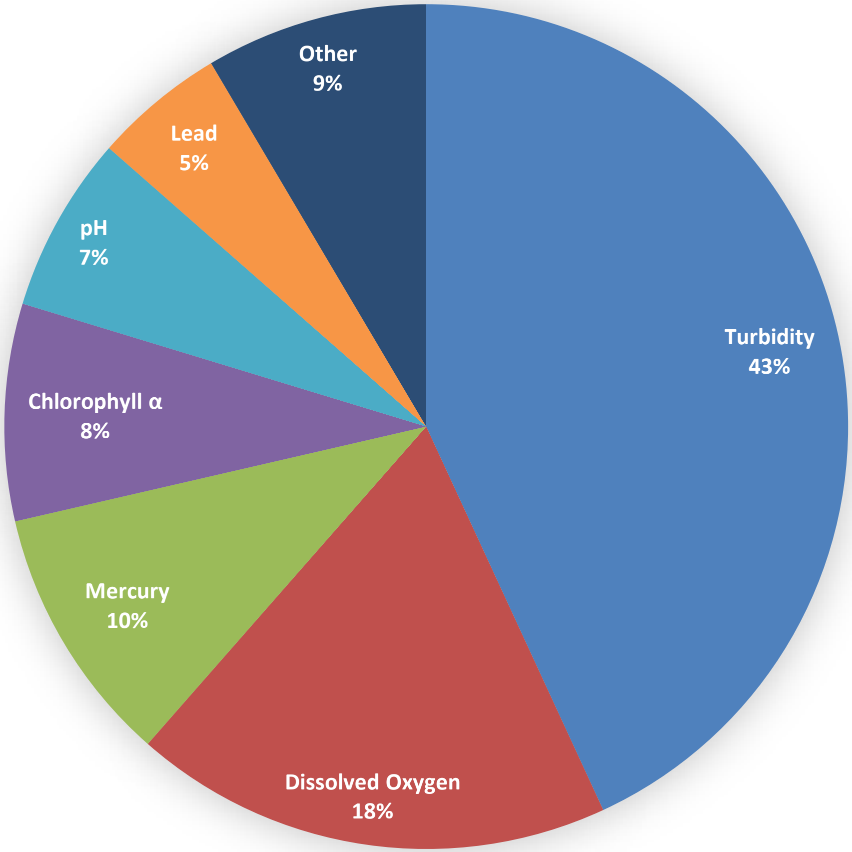
Impacts & Implications of Background Bacterial Sources on Water Quality Management Efforts

Kevin Wagner, George DiGiovanni, Terry Gentry

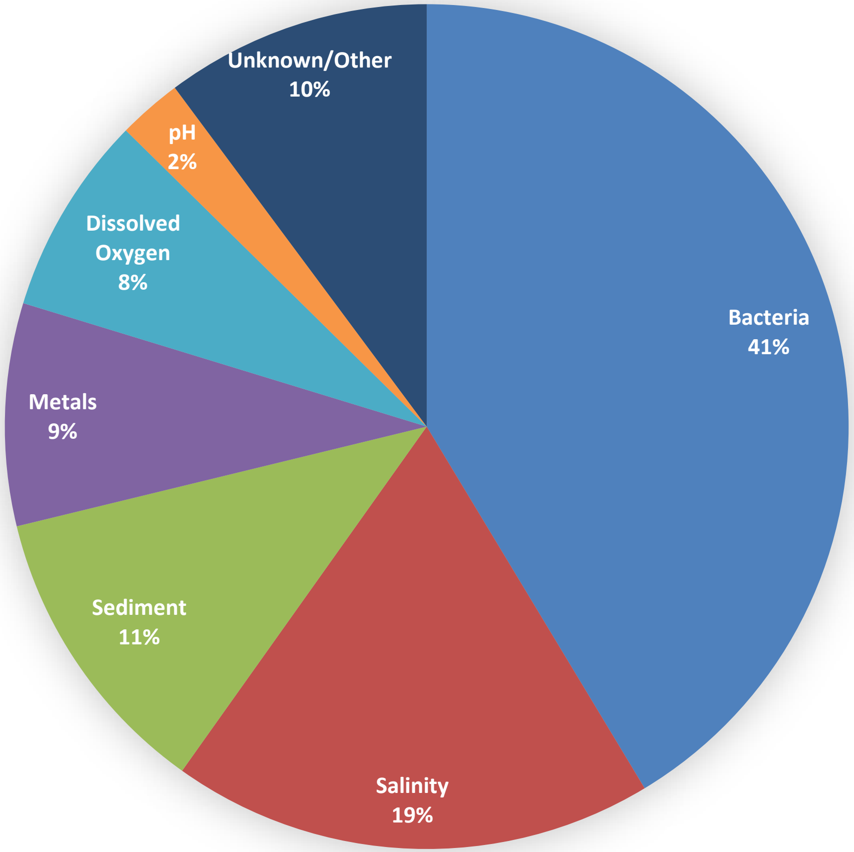
Bacteria/Pathogens

The #1 Cause of Water Quality Impairment in Oklahoma

Lakes

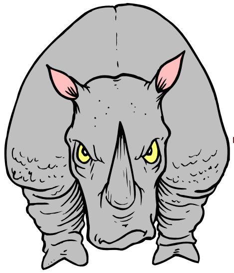


Streams/Rivers

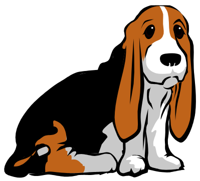


Where did the Bacteria (*E. coli*) Come From?

- Potential sources
  - Humans
  - Domesticated animals
  - Wildlife
    - ~101 mammals
    - ~455 birds
- Methods for determining sources
  - Source survey
  - Modeling
  - Bacterial source tracking (BST)



PREMISE BEHIND BST

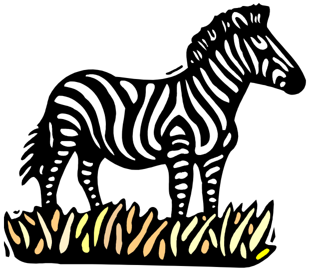


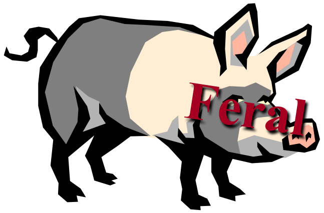
Different guts → Different adaptations

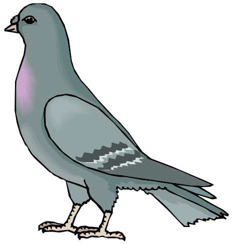
→ Different *E. coli* strains →

Genetic Differences

Phenotypic Differences

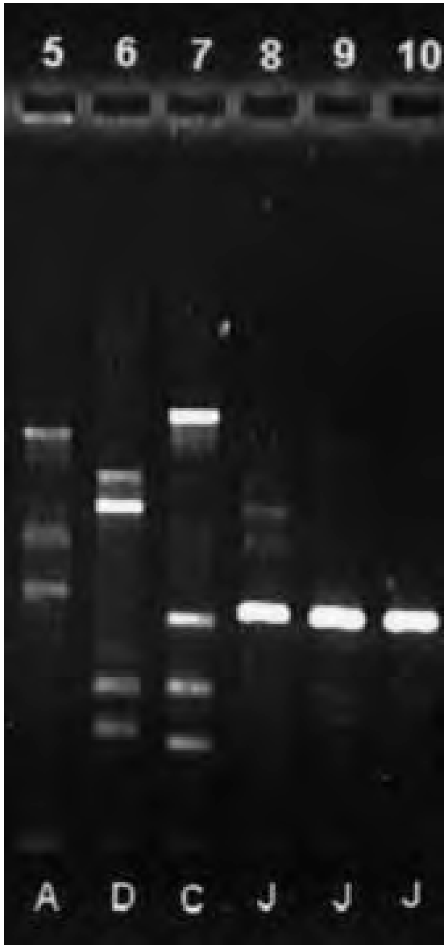






Establishment of Texas BST Program (2007)

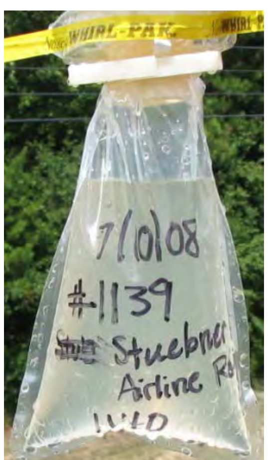
- Two DNA fingerprinting methods selected:
  - Enterobacterial repetitive intergenic consensus sequence-polymerase chain reaction (ERIC-PCR)
  - RiboPrinting® (RP)
- Required BST Library Development



Methods

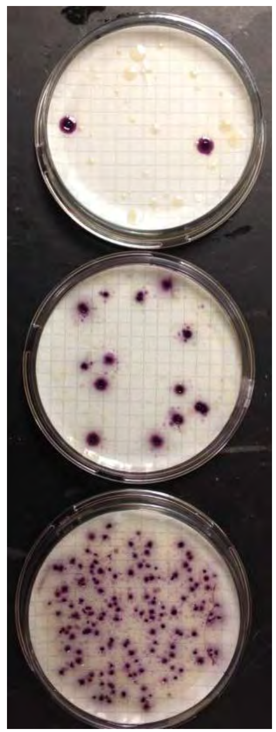
Known Sources

Unknown Source



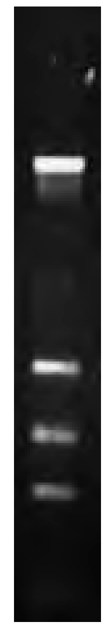
Isolate

E. coli



DNA

Fingerprint



Add to

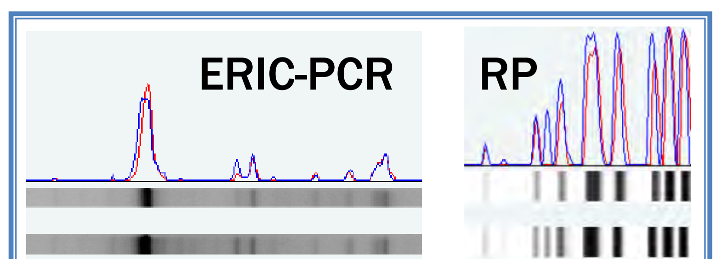
Library

Compare

to Library

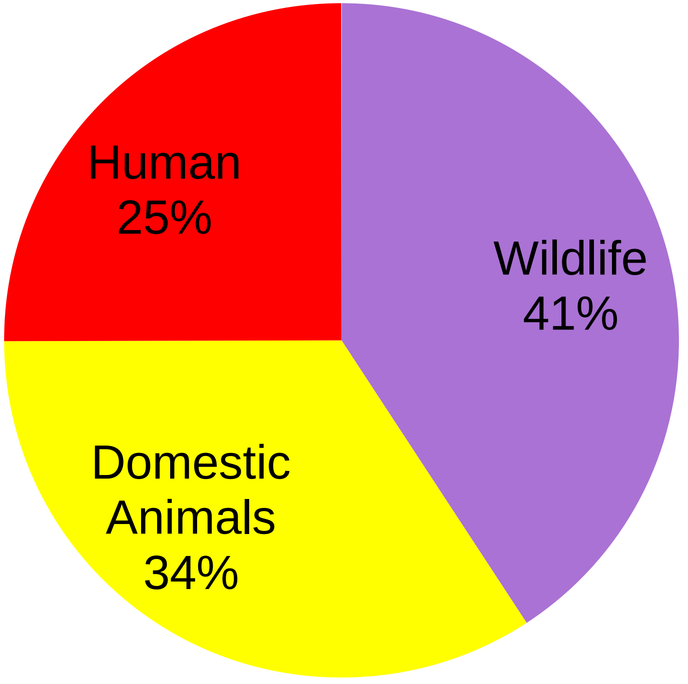
for Source

ID

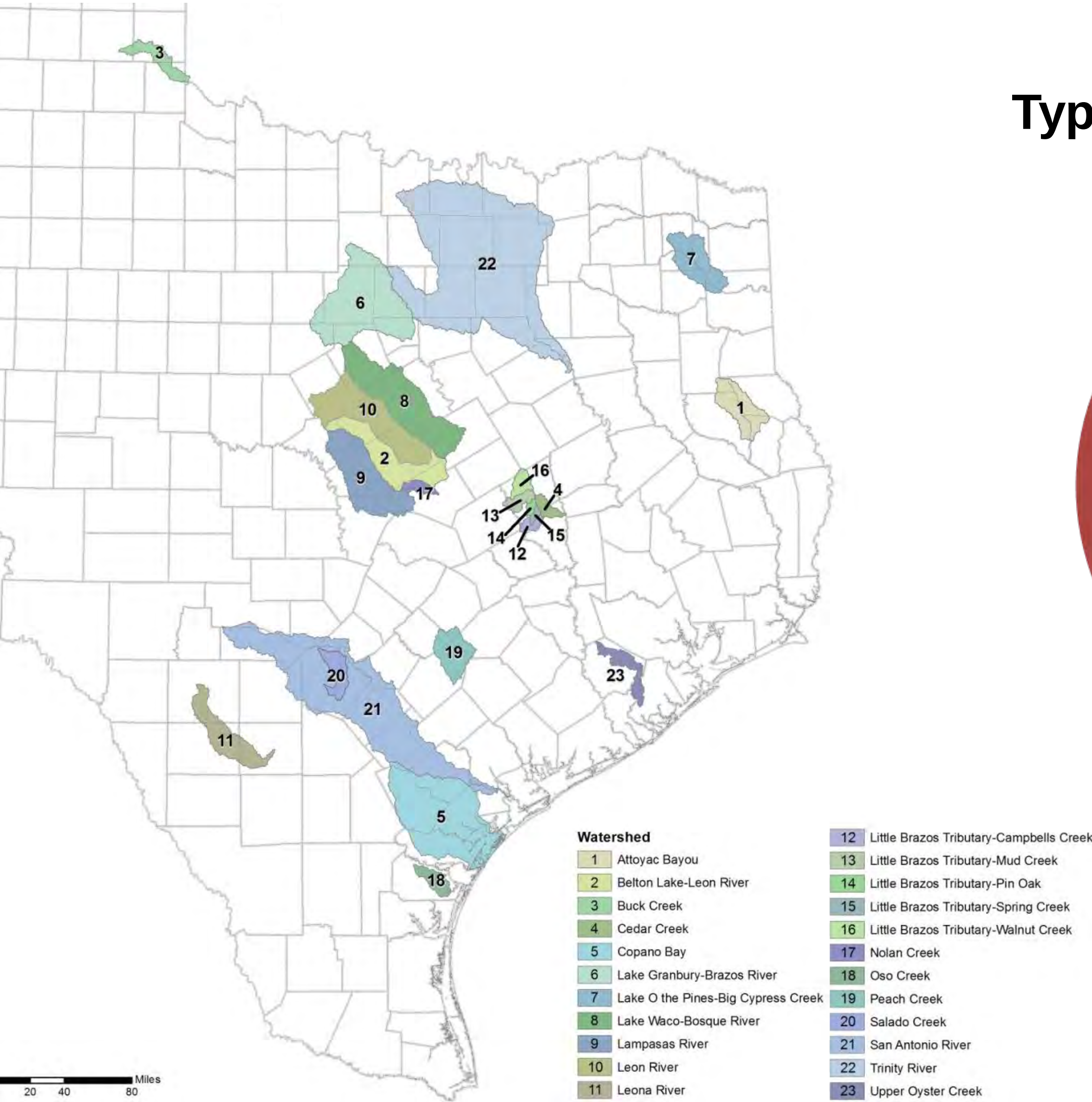


Texas *E. coli* BST Library

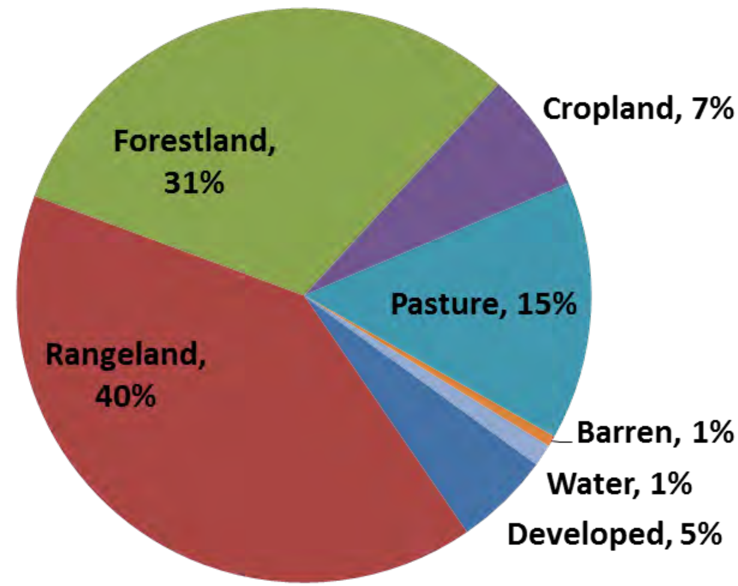
- **Contains**
  - **1,669 *E. coli* isolates**
  - **From 1,455 different fecal samples**
  - **Representing >50 animal subclasses**
  - **Collected from 13 watersheds (& growing) across Texas**



Texas BST Studies To Date

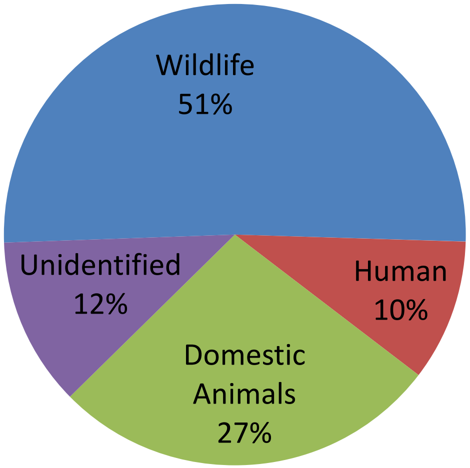


Typical Landuse in 11 BST Watersheds



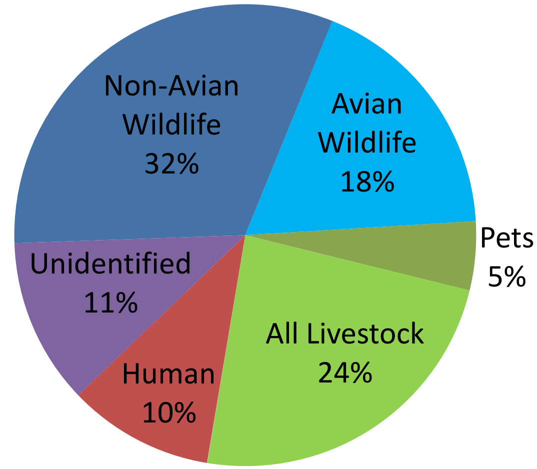
3-Way Split

(averages based on findings in 11 watersheds)



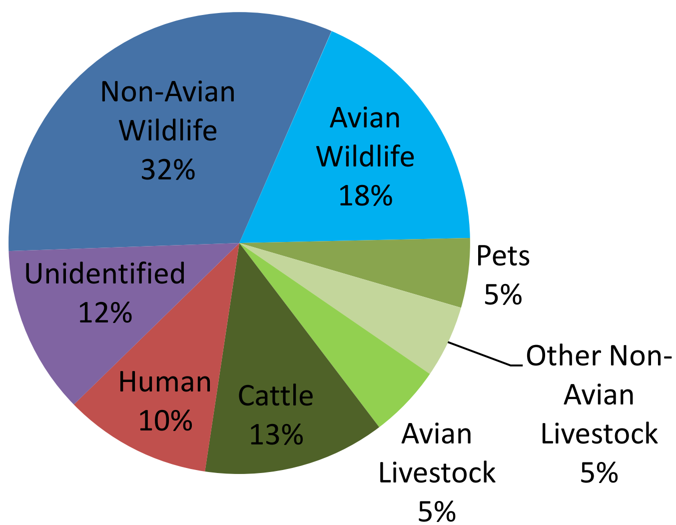
5-Way Split

(averages based on findings in 10 watersheds)



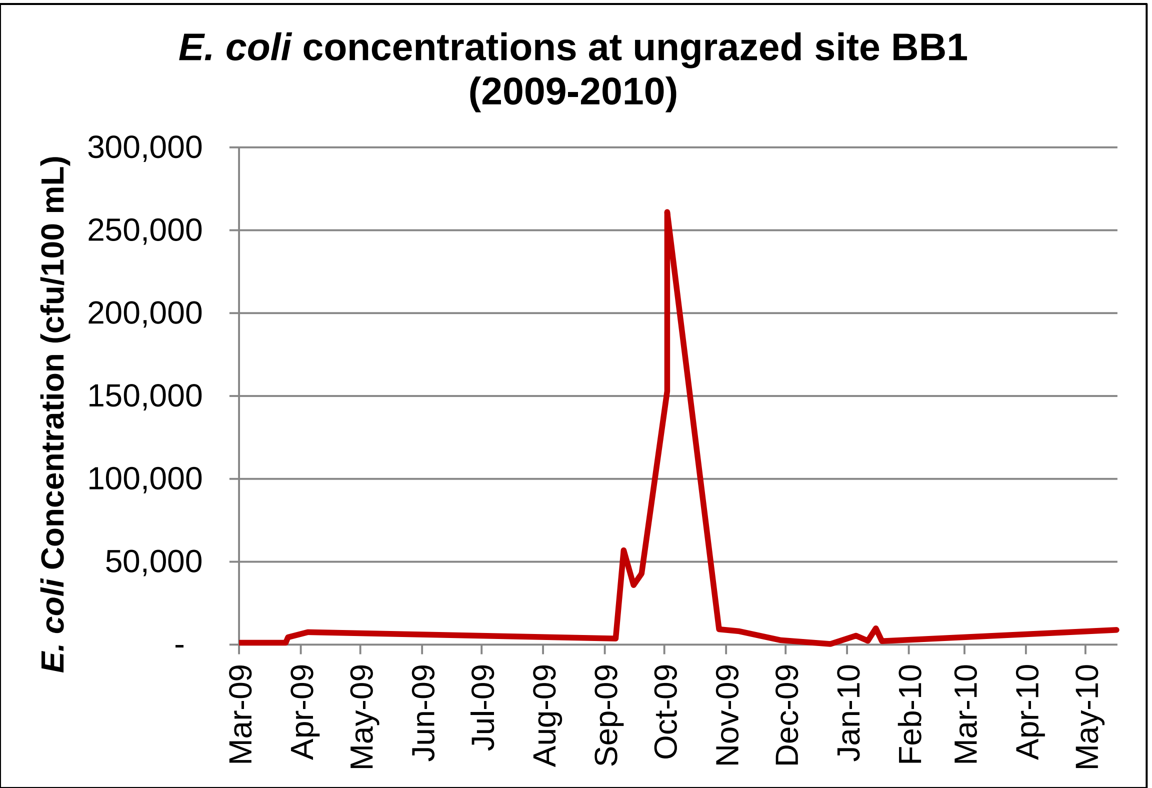
7-Way Split

(averages based on findings in 7 watersheds)



Impacts of wildlife on *E. coli* runoff

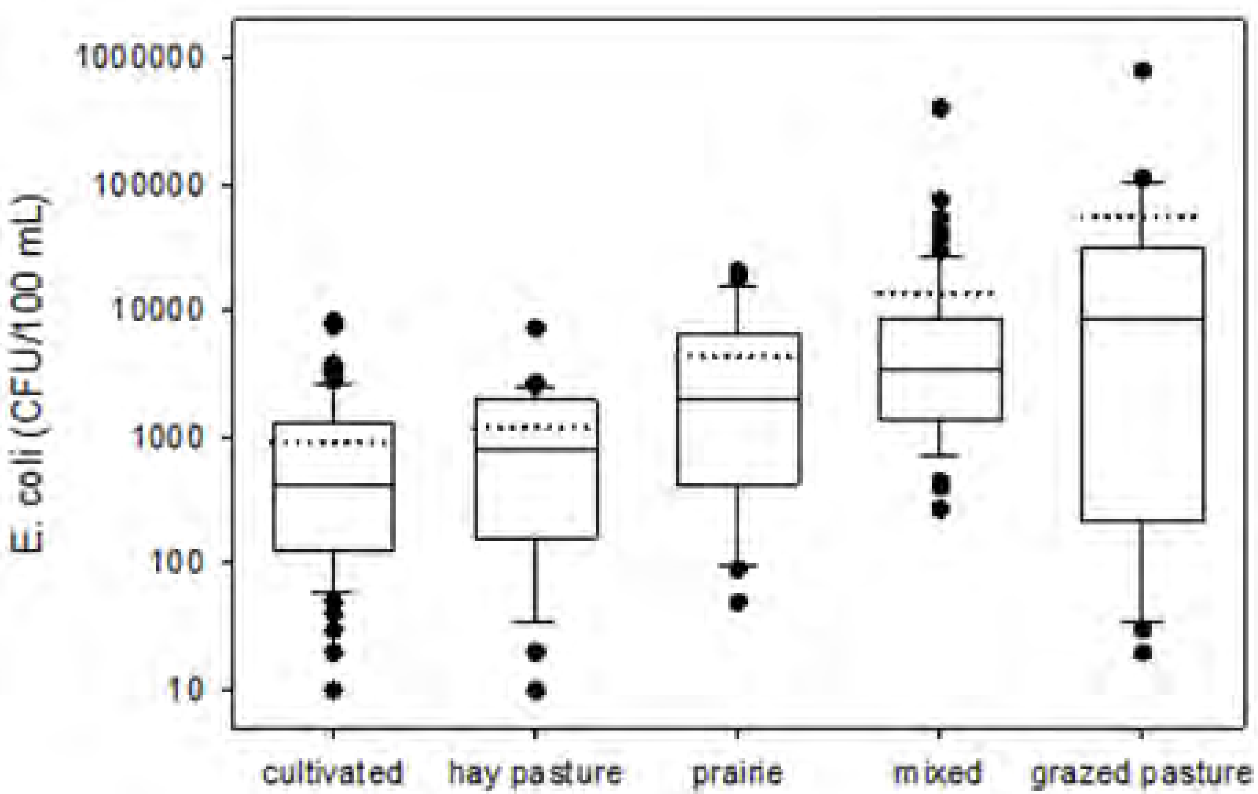
Site	Fecal Coliform (#/100 mL)	*E. coli* (cfu/100 mL)	Reference
Ungrazed pasture	10,000		Robbins et al. 1972
Ungrazed pasture	6,600		Doran et al. 1981
Control plots		6,800	Guzman et al. 2010
Pasture destocked >2 mos.		1,000-10,000	Collins et al. 2005
Ungrazed pasture		6,200-11,000	Wagner et al. 2012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



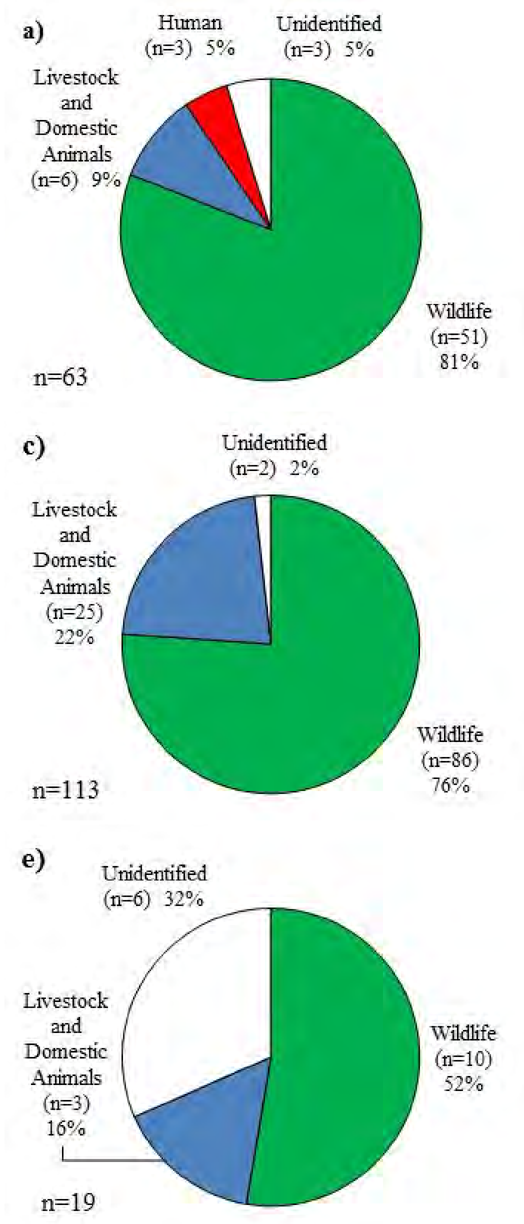
Wildlife contributed >80% of *E. coli* loading at grazed sites in 2009

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:

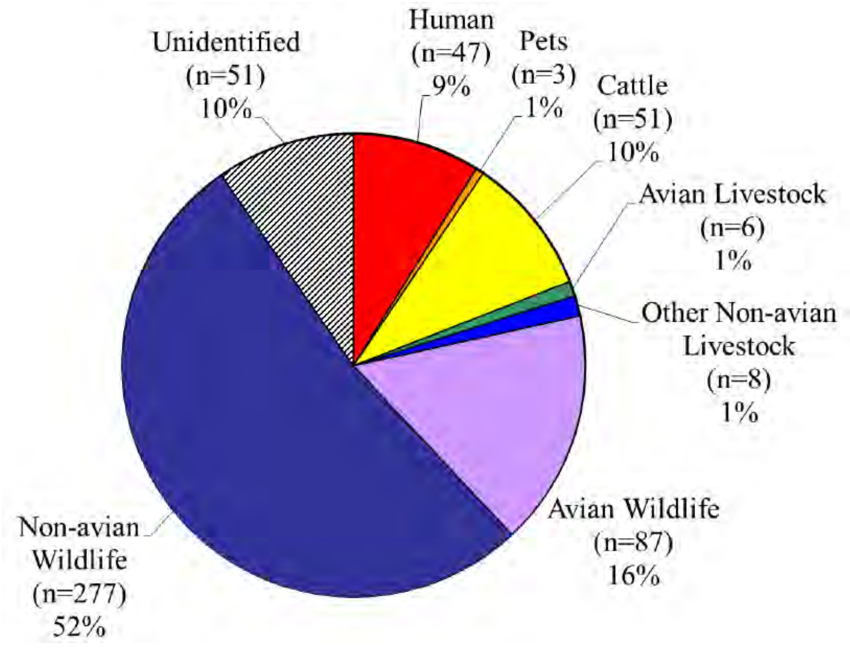
- BST performing well (100% 3-way RCC; 92% 7-way RCC)
  - Proving to be useful tool for identifying significant bacteria sources
- Wildlife = source of 50% of isolates in predominately rural watersheds
  - Edge of field monitoring confirms significance of background sources

Implications:

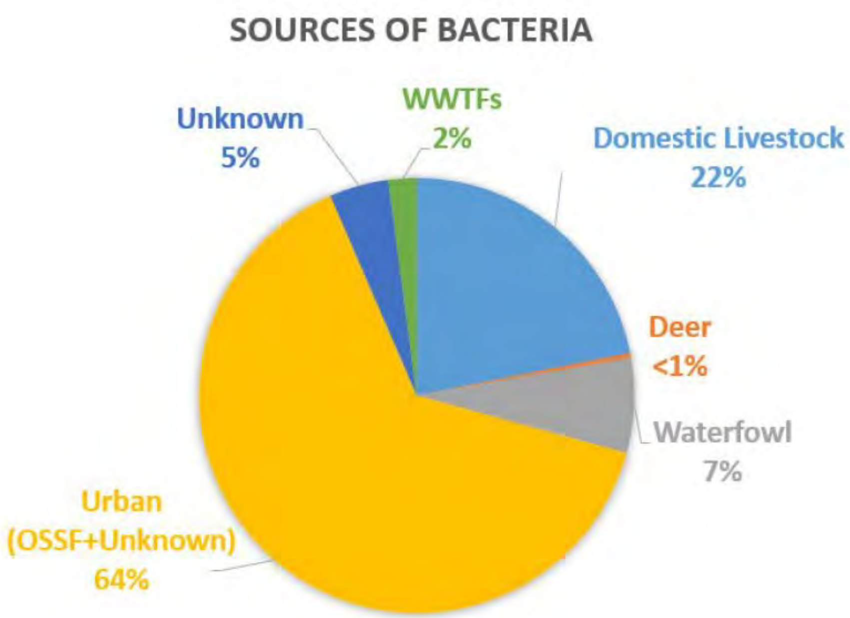
- Background/wildlife loadings need to be considered when:
  - Applying water quality standards
  - Developing tmdls and watershed based plans
- Ignoring background concentrations may lead to:
  - Nonattainment of water quality standards
  - Inaccurate load allocations and reductions

Integrating Modeling & BST: Arroyo Colorado Case Study

BST Results

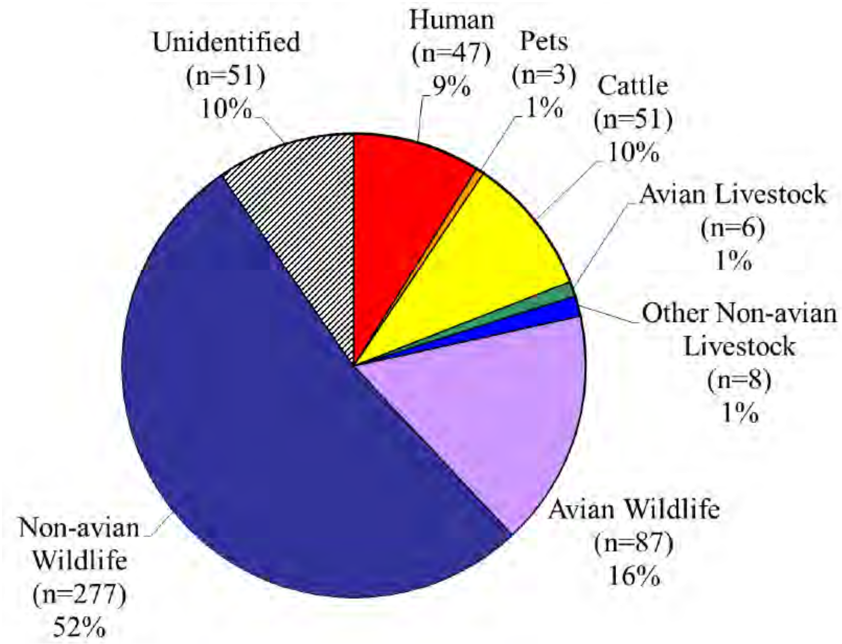


Initial SWAT Model Results

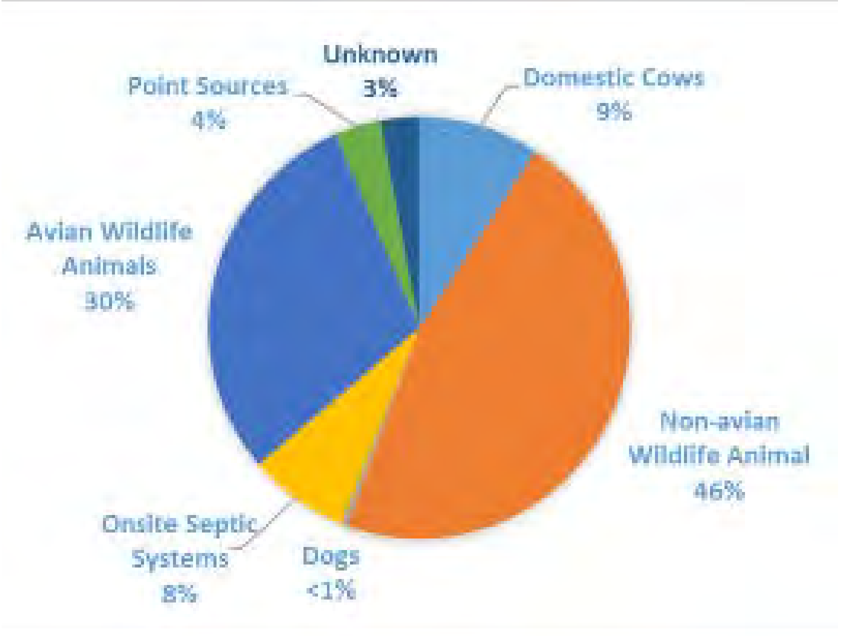


Calibrated/validated SWAT with BST

BST Results



Final SWAT Model Results



WHAT CAN WE DO ABOUT BACTERIA FROM WILDLIFE?

Wildlife (& Exotics) Mgmt.

Upper Llano

Goal: Increase number of "active" TPWD Wildlife Management Plans in watershed by 2/year to a total of 66 wildlife management plans in 10 years – i.e. increase acreage under wildlife management plan from 85,410 to 125,000

Description: This strategy focuses on the overpopulation of deer (native and exotic) throughout the watershed by promoting an increase in the acreage under Wildlife Management Plans and Wildlife Management Associations. Landowners can receive technical guidance from TPWD on matters pertaining to wildlife habitat management and deer population management. Landowners, with assistance from TPWD, can establish wildlife management associations or co-ops to create wildlife management plans for large contiguous areas. Landowners can also seek to acquire Managed Land Deer Permits from TPWD to allow hunting seasons to be extended. This management strategy requires ongoing commitment and collaboration by landowners in each county. Landowners and deer processing facilities can collaborate to evaluate possible incentives for culling the deer population. .

Implementation Strategies

Participation	Recommended Strategies	Period	Capital Costs
Landowners, land managers, lessees especially in subbasins with riparian areas; TPWD	Evaluate formation of Wildlife Management Association(s)	2016–2025	N/A
	Enroll and continue participation implementation of Wildlife Management Plans	2016–2025	N/A
	Work with TPWD biologists to develop and implement Wildlife Management Programs or Landowner Incentive Programs	2016–2025	N/A
	Voluntarily locate supplemental feeding locations away from riparian areas.	2016-2025	N/A
	Voluntarily participate with professional harvesting services to remove exotics	2016-2025	N/A
LRFS, AgriLife Extension and TPWD	Educate citizens, hunters and landowners on wildlife management and benefits of developing and implementing Wildlife Management Plans, participating in Landowner Incentive Program, and forming Wildlife Management Association(s)	2016-2025	$2,000/each $7,500/each traveling event
LRFS, Local Chambers of Commerce and TPWD	Coordinate and facilitate pairing of hunters seeking exotic hunts with landowners, highlighting the potential economic benefits of year-round hunting.	2016-2018	N/A

Estimated Load Reduction

There are no specific loading data for exotics. For comparison, decreasing deer population densities in the riparian zone from one deer per 2 acres to one deer per 10 acres results in nitrogen decreasing 36kg/yr or 16%; phosphorus decreasing 41 kg/yr or 12%; and sediment decreasing 65 tons/yr or 12%.

Feral Hog Control

Attoyac Bayou

Goal: To manage the feral hog population through available means in efforts to reduce the total number of hogs in the watershed by 10% (1,015 hogs) and maintain that level of reduction annually.			
Description: Voluntarily implement efforts to reduce feral hog populations throughout the watershed by reducing food supplies, removing hogs as practical and educating landowners on BMPs for hog removal.			
Implementation Strategies			
Participation	**Recommended Strategies**	**Period**	**Capital Costs**
Landowners, land managers, lessees	Voluntarily construct fencing around deer feeders to prevent feral hog utilization	2015–2018	$200 per feeder exclusion
	Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce hog numbers	2015–2025	N/A
	Voluntarily shoot all hogs on site; ensure that lessees shoot all hogs on site	2015–2025	N/A
AgriLife Extension	Deliver Feral Hog Education workshop	2015, 2018, 2025	$7,500 ea.
County/AgriLife Extension	Promote use of Extension's online tracking tool to report hog harvest data	2015–2025	$10,000
Estimated Load Reduction			
Reducing the feral hog population will reduce bacteria loading to the landscape and direct deposition to the creek. This effort will primarily reduce direct deposition as these animals spend the majority of their time in the riparian corridor. As estimated and used in the SELECT model, each feral hog can contribute as much as 1.16 E+09 cfu of *E. coli* to the watershed daily. Using this number plus a reasonable attenuation factor that assumes 25% of the fecal bacteria deposited by feral hogs reaches the water body, reducing the population by 10% yields a maximum annual load reduction of 1.07 E+14 cfu of *E. coli*. See Appendix D for calculations.			

Pets & Urban Wildlife

Management Measure	Responsible Party	Unit Cost	Number Implemented			Total Cost
			Year			
			1-3	4-6	7-10	
Urban Stormwater Management Measures						
Pet Waste Collection Stations	City of Kyle	$620/station installation $85 annual/station	10	4	4	$22,040[1]
Pet Waste Collection Stations	City of Lockhart	$620/station installation $85 annual/station	10	4	4	$22,040
Pet Waste Collection Stations	City of Luling	$620/station installation $85 annual/station	6	2	2	$12,475
Pet Waste Collection Stations	City of Buda	$620/station installation $85 annual/station	10	4	4	$22,040
Comprehensive Urban Stormwater Assessment	City of Kyle	$30,000/survey	1	—	—	$30,000[1]
Retrofit Stormwater Detention Basins	City of Kyle	$35,000 engineering $50,000/basin	2	—	—	$135,000[1]
Initiate Street Sweeping Program	City of Kyle	$110,000/sweeper	—	—	—	$110,000[2]
Comprehensive Urban Stormwater Assessment	City of Lockhart	$25,000/survey	1	—	—	$25,000
Manage Urban Waterfowl Populations	City of Lockhart	—	—	—	—	N/A
Comprehensive Urban Stormwater Assessment	City of Luling	$20,000/survey	1	—	—	$20,000
Rehabilitate Stormwater Retention Pond	City of Luling	$500,000/pond	1		—	$500,000
Initiate Street Sweeping Program	City of Buda	$150,000/sweeper	1	—	—	$150,000[2]

Plum Creek WPP

Impact of Other Common Management Measures???

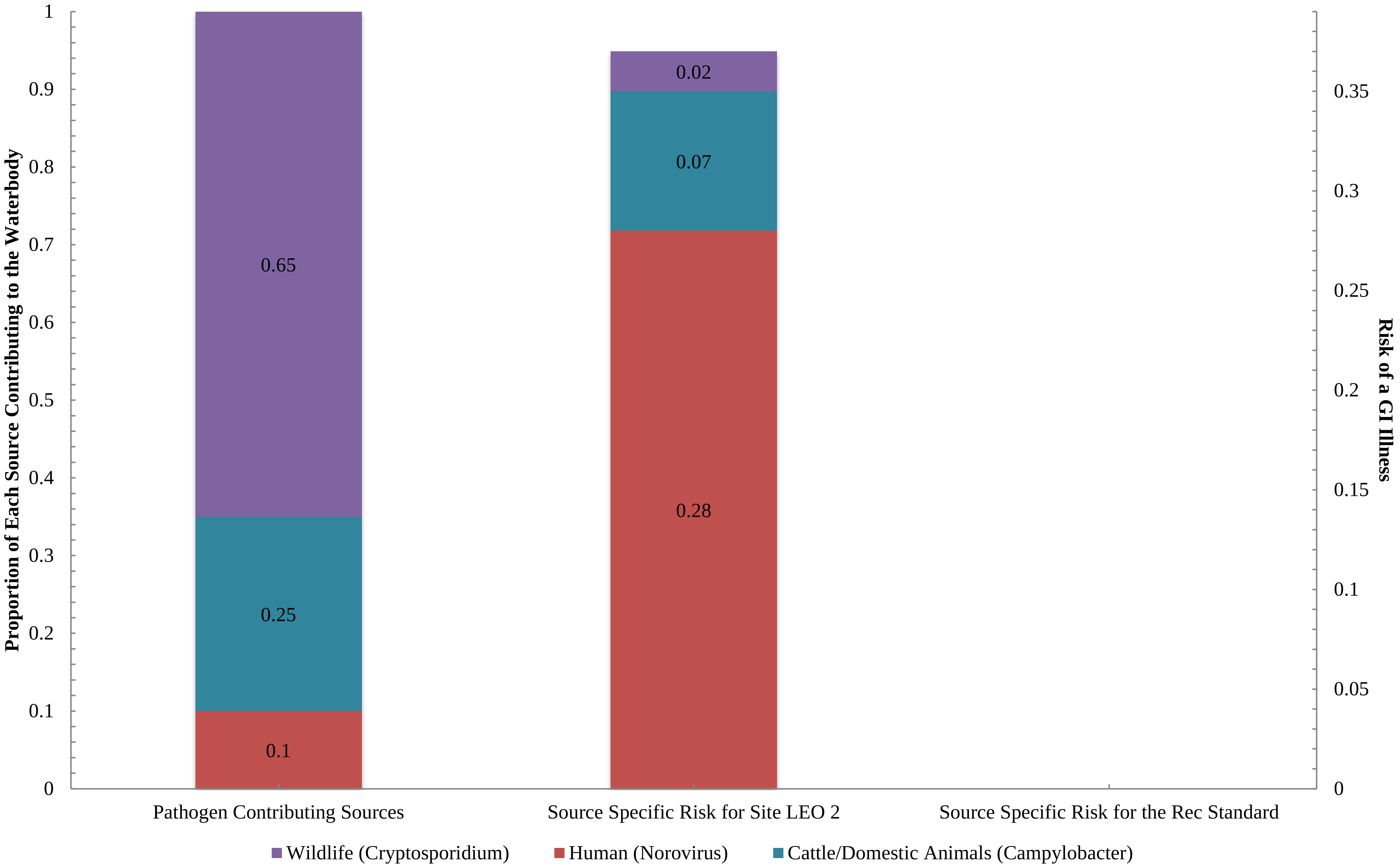
- Urban stormwater management :
  - Stormwater BMP implementation
    - Stormwater detention ponds = 88-90% reduction
    - Stormwater retention ponds = 47-68% reduction
- Ag management:
  - Develop and implement Conservation Plans
    - Prescribed grazing = 66-72% reduction

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



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 <u>not</u> 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?

- Terry Gentry
- Texas A&M AgriLife Research
- 979-845-5323
- tjgentry@tamu.edu

- George Di Giovanni
- Metro. Water District of Southern California
- 909-392-5474
- gdigiovanni@mwdh2o.com

- Kevin Wagner
- Oklahoma Water Resources Center
- 405-744-5616
- kevin.wagner@okstate.edu

Texas A&M AgriLife Research

The Metropolitan Water District of Southern California

Oklahoma Water Resources Center