Using Bacterial Source Tracking to Develop Watershed Restoration Plans

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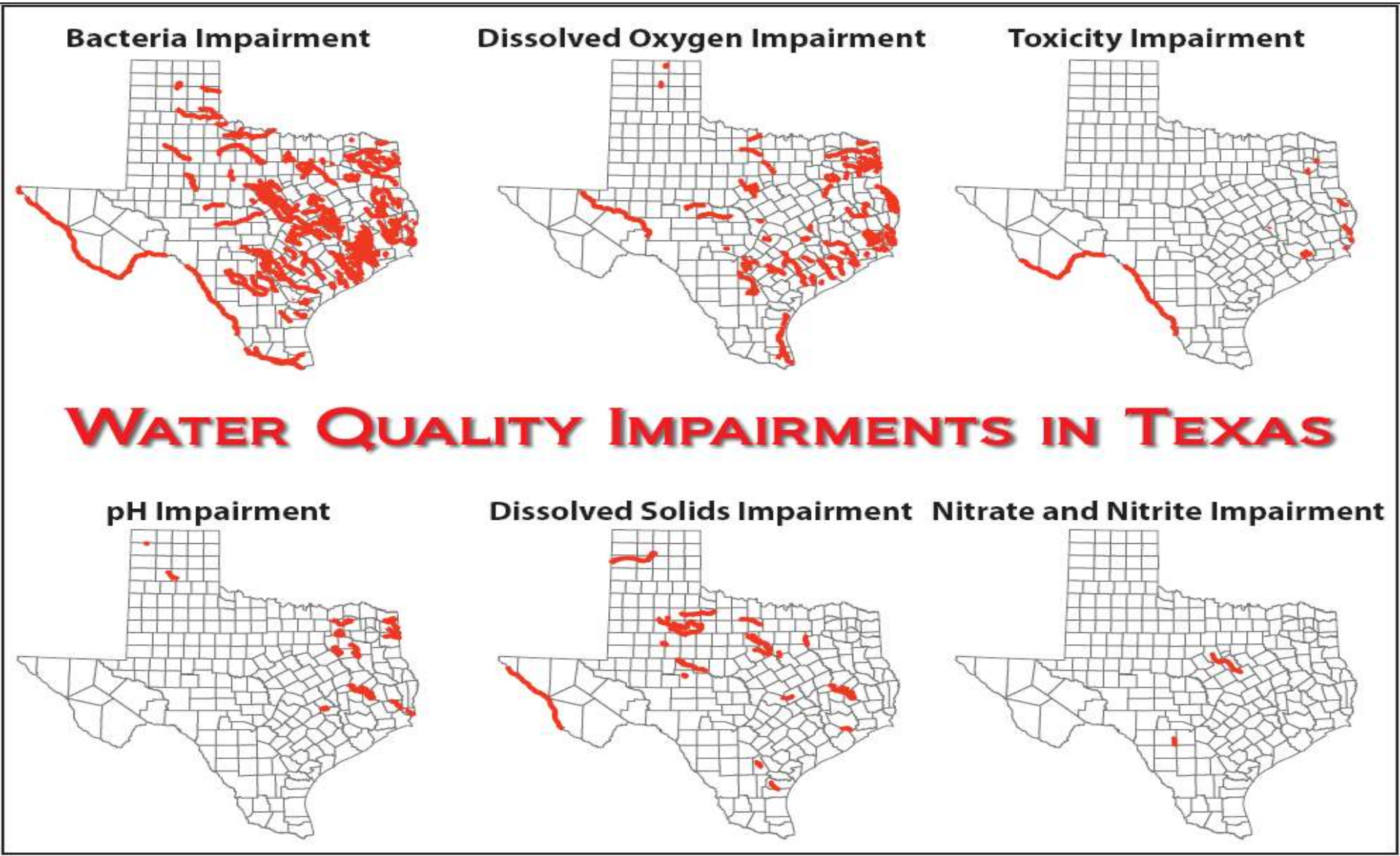
Bacteria/Pathogens

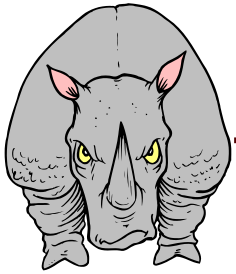
The #1 Cause of Water Quality Impairment in Texas

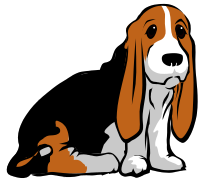


Where did the Bacteria (*E. coli*) Come From?

- **Potential sources**
  - **Humans**
  - **Domesticated animals**
  - **Wildlife**
    - **~140 mammals**
    - **~650 birds**
- **Methods for determining sources**
  - **Source survey**
  - **Modeling**
  - **Bacterial source tracking (BST)**

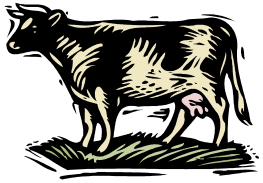
PREMISE BEHIND BST





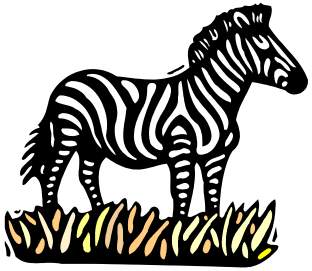
Different guts → Different adaptations

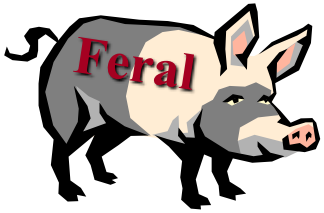
→ Different *E. coli* strains →

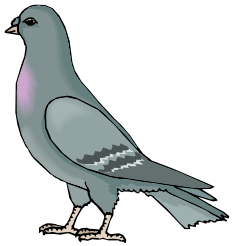


Genetic Differences

Phenotypic Differences

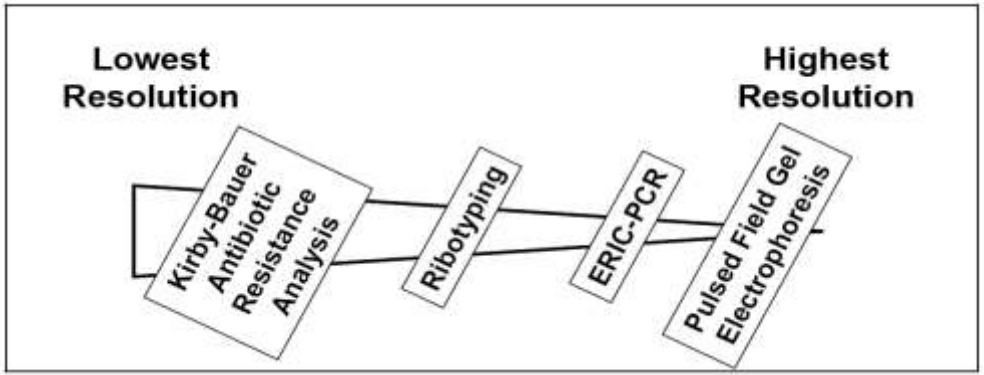


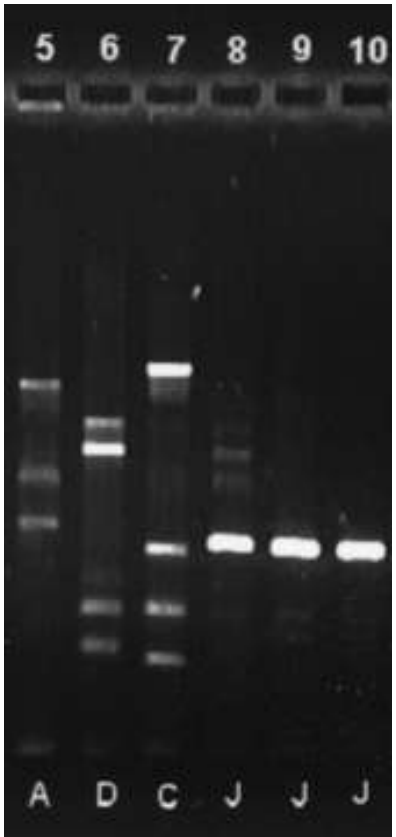




History of BST in Texas

- Lake Waco/Belton Project (2002-2006)
  - Evaluated utility & methods
  - Recommended 2-method composite
  - Enterobacterial repetitive intergenic consensus sequence-polymerase chain reaction (ERIC-PCR)
  - RiboPrinting® (RP)
- TMDL Task Force Report – 2007
  - Confirmed ERIC-RP as recommended method
- Required BST Library Development





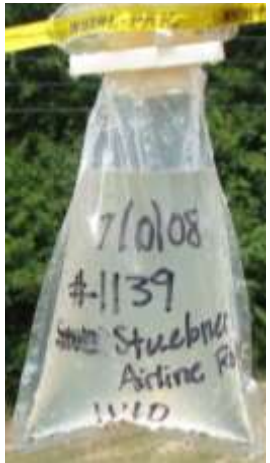
Methods

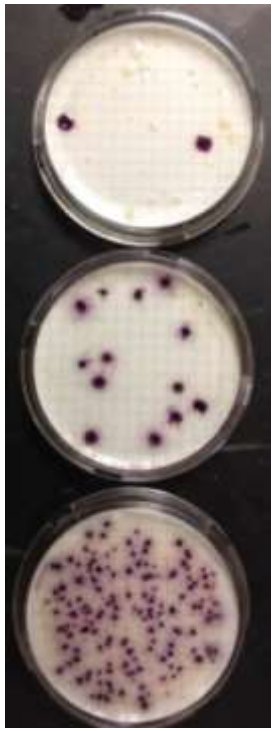
Known Sources

Isolate

E. coli

Unknown Source

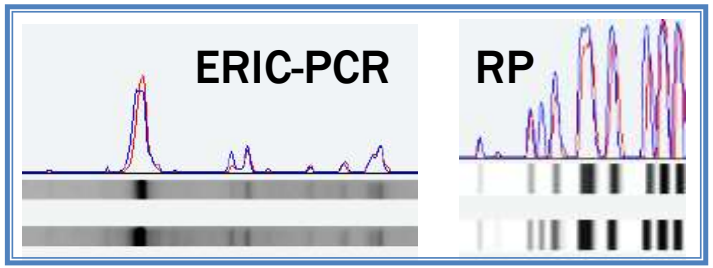




DNA Fingerprint

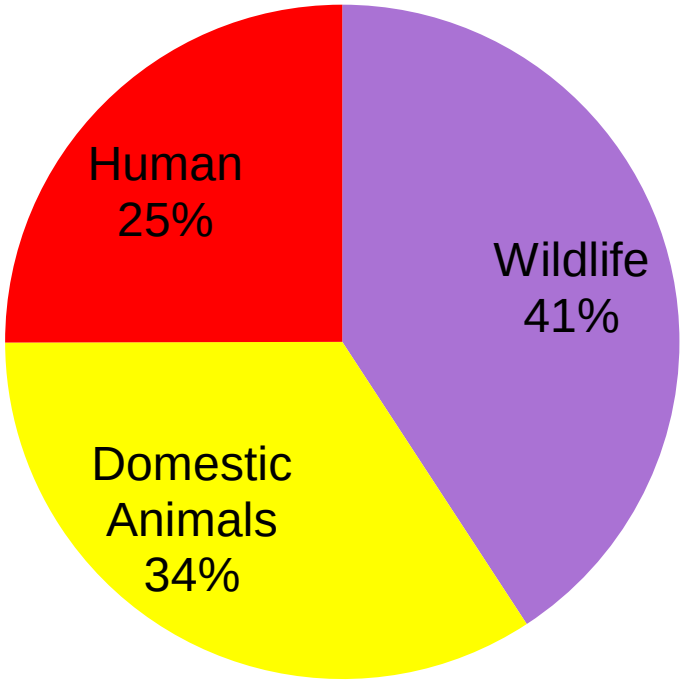
Add to Library

Compare to Library for Source ID

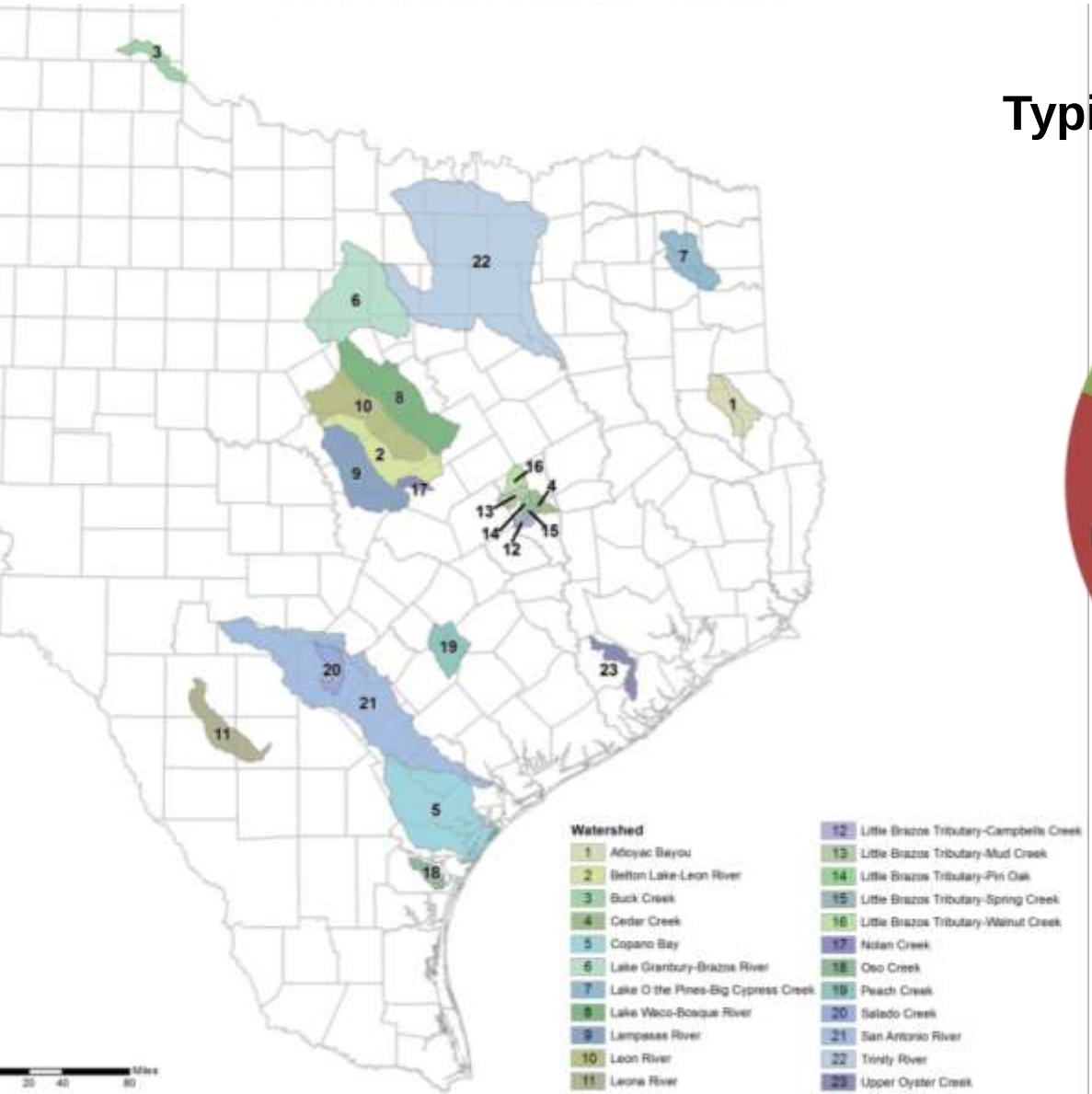


Texas *E. coli* BST Library

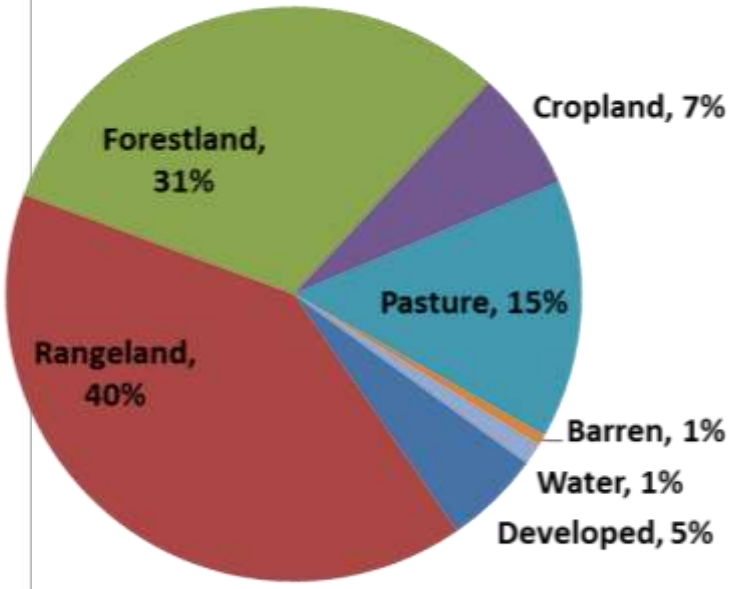
- Contains
  - 1,669 *E. coli* isolates
  - From 1,455 different fecal samples
  - Representing >50 animal subclasses
  - Collected from 13 watersheds (& growing) across Texas



Texas BST Studies To Date

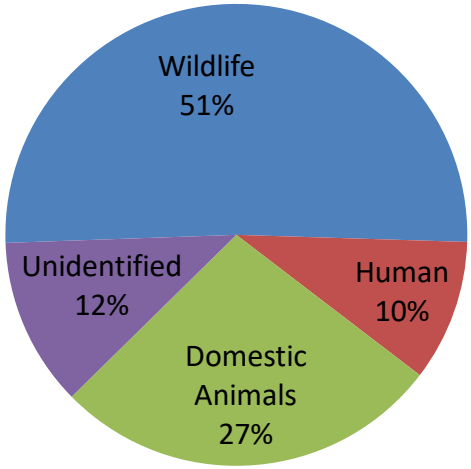


Typical Landuse in 11 BST Watersheds



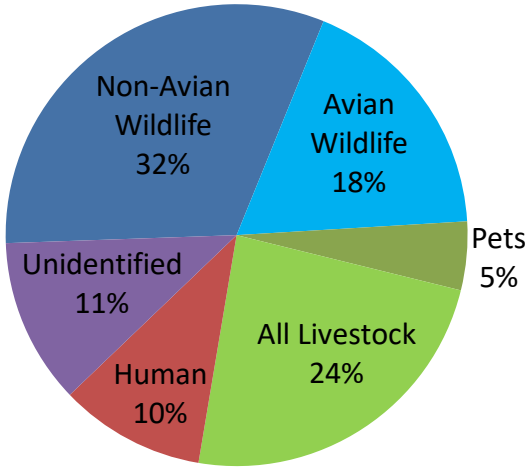
3-Way Split

(averages based on findings in 11 watersheds)



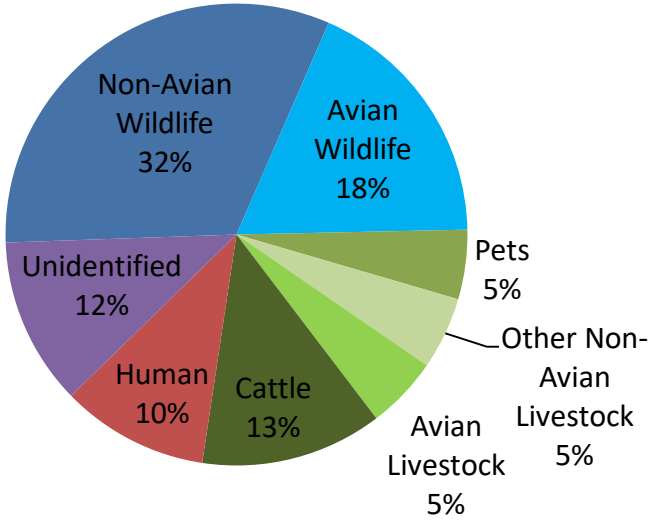
5-Way Split

(averages based on findings in 10 watersheds)



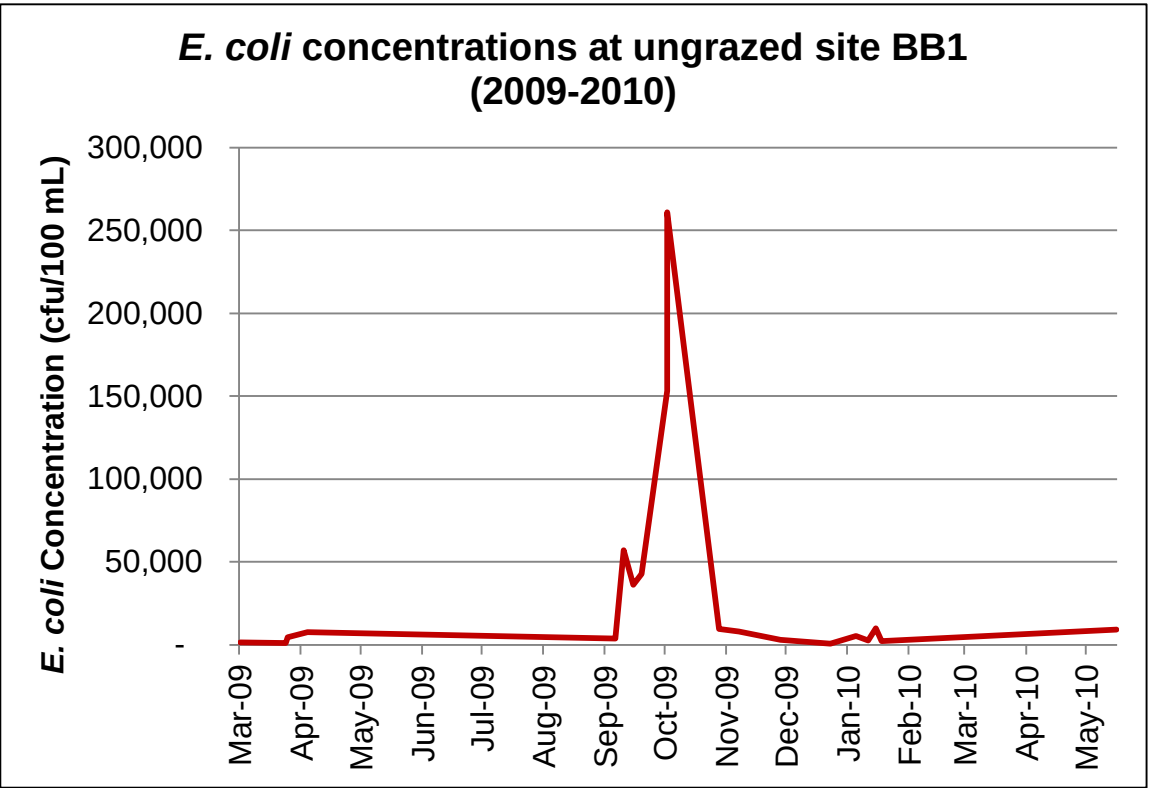
7-Way Split

(averages based on findings in 7 watersheds)



Impacts of wildlife on *E. coli* runoff

Site	Fecal Coliform (#/100 mL)	*E. coli* (cfu/100 mL)	Reference
Ungrazed pasture	10,000		Robbins et al. 1972
Ungrazed pasture	6,600		Doran et al. 1981
Control plots		6,800	Guzman et al. 2010
Pasture destocked >2 mos.		1,000-10,000	Collins et al. 2005
Ungrazed pasture		6,200-11,000	Wagner et al. 2012
Pasture destocked >2 wks.		2,200-6,000	Wagner et al. 2012



Wildlife contributed >80% of *E. coli* loading at grazed sites in 2009

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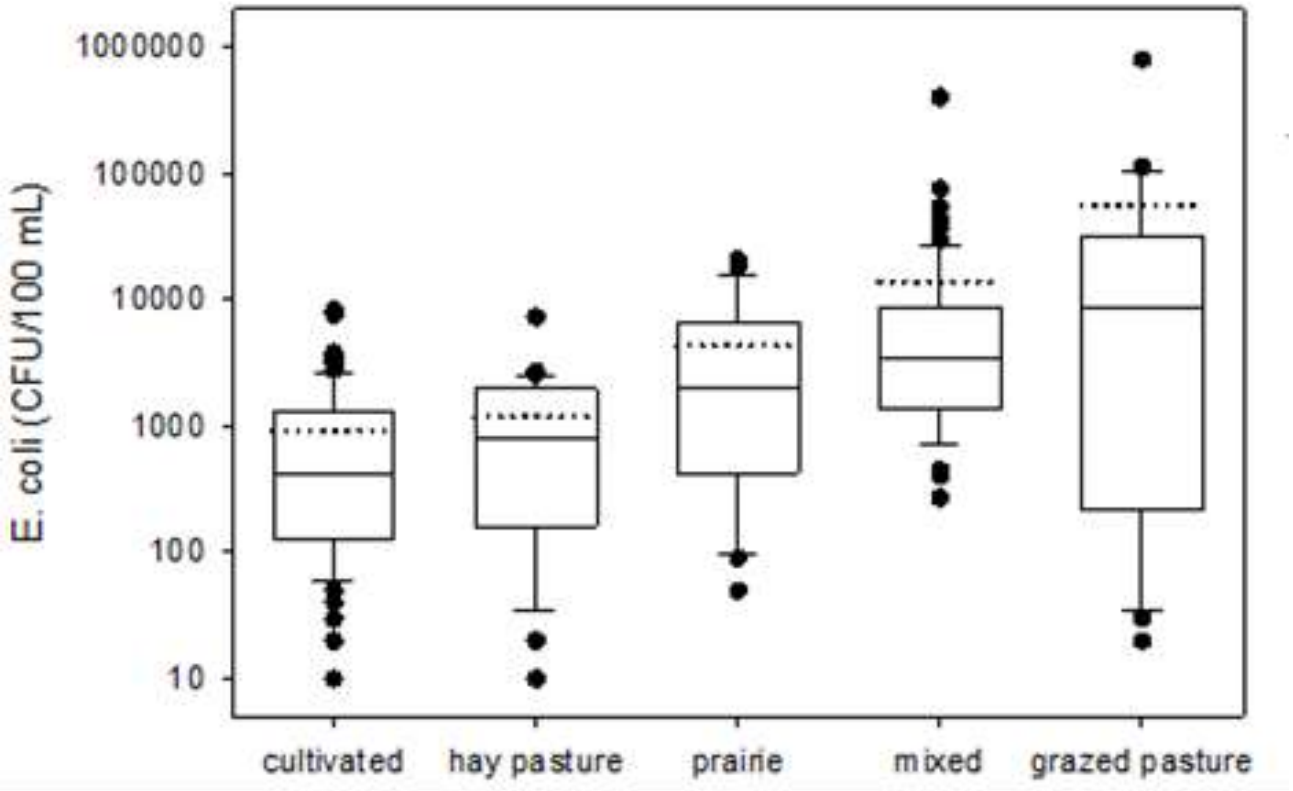
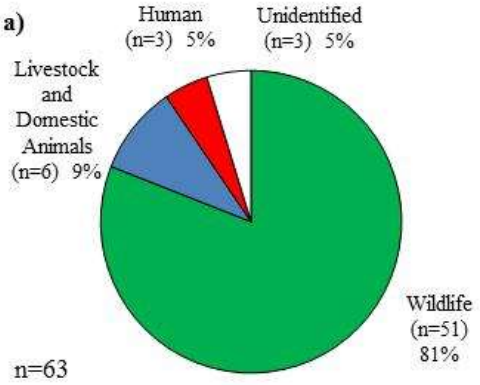
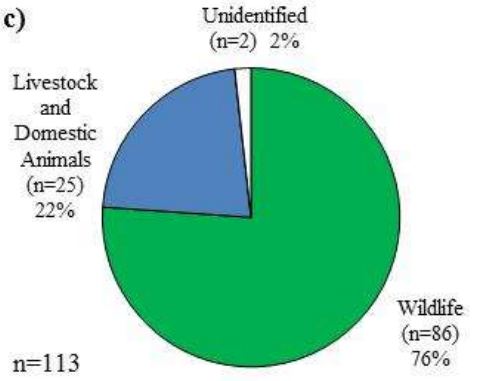
Increasing E. coli with increasing wildlife habitat

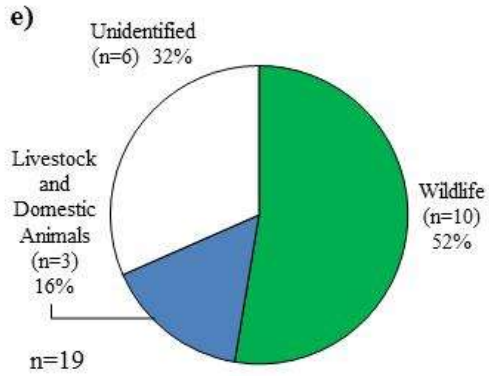
Edge-of-field runoff *E. coli* concentrations (Harmel)



Soil *E. coli* sources (Gregory)







Summary & Implications of BST Findings

Summary:

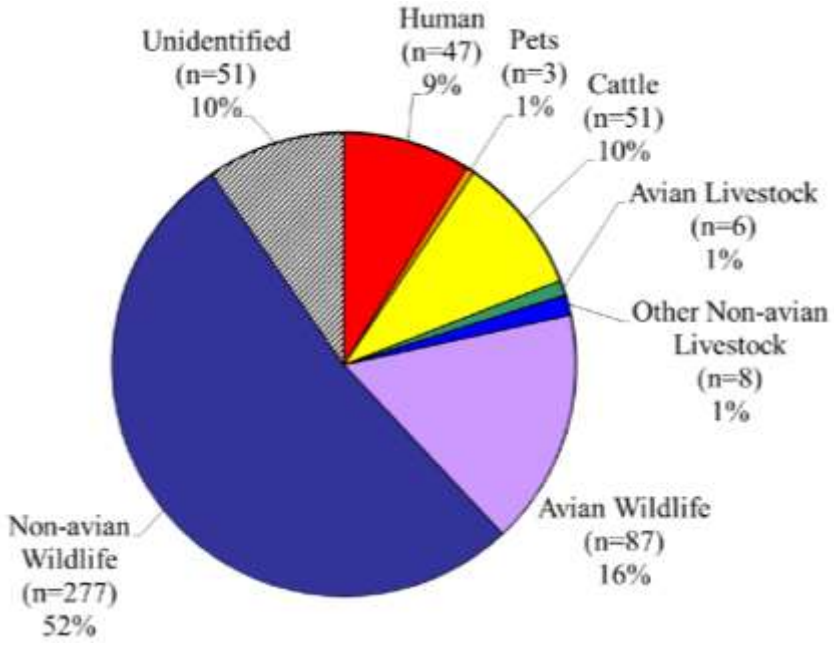
- BST performing well (100% 3-way RCC; 92% 7-way RCC)
  - Proving to be useful tool for identifying significant bacteria sources
- Wildlife = source of 50% of isolates in predominately rural watersheds
  - Edge of field monitoring confirms significance of background sources

Implications:

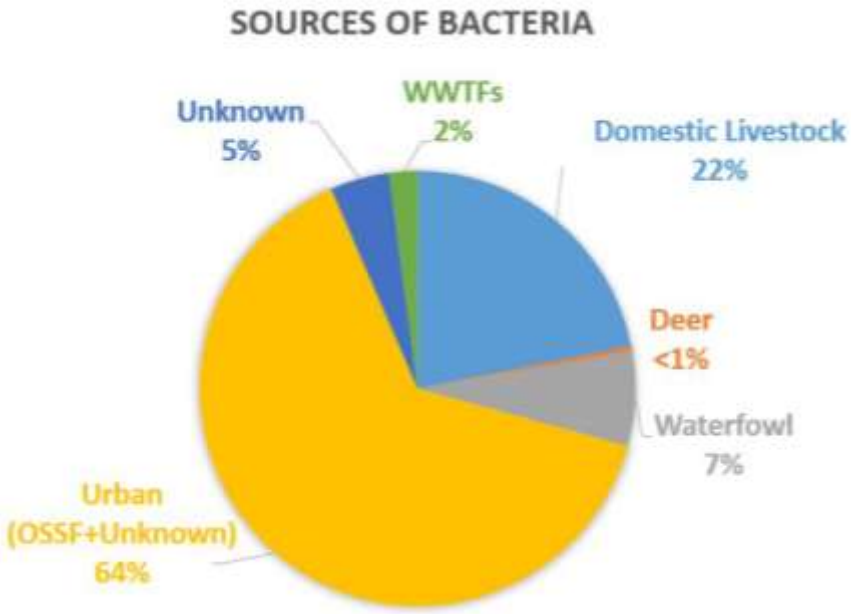
- Background/wildlife loadings need to be considered when:
  - Applying water quality standards
  - Developing tmdls and watershed based plans
- Ignoring background concentrations may lead to:
  - Nonattainment of water quality standards
  - Inaccurate load allocations and reductions

Integrating Modeling & BST: Arroyo Colorado Case Study

BST Results



Initial SWAT Model Results



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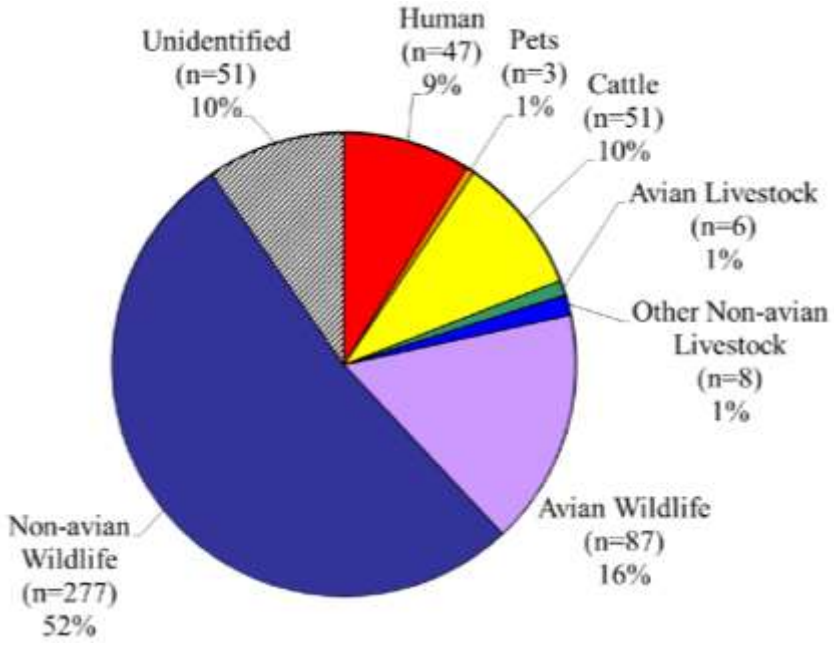
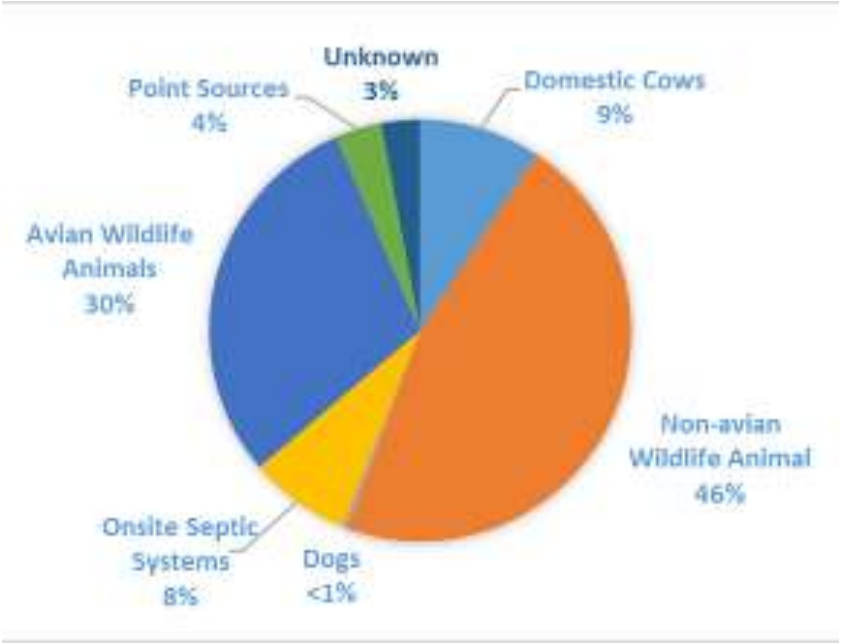
Calibrated/validated SWAT with BST

BST Results



Final SWAT Model Results



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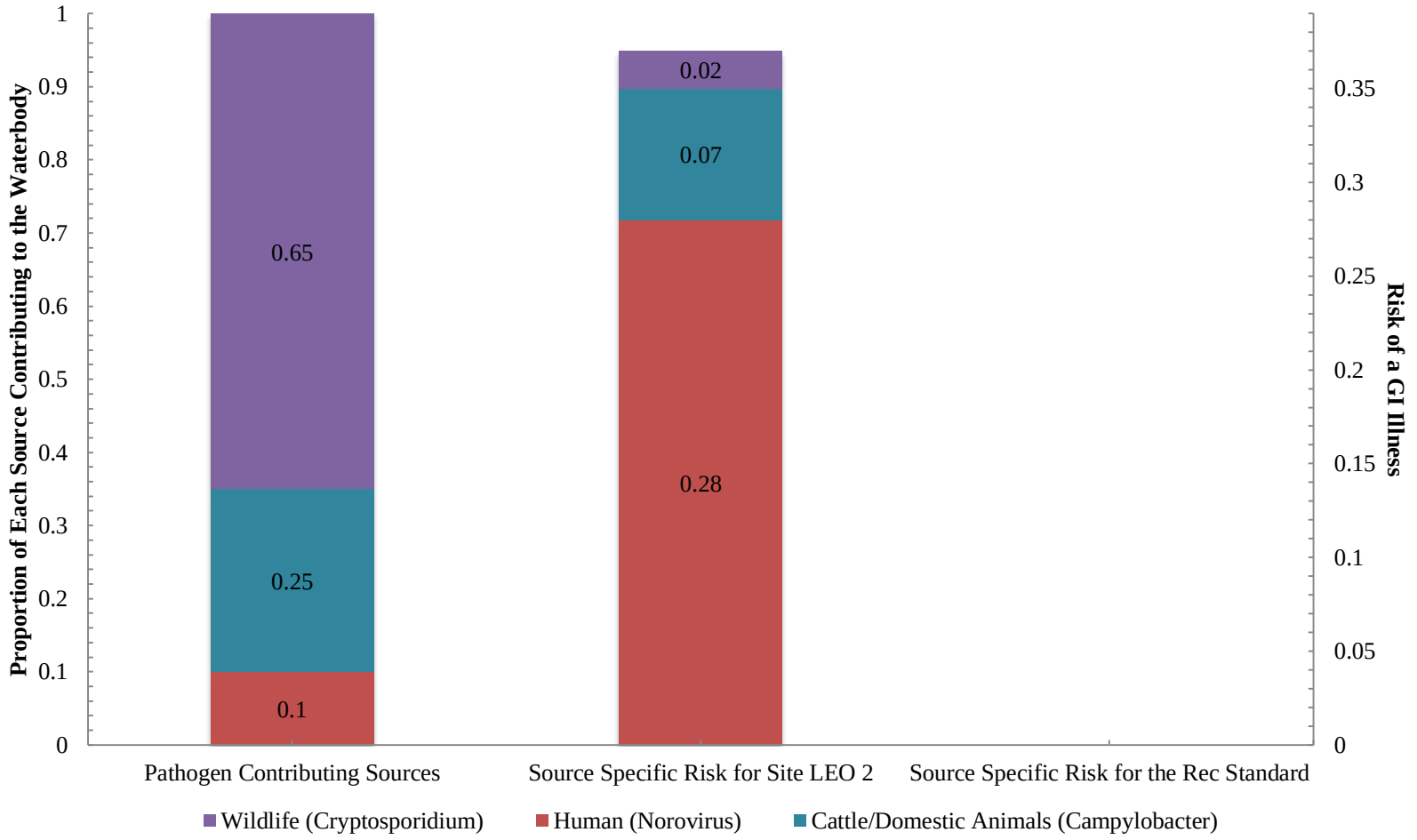
Future uses of BST:
Quantitative Microbial Risk Assessment

- EPA 2012 recreational water quality criteria provided tools for developing site-specific criteria:
  - epidemiological studies
  - quantitative microbial risk assessment
  - use of alternative indicators or methods

Walnut Creek QMRA Case Study:
Risk of GI Illness ≠ BST Percentages



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QMRA Findings & Implications

- Human and non-human fecal sources have different potential risks for a GI illness
  - Proportion of a single source contributing to the overall *E.coli* concentration not an indicator of overall human health risk
- Risk driven by human source
- Management toward reducing human sources
  - Compliance & maintenance of WWTPs, sanitary sewer systems, wastewater collection systems & infrastructure

Questions?

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