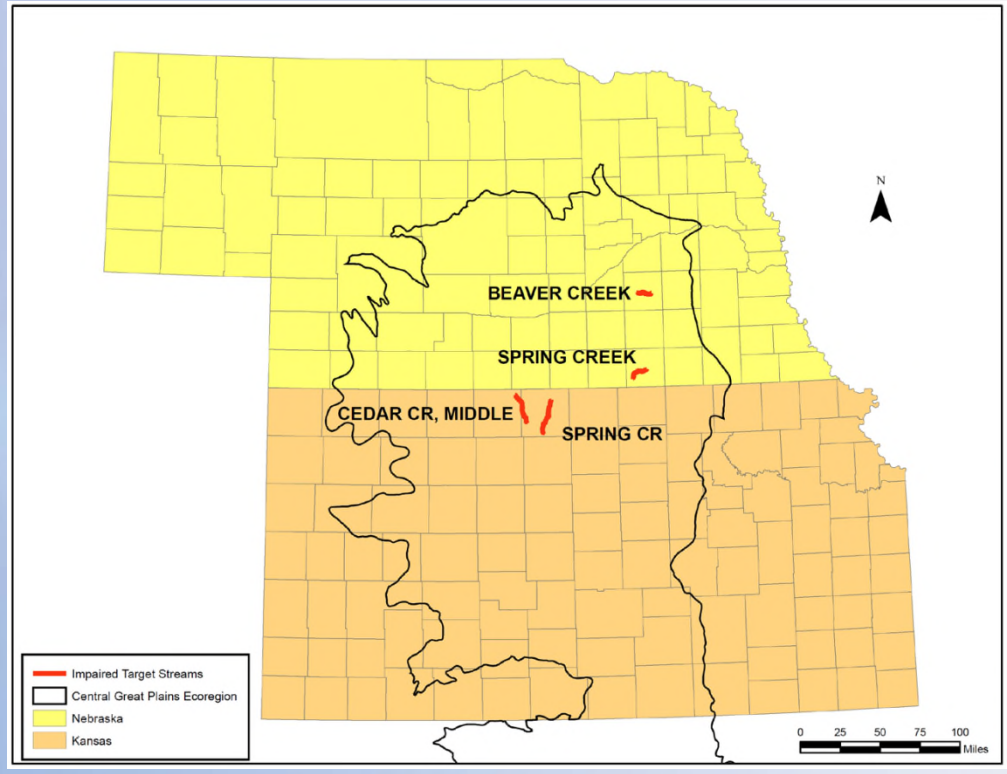
- 16 waterbodies
  - 4 impaired streams (2 in each state, identified by EPA Region 7)
  - 12 “reference” streams, identified by GIS data
- Field data collection
  - Ambient water quality, biology, and habitat
  - Sample twice (spring and summer)
- Stressor Identification
  - CADDIS method
- Analytical Procedures



Central Great Plains Ecoregion

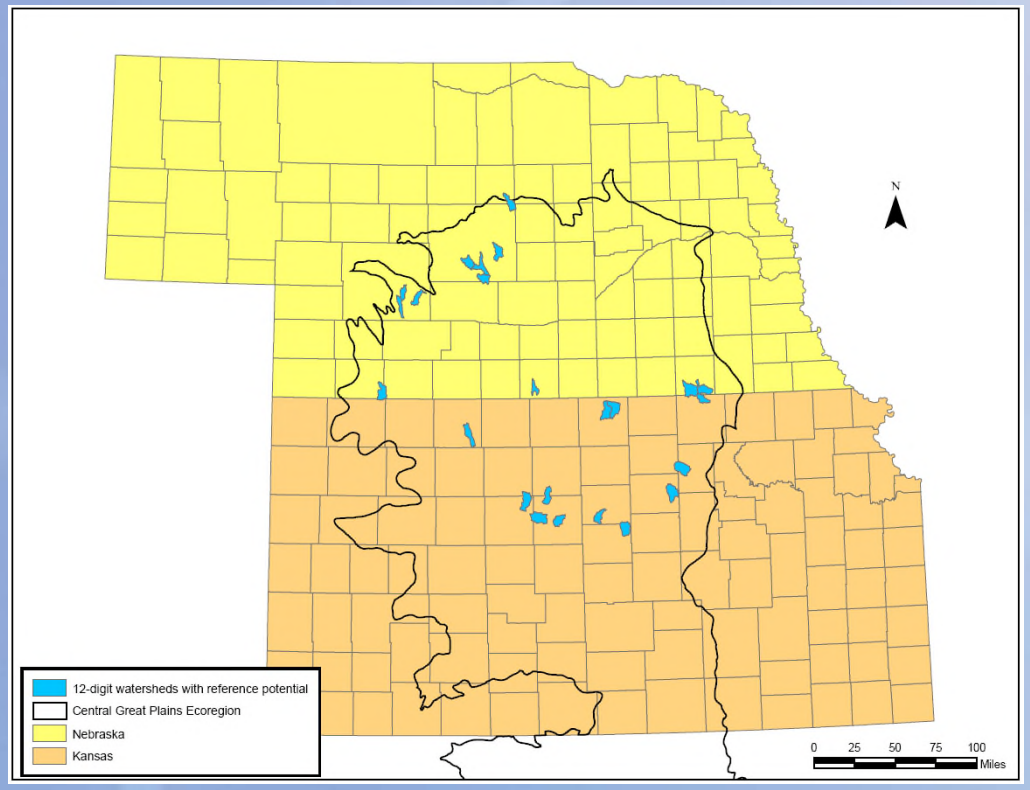
Impaired Sites

- Nebraska
  - Beaver Creek
  - Spring Creek
  - Impaired biota
- Kansas
  - Middle Cedar Creek
    - TSS, arsenic, E. Coli, impaired biota
  - Spring Creek
  - TSS, arsenic, E. Coli, impaired biota



Impaired Target Streams

Reference Sites



12-digit watersheds with reference potential

GIS Analysis Criteria

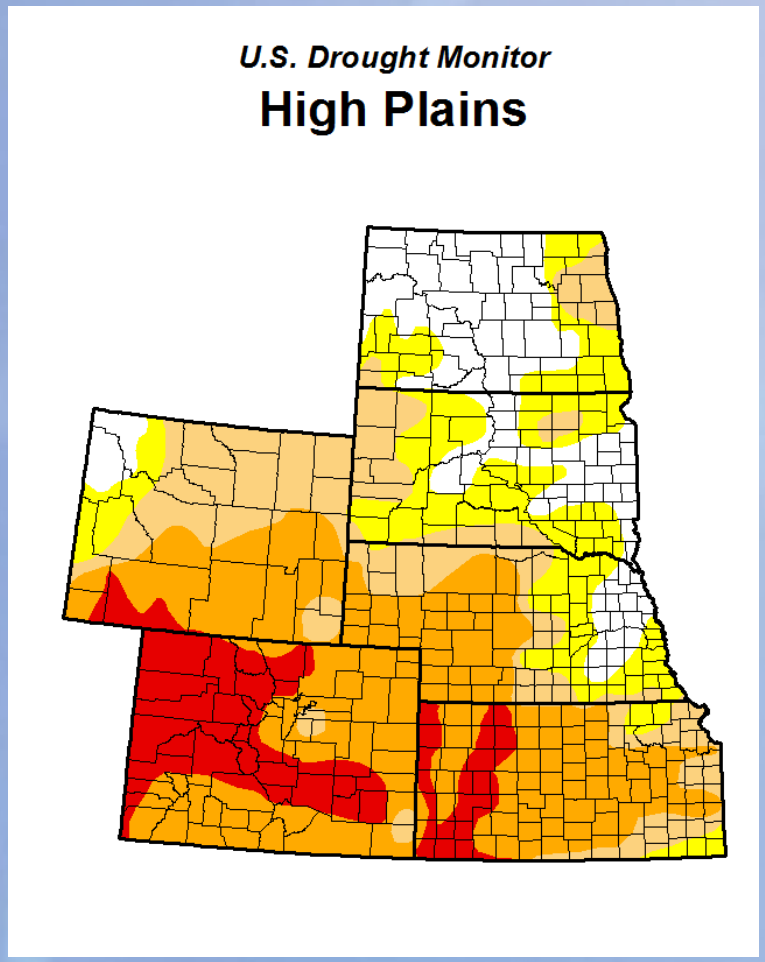
- NLCD (2006)
- state land cover datasets (2005)
- NHD streams
- 12-digit HUC watersheds
- dams
- irrigation
- rural water distribution
- landfills
- stream monitoring
- treatment storage disposal sites
- protected areas
- Kansas Disturbance Index
- NPDES permits
- 303d listed stream reaches
- riparian condition
- state road
- Bing aerial photographs
- railroads

Challenges to Stressor Identification Process

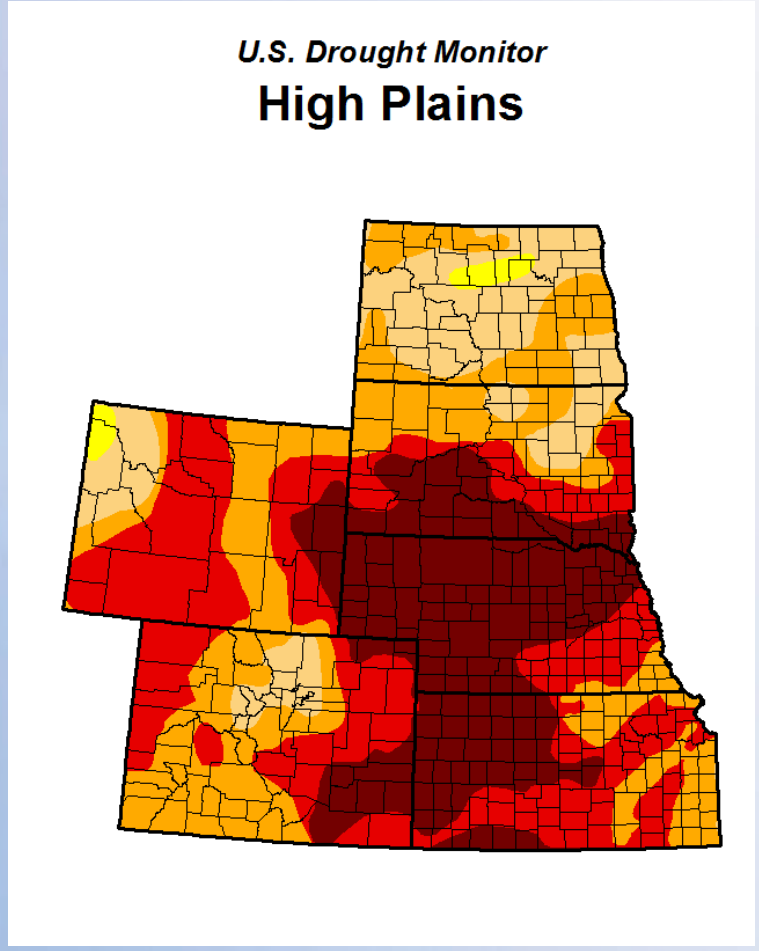
Spring Creek in Nebraska, Spring and Fall 2012

- Data collection was limited due to
  - landowner permission
  - drought
- Single year of data collection made it difficult to determine effects of typical stressors vs. those that were climate/weather related

Drought Conditions



June 26, 2012



October 23, 2012

Sample Size

Table 3-1. List of sampled water bodies.

Site	Stream	State	Type	Spring	Fall	Additional Water Quality Samples
NE-BEAV-UI-105	Beaver Creek	NE	Impaired	yes	yes	4
NE-SPRC-DI-104	Spring Creek	NE	Impaired	yes	no	2
NE-DSAN-UR-102	Dry			s	no	None
KS-MCED-DI-104	Mid			s	yes	3
KS-MCED-UI-107	Mid			s	No	None
KS-SPCR-DI-105	Spri			s	Yes	None
KS-SPCR-UI-106	Spri			s	Yes	1
KS-HFIV-DR-101	Hea Creek	KS	Reference	yes	Yes	None
KS-HFIV-UR-102	Headwaters to Five Creek	KS	Reference	yes	No	None
KS-BTCR-DR-108	Big Timber Creek	KS	Reference	yes	no	None
KS-TBRO-DR-103	Table Rock Creek - Mulberry Creek	KS	Reference	yes	yes	1

Sample Sizes

	Spring	Fall
Reference	5	2
Impaired	6	4

Stressor Identification Steps

Step 1 – Describe the impairment

Step 2 – List possible causes

Step 3 – Develop conceptual models

Step 4 – Analyze evidence

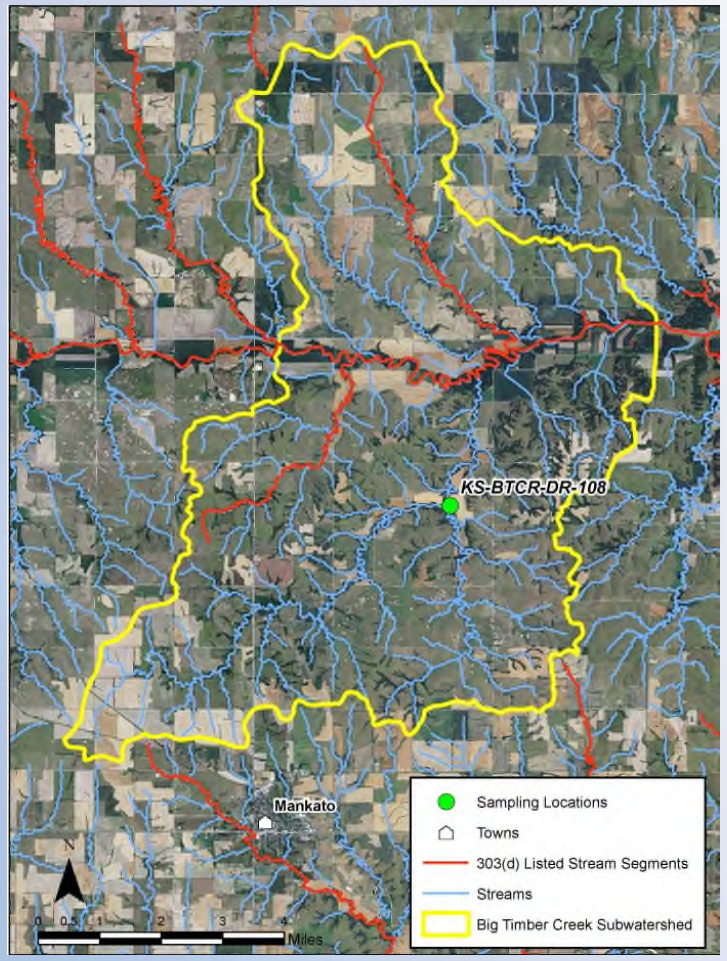
Step 5 – Characterize the cause

Step 6 – Identify probably causes

Step 7 – Make a decision

Stressor ID Step 1 – Describe the Impairment

- What is the observed effect?
- How was the effect determined?
- Where is the impairment?



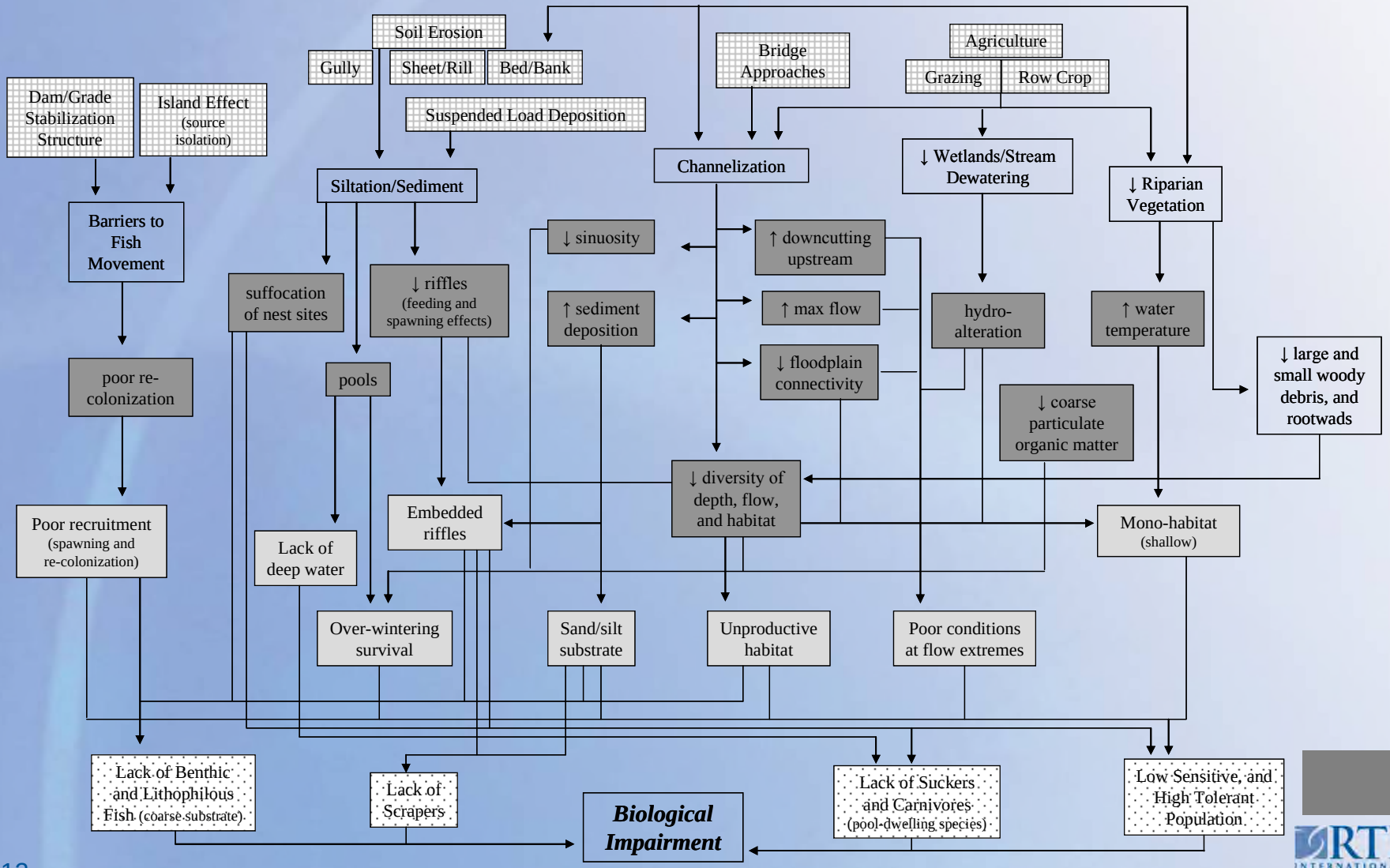
Big Timber Creek subwatershed; sampling point is on the selected reference water body.

Stressor ID Step 2 – List Possible Causes

• Toxins - Metals - Arsenic - Cadmium - Chromium - Copper - Lead - Selenium - Zinc - Other metal toxin - Non-Metals - Chloride - Chlorine - Cyanide - Sulfur - Unionized Ammonia - Priority organics - Non-priority organics - Other non-metal toxins	1
• Habitat Alterations - Barriers to movement - Siltation - Channelization - Riparian vegetation loss - Stream dewatering - Algal growth	1
• Nutrients - Phosphorus - Nitrogen (Nitrate, Nitrite, TKN, Total ammonia)	1
• Physical and Chemical Traits of Water - Turbidity - Suspended solids - TDS	2

1 = high potential; 2 = moderate potential; 3 = high potential

Stressor ID Step 3 – Conceptual Models



Stressor ID Step 4: Analyze the Evidence

- Each stream site was sampled twice (Spring and Fall)
- Sampling included:
  - Benthic macroinvertebrate community
  - 24-hour continuous DO monitoring
  - *In situ* water sampling and water samples for laboratory analysis
  - Physical habitat assessment
  - Photodocumentation
- Results
  - Nebraska – 2 impaired streams, 1 reference stream
  - Kansas – 2 impaired streams 3 reference streams
- Supplemental water samples and *in situ* water quality measurements at locations up and downstream from previously sampled locations

Stressor ID Step 5 – Characterize the Cause

	Tempera-ture	Conduc-tivity	pH	DO	Nitrogen	Phospho-rus	Copper
i. co-occurrence	-	+	-	+	+	+	+
ii. temporality	-	+	-	+	+	+	+
iii. biological gradient	-	0	-	-	0	0	0
iv. exposure pathway	-	+	+	+	+	+	+
v. consistency of association	-	+	-	-	+	+	+
vi. experiment	0	0	0	0	0	0	0
vii. plausibility	-	-	-	-	+	+	+
viii. analogy	-	-	+	+	+	+	+
ix. specificity of cause	0	0	0	0	0	0	0
x. predictive performance	-	-	-	-	+	+	+
xi. evidence consistency	-	-	-	-	+	+	+
xii evidence coherence	-	-	-	-	0	0	+
Total	-10	+1	-6	-2	+8	+8	+9

+ = evidence supports; - = evidence refutes; 0 = neither refutes or supports

Stressor ID Step 6 – Identify Probable Causes

- Altered flow regime
- Nitrogen and phosphorus loading from agricultural lands
- Habitat degradation
- Low dissolved oxygen

Middle Cedar Creek water surface was completely blanketed with duckweed during the Fall.

Stressor ID Step 7 – Make a decision

- Recommendations

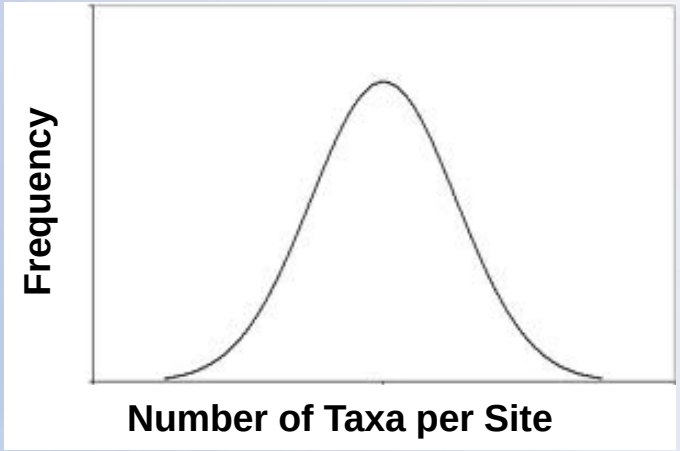
Data Analysis Techniques

- Sample size limitations
- Exploring variability
  - Dot plots and box plots
- Comparing Distributions
  - Kolmogorov-Smirnov (K-S) test
- Exploring stressor-indicator relationships
  - Spearman Rank Order Correlation
- Examining temporal change in indicators
  - Wilcoxon Signed Rank Test
- Examining spatial variability
  - Coordinates overlaid on land use GIS and data plotted

Sample Size Limitations

Sample Sizes*		
	Spring	Fall
Reference	5	2
Impaired	6	4

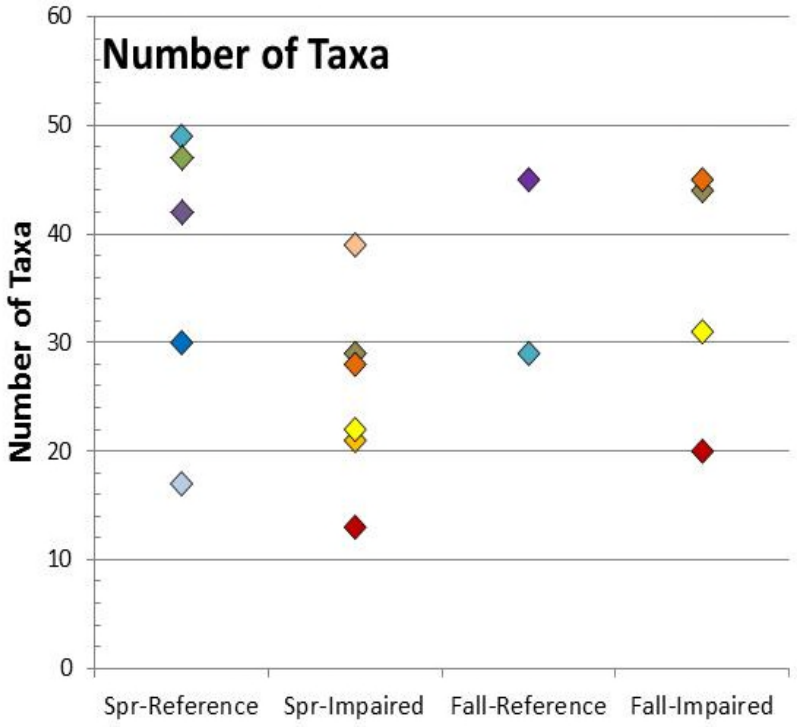
*Sample size was smaller for biotic indices that were calculated for only one state



- Small sample sizes can only give a limited view of the true distribution of data
- Confounded statistical results and misleading conclusions
- Adapted Goals:

1. Use non-parametric methods to analyze data and
2. Identify statistical methods for use in the future when more data become available

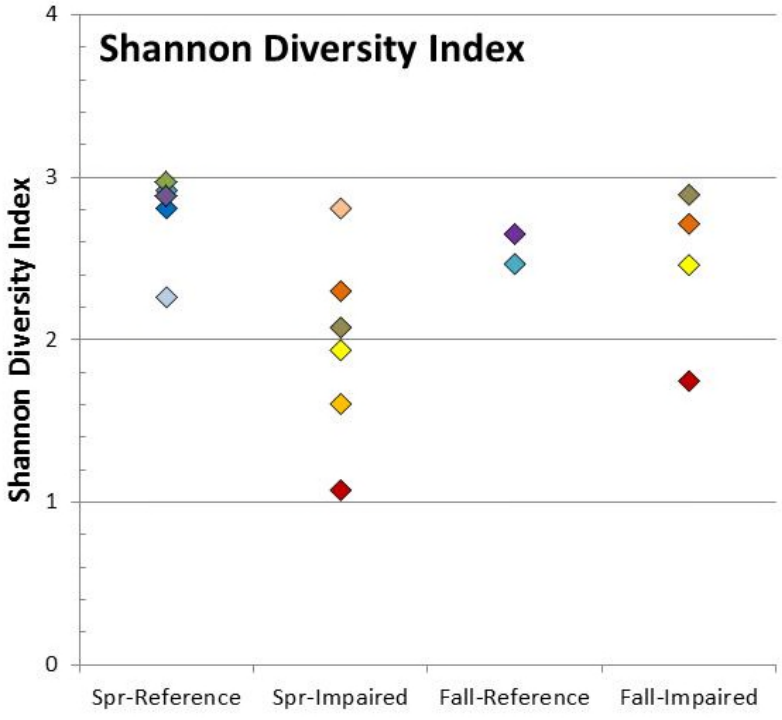
Exploring Variability: Dot Plots and Box Plots

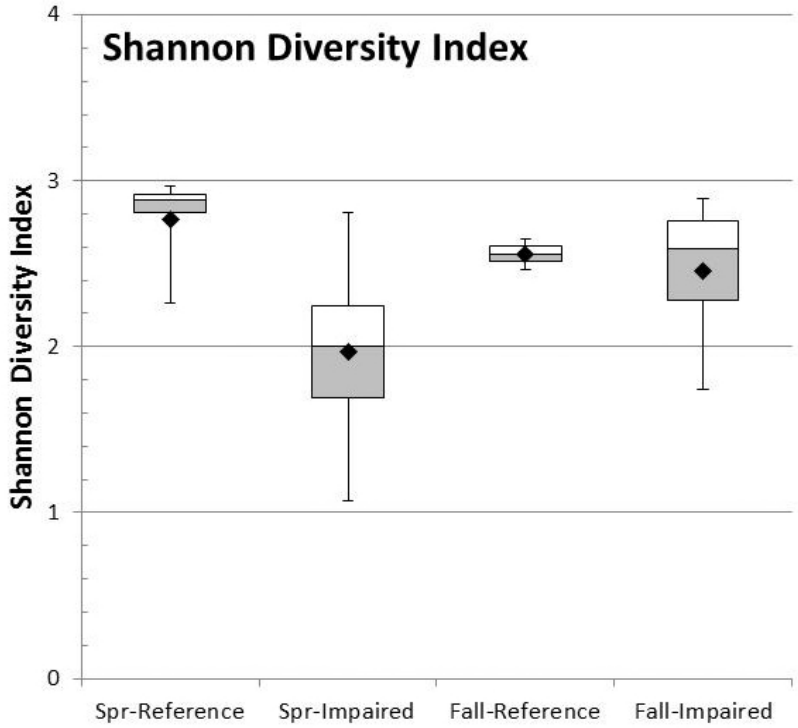


Site	Color	Color Name
KS-BTCR-DR-108		Bright Blue
KS-HFIV-DR-101		Aqua
KS-HFIV-UR-102		Green
KS-TBRO-DR-103		Purple
NE-DSAN-UR-102		Light Blue
KS-MCED-DI-104		Brown
KS-MCED-UI-107		Bright Orange
KS-SPCR-DI-105		Yellow
KS-SPCR-UI-106		Dark Orange
NE-BEAV-UI-105		Red
NE-SPCR-DI-104		Peach

- Dot plots
  - Dots are individual sites
  - Allows visual comparisons: reference vs. impaired; spring vs. fall

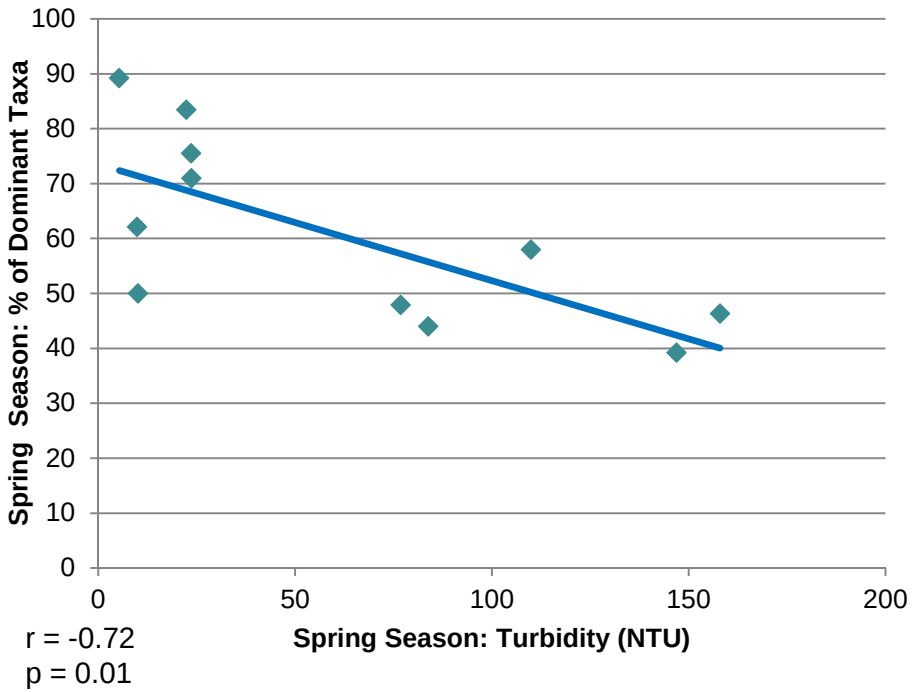
Exploring Variability: Dot Plots and Box Plots





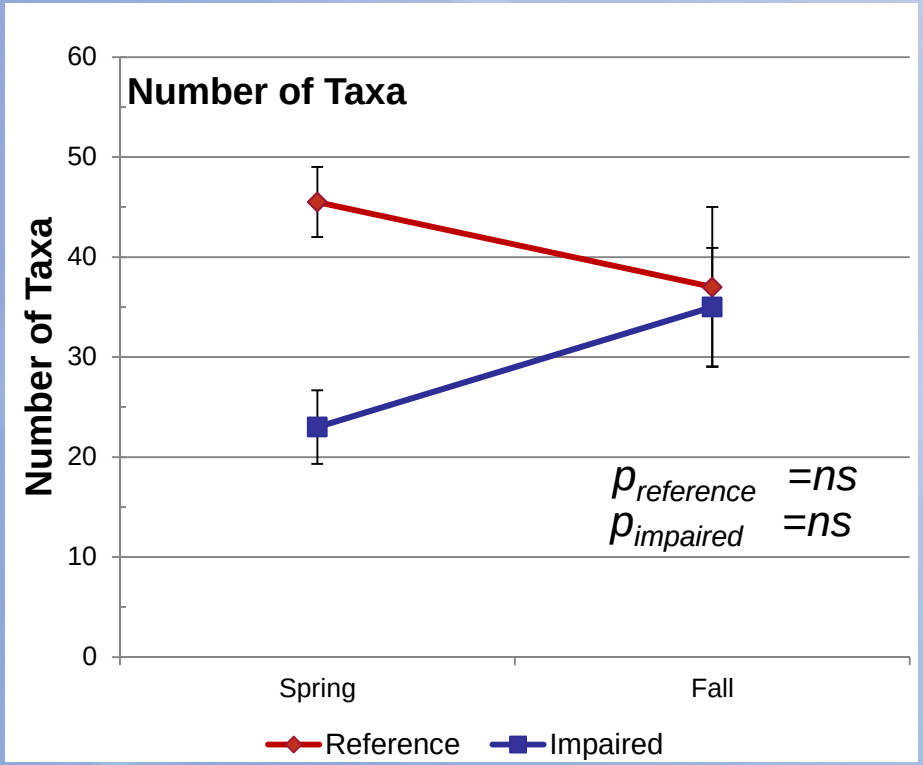
- Box plots
  - Depicts the mean, median, 25th percentile, 75th percentile, minimum and maximum values

Exploring Stressor-Indicator Relationships



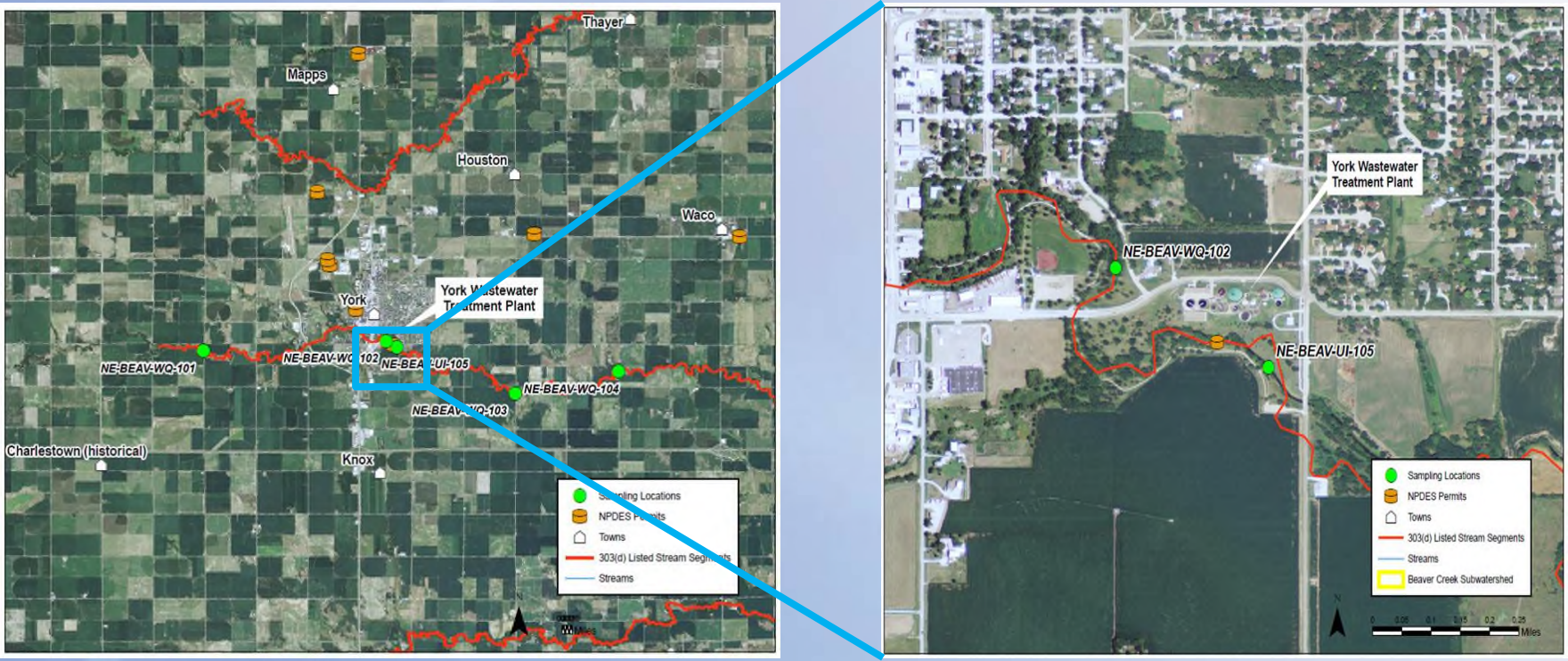
- Used Spearman Rank Order Correlation
- Water quality stressors vs. biological indicators
- Assessed significance with *r* at $p<0.05$

Examining Temporal Change in Indicators



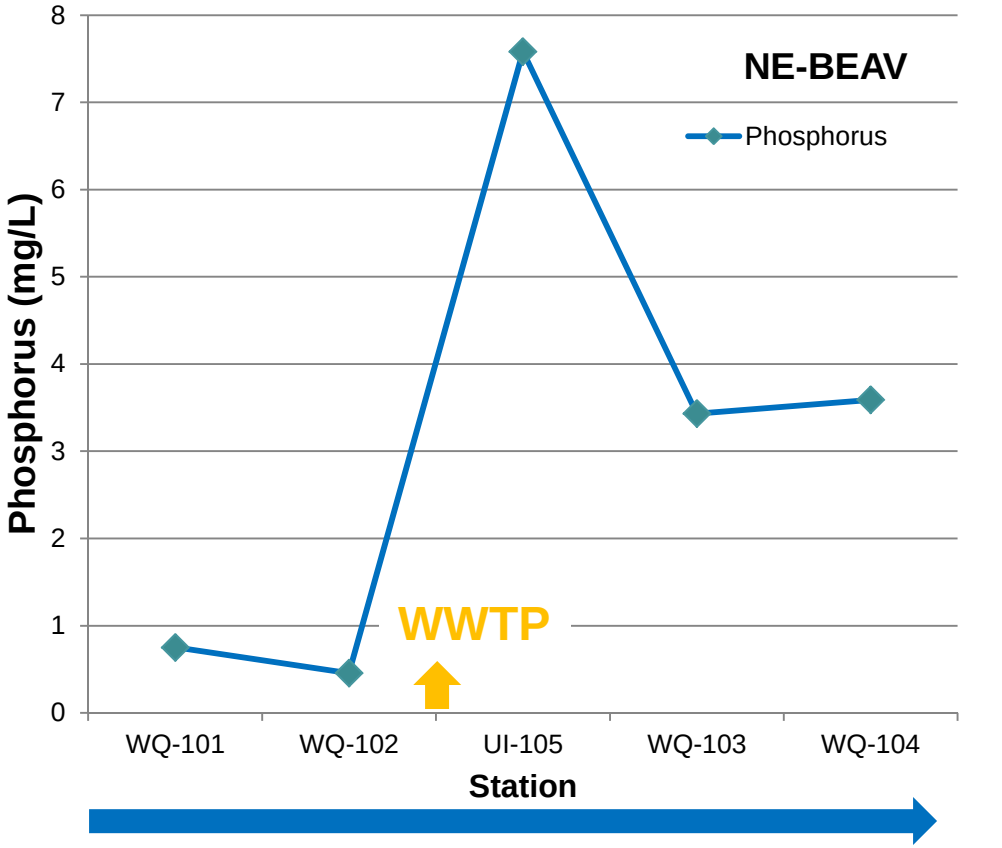
- Used Wilcoxon Signed Rank Test
- Compared spring vs. fall for both reference (n=2) and impaired (n=4)
- This is a paired test so only sites that were sampled in both spring and fall were included
- Significance assessed with the test statistic at the $p<0.05$ level

Examining Spatial Variability



- Overlaid coordinates on land use and plotted data
- Done for two subwatersheds that each contain a WWTP
- Sampling occurred both above and below the WWTP during fall

Examining Spatial Variability



- Example: Phosphorus spiked below the WWTP

Alternate Techniques for Future Use

Test Used	Alternate Tests
Kolmogorov-Smirnov Test	Mann-Whitney U Test; ANOVA
Cluster Analysis	PAM; CART; Other Agglomerative Methods
Spearman Rank Correlation	Pearson Correlation
Wilcoxon Signed Rank Test	Paired t Test

- If more data become available, a variety of other tests that may offer greater statistical power are available

Outcomes

- Provide Nebraska and Kansas with methods for future work in headwater streams
  - Identification of reference sites
  - Data analyses techniques
  - Starting point for identification of stressors
- Importance of flexible Sampling Plan
- Positive interaction with landowners
- Provide baseline information on drought conditions

Thank you to the Project Team

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Questions

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