Effect of Manure Management and Conservation Practices on Bacterial Contamination of Surface Water.

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Conservation Practices

- Contamination of surface water by fecal indicator bacteria and pathogens is often attributed to animal agriculture.
- Specific practices have been suggested to reduce off-site losses of bacteria.
- How have we measured the effectiveness of these practices?
- What is the effectiveness of these practices?
- What are our prospects for improvement?

Manure Sources

- Animal confinement facilities
- Land application of manure
- Grazed pastures

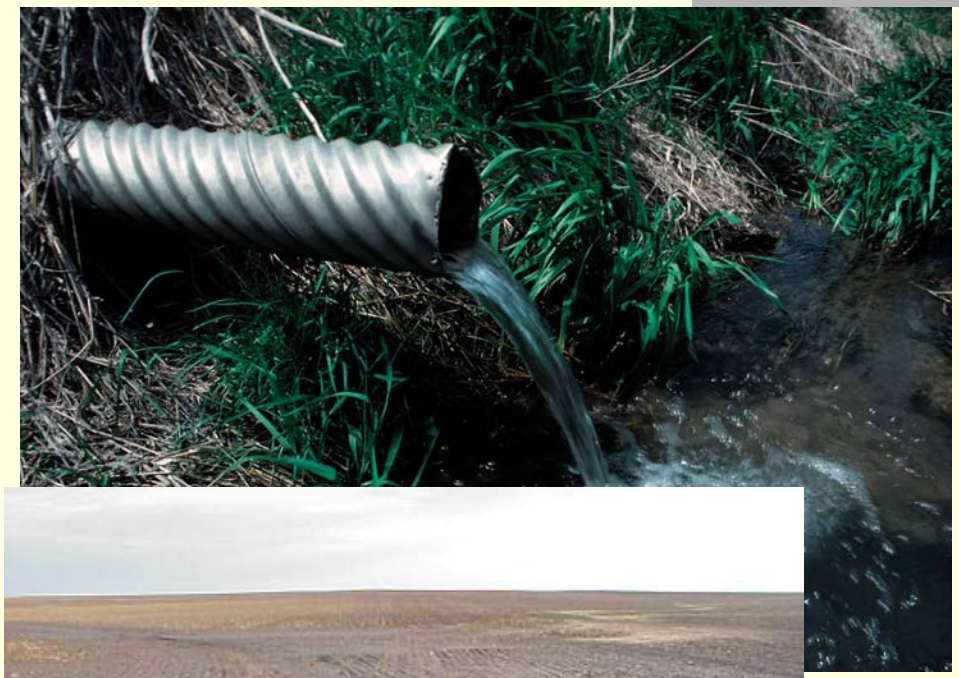
Conservation Practices

Grassed waterways, filter strips, terraces, buffers

Designed for erosion prevention

- reduce flow velocity
- filtration
- increase infiltration
- must intercept flow path

Conservation Practices
Subsurface (“tile”) drainage



Land Application of Animal Manure

Application Method

Injection and incorporation reduce the *E coli* available for runoff.

Manure Storage Reduces Risk
Liquid dairy manure

Storage time (d)	*E coli*-start (cells/g)	*E coli*-end (cells/g)	Reduction	T90 (d)
33	7.5×10^5	8.1×10^3	98.9	17
84	3.1×10^5	1.3×10^3	99.6	36
27	6.7×10^5	7.7×10^3	98.8	14
83	3.9×10^5	10^2	99.9	23

Meals and Braun, JEQ, 2006

Factors Affecting Transport and Buffer Performance

- Bacterial density at soil surface
  - density in manure
  - time after application
  - die-off rate
  - application method
  - mixing depth
- Infiltration rate
- Rainfall intensity
- Rainfall duration
- Buffer width
- Topography
  - Slope
  - Catchment to buffer ratio
  - Placement in watershed

Effect of Filter Strips on Removal of Fecal Bacteria

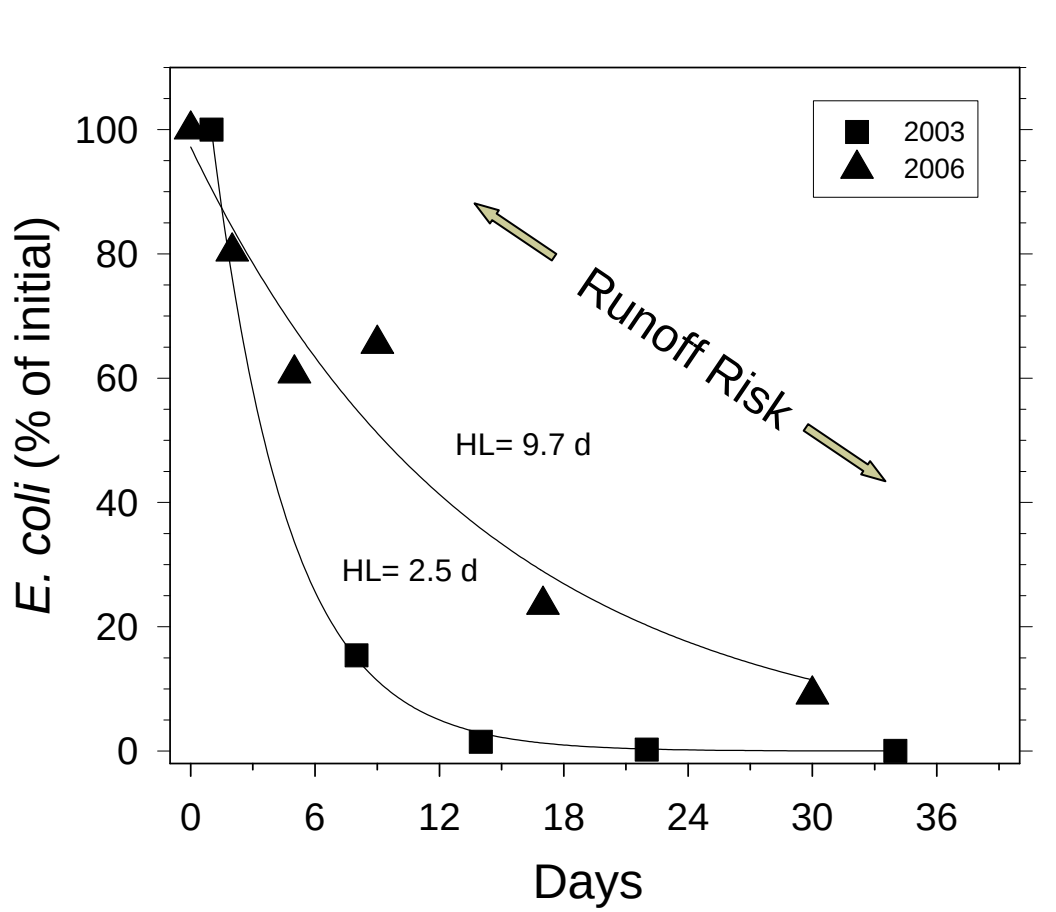
System	Manure	Reduction	Ref.
Filter strip plot	FC dairy runoff	31%	Schellinger and Clausen, 1992
Filter strip box	FC, cattle	61-70%	Stout et al, 2005
Filter strip lysimeter	FC, cattle	99%	Roodsari et al, 2005
Filter strip plots	FC, poultry	42-95%	Coyne et al, 1998
Filter strips	FC, cattle pasture	100%	Lim et al, 1997
Filter strips plots	EC, Campy, dairy	0-95	Collins et al., 2004

% reduction is [1-output/input]*100

Differences Between Plots and Landscape Scale

- Catchment area to buffer ratio
- Concentrated flow more evident on landscape
- Wildlife contributions
- Natural rainfall events are more variable

E. coli survival after swine manure application in the field.



RUNOFF

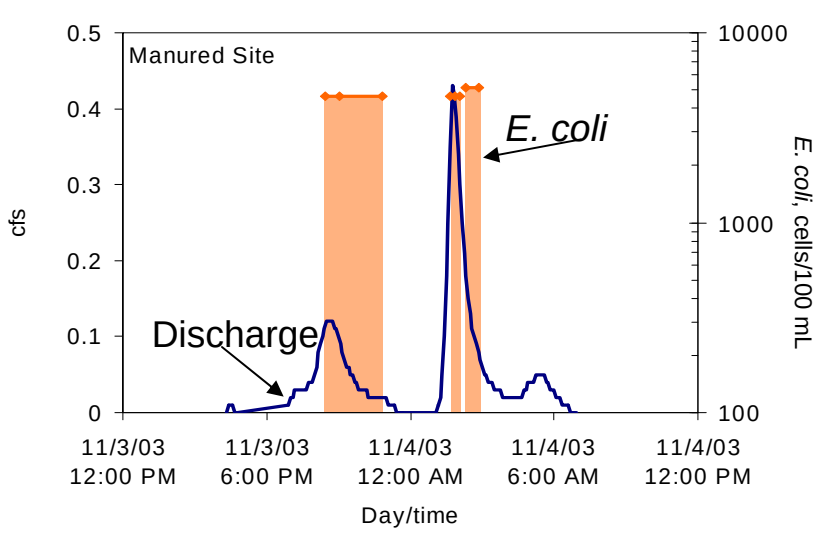
Comparison of *E. coli* transport at manured and non-manured sites

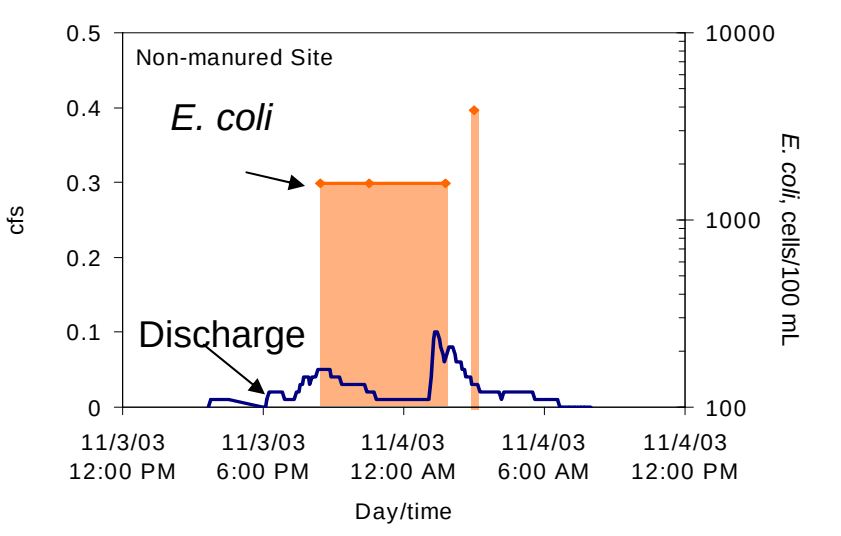
- One site receives manure every other year (after soybean)
- One site long-term no manure
- Surface run-off volume and samples (same day analysis of *E. coli*)
- Soil sampling for *E. coli*

Runoff Event – Field Scale

November 2003, 6 days after swine manure application

Two sites: manured and non-manured



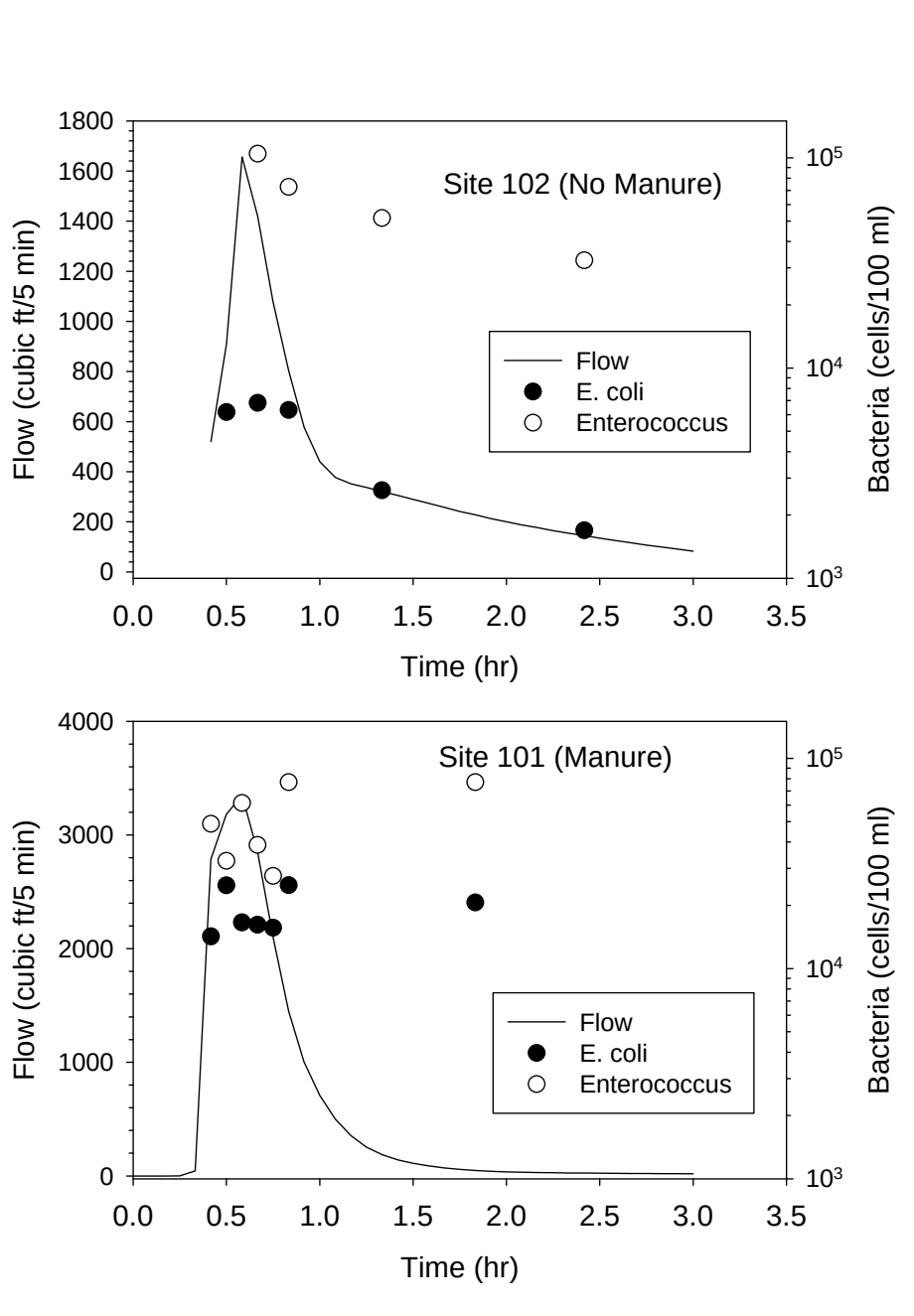


E coli in non-manured field

Cells/g soil	% Samples
>10000	10
1000-10000	6.7
500-999	3.3
100-499	33
Nondetect to 99	47

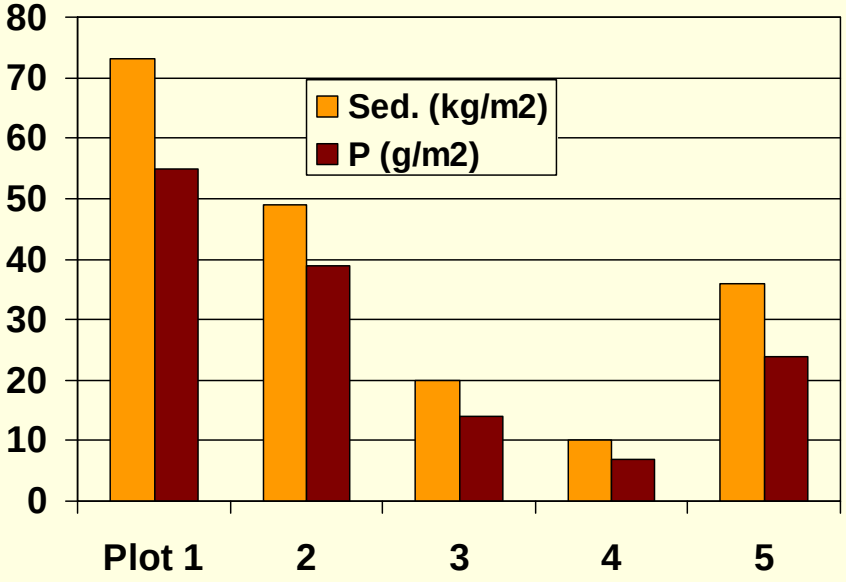
Runoff Event: August 2007

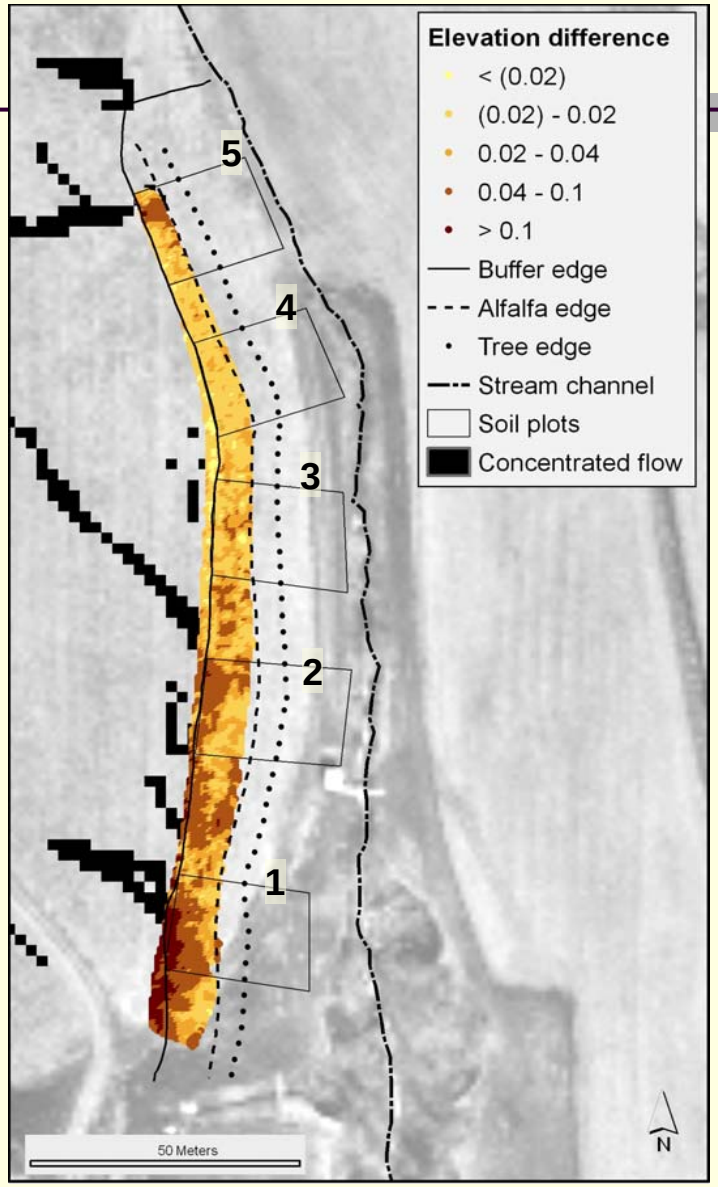
- Last manure application November 2006
- Enterococcus > E. coli
- Flow 100 to 200 times greater than the Nov 2003 events.
- *E coli* 5 to 10 times greater.



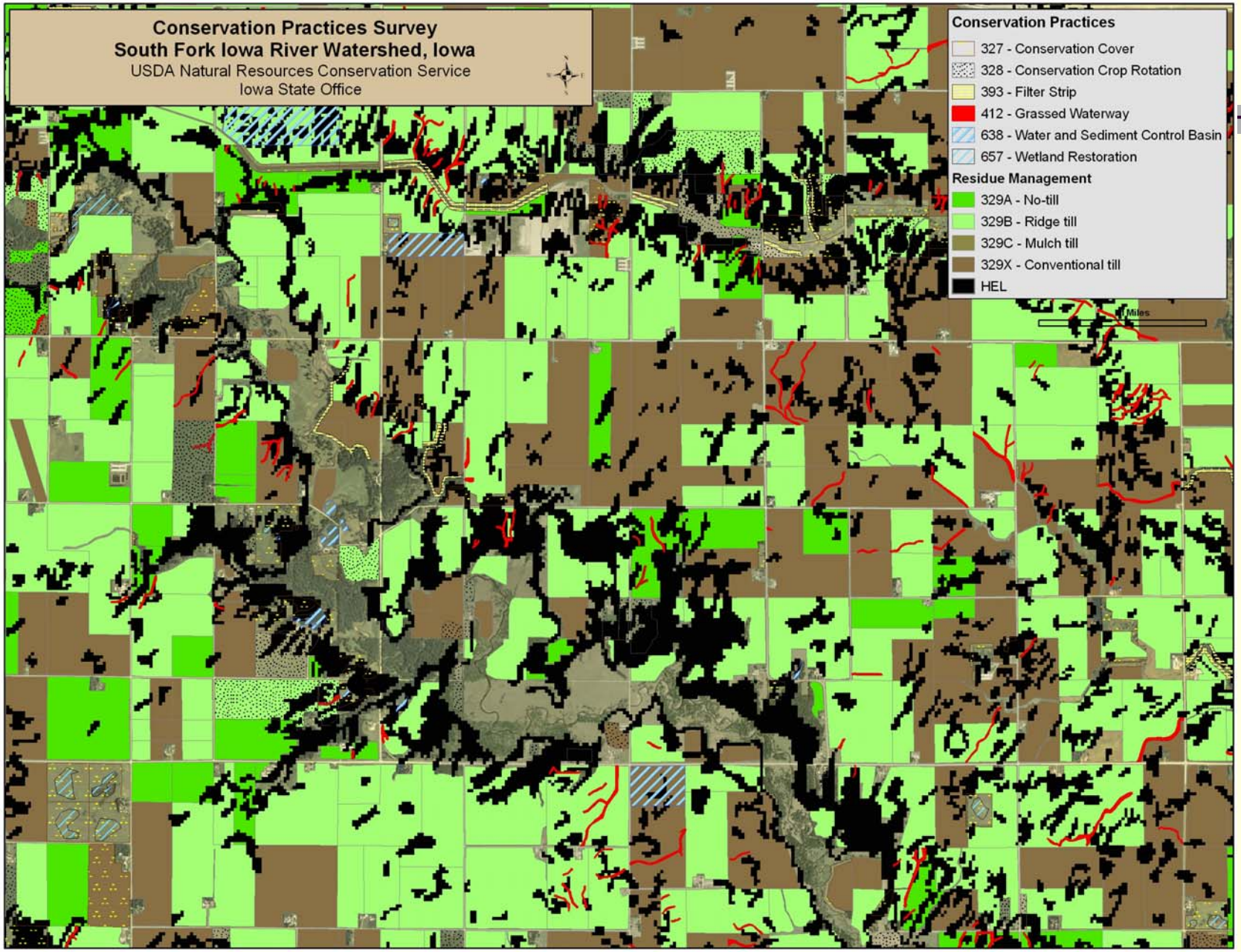
Concentrated Flow Effects Performance

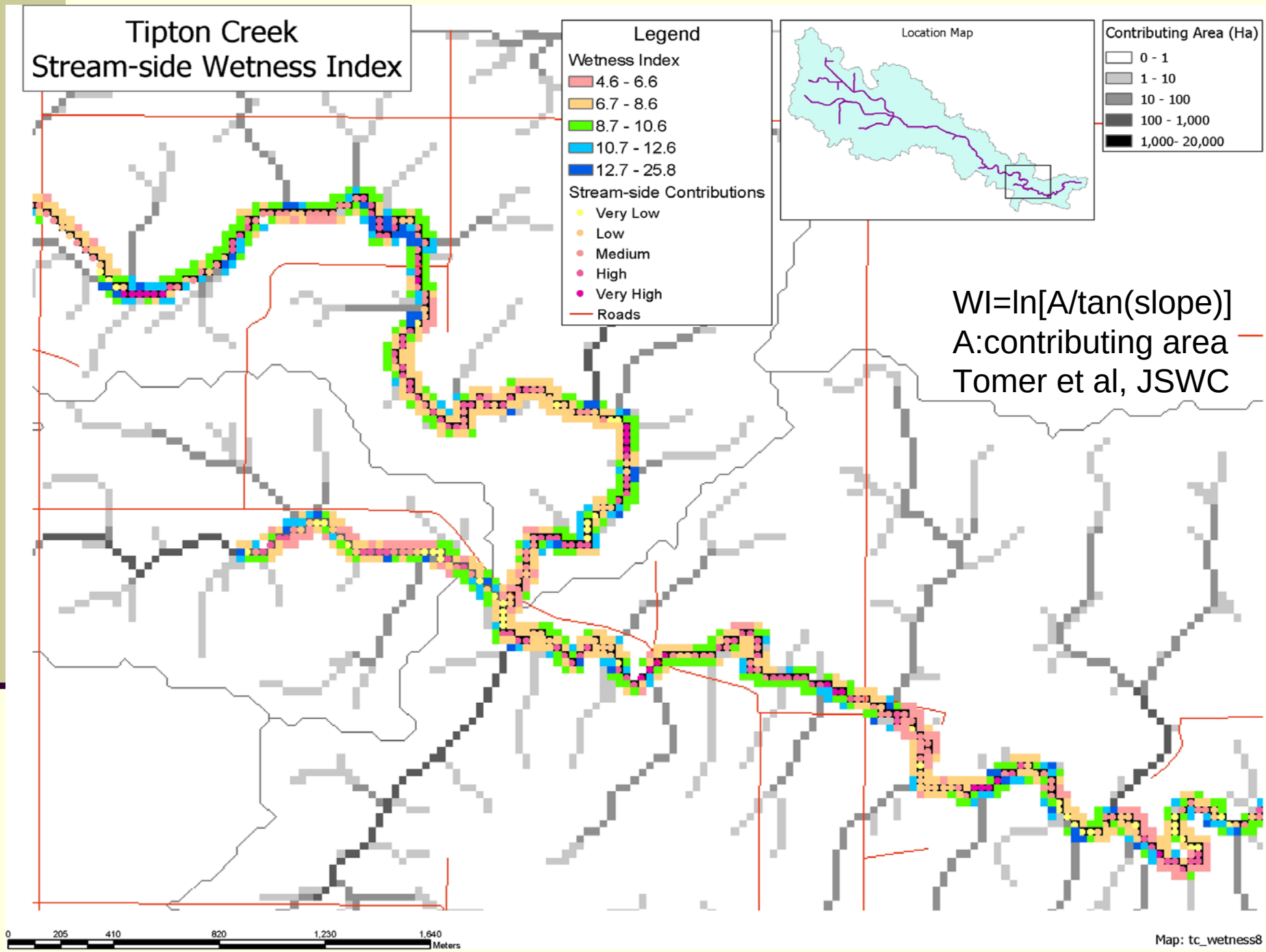
Sediment and P Trapping in Riparian Buffer in Western Iowa





Where is runoff important?

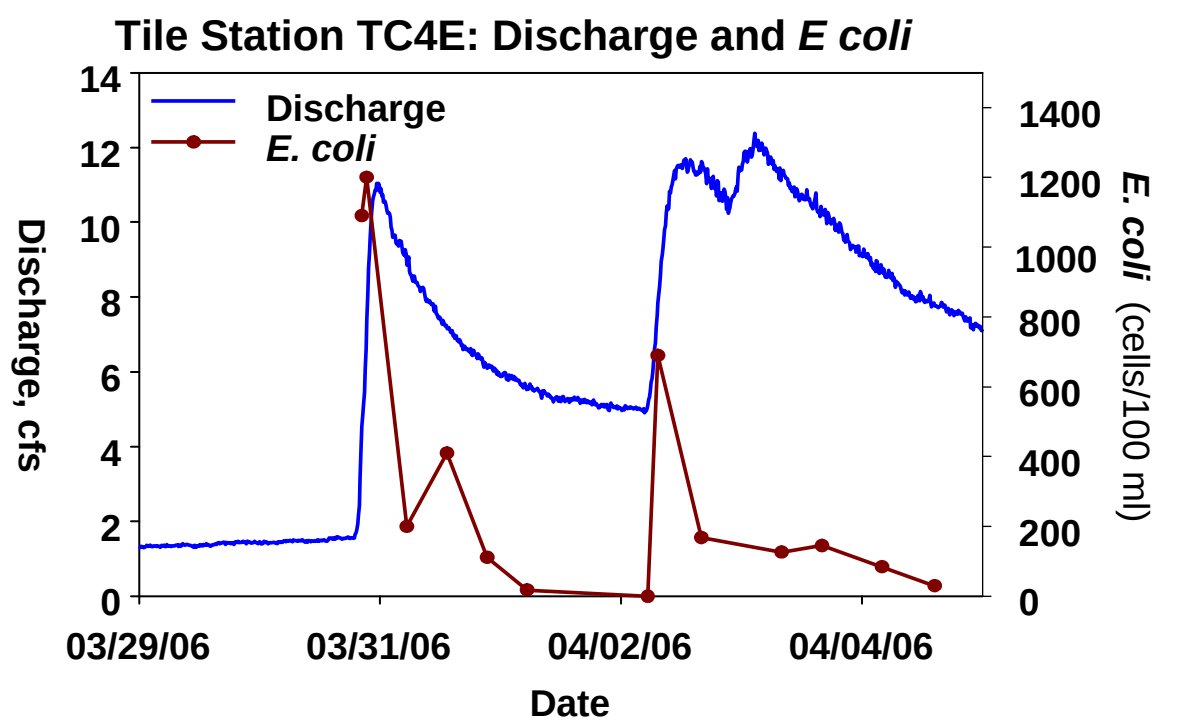



Tipton Creek
Stream-side Wetness Index
Legend
Wetness Index
4.6 - 6.6
6.7 - 8.6
8.7 - 10.6
10.7 - 12.6
12.7 - 25.8
Stream-side Contributions
Very Low
Low
Medium
High
Very High
Roads
Location Map
Contributing Area (Ha)
0 - 1
1 - 10
10 - 100
100 - 1,000
1,000- 20,000
WI=ln[A/tan(slope)]
A:contributing area
Tomer et al, JSWC
0
205
410
820
1,230
1,640
Meters
Map: tc_wetness8

Tile Discharge:

Tiles Deliver Large Volumes of Water

E coli concentration dependent on storms and surface inlets



Tile	TC2	TC4E	TC4W	TC10
Mean (cells/100 ml)	11.2	178	299	184
Max	102	8160	>2420	816

Watershed-Scale Evaluation

- 10 yr study of Owl Run watershed by Inamdar et al (JAWRA, 2002) in Virginia
- Manure storage, fencing, watering troghs, nutrient management
- 3 yr pre-treatment compared to 7 yr post treatment
- Slight decreasing trend in post years, but 48-94% of samples still exceeded recal coliform standard

Conclusions

- Filter strips, buffers, grassed waterways are marginally effective (50-70%) compared to the 2 to 3 log unit reduction needed.
- Systems like vegetative treatment units or wetlands may be effective if residence times are great enough.
- Practices to protect tile inlets are needed.
- Manure treatment or application systems that decrease bacteria on soil surface have greatest potential.
- Research at field scale is needed.

Questions?

Manure Management Practices

- Land Application
  - Manure Spreading
  - Spray Irrigation
  - Injection
- Barriers
  - Fencing
  - Filter strips
- Storage/Treatment
  - Composting
  - Holding ponds& Lagoons
  - Wetlands
  - Incineration
  - Anaerobic digestion