Assessment of Biological Conditions in Streams of Johnson County, Kansas

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Topeka, Kansas

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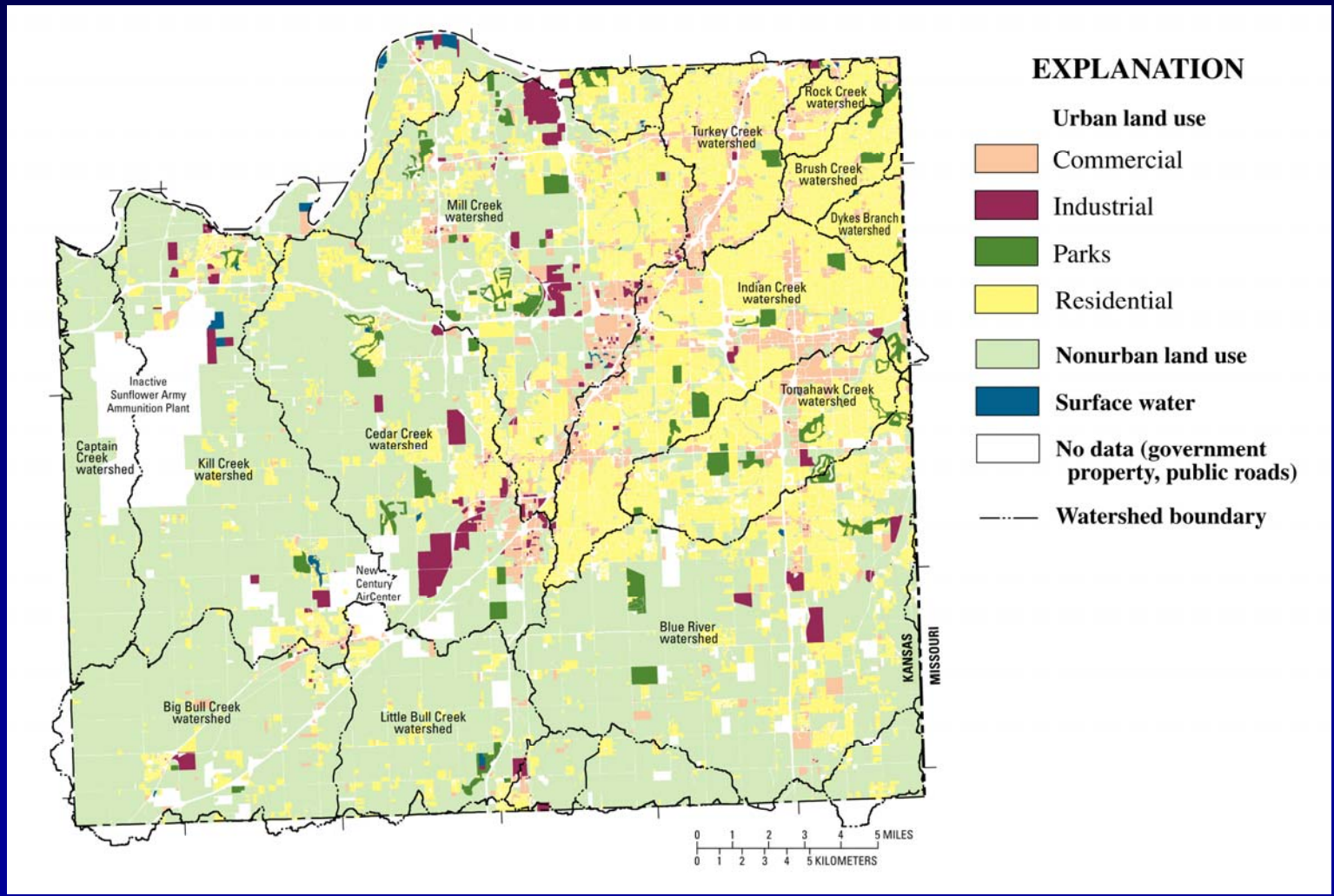
Johnson County Stormwater Management

Johnson County is undergoing rapid development



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Urban development affects stream communities

- Alters stream hydrology
- Changes stream geomorphology
- Affects water chemistry
- Changes habitat

Tomahawk Creek

Indian Creek

Indian Creek

USGS

Johnson County municipalities are subject to requirements of the Clean Water Act

- National Pollutant Discharge Elimination System (NPDES) permitting –point and nonpoint sources
- 303(d) listings – identifying streams that do not meet water-quality standards
- Total maximum daily loads (TMDLs)
- Best management practices (BMPs)

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Most water-quality impairments in Johnson County are related to excessive bacteria, nutrients, and sediment

High priority impairments

Fecal coliform bacteria	Cedar Creek, Kill Creek, Mill Creek
Nitrates/nitrites	Cedar Creek (in EPA review)
Ammonia	Turkey Creek
Biological	Mill Creek (in EPA review)
Eutrophication	Lakes - Gardner City, Hillsdale, Olathe and Cedar (in EPA review)

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Cooperative water-quality study between USGS and the Johnson County Stormwater Management Program

- To characterize water-quality of Johnson County streams
- To identify contaminant source areas
- To estimate contaminant concentrations and loads
- To evaluate effects of urbanization on water quality
- To monitor changes in water quality
- To provide information for developing effective water-quality management plans
- To help meet requirements of the Clean Water Act

Mill Creek near
Shawnee Mission Park

USGS

Overall study approach – 3 components

1. Water and sediment sampling to identify contaminant sources

2. Continuous water-quality monitoring to estimate chemical concentrations and loads

3. Biological assessment to describe biological conditions

Riffle beetle

Stonefly

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Biological information is valuable to water-quality programs

Fish

Algae (periphyton)

Aquatic plants (macrophytes)

Bottom-dwelling (benthic) invertebrates

- Determines how well water bodies support aquatic life
- Aquatic life integrates cumulative effects including variable streamflow, habitat, chemistry, sediment
- Can be used to develop criteria and establish long-term goals

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Photos from http://uhl.uiowa.edu/services/environment/waterquality/limnology/

Basics of biological assessments using macroinvertebrates

1. Macroinvertebrate samples are collected using specific protocols

Kansas protocol – two independent 100-count samples, multiple habitats, limited time, lab ID

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Basics of biological assessments using macroinvertebrates (continued)

2. After organisms are identified and counted in the lab, the information is used to calculate various metrics

- Calculated according to published literature
- Used to measure and evaluate macroinvertebrate response to various factors such as human disturbance

Metrics are values used to describe specific attributes of a community (such as diversity, composition, abundance, tolerance)

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Basics of biological assessments using macroinvertebrates (continued)

Common metrics include:

* • Macroinvertebrate Biotic Index (MBI) – tolerance levels
* • Kansas Biotic Index (KBI-NO) – tolerance to nutrient (N) and oxygen-demanding substances (O)
* • EPT richness – total number of Ephemeroptera (mayflies) Plecoptera (stoneflies) Trichoptera (caddisflies) taxa
* • EPT abundance – EPT as percent of total number of organisms
  • Total taxa richness – total number of different types of organisms
  • Multimetric combinations

* Used by KDHE for aquatic-life-support status

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Basics of biological assessments using macroinvertebrates (continued)

3. Reference sites are often used as a basis for comparison when evaluating nearby sites

Reference site – limited number of sites designated by the State as being minimally affected by human disturbance

Captain Creek,
Kansas reference site

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Basics of biological assessments using macroinvertebrates (continued)

4. The type and number of macroinvertebrates are indicative of water quality conditions

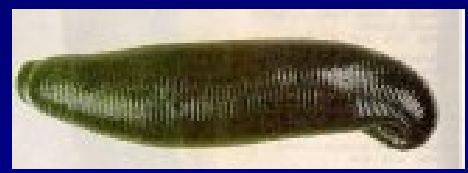
Macroinvertebrates generally associated with healthy streams include:

Stoneflies (Plecoptera)

Mayfly (Ephemeroptera)

Caddisfly (Trichoptera)

Macroinvertebrates generally associated with more polluted streams include:



Leech

Midges (Chironomidae)

Worm (Oligochaeta)

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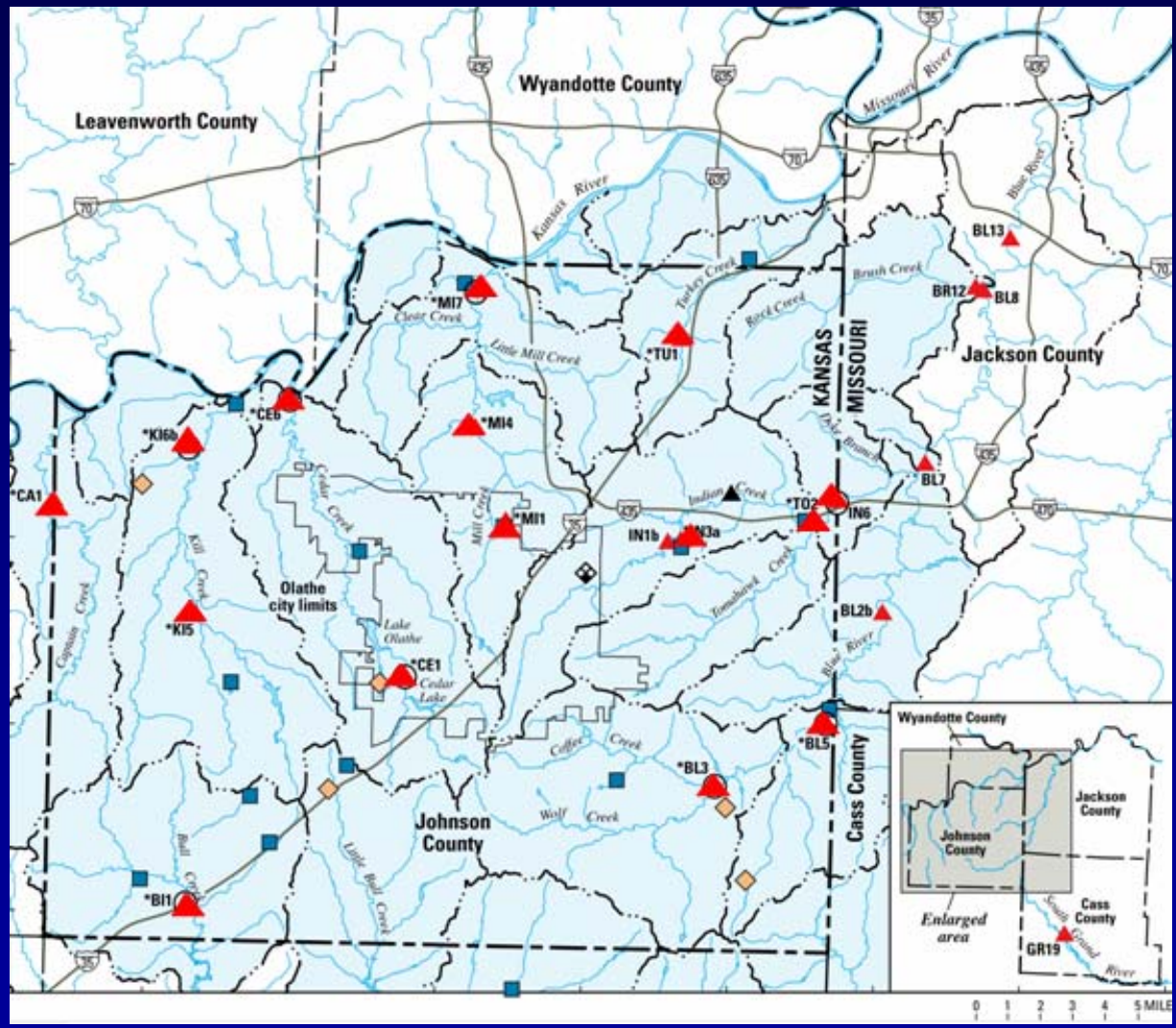
Photos from www.epa.gov/bioindicators/html/photos_invertebrates.html

Johnson County biological assessment

- Sampled 15 stream sites in Johnson County in early spring of 2003 and 2004
- Also evaluated published data from 7 additional sites, mostly in Missouri
- Available land use and water- and streambed-sediment quality data also evaluated



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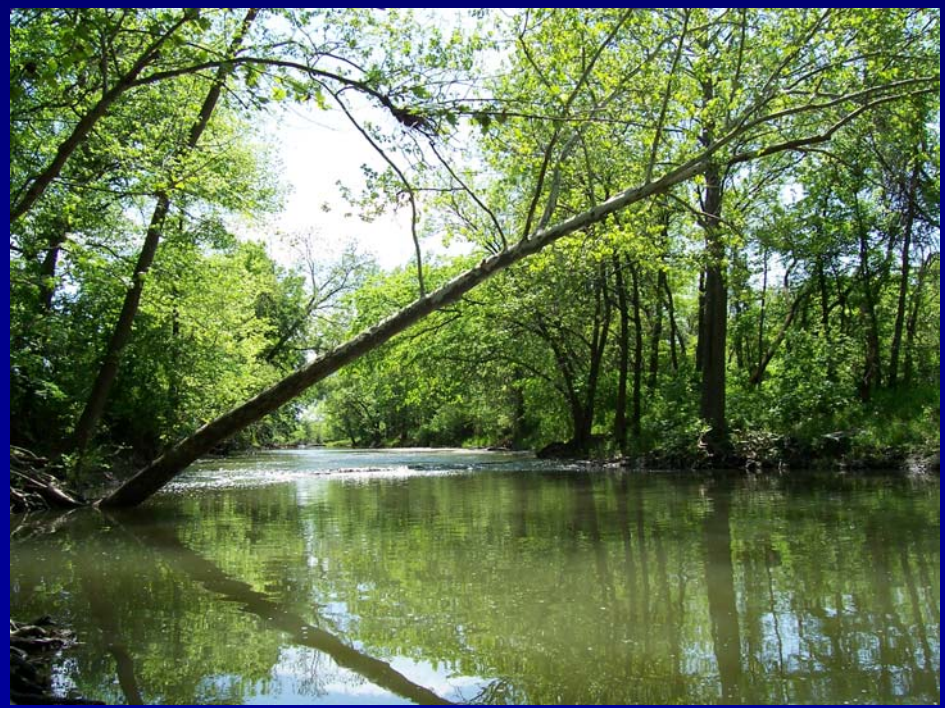
Relative biological conditions were assessed by:

- Examining macroinvertebrate community composition
- Scoring, ranking and grouping sites according to metrics
- Describing relations between macroinvertebrates and land use, water and stream quality
- Evaluating effects of urbanization on macroinvertebrate communities
- Comparing conditions at Johnson County sites to downstream sites in Missouri
- Comparing stream conditions to State biological criteria



Mill Creek near Shawnee Mission Park

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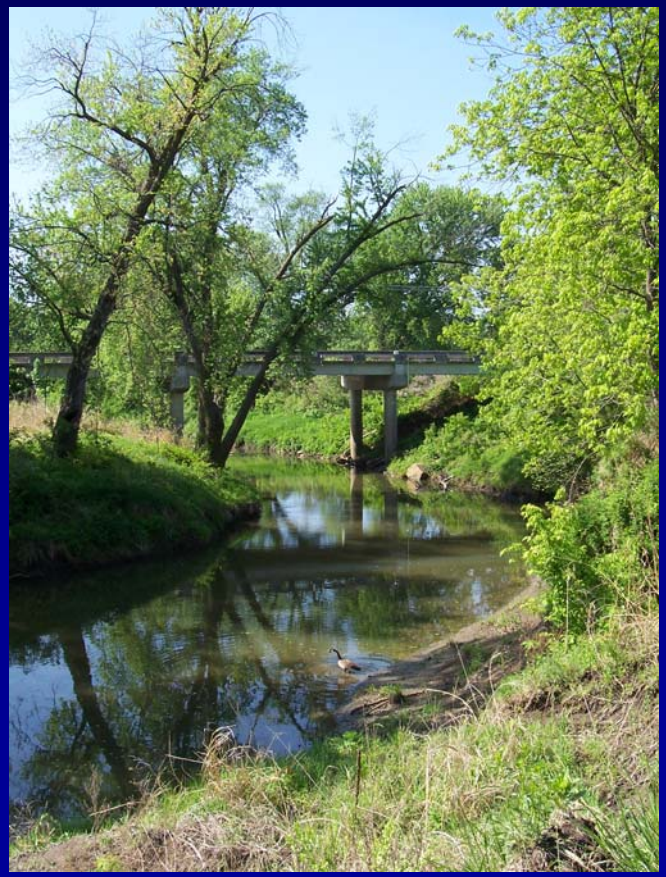
Results

Most rural sites contained a diversity of insects including those normally associated with healthy streams



Kill Creek at 95th St

Indian Creek at State Line Rd

More urban sites had none or few insects associated with healthy streams and were dominated by pollution-tolerant insects

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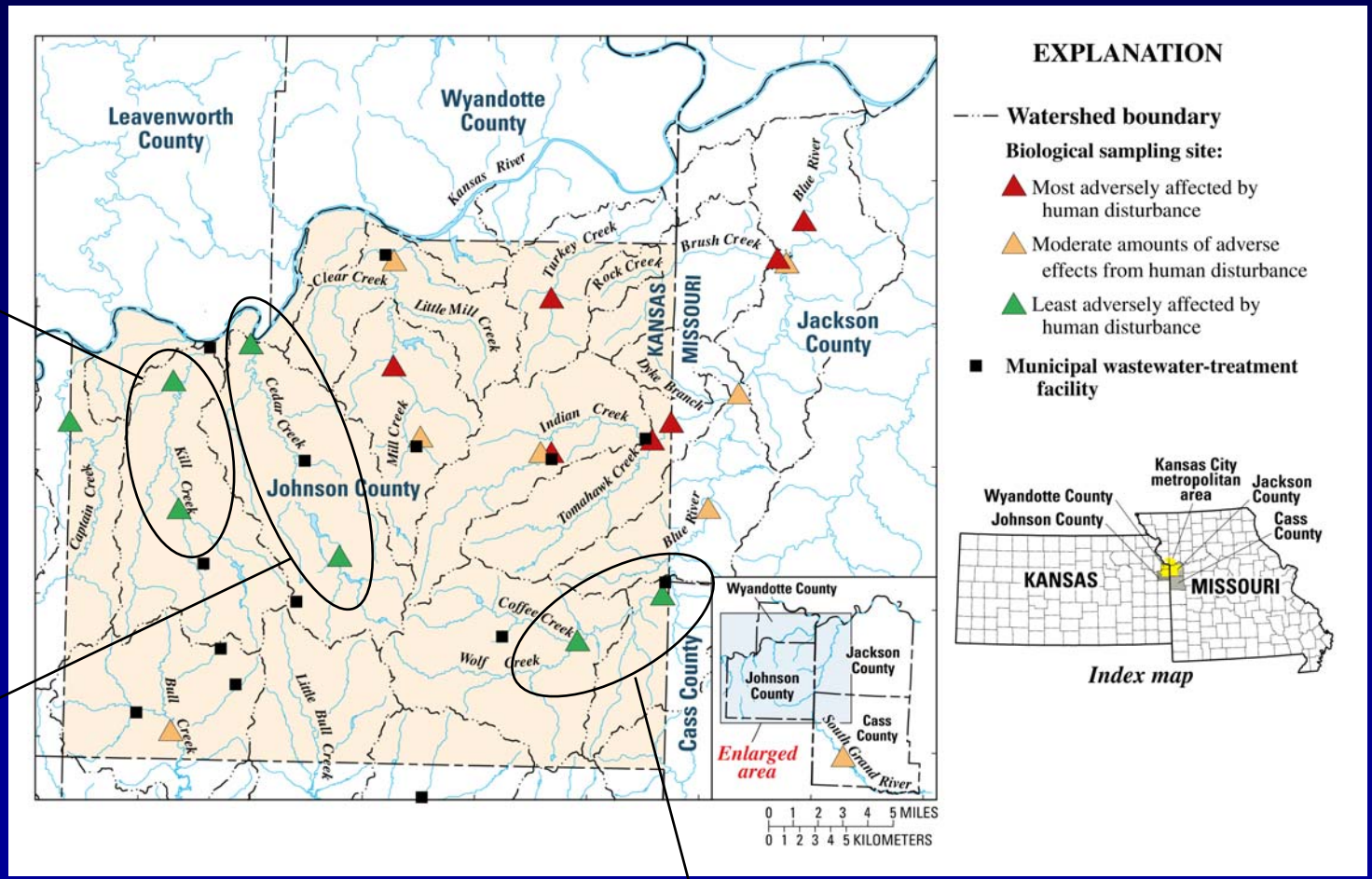
Rural sites consistently scored among those least adversely affected

Kill Creek sites

Cedar Creek sites



Upstream Blue River sites

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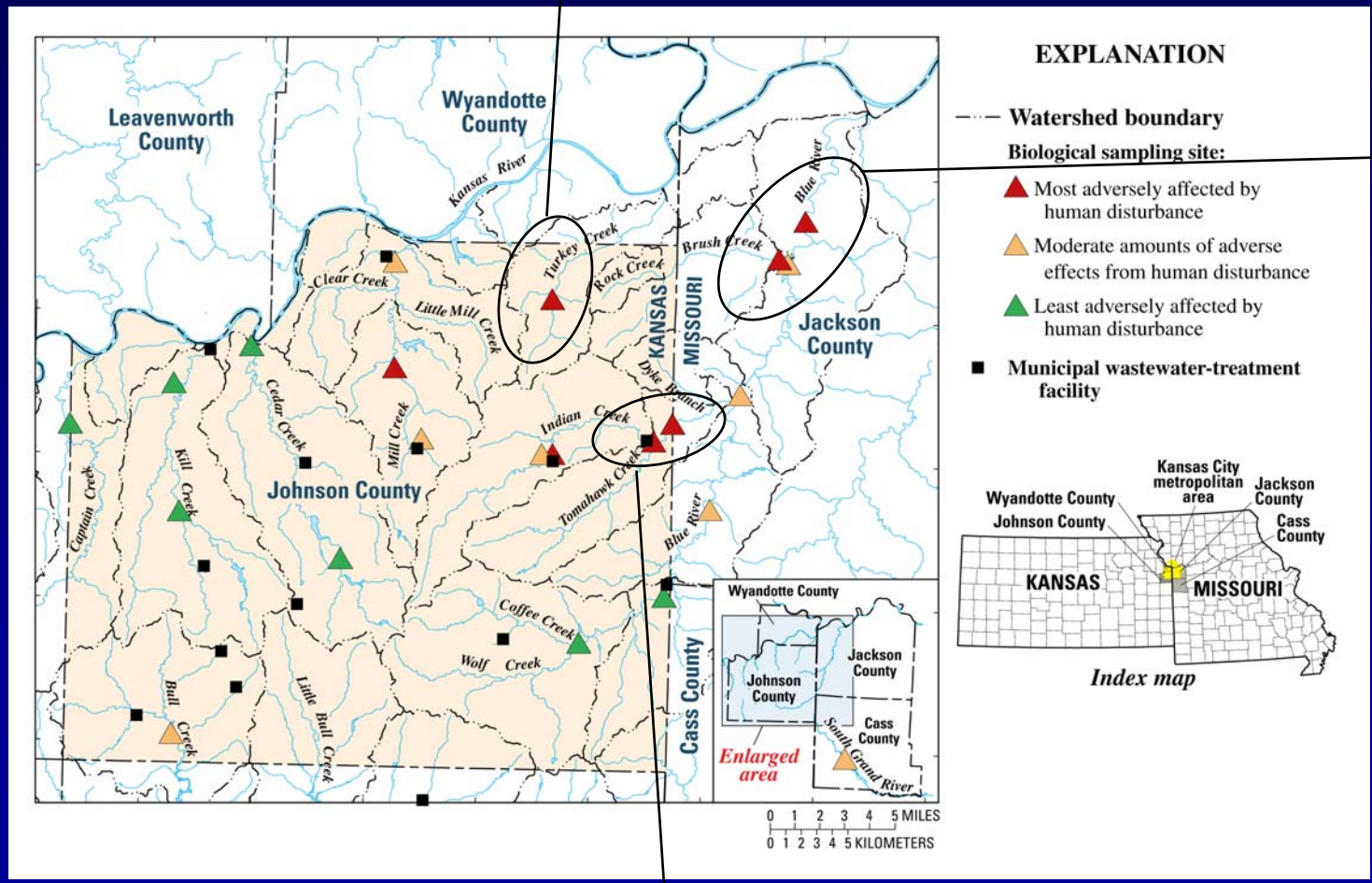
Sites downstream from treatment facilities and large impervious areas consistently scored among those most adversely affected

Turkey Creek



Downstream Blue River sites

Indian and Tomahawk Creek sites

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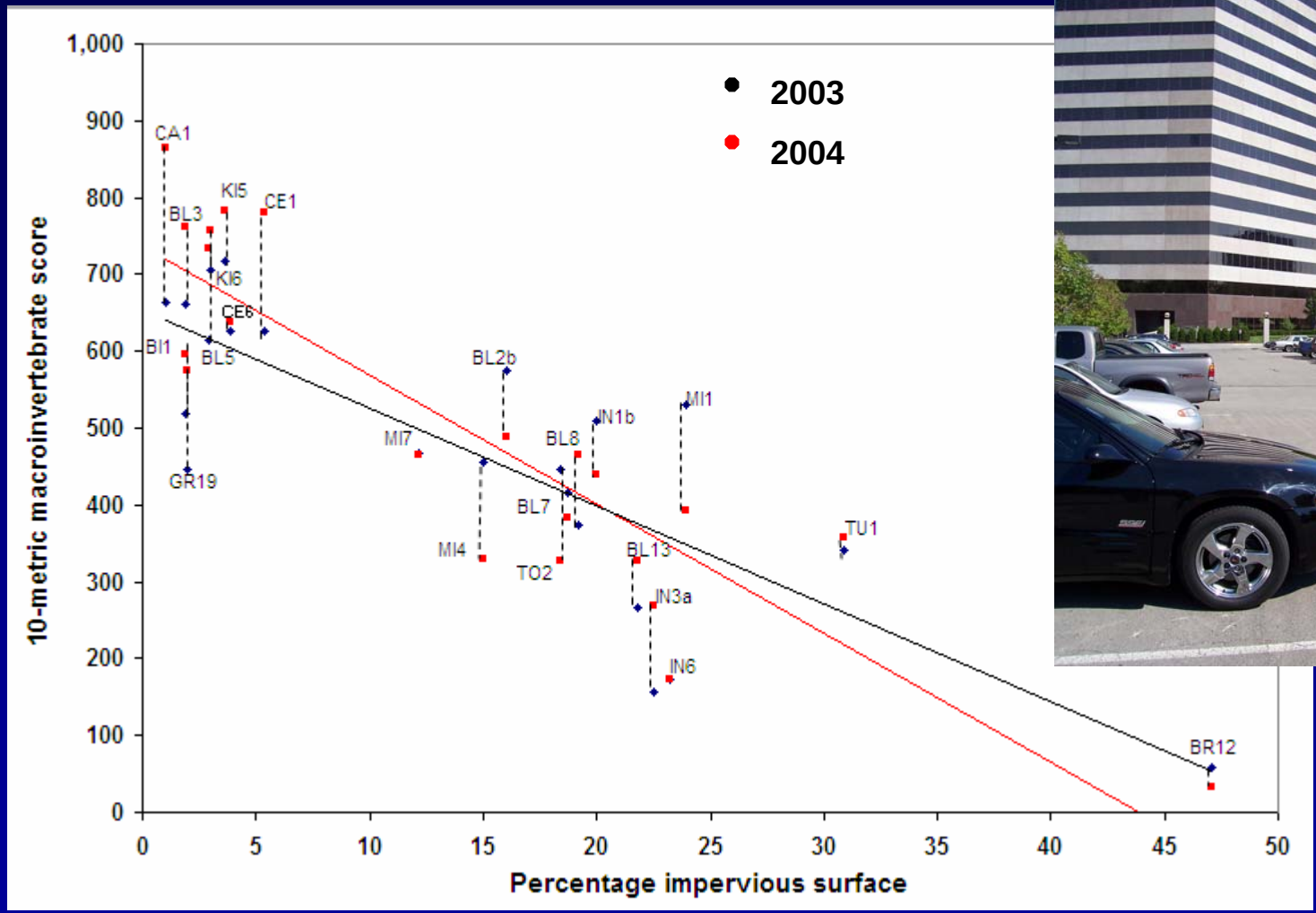
Generally, as urban land use (percent impervious surface) upstream from the sampling sites increased, biological quality decreased



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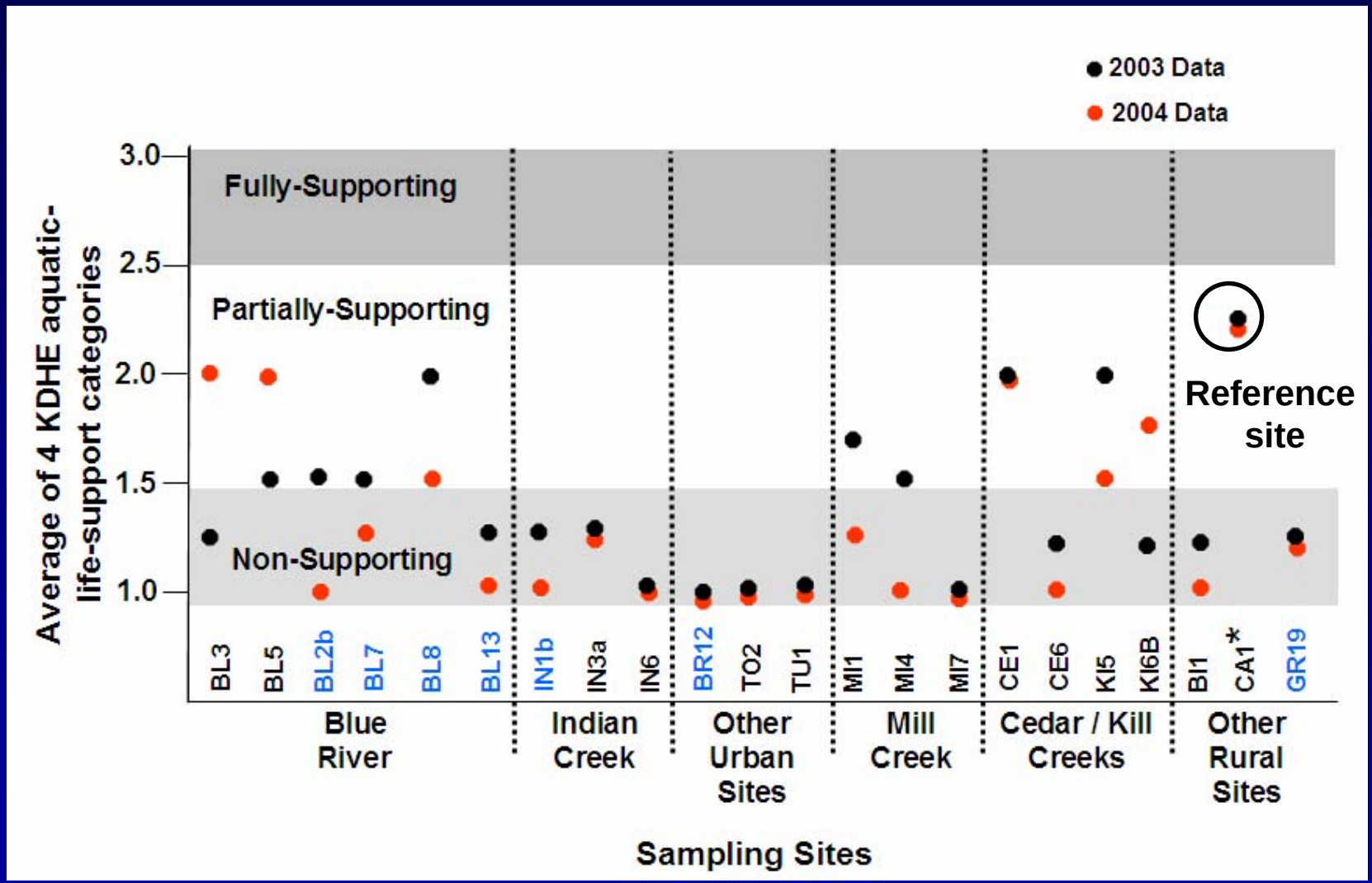
No sites, including the reference site, met State criteria for full support of aquatic life



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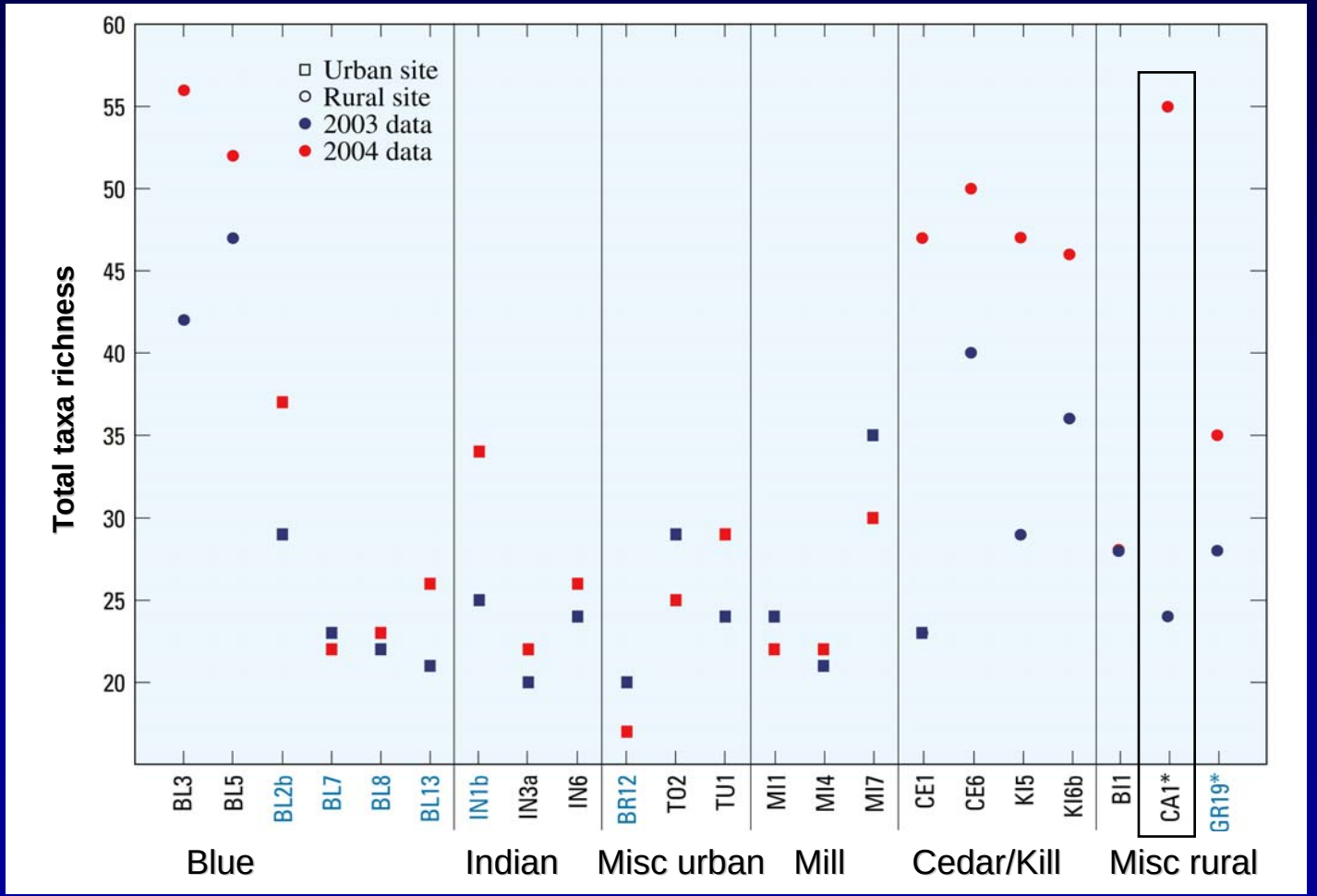
Species diversity at rural sites was comparable to that of the reference site



- **High annual variability in richness metrics**

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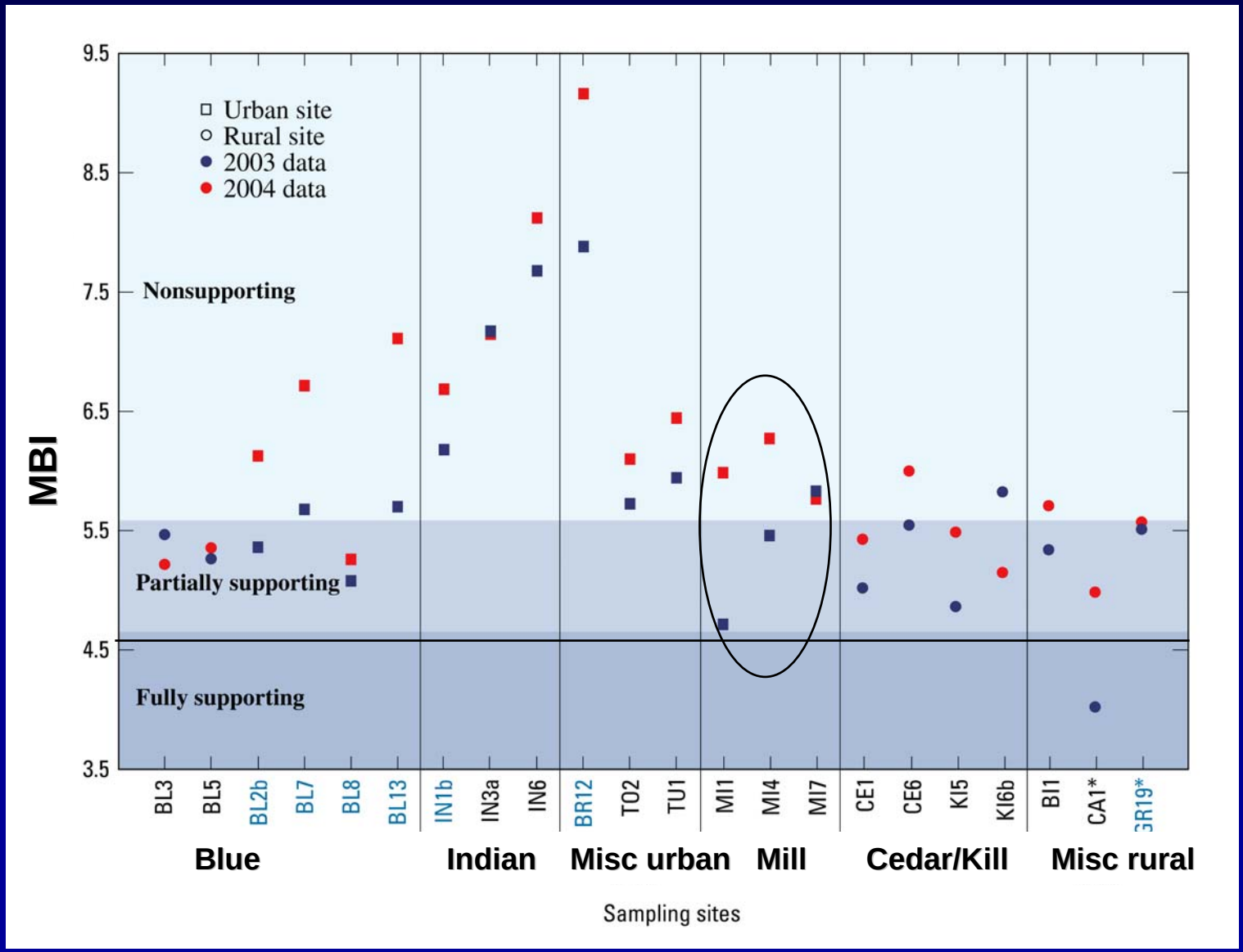
Mill Creek did not meet desired MBI endpoint of 4.5 or less listed in draft (Jan 2006) TMDL for biological impairment



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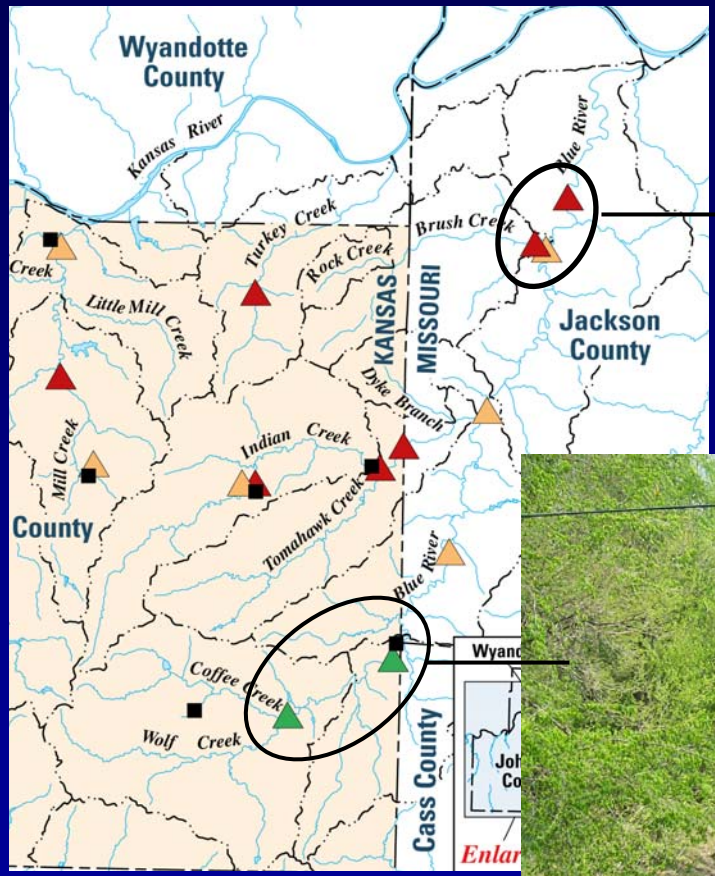
Biological conditions in the Blue River watershed range from minimum adverse effect (upstream) to maximum adverse effect (downstream)



Blue River near Stadium Drive

Blue River at Kenneth Road

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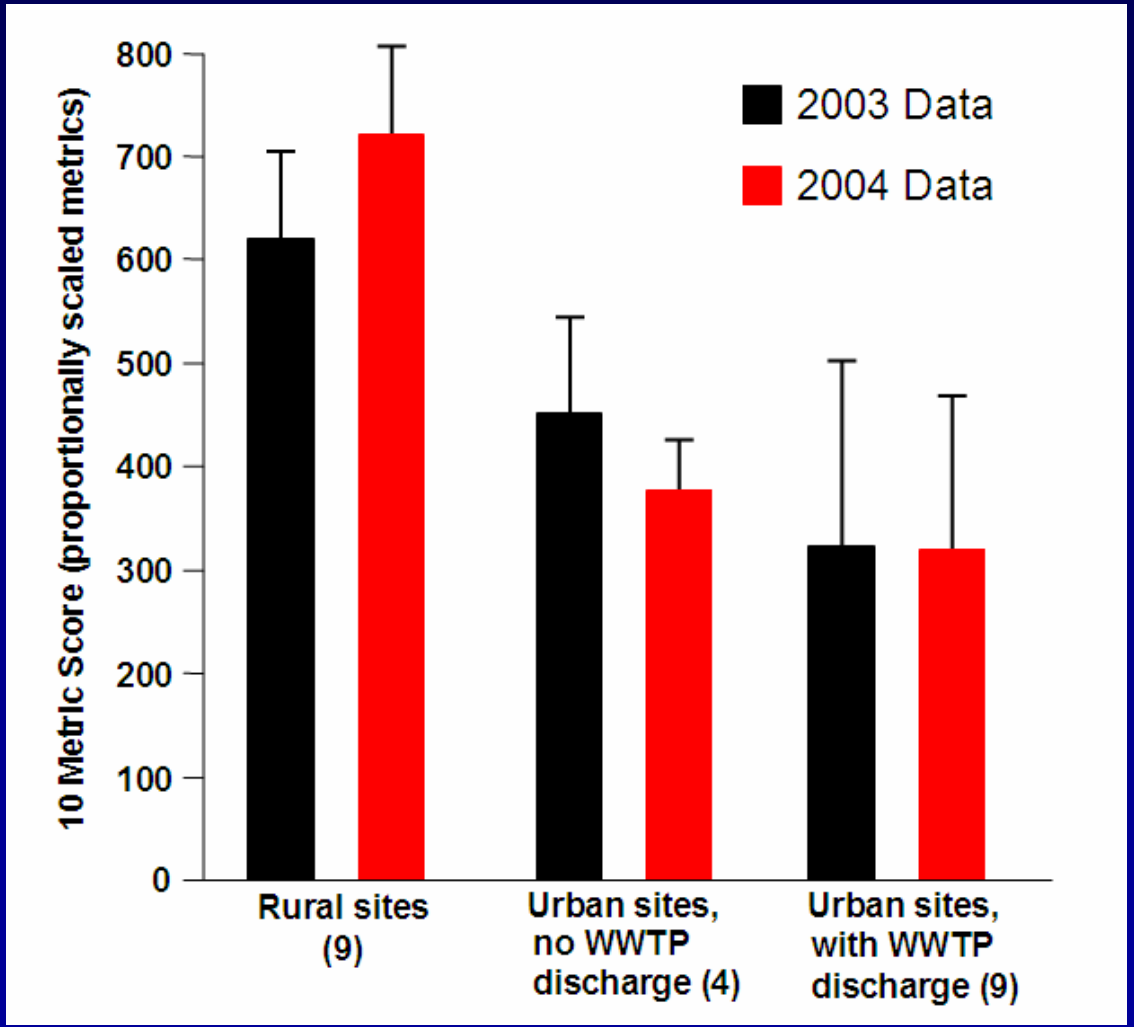
Macroinvertebrate scores at urban sites with wastewater treatment facility discharges were slightly lower than at other urban sites with no discharges



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Biological conditions are being adversely affected by both general urbanization and effects of wastewater discharges, but these 2 factors were not evaluated separately

Harold Street wastewater treatment plant

Sites less than 3 miles downstream from WWTF discharges (Indian Creek at College Blvd and at State Line) consistently scored among the most adversely affected sites

Other urban sites with no WWTF discharge but the largest impervious surface area (Turkey, Tomahawk, downstream Brush Creek) also scored among the most adversely affected sites

Turkey Creek near 67th St

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Wastewater discharges affect biological communities

- Alter natural variability in streamflow
- Increase nutrient concentrations resulting in excessive algae growth

  - decreases DO and increases magnitude of diel fluctuations

  - retains fine particulates leading to more substrate embeddedness
- May increase concentrations of dissolved solids, metals, organic compounds

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Environmental variables that were significantly correlated with adversely affected biological conditions included:

Land use

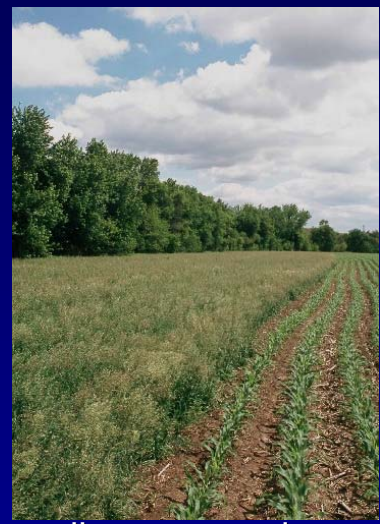
- **Percent impervious surface**
- **Percent urban land use**
- **Percent agricultural land use**

Water quality

- **Total nitrogen, total phosphorus**
- **Total concentration of organic wastewater compounds**

Streambed-sediment quality

- **PAHs**
- **Nonylphenol diethoxylate**
- **Fecal coliform**



Photos from http://photogallery.nrcs.usda.gov

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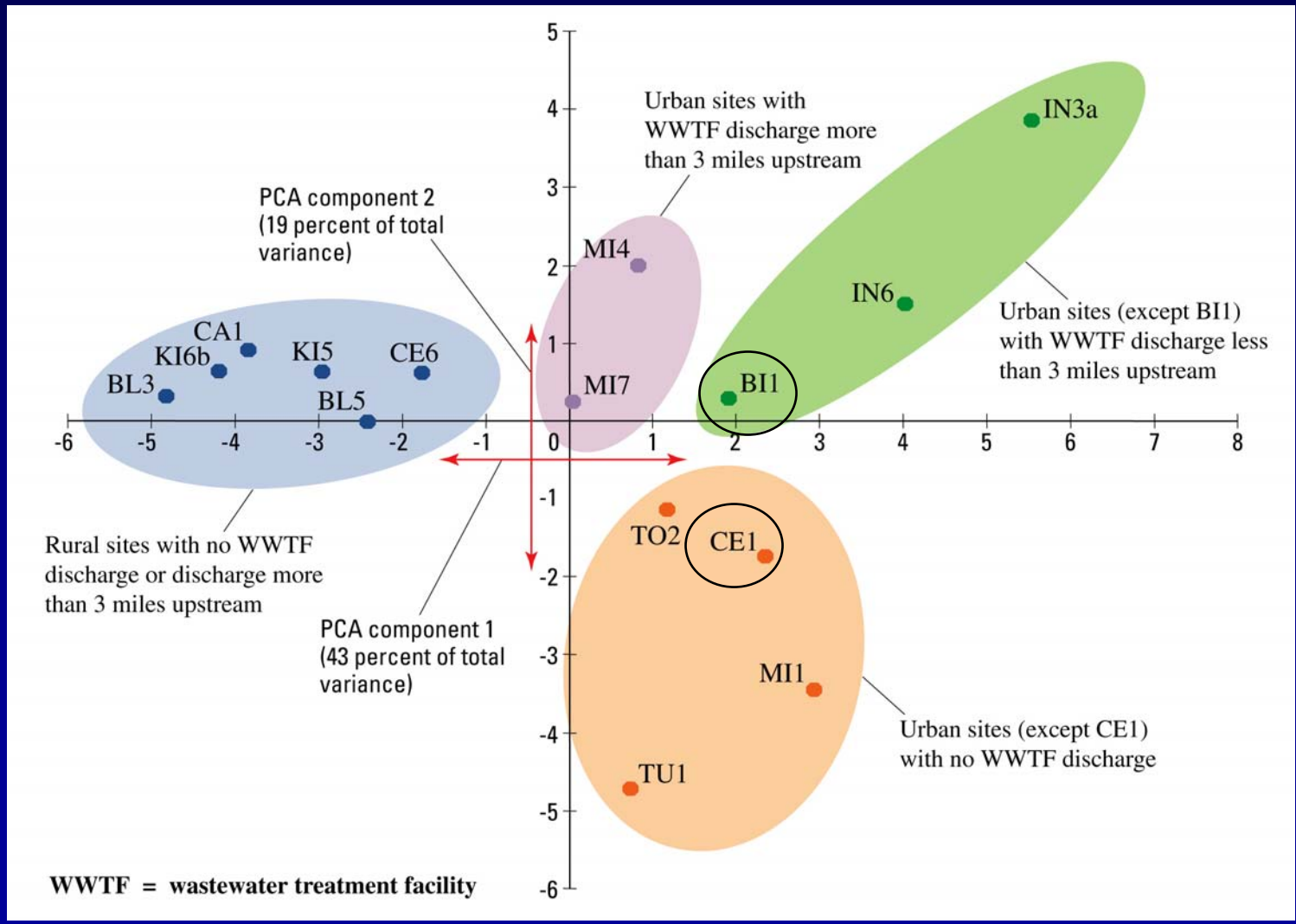
When environmental variables were evaluated against metrics, similar sites grouped together, with a few notable exceptions (upper Cedar Creek, Big Bull)



Ongoing work

Collected samples at 20 Johnson County sites – March 2007

- **Macroinvertebrates**
- **Water**
- **Streambed sediment**
- **Periphyton**

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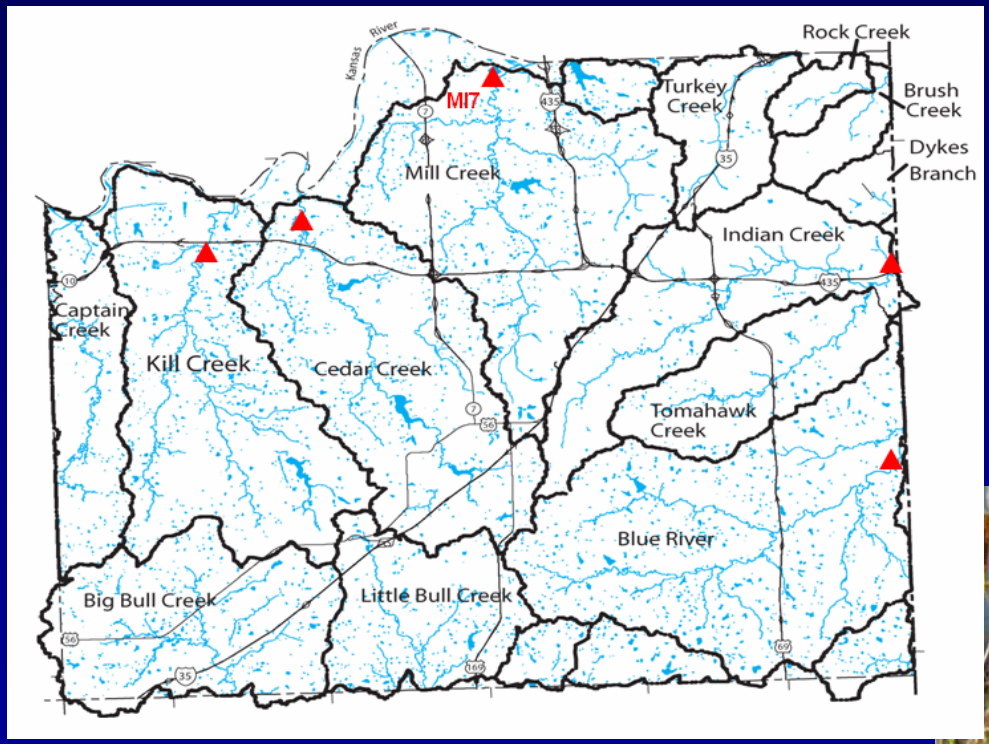
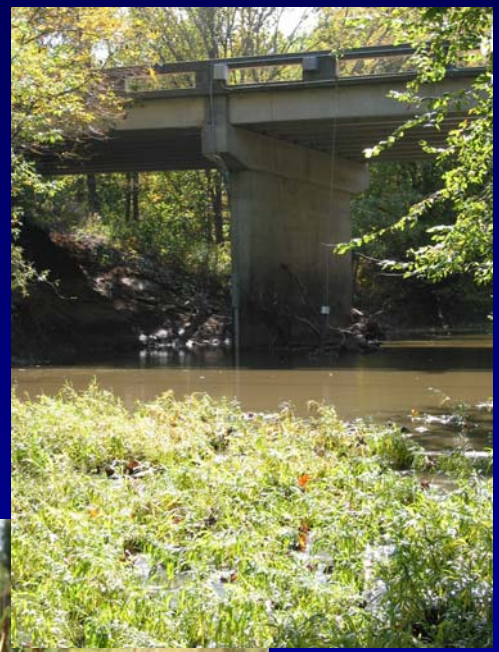
Ongoing work

Continuous water-quality monitoring at 5 sites – to provide continuous estimates of chemical concentrations and loads, define variability, and monitor changes





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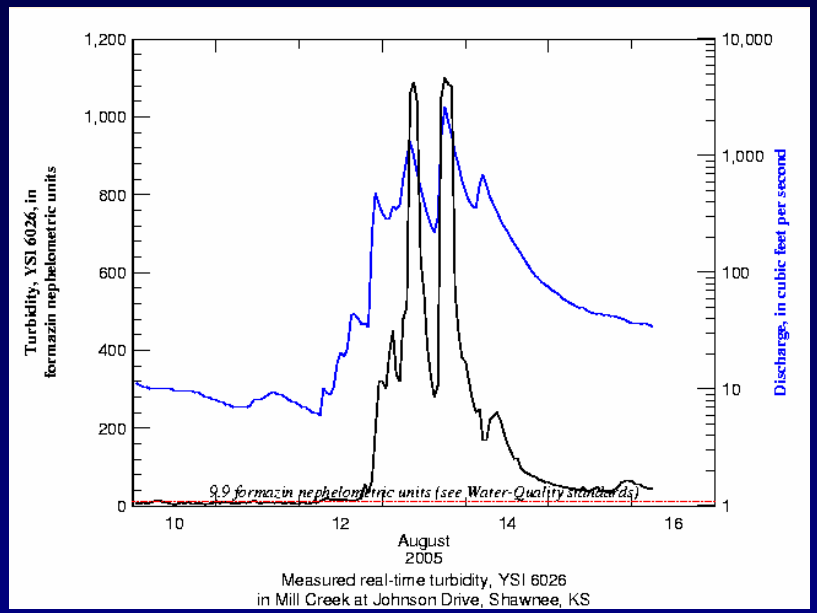
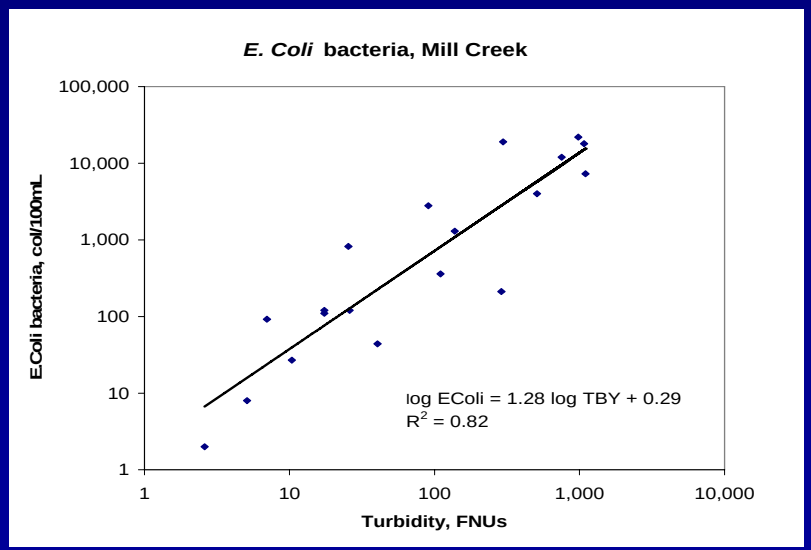
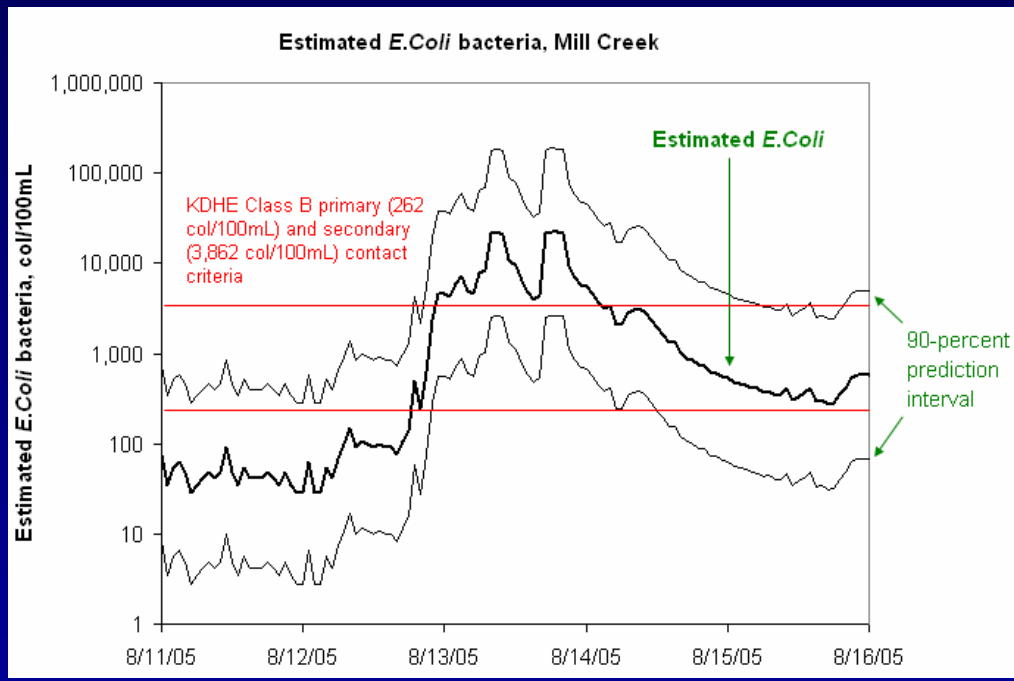
Ongoing work (continued)





Continuous stream-water quality monitoring



Continuous data available in real time at: http://ks.water.usgs.gov/Kansas/rtqw

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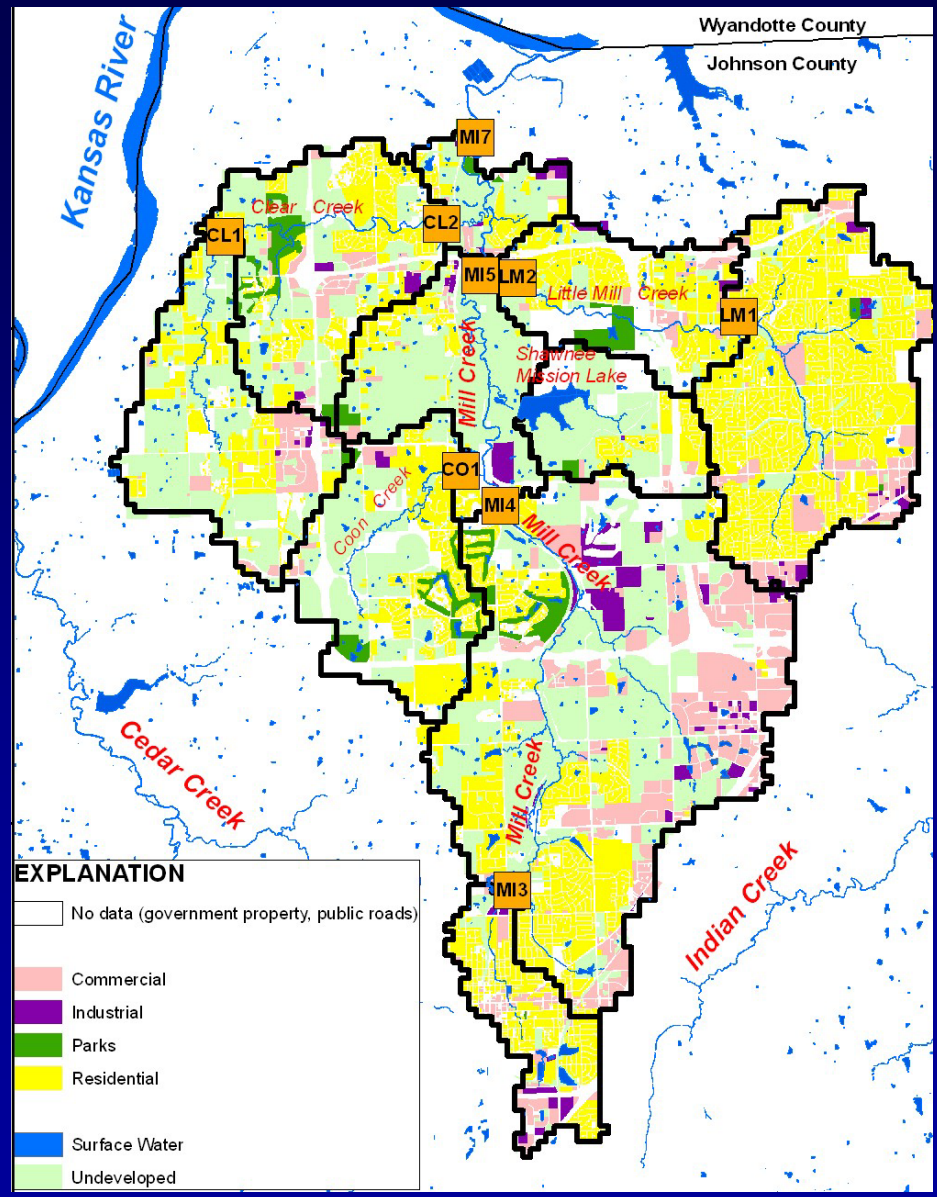
Ongoing work (continued)

Mill Creek watershed sediment sources study

- Monitor sediment loads throughout the Mill Creek watershed
- Use chemical tracers to estimate sources of suspended sediment
- Will help county officials evaluate appropriate best management practices



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Summary

- Biological conditions generally reflected a gradient in upstream land use; as urbanization (impervious area, wastewater) increased, biological quality decreased
- In Johnson County, rural stream sites had healthier invertebrate communities than urban sites
- Several (all rural) stream sites had biological conditions similar to the State reference site
- No sites met State criteria for full support of aquatic life
- Macroinvertebrate measures were most strongly related to upstream land use and PAHs in streambed sediment
- Water-quality studies are ongoing
- Information is important for effective management of water resources

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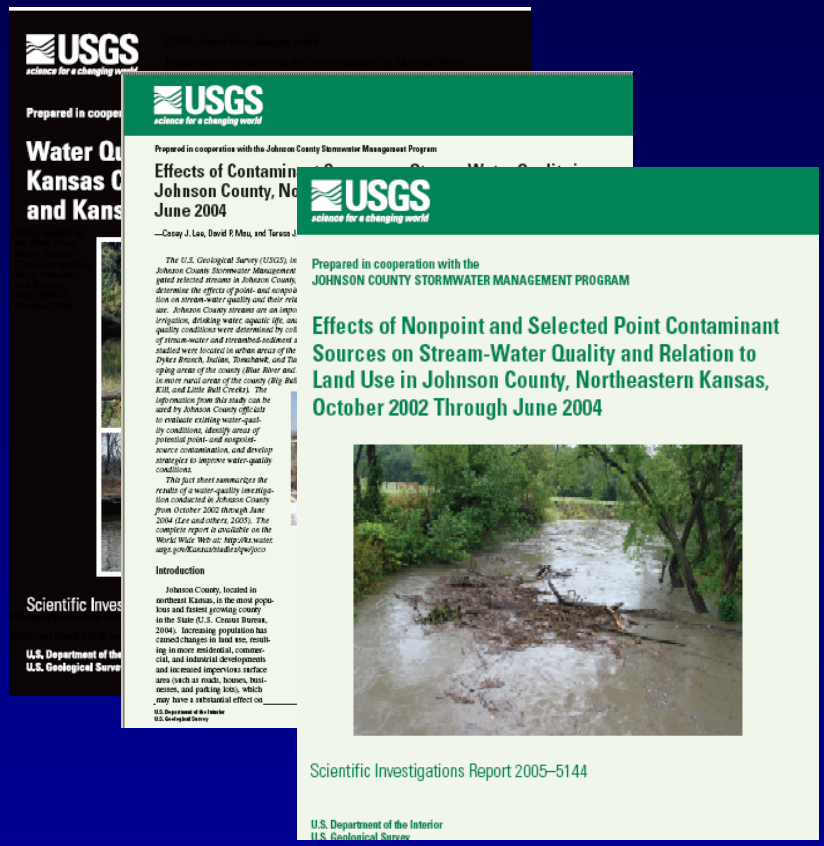
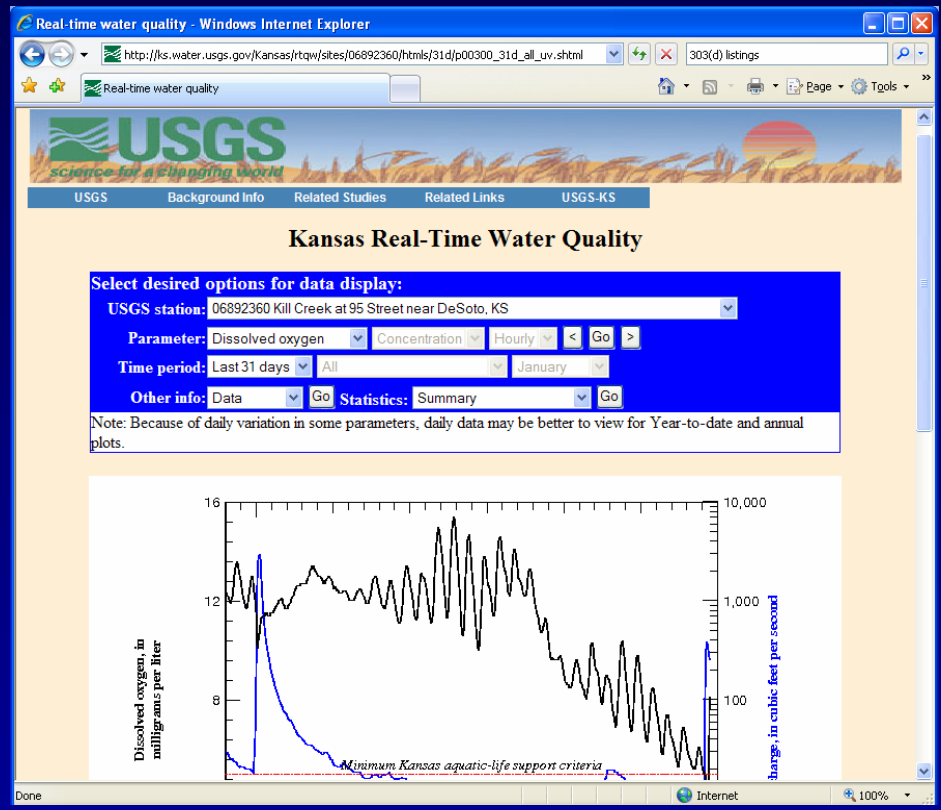
For more information

http://ks.water.usgs.gov/Kansas/studies/qw/joco





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