# “Re-plumbing” Roadside Ditch Networks for Improving Stream Health

Ditches - The unrecognized driver of flooding, water pollution, and in-stream erosion and habitat degradation

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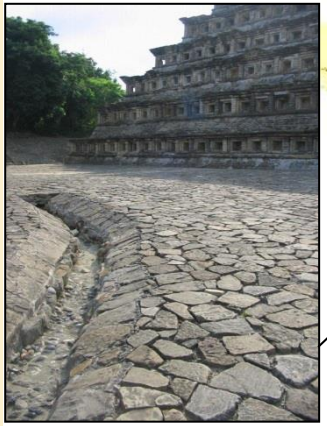
**Cornell Local Roads**

***NE Transportation and Wildlife Conference***
***Sept 2016***

# Global Impact of Roadside Ditches

**Worldwide Road Density**

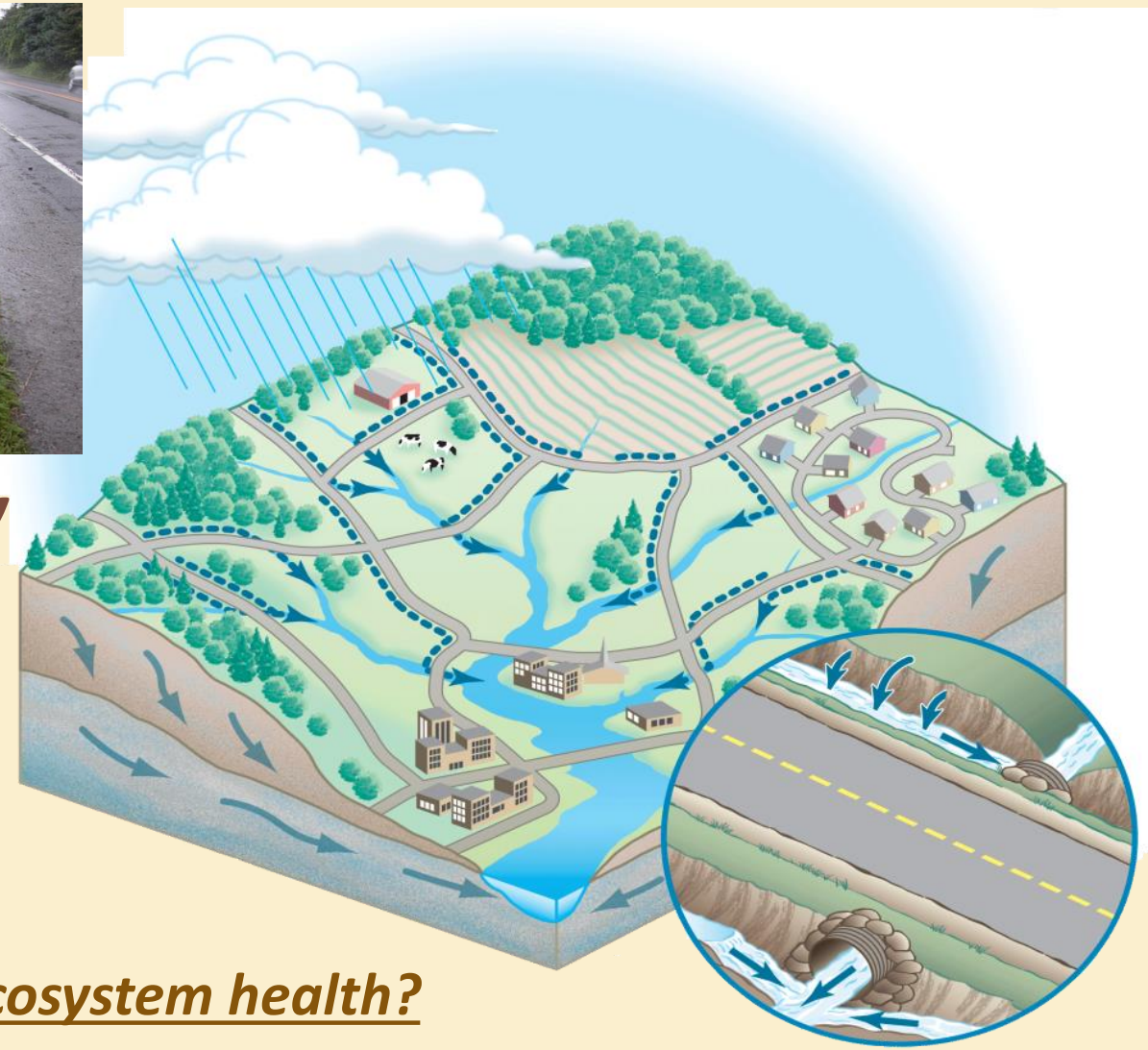
**50% of the contiguous US is within 382 meters of a road**



Road Density (km / sq km)

- 0.00 - 0.10
- 0.10 - 0.25
- 0.25 - 1.32

# Roadside Drainage Networks



***What role do they play in:***

- ***Floods?***
- ***Droughts?***
- ***Water pollution?***
- ***<u>Stream and lake ecosystem health?</u>***

# Roadside Ditch Team

*Faculty:*

- D. Orr*, Cornell Local Roads Program*
- T. Walter*, Dept. Biological and Environmental Engineering*
- D. Buckley, P. Bergholz, *Dept. Crops and Soils*
- R. Marino, R. Howarth, K. Sparks, *Dept. Ecology*

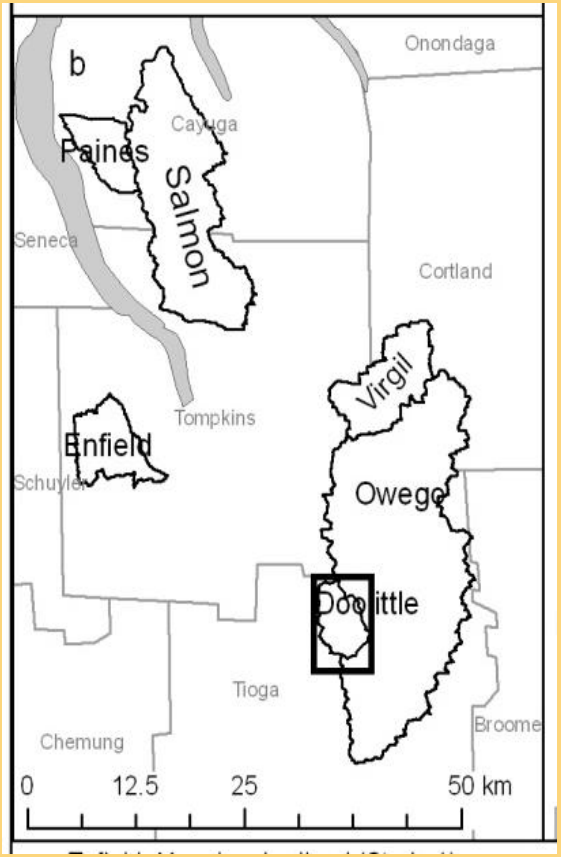
*Graduate Students:*

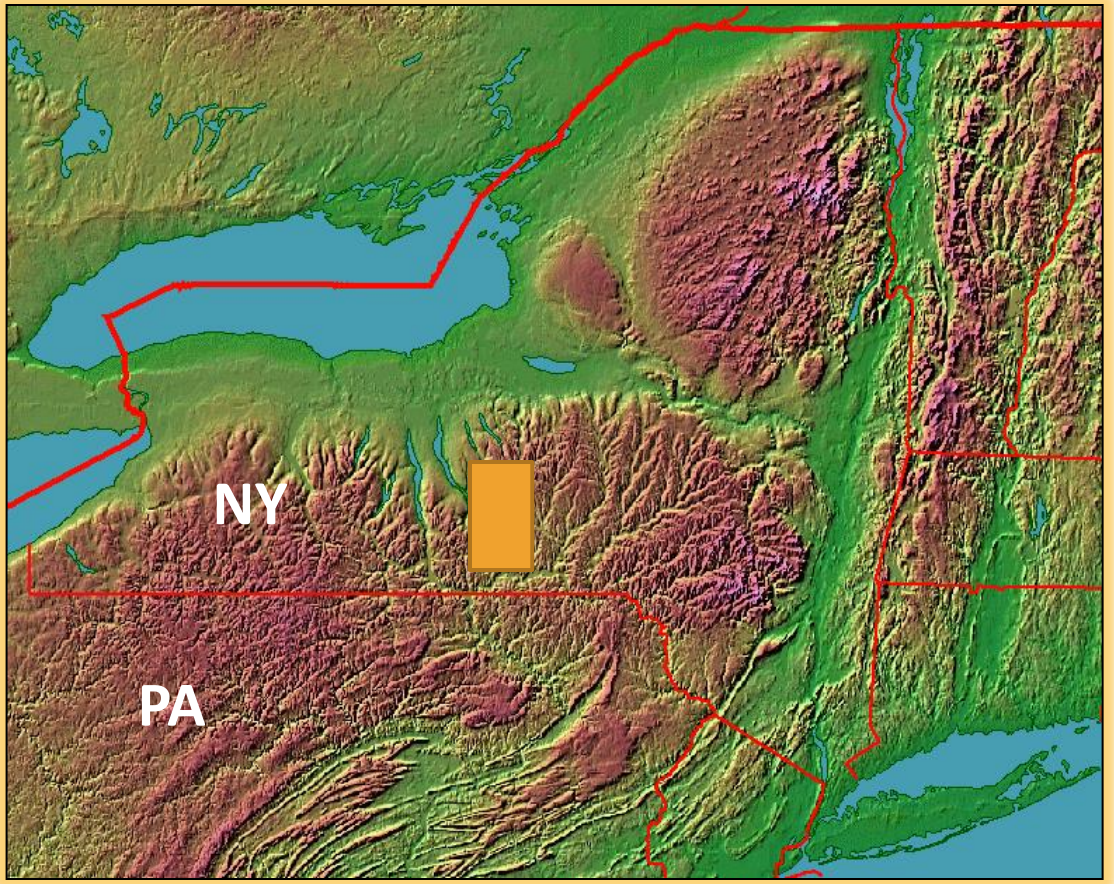
- K. Falbo, B. Buchanan, J. Diaz-Robles, J. Archibald, L. McPhillips, S. Davis, T. Johnson, J. Kimchi *(Undergr);*

Cornell University

USDA United States Department of Agriculture
National Institute of Food and Agriculture

# Study Sites

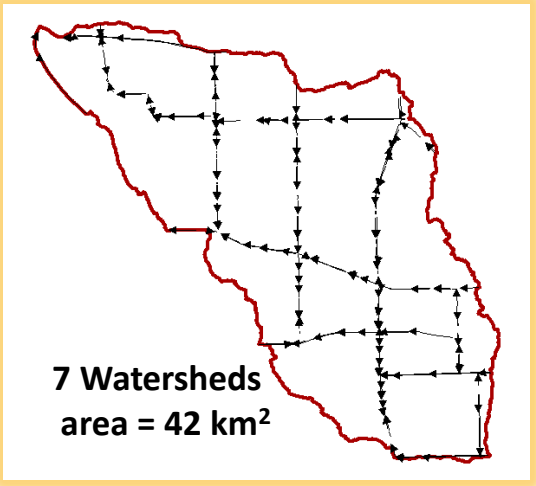

b
Onondaga
Cayuga
Paines
Salmon
Seneca
Cortland
Virgil
Tompkins
Enfield
Schuyler
Owego
Doolittle
Tioga
Broome
Chemung
0
12.5
25
50 km


NY
PA

# APPROACHES


## *(1) MONITORING*

- ❑ Total water flow
- ❑ Suspended sediment
- ❑ Dissolved chemicals
- ❑ Bedload
- ❑ Fecal coliforms




## *(2) GPS and ARC-GIS MAPPING*

- ❑ Ditch lengths
- ❑ Connections to streams
- ❑ Management types

## *(3) MODELING*

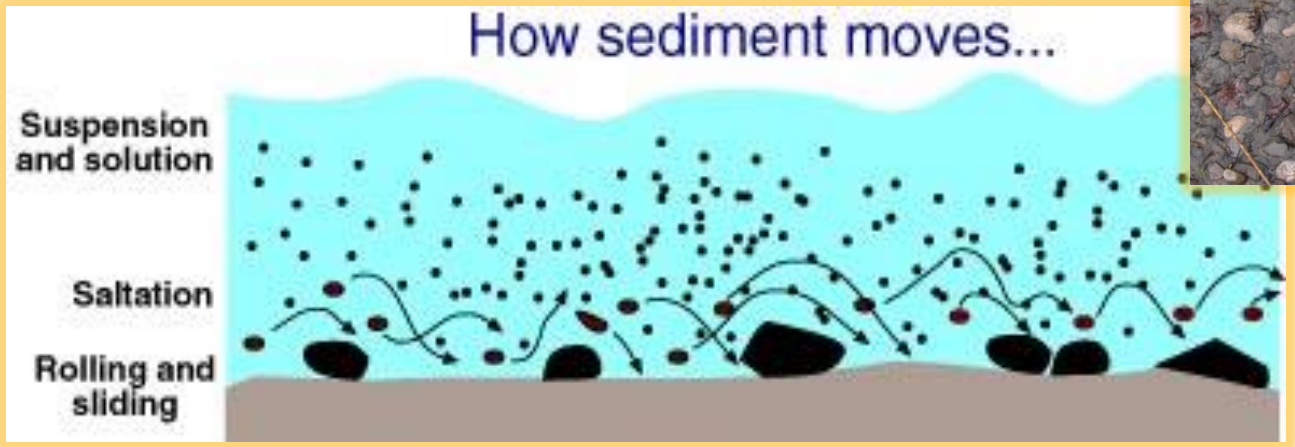
## *(4) EXTENSION*

# Methods

## *Monitor*

- *Total water flow*
- *Suspended sediment*
- *Dissolved chemicals*


## Bedload Transport



# Ditch Study Sites

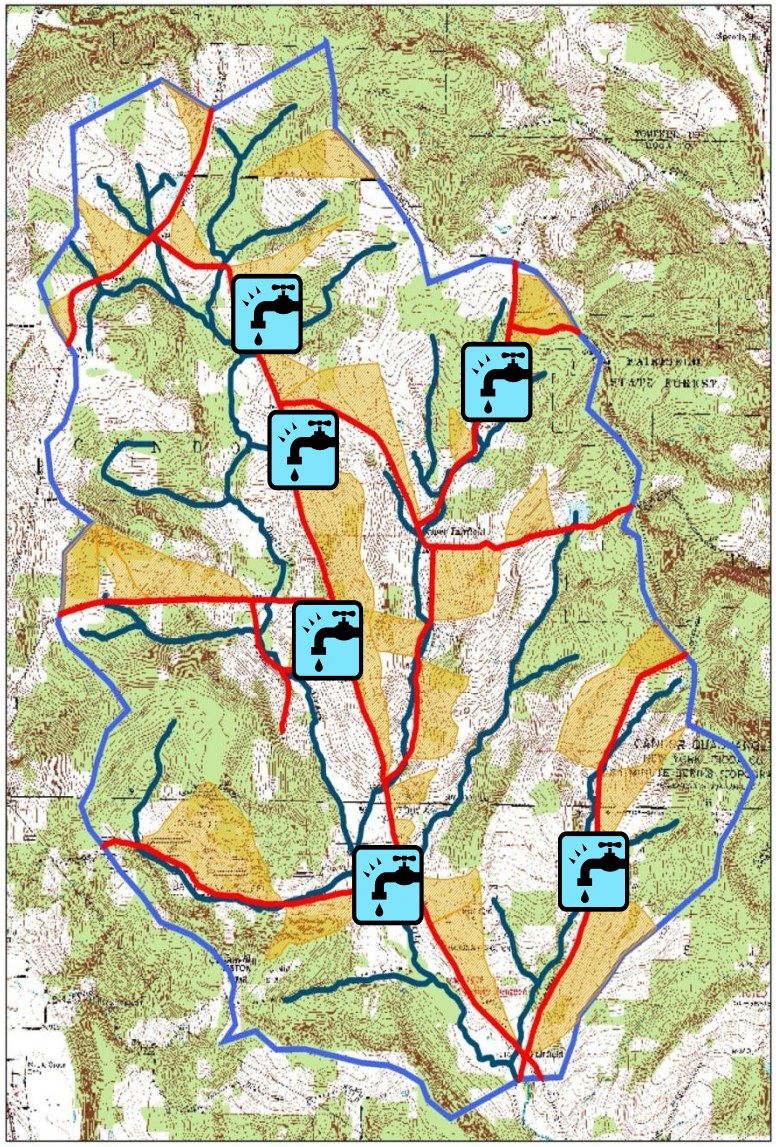

vegetated

exposed, scraped

# Results - Drainage Mapping

| Characteristic | Average value |
| --- | --- |
| Watershed area | 42.3 $km^2$ |
| Road length | 54.3 km |
| % road surface area of wtshd | 0.69 % |
| Roadside ditch length | 81.4 km |
| Total # of direct connections to strms | 94 |
| Total ditch length connected to strms | 51.0 km |
| Area of basins draining to ditches | 8.1 $km^2$ |
| % of watershed draining to ditches | 22.3 % |
| Stream channel length (no ditches) | 66.0 km |
| Stream channel density w/o ditches | 1.55 (km/km2) |
| Stream channel density with ditches | 2.73 (km/km2) |

# Results – Drainage Mapping



Ditch drainage basins potentially intercept ~22 % of the surface runoff and shallow groundwater from each watershed and rapidly shunt it to the nearest stream.

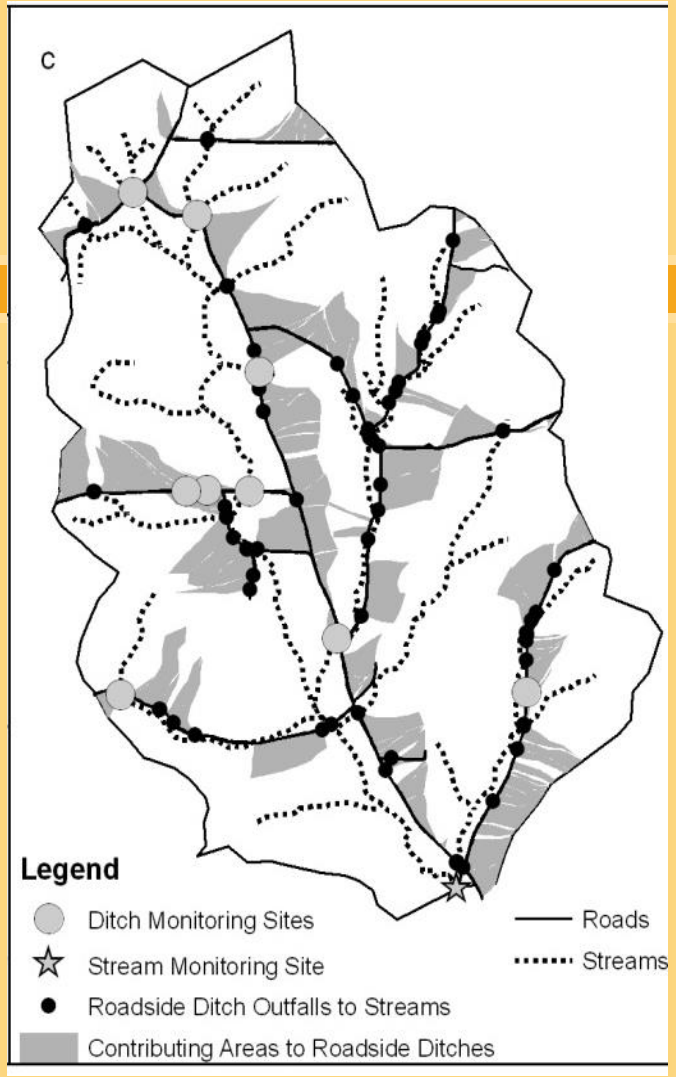
Ditch drainage basins

Stream

Road ditches

Ditch outflows

# Results – Hydrology




***Doolittle Creek Watershed***

- ***8 ditch monitoring stations and Doolittle Crk***
- ***10 storms 2005-2006; 1.3 – 12.9 cm total rain/event***
- ***Each ditch captured avg of 51% of rainfall in the ditch's basin***

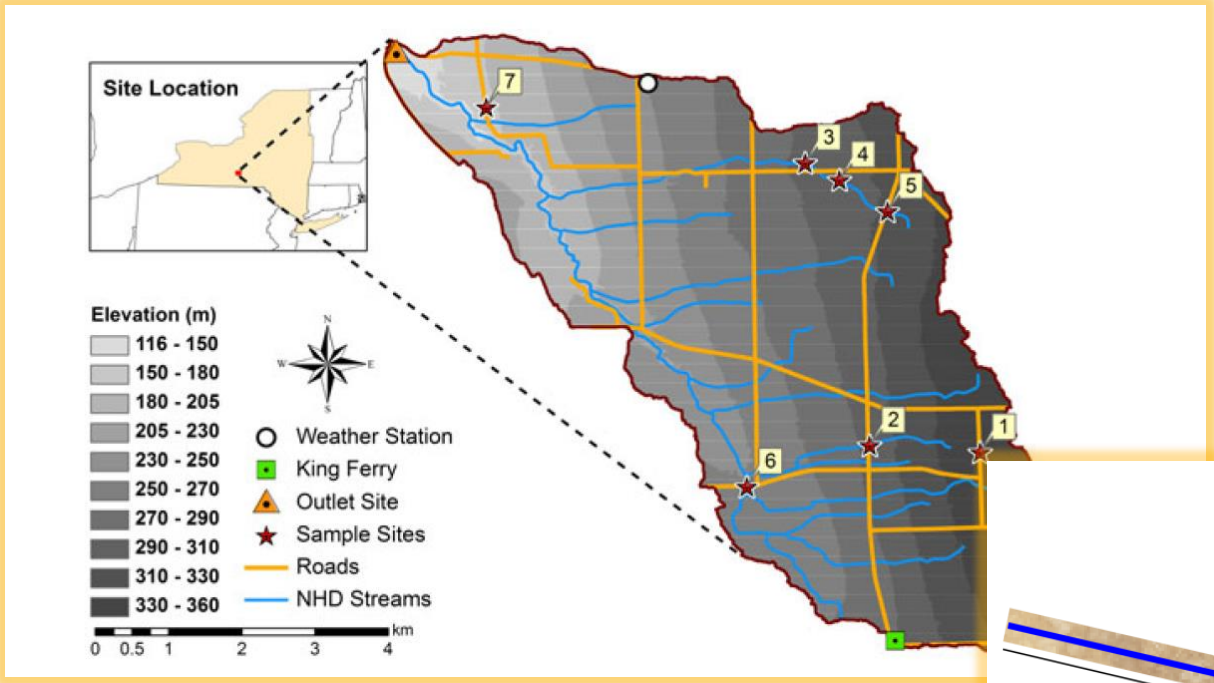
*Diaz-Robles 2007*

# Results – Hydrologic Model

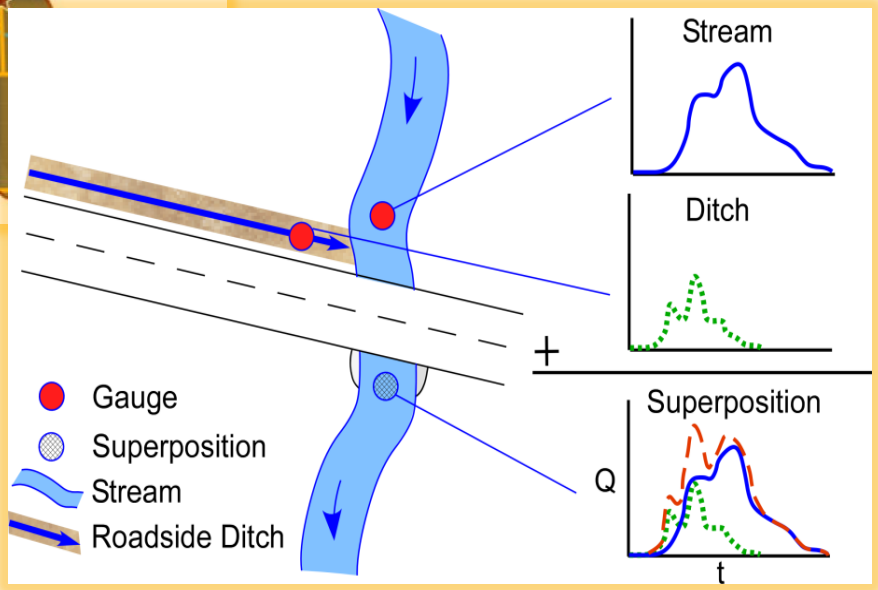
***Entire Modeled Ditch Drainage Networks:***

- ***Doolittle: transported 45,400 $m^3$ water / storm = 3.6% (+/- 1.4%) of incoming precipitation and 19.5% (+/- 9.7%) of total stream flow measured in each storm***
- ***Paine's Creek: 22% of total stream flow in spring storm event and 29% of total stream flow in a summer storm event.***

# Results - Hydrology




***7 ditches***
***34 storms***
***2.5 – 40 mm rain***
***April – Dec. 2009***

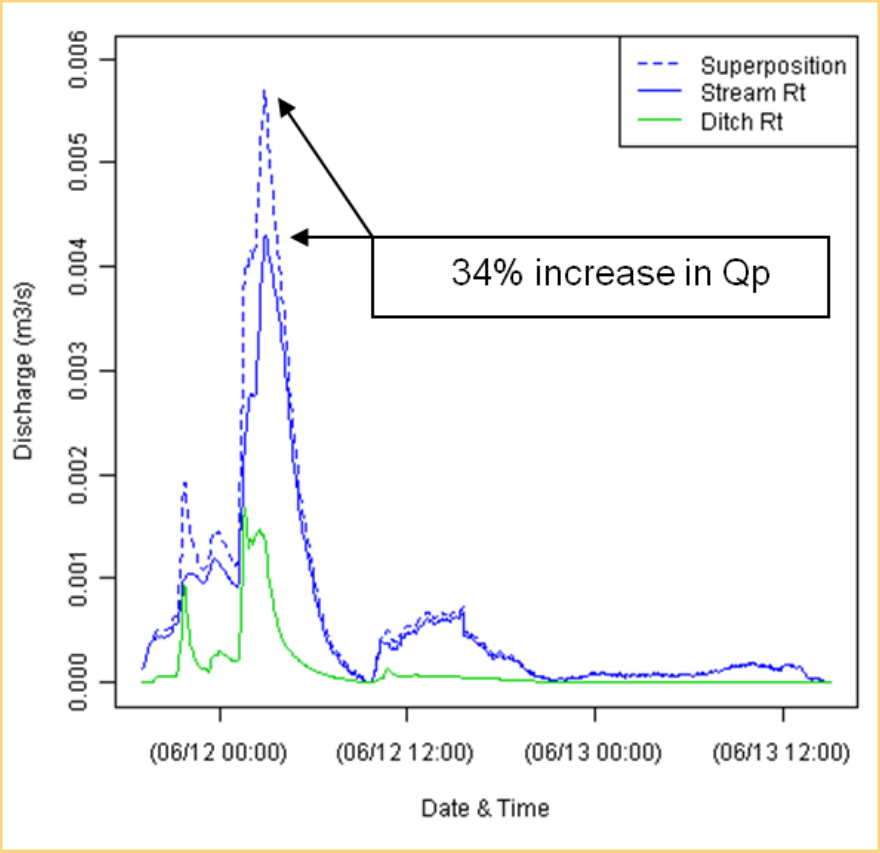



***Paine's Creek Watershed***

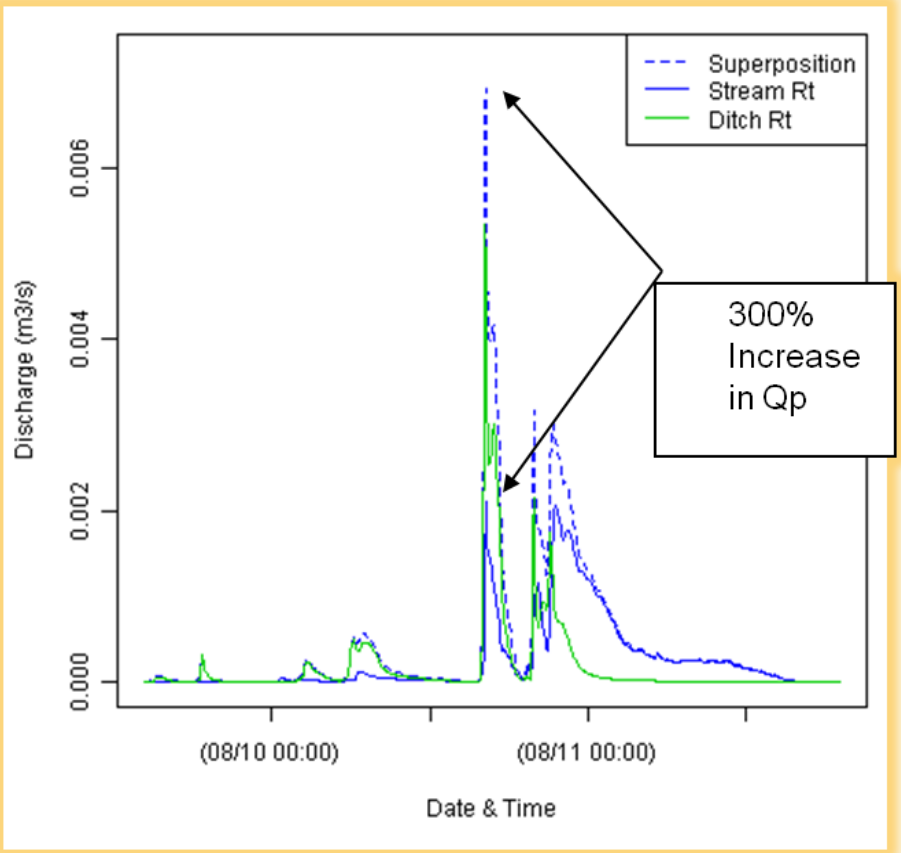
*Buchanan et al. 2012*

# Results – Hydrology

*spring*

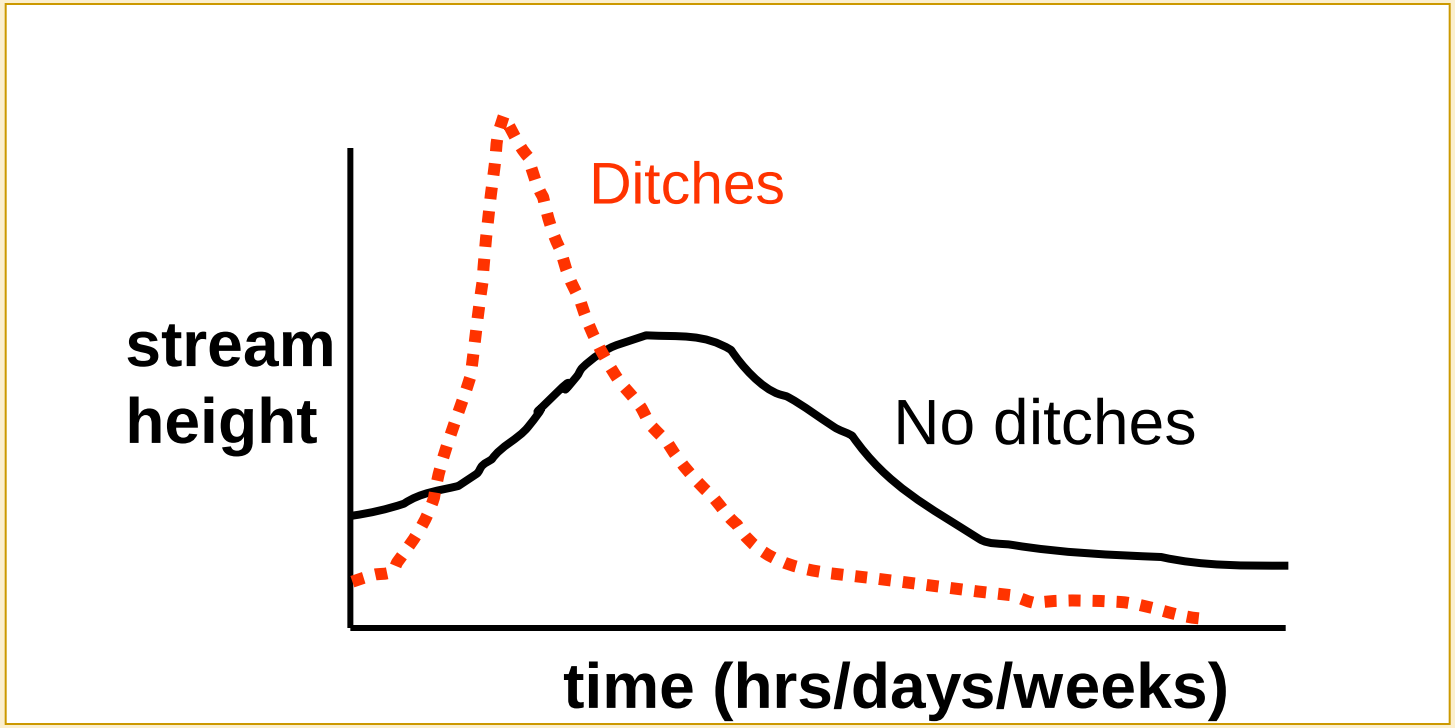



*summer*



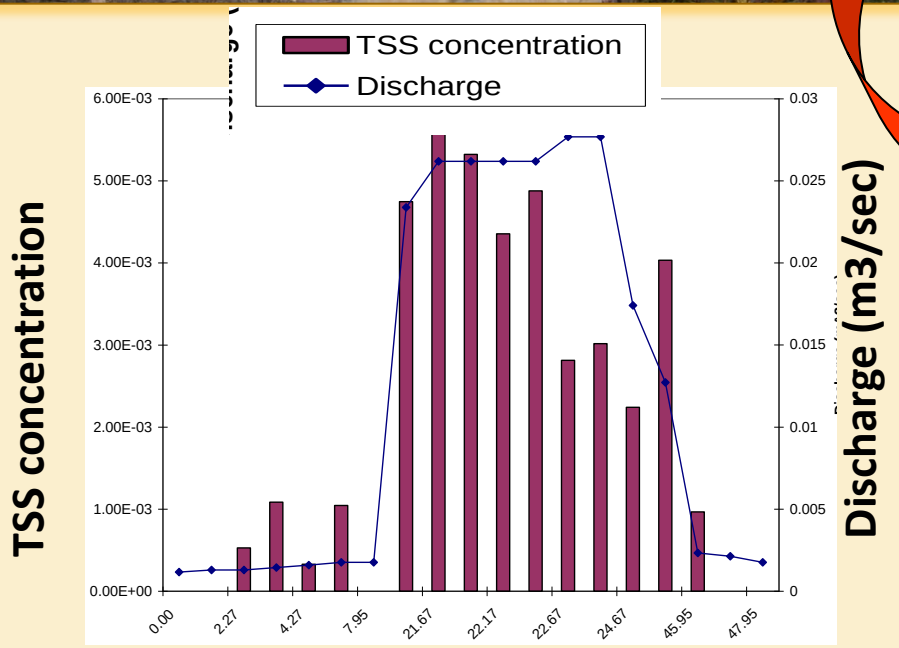

Ditch discharges contribute to increased peak flows (avg 78%) and total flows (avg 57%) in streams. *Buchanan et al. 2012*

# *Altering the Natural Flow Regime, Aka Environmental Flows*



# Results – Sediment


**Ditches are a source of sediment and associated contaminants to downstream waters, especially when scraped.**




*Diaz-Robles, 2007*

# Results – Nutrients, Cations

A diversity of chemicals dissolved in the water and adsorbed on the sediment particles are transported by ditches downstream.

| | Element | Total load (kg) |
|---|---|---|
| Nutrients | Ortho-Phosphates | 1.43 |
| | Total P | 83.43 |
| | $NO_3^- + NO_2^-$ | 21.43 |
| Trace Metals | Al | 22.64 |
| | Mn | 1.48 |
| | Fe | 52.27 |
| | Ni | 6.39 |
| | Cu | 1.28 |
| | Pb | 0.25 |
| | Cr | 3.79 |
| | Zn | 2.90 |
| Cations | $Na^+$ | 11,100.58 |
| | $Mg^{2+}$ | 737.39 |
| | $K^+$ | 75.78 |
| | $Ca^{2+}$ | 3,205.36 |
| Anions | $As^{3-}$ | 0.16 |

**Dissolved Chemical Loads over 10 storms**

*De-icers*

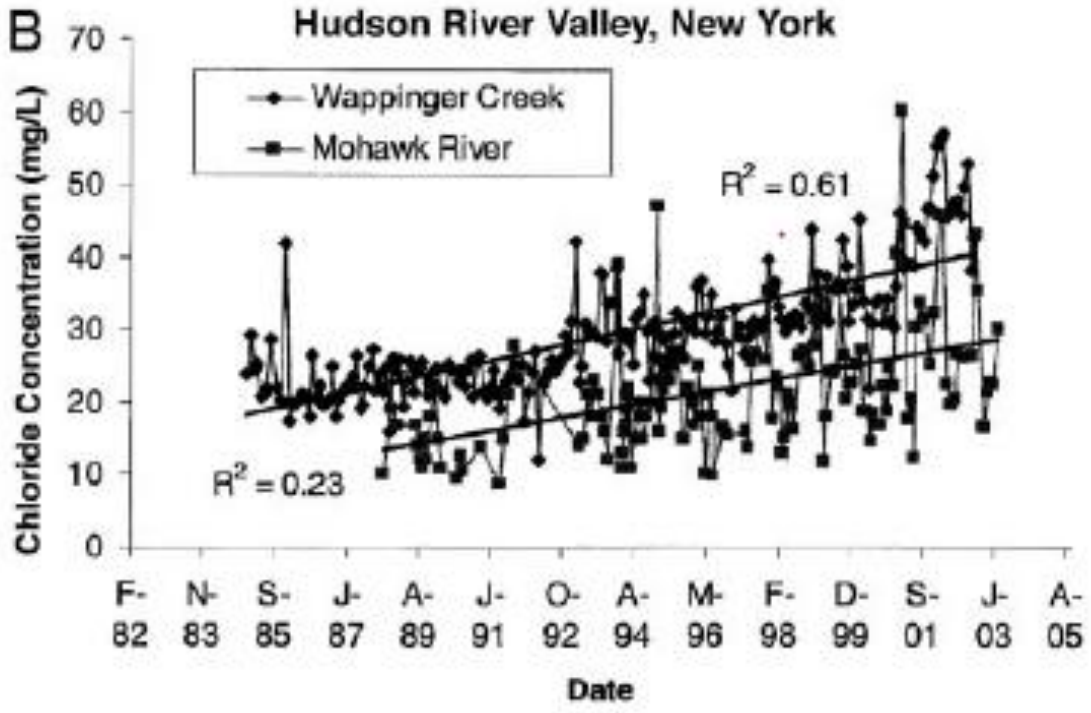
*Diaz-Robles 2007*

# Increased salinization of fresh water in the northeastern United States

Sujay S. Kaushal*†‡, Peter M. Groffman*, Gene E. Likens*‡, Kenneth T. Belt§, William P. Stack¶, Victoria R. Kelly*, Lawrence E. Band‖, and Gary T. Fisher**

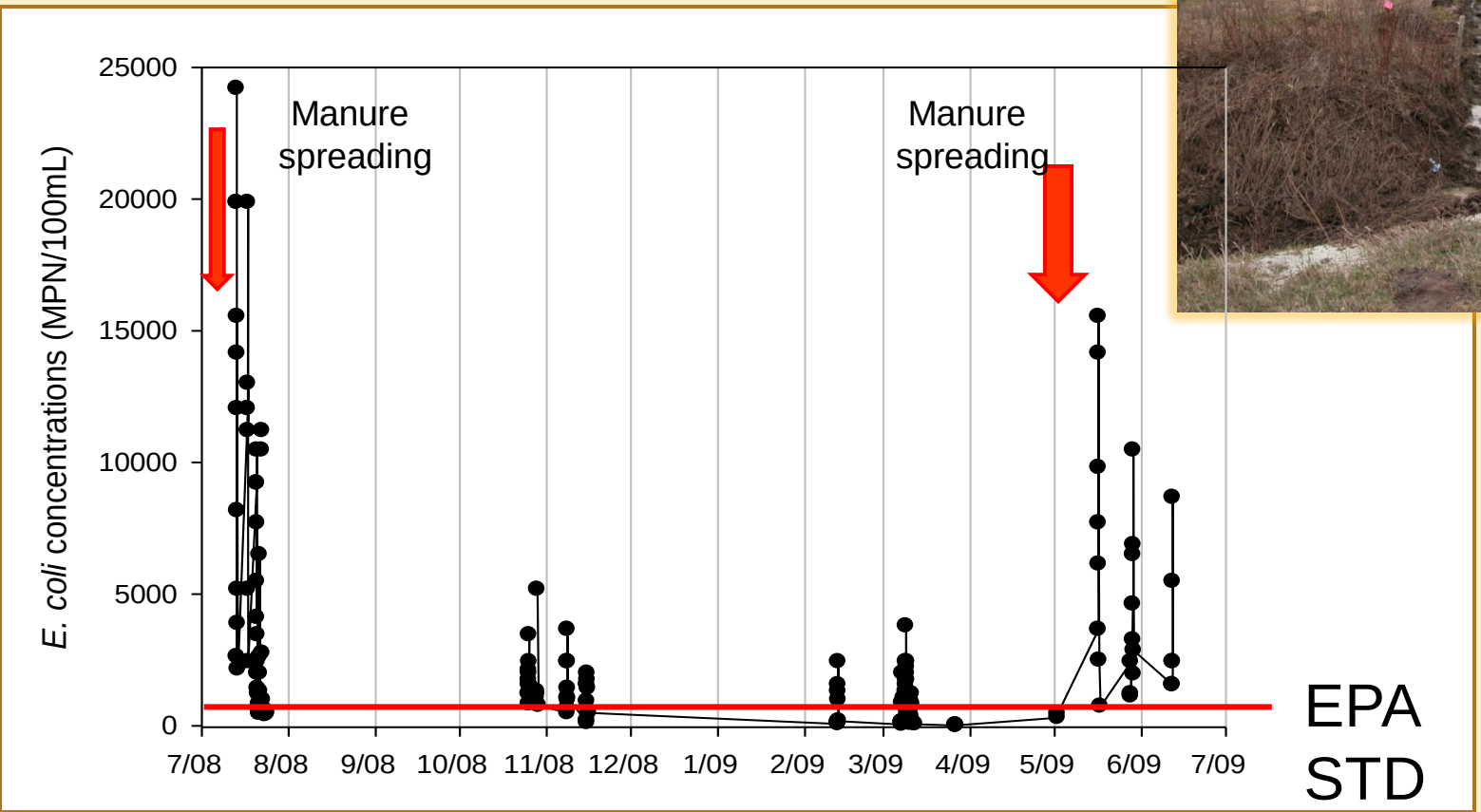
*Institute of Ecosystem Studies, Box AB Route 44A, Millbrook, NY 12545; §U.S. Department of Agriculture Forest Service, Northeastern Research Station, University of Maryland Baltimore County, Baltimore, MD 21227; ¶Baltimore Department of Public Works, 3001 Druid Park Drive, Baltimore, MD 21215; ‖Department of Geography, University of North Carolina, Chapel Hill, NC 27599; and **U.S. Geological Survey, 8987 Yellow Brick Road, Baltimore, MD 21237

Contributed by Gene E. Likens, August 4, 2005

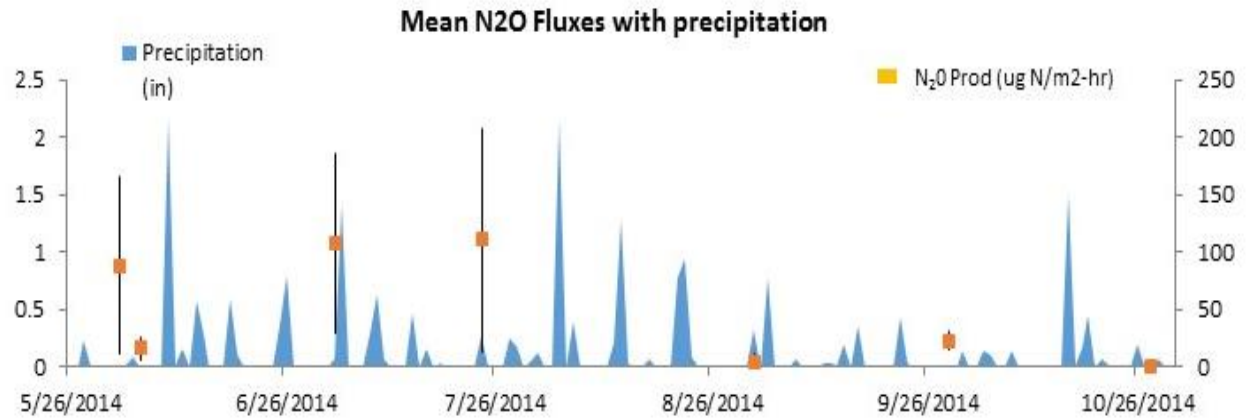



# Results - Microbes

**Manure spreading, livestock pasturing … microbes move via tile drains to roadside ditches**



# On-going Research: Conduits/ filters of Nitrogen?



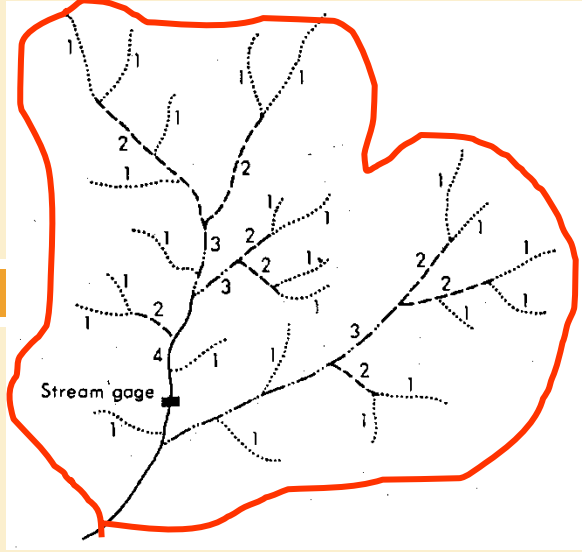

$NO_3$
~20 mg/l

$N_2O$
~50 ug/$m^2$-hr

Groundwater Exchange

$NO_3$
~17 mg/l

# In-stream Impacts




## Upstream / Downstream Movement via road culverts

*http://www.wellsreserve.org/blog/tags/culvert*

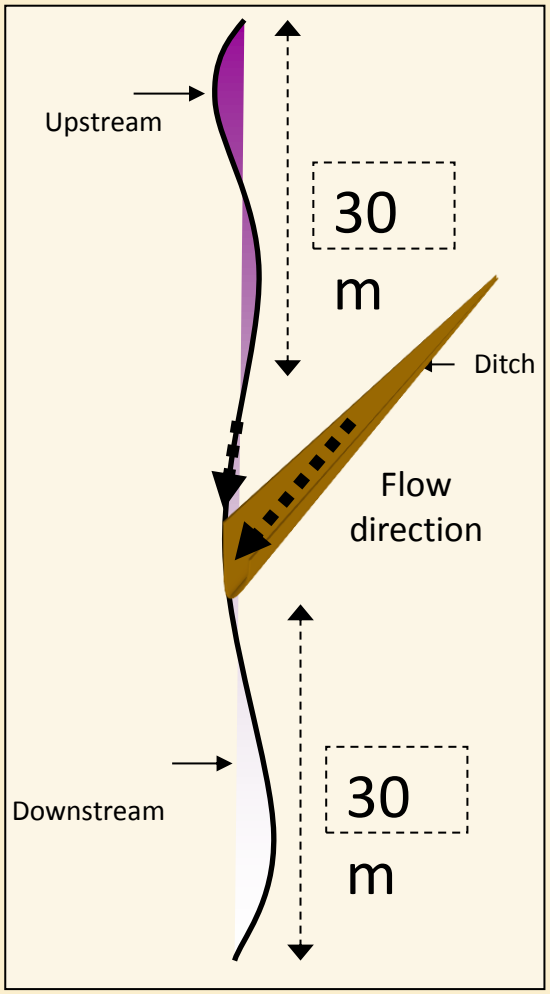
# Results – Bedload

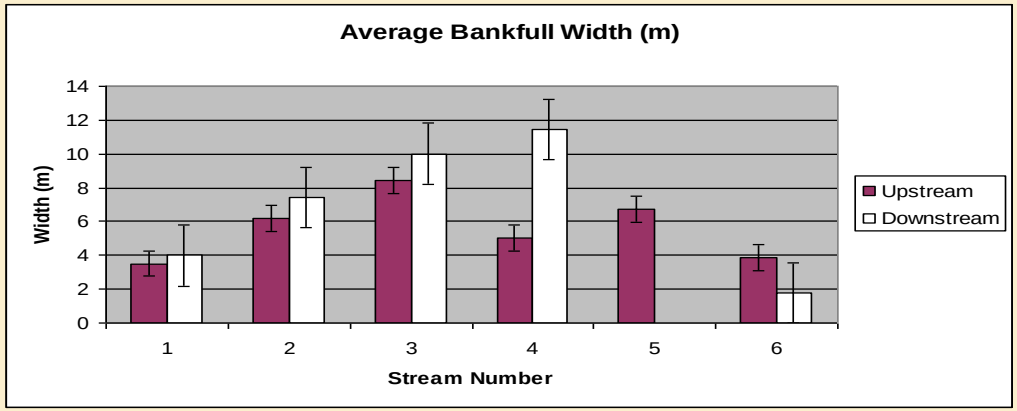

**Large quantities of gravel, rocks and other bedload move out of ditches and form deltas in the streams.**

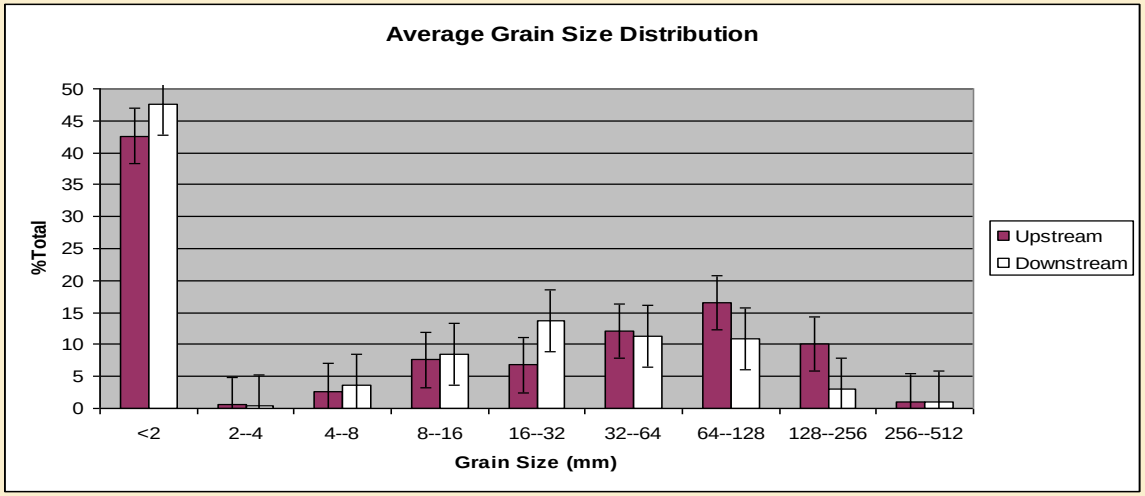
# Results – Bedload + Discharge Stream Geomorphology


**High velocity discharges, bedload deltas impact stream at ~94 locations in each watershed.**

# Results – Hydraulic Radius and Substrate



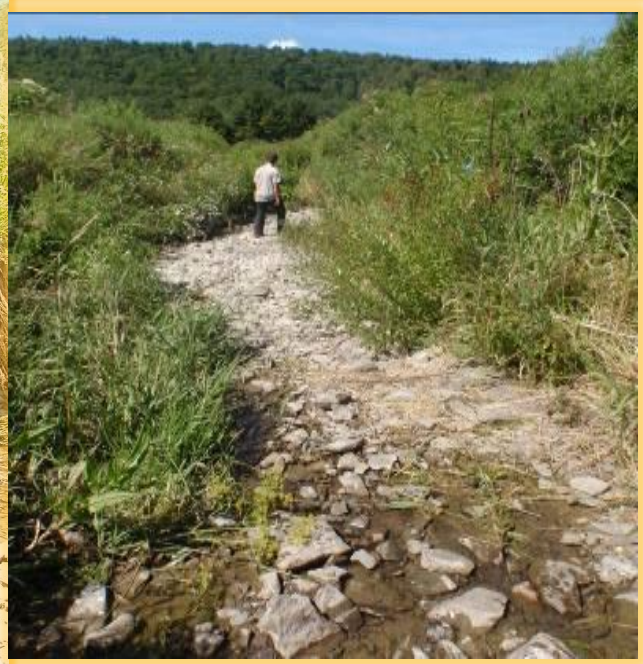




*Kimchi 2010*

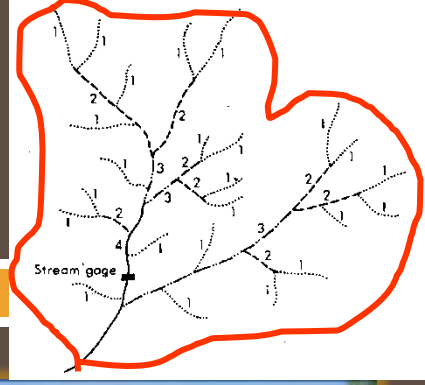
# Streams are in chronic disequilibrium with a storm-driven geomorphology

upstream

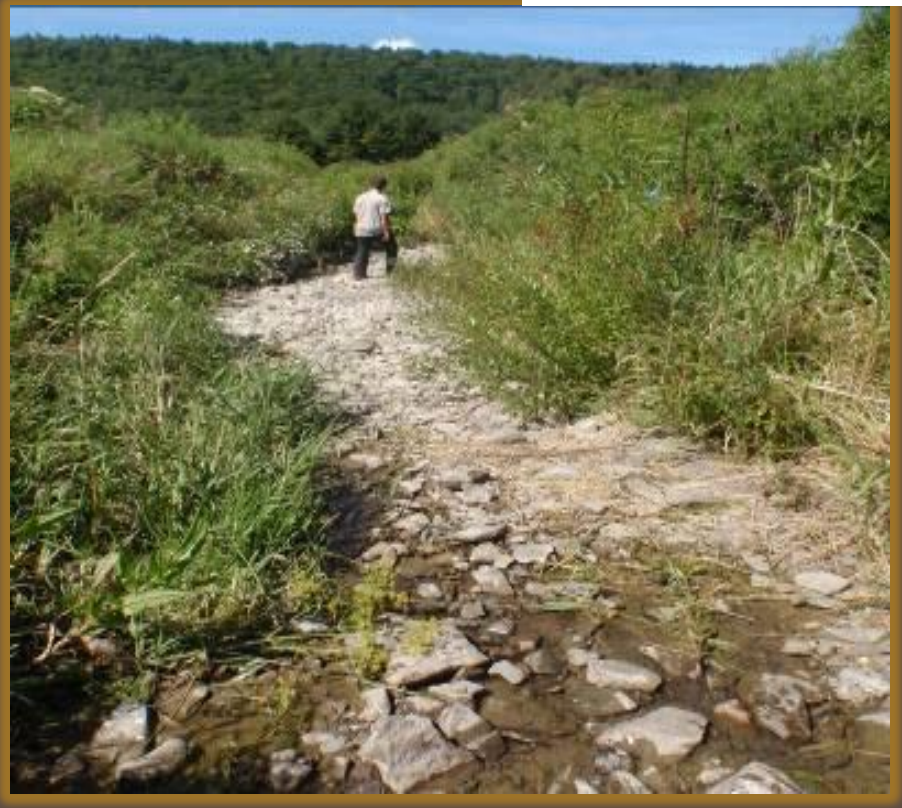
downstream



# Impacts on Stream Health

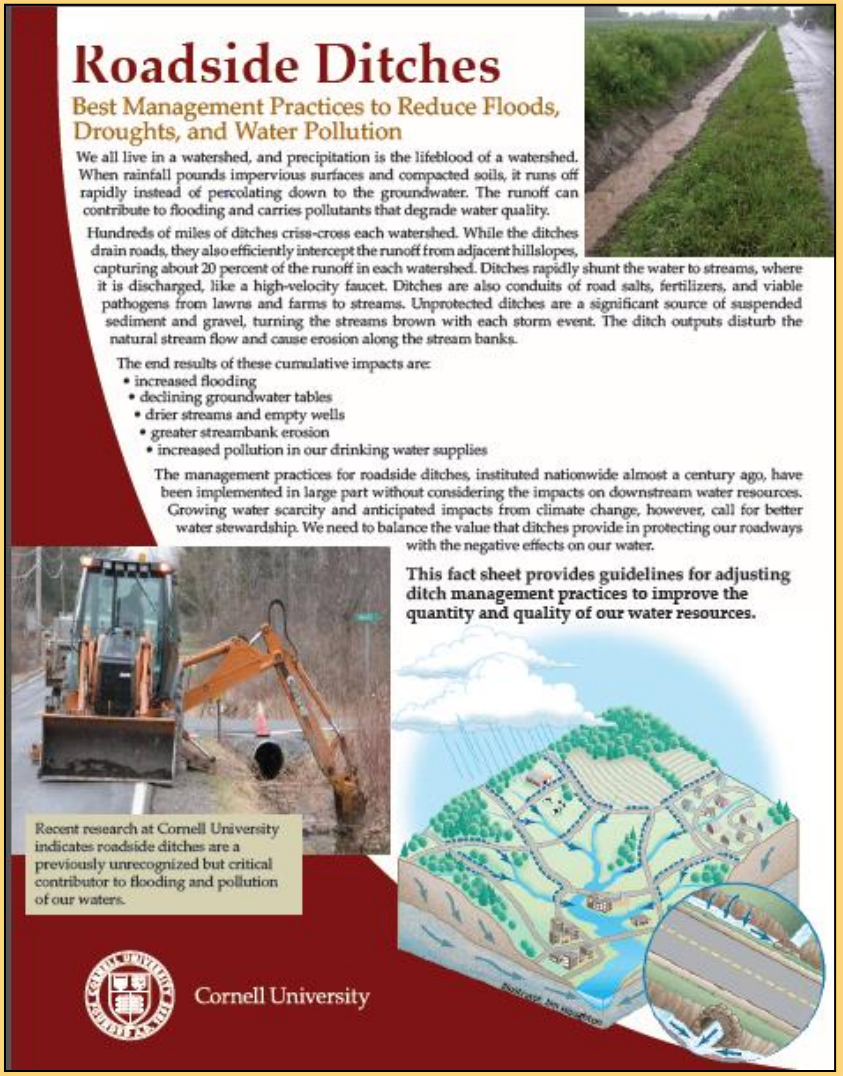



- Change hydrologic regime – higher floods
- Dry out headwaters
- Increase turbidity, pollution
- Alter geomorphology

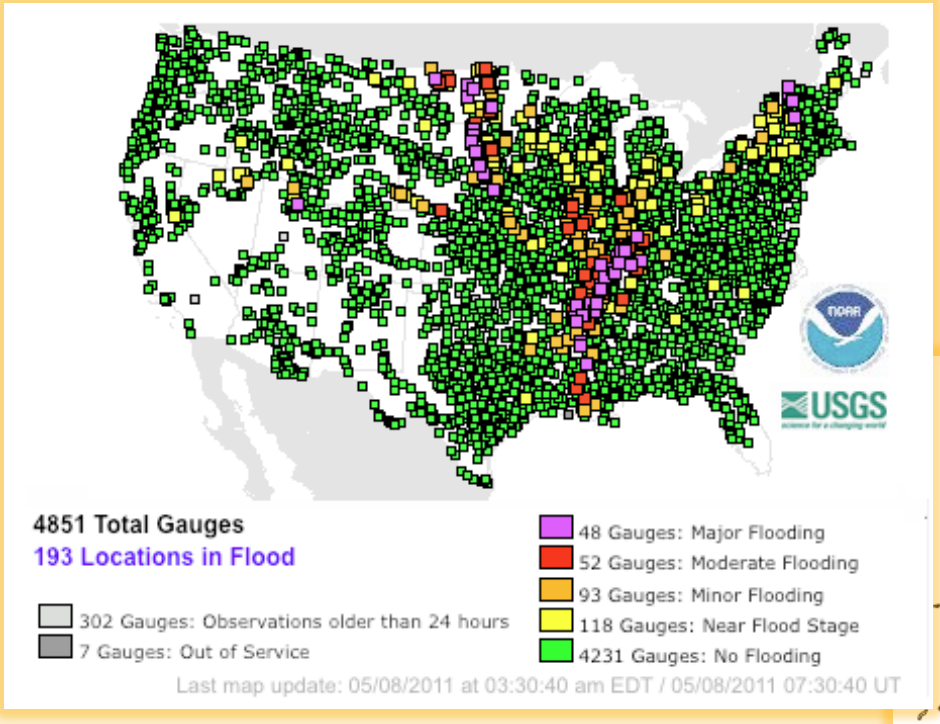


# Extension Program on Re-plumbing Ditches

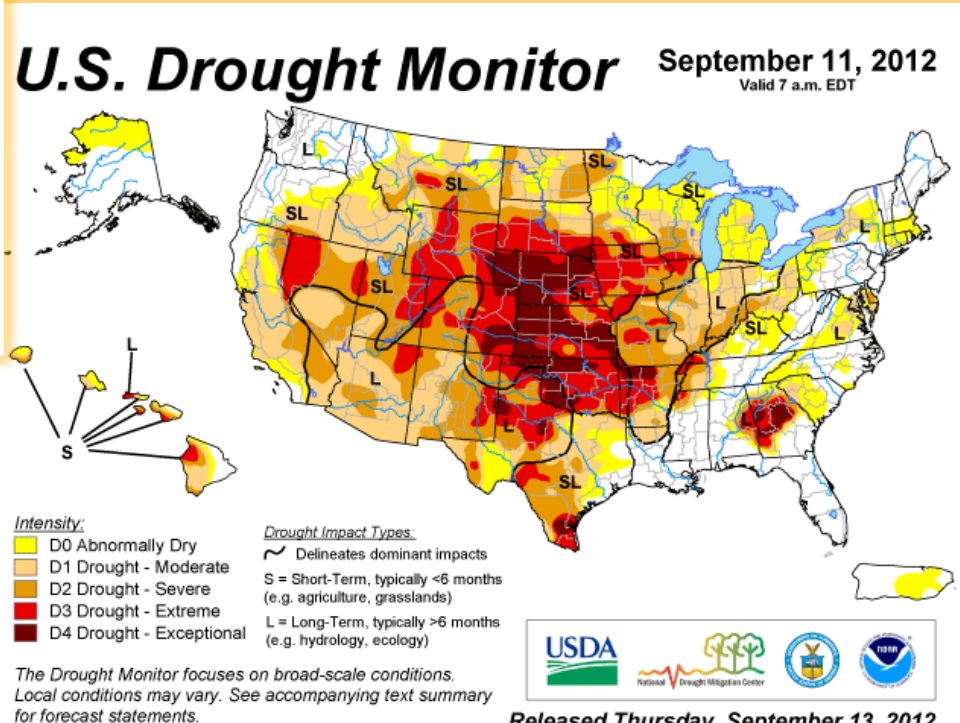
- *Presentations to ~2,500 town highway staff – Cornell Local Roads Highway School, Town govts*
- *Chesapeake Bay Watershed Conference and Report 2016*



# Roadside Ditch Management: Catch and save the rain to buffer the impacts of climate change




***2011 Flooding***
***Mississippi R.***



# Questions?

http://blogs.cornell.edu/sustainablewaterresourcemanagement/

# Status of NYS Ditch Management

- Avg number of miles of ditches maintained: 60 +/- 145
- 25-49% of HDs reported spending average of 43% of their time spent on ditch maintenance
- 60% HDs report scraping/ cleaning as most common method of ditch maintenance; 11% report mowing as most common method
- How often scraped? 42% of HDs reported 1x/ 2-4 years
- % scraped that are reseeded immediately?
  - 50% HDs reported 0% are reseeded immediately
  - ¼ of ditches reseeded immediately by only 21% of HDs