

# Monitoring and TMDL Modeling Techniques to Assess Bacterial Loading in Estuarine Environments and Improve Management Programs

## Cooperators and Participants

NCSU College of Design

NCSU CMAST

NCSU Water Quality Group

NC Division of Health, Shellfish Sanitation Program

Duke Marine Laboratory

NOAA/NOS Center for Coastal Environmental Health and Bimolecular Research

UNC-Institute of Marine Sciences

Carteret Craven Electric Cooperative

Jumping Run Creek Watershed Citizens

Croatan National Forest

Open Grounds Farm

USDA-CSREES

NC DENR Division of Water Quality, 319 Program

NC Clean Water Management Trust Fund

NC Wetland Restoration Program



# Project Objectives

1. Implement and <sup>call</sup> assess BST technology in <sup>10/4</sup> NC as part of watershed-based toolbox approach to reduce bacterial loading.
2. Review TMDL process using BST / Toolbox data.
3. Review / recommend management strategies.
4. Disseminate information to coastal local governments.
5. Incorporate information into coastal environmental management / policy curriculum.

← 2027  
← 2322  
← 1756  
← 2559  
← 946  
← 23130

5 4 3 2 1 2 6 \* 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

# Jumping Run

Total drainage area:  
~800 acres  
Mobile and RV  
Housing  
Low density single  
family residential  
Industrial  
No agriculture



Sources? **Dogs, cats, waterfowl, domestic wildlife, septic tanks.**

Transport vectors? **Ditches, surface runoff, surficial groundwater, airborne, direct deposit.**



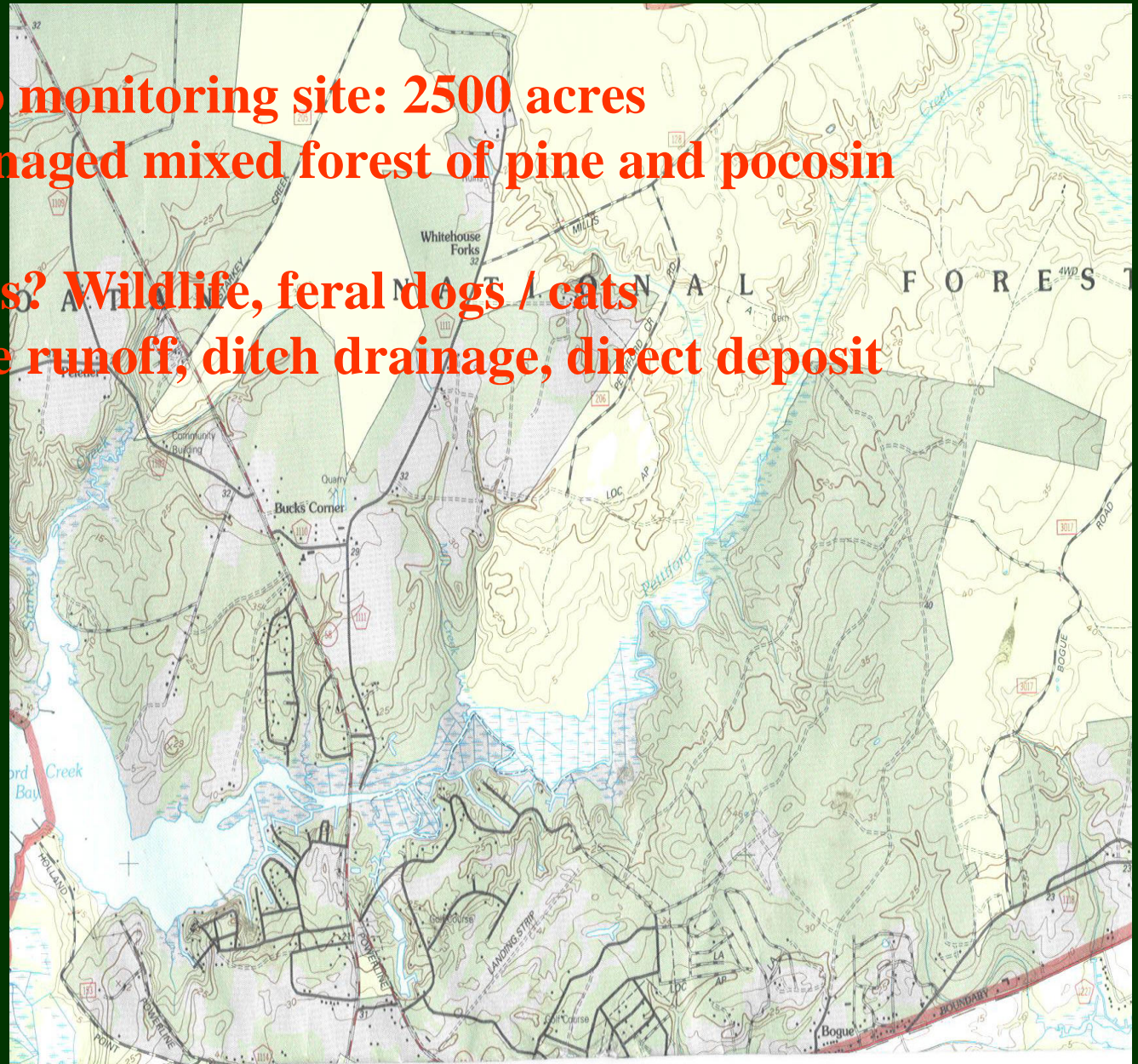
# Pettiford Creek-Croatan National Forest

Drainage area to monitoring site: 2500 acres

Land cover: Managed mixed forest of pine and pocosin

Bacterial Sources? Wildlife, feral dogs / cats

Vectors? Surface runoff, ditch drainage, direct deposit



# South River: Open Grounds Farm

Drainage Area to monitoring site: 3000 acres

Land cover: Cultivated row crop agriculture

Bacterial Sources? Wildlife, waterfowl and other birds, rodents, dogs  
Transport vectors? Surface runoff, ditch flow, direct deposit.



# Methods: Integration of watershed - based field assessment and laboratory techniques

## Watershed Assessment:

Land use / land cover surveys

Flow Monitoring

Time, travel, dilution studies

Rainfall / runoff measurements

Water sampling: Sound and base flow grabs,  
flow-weighted storm event for fecal and N, P, TSS

## Laboratory:

MPN quantification of fecal and water samples

e. coli speciation for fecal and water samples

Watershed-based fecal source library for MAR and DNA

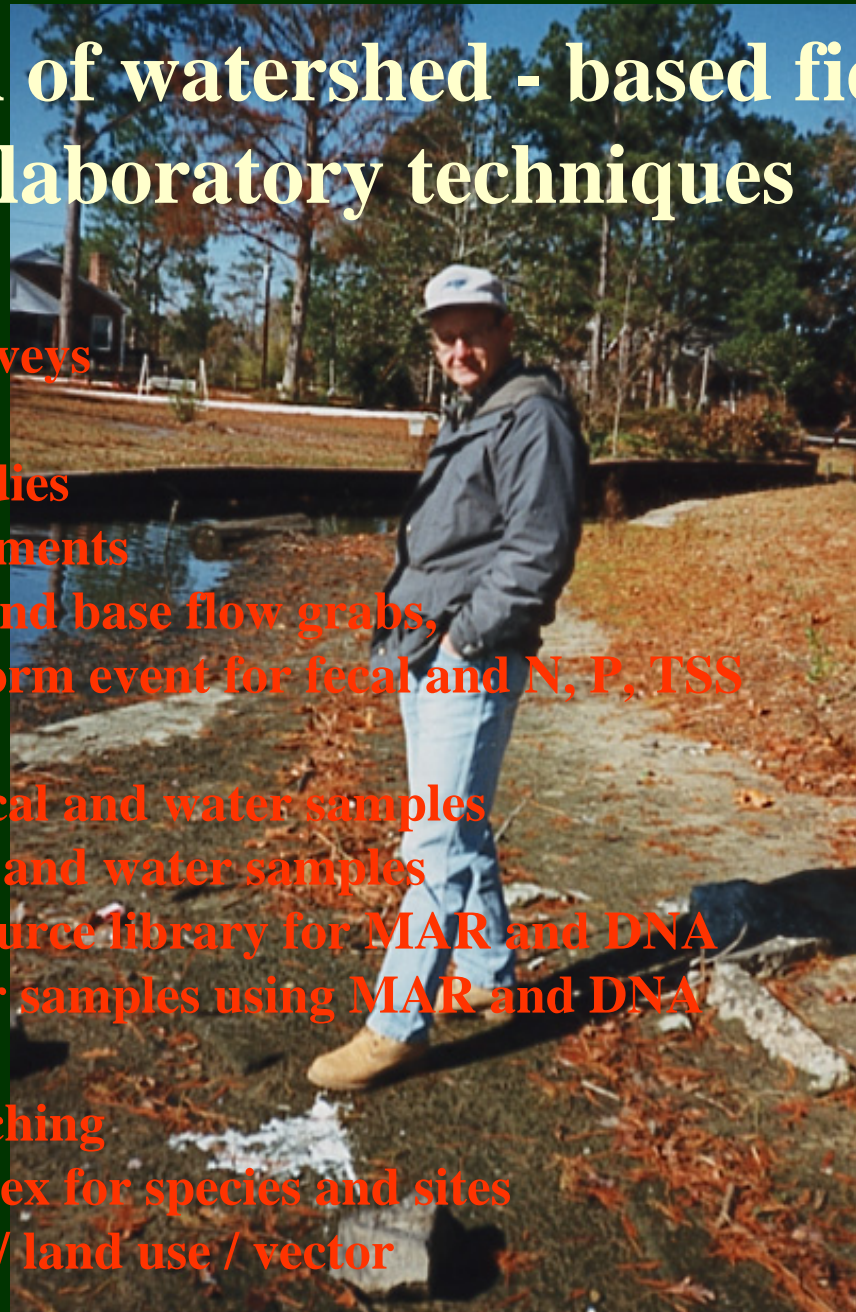
Characterization of water samples using MAR and DNA

## Analyses:

Spatial and seasonal matching

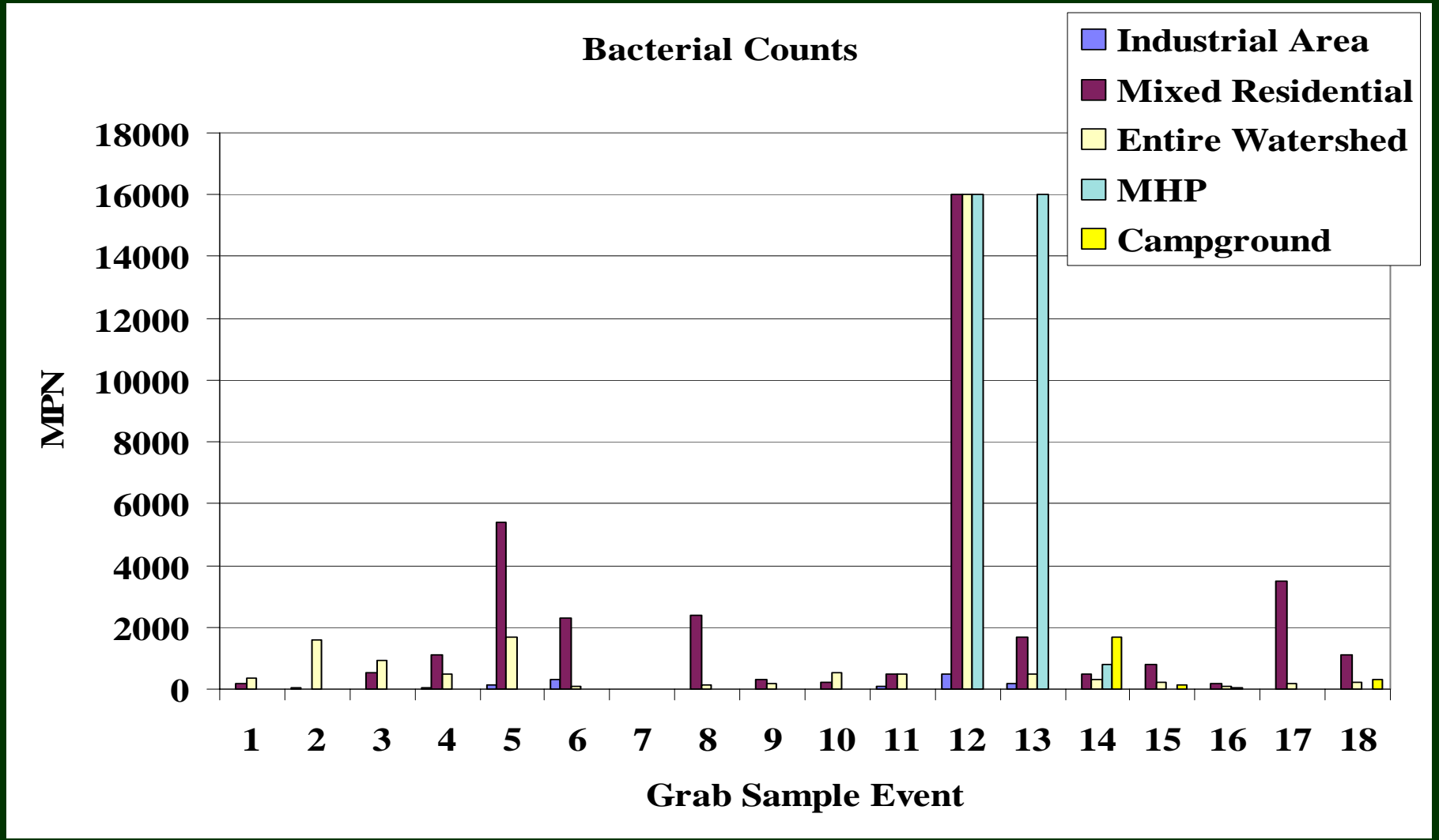
Resistance/ sensitivity index for species and sites

Loading analysis by type / land use / vector



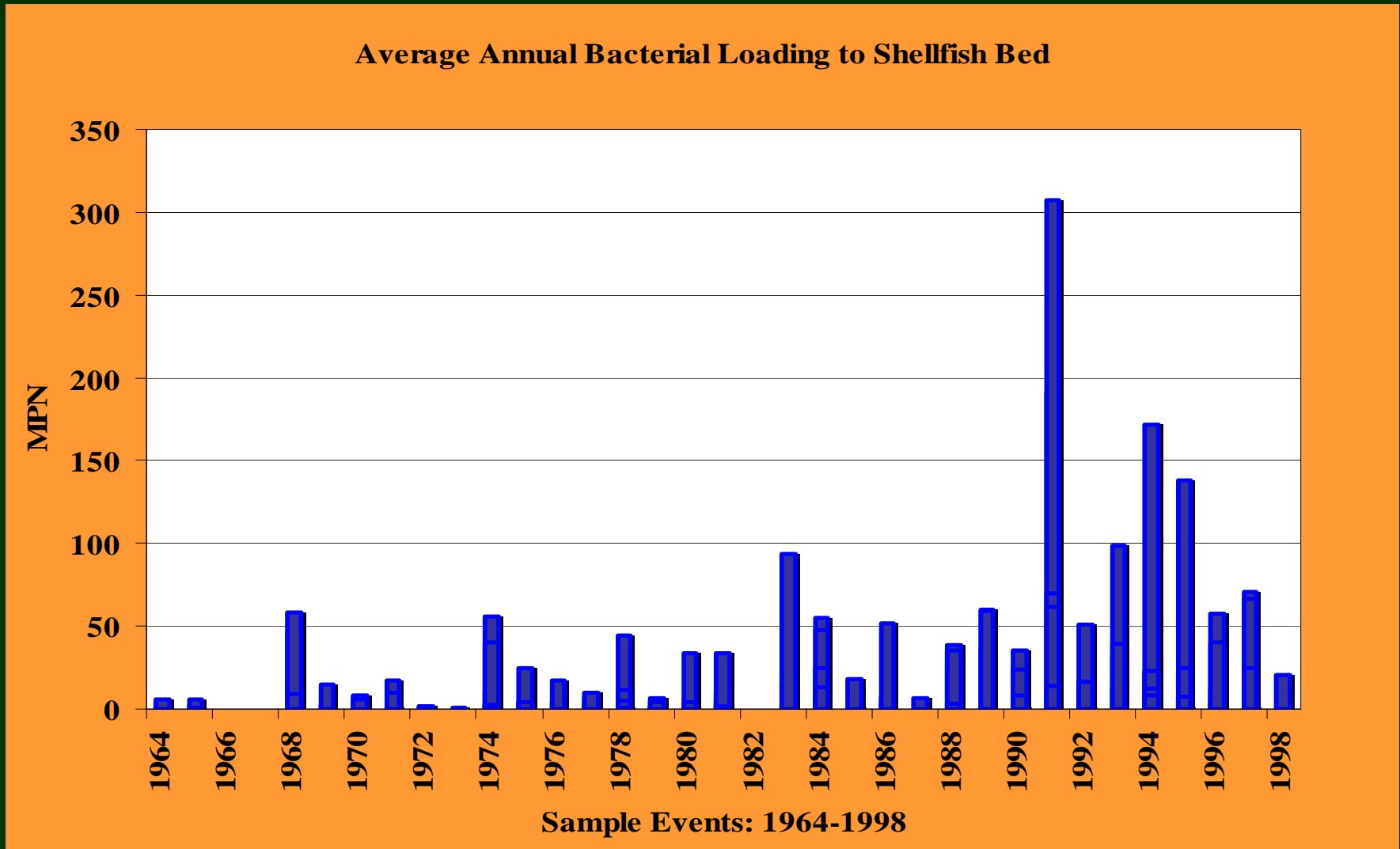
# Tailwater grab samples: Jumping Run

❖ Used to quantify bacterial densities and MAR/ DNA profile for the draw-down/ baseflow component of the hydrograph.



# Sound – based grab sample data: Jumping Run

❖ Will be used to quantify bacterial density and the MAR/ DNA profiles in the shellfish beds.





# Watershed Assessment: Jumping Run

❖ Used to spatially assess bacterial sources, transport vectors, and to ground truth land use / land cover

Location	Visits	SV	Dogs
MHP	47	0	23
Med. Density	66	2	60
Low Density	14	0	7
Campground	1	0	0
Totals	128	2	90

\*Does not include Roads

Location	Cats	Other	Imperviousness
MHP	6	3	40,000sft
Med. Density	47	25	185,000
Low Density	0	0	95,000sft
Campground	0	0	5,000sft
Totals	53	28	325,000sft or 7.5 acres



# Results: Dye/ Time and Travel Studies Jumping Run



❖ Information is using to determine ditch drainage patterns, water movement direction and timing, as well as dilution and dispersion

Date	Guage Ht	CFS	Time Travel
21-Jan-98	1.38'	8.4	n/a
22-Jan-98	1.18'	5.8	MHP-Outlet, 5hrs
04-Feb-98	3'	18.2	MHP-Gauge, 2.5hrs
23-Feb-98	1.7'	10.9	n/a
03-Mar-98	1.13'	3.21	Headwaters-Gauge, 3hrs.
04-Mar-98	1.10'	2.73	CmpGrnd to Outlet, 1.5hrs.
03-Apr	0.95	5.96	n/a
04/17/1998	0.9	10.4	n/a
04/30/1998	0.84	5.1	n/a
06/18/1998	0.76	4.6	n/a
07/14/1998	0.72	4.5	n/a



## Land Cover Change Assessment: Jumping Run

- ❖ Develop land use loading rates for TMDL assessment.
- ❖ Information is used to help direct and design restoration and management strategies for testing.

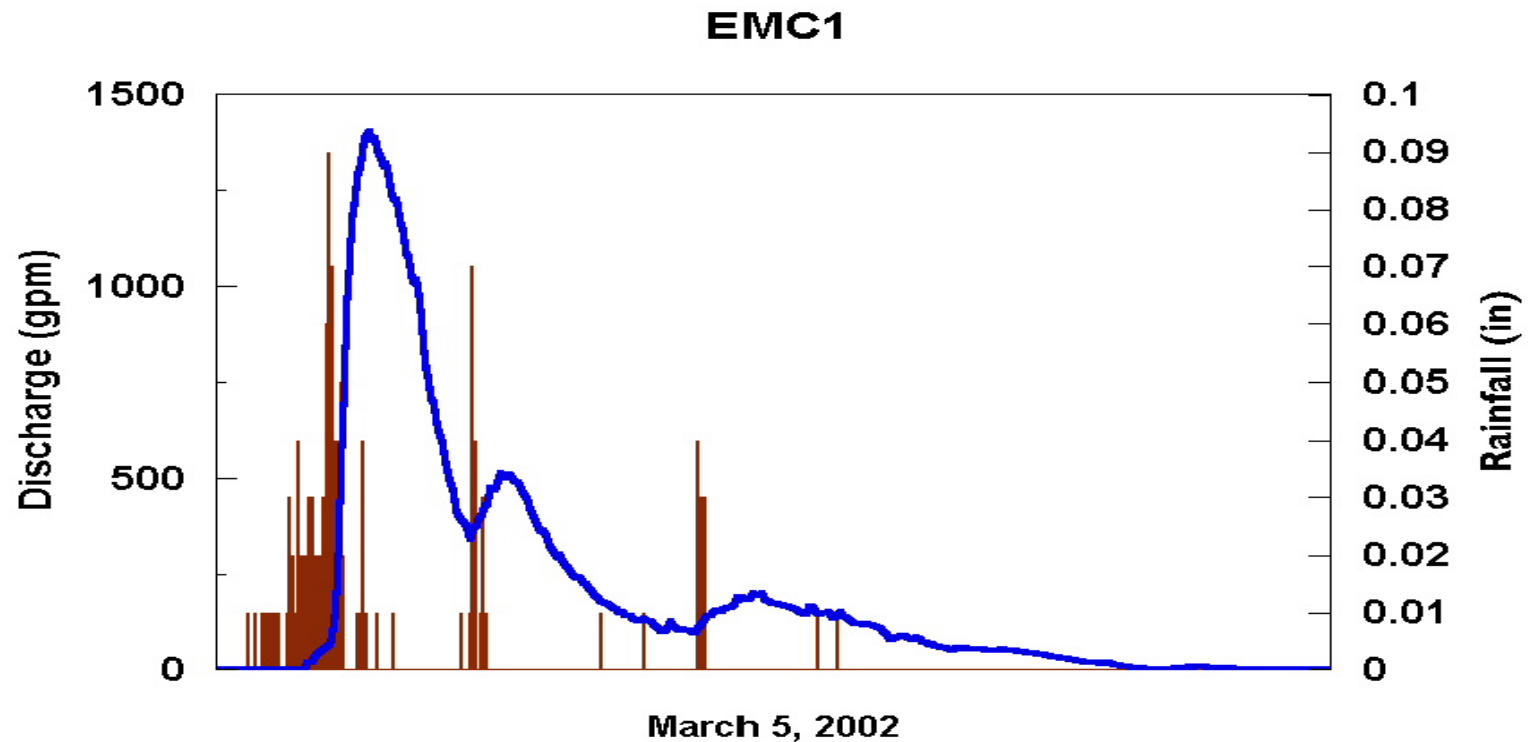




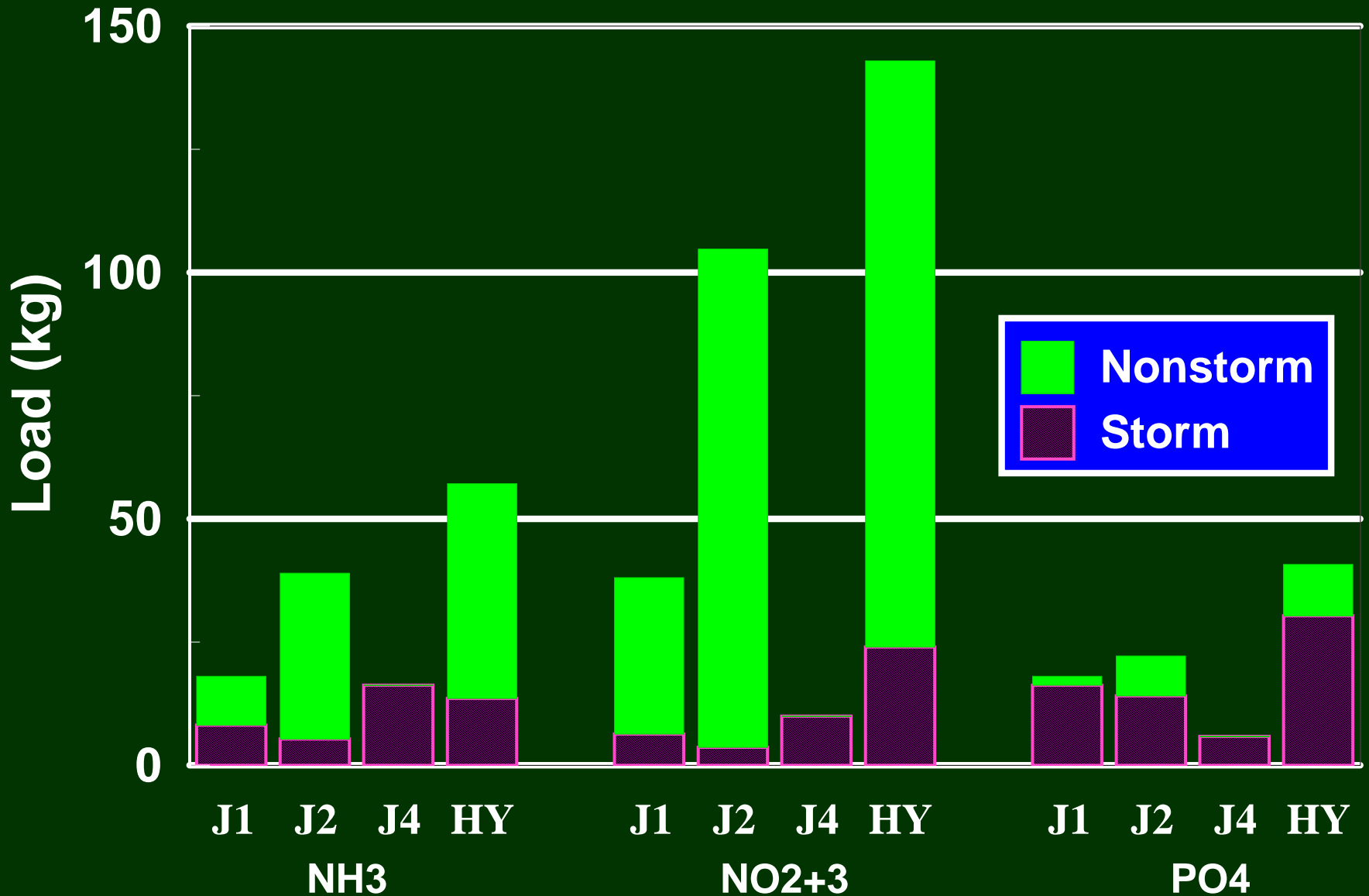
# Storm Event Monitoring



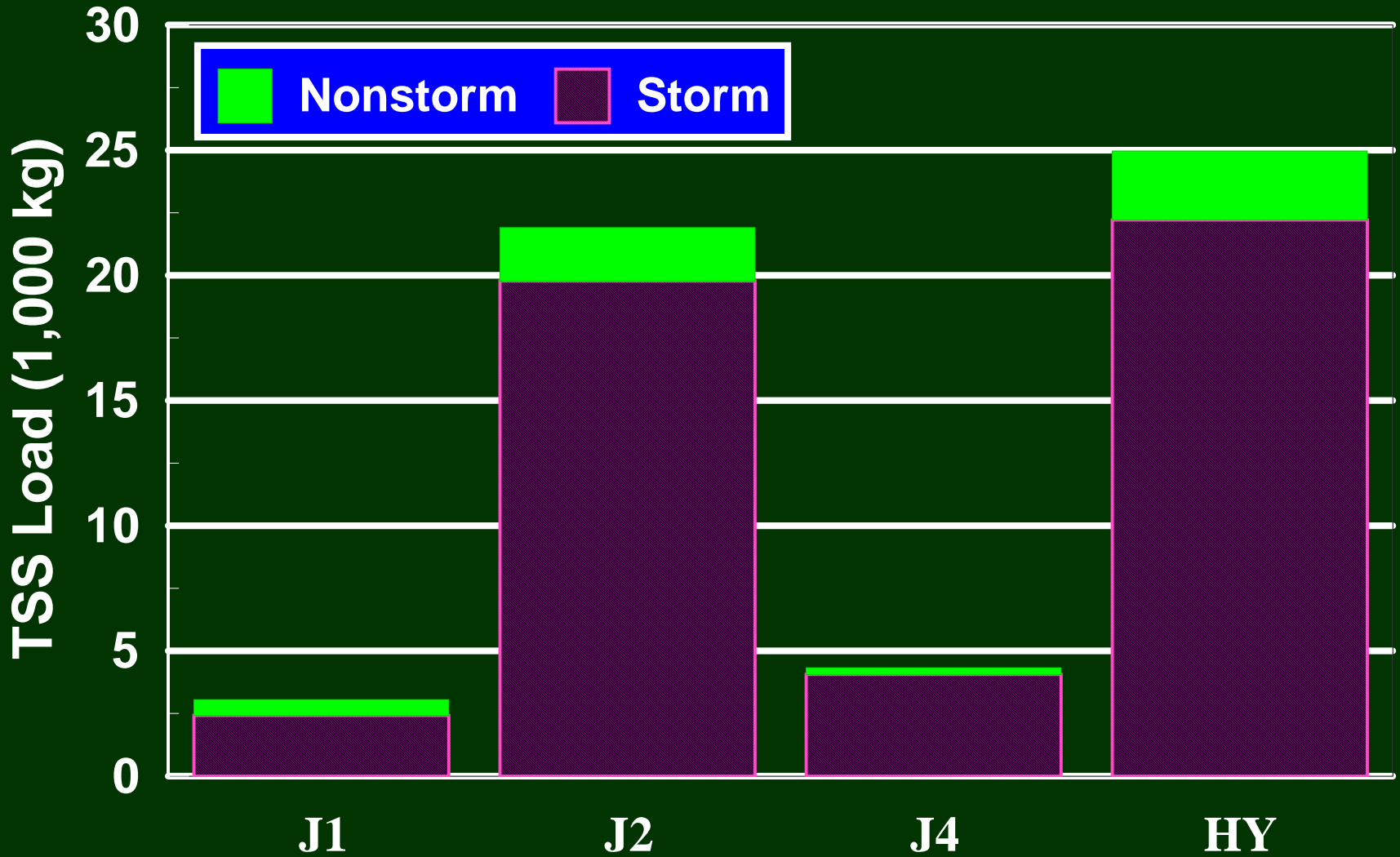
# Hydrographic Analysis: Developing rainfall / runoff relationships, flow volumes, loading calculations.



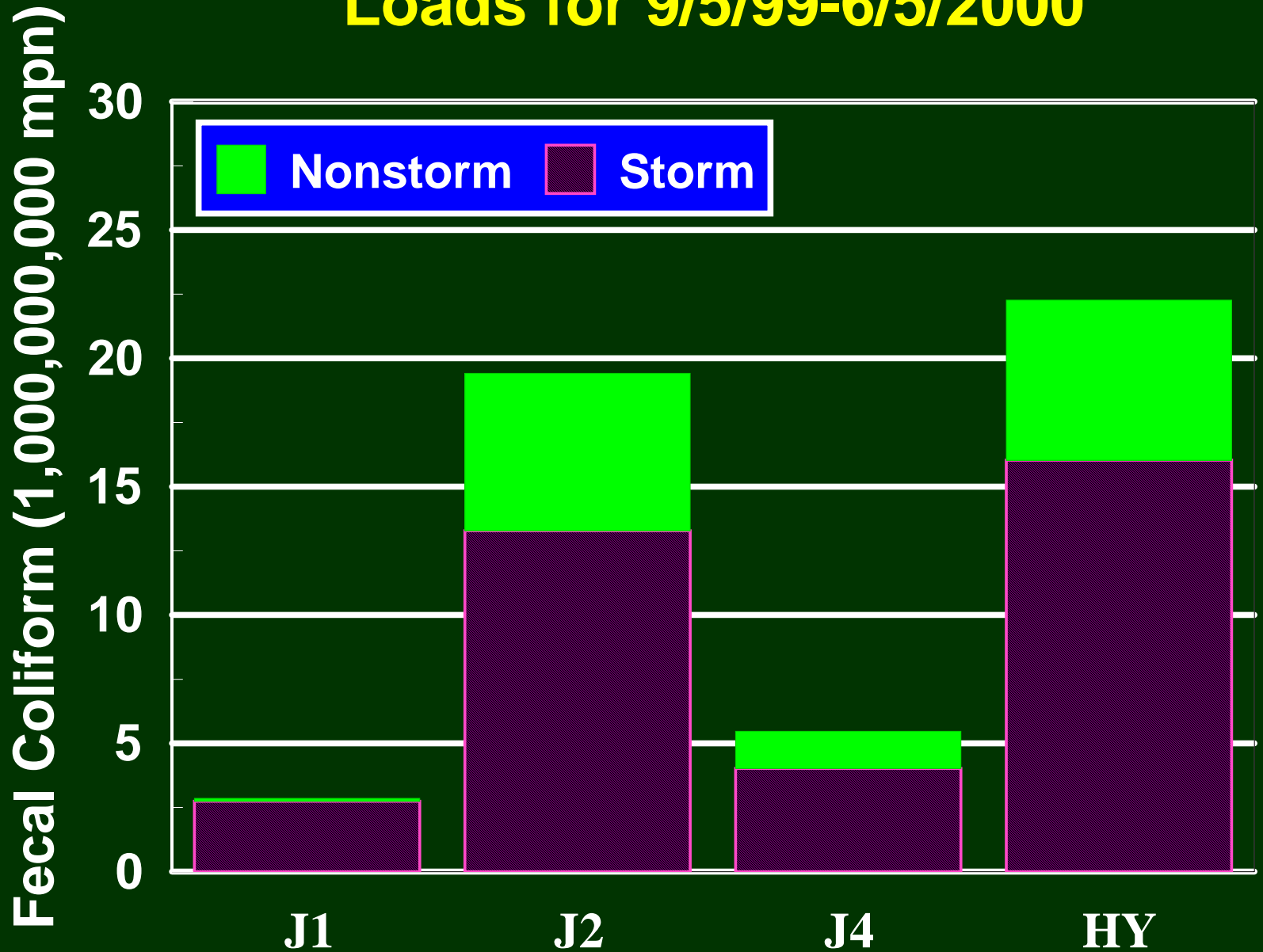
# Loads from 9/5/99-6/5/00



# Loads from 9/5/99-6/5/00



# Loads for 9/5/99-6/5/2000





## MAR and DNA Data

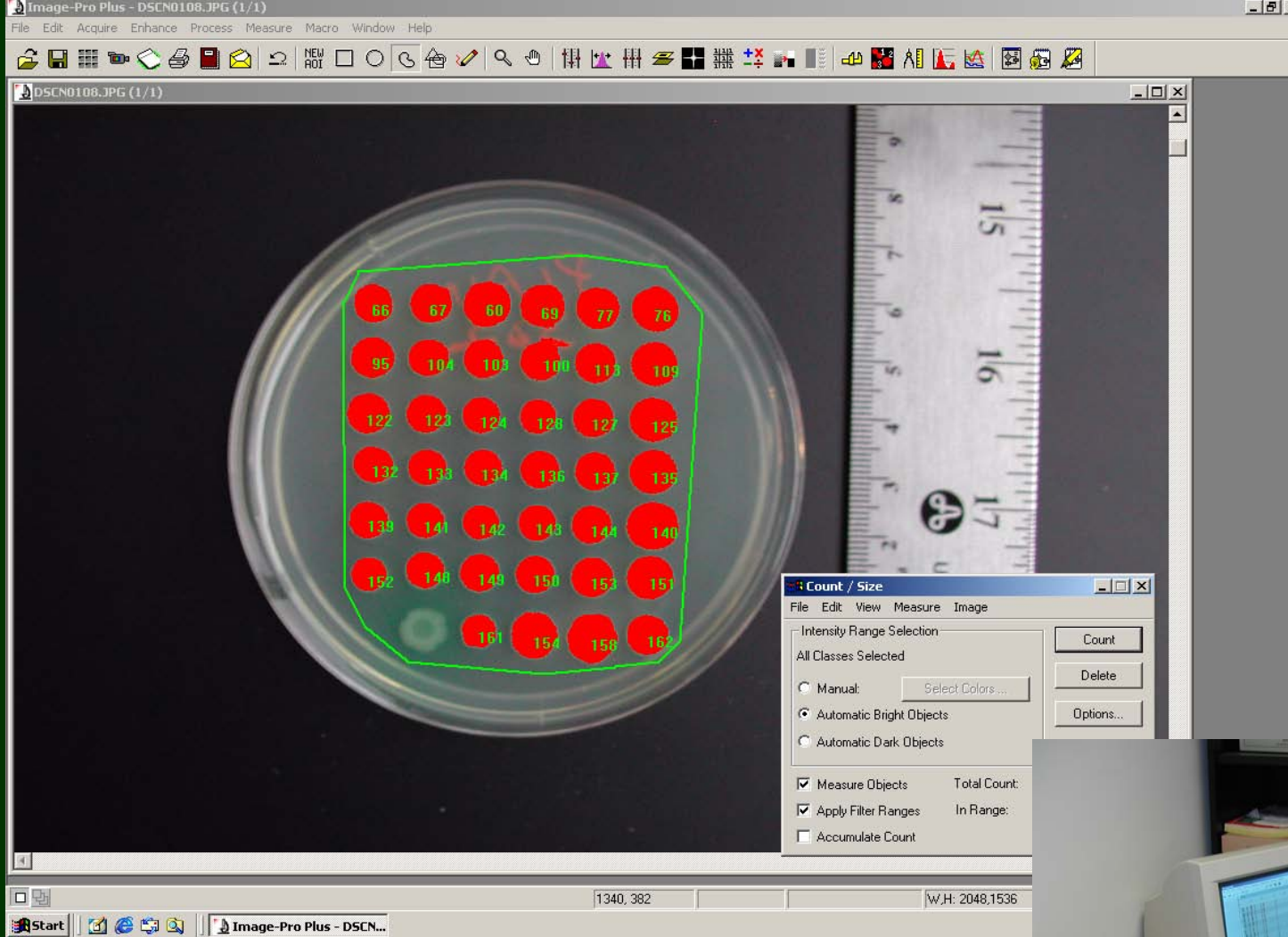
MPN is calculated for both water / fecal library samples to link densities with water volume and flow.



## Mar and DNA Data

Ten *e. coli* isolates are developed for each sample and tested for multiple antibiotic resistance.





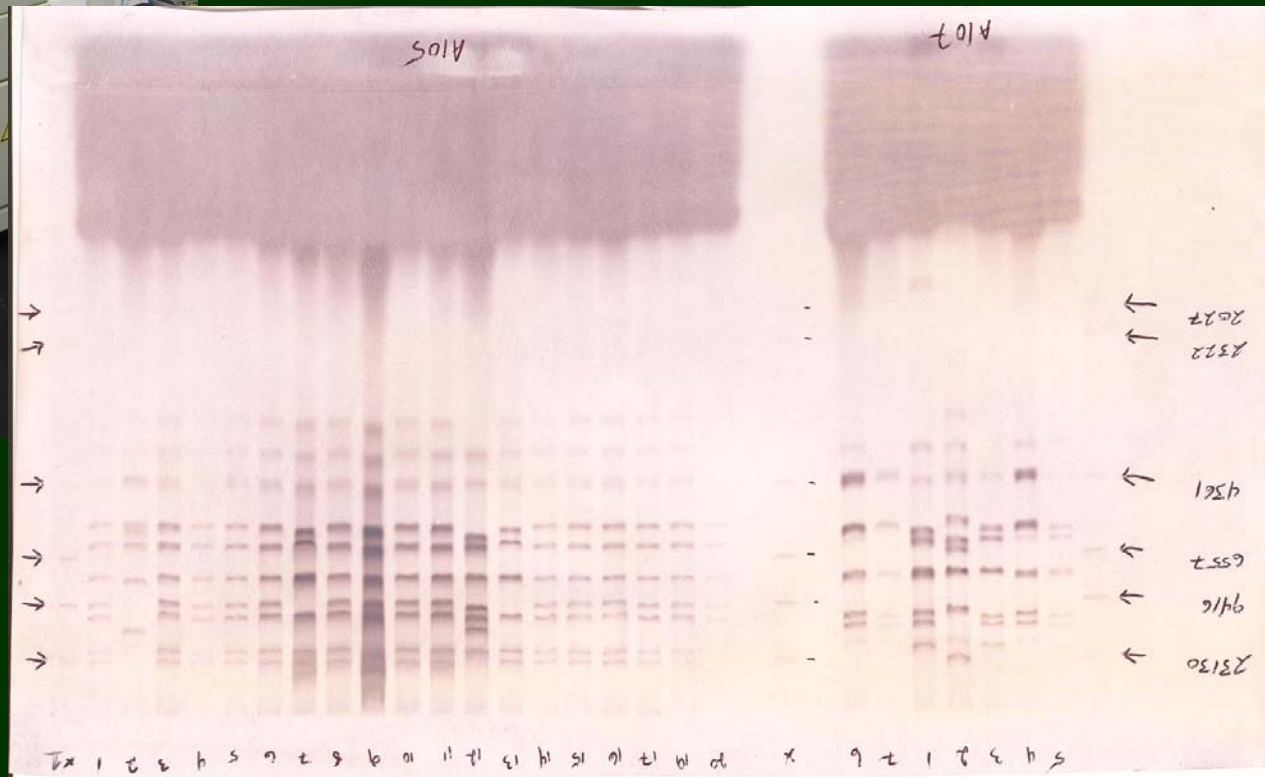
**Plates are digitally photographed and cell growth measured relative to two controls using image analysis techniques.**





DNA analysis is conducted on all library and resistant water samples and 50% of the sensitive water samples.

Tracks of DNA material are delineated and banding patterns numbered to create a profile for each sample.



## **Preliminary MAR Results**

**Jumping Run: 27 Water samples, Avg MPN: 3000 / 100ml, 178 isolates**

**Sensitivity index: 48 or 26 % were 10% resistant**

**4 or 2% were 20% resistant**

**7 or 0.7% were greater than 30% resistant**

**Croatan: 8 water samples, Avg MPN: 326 / 100ml, Number of isolates: 50**

**Sensitivity index: 8 or 16% were 10% resistant**

**1 or 2% were 20% resistant**

**None greater than 20%**

**Open Grounds: 6 water samples, Avg MPN 4300/ 100ml, 64 isolates**

**Sensitivity index: 17 or 26% were 10% resistant**

**1 or 1% were 20% resistant**

**1 or 1% were 40% resistant**

## Preliminary Library Summary: 26 samples, 246 isolates

**Sensitivity index:**

- 42 or 17% were 10% resistant**
- 16 or 6% were 20% resistant**
- 8 or 3% were 30% resistant**
- 2 or 0.8% were 40% resistant**
- 2 or 0.8% were 50% resistant**
- 2 or 0.8% were 60% resistant**
- 5 or 2% were 70% resistant**

### **Resistant Species:**

- Woodpecker**
- Septic Samples**
- Dog**
- Horse**
- Deer**
- Duck**
- Opossum**

### **Sensitive Species:**

- Squirrel**
- Raccoon**
- Cat**
- Bear**
- Hawk**

**In progress. . .**

**Developing the DNA database.**

**Characterizing the MAR and DNA profiles.**

**Conducting the matching analyses.**

**Developing the loading calculations for South River and Croatan**

**Assessment of the land use TMDL contributions.**

**Assessment of management options.**

**Curriculum development.**

**Educational and outreach delivery.**



## Lessons Learned . . .

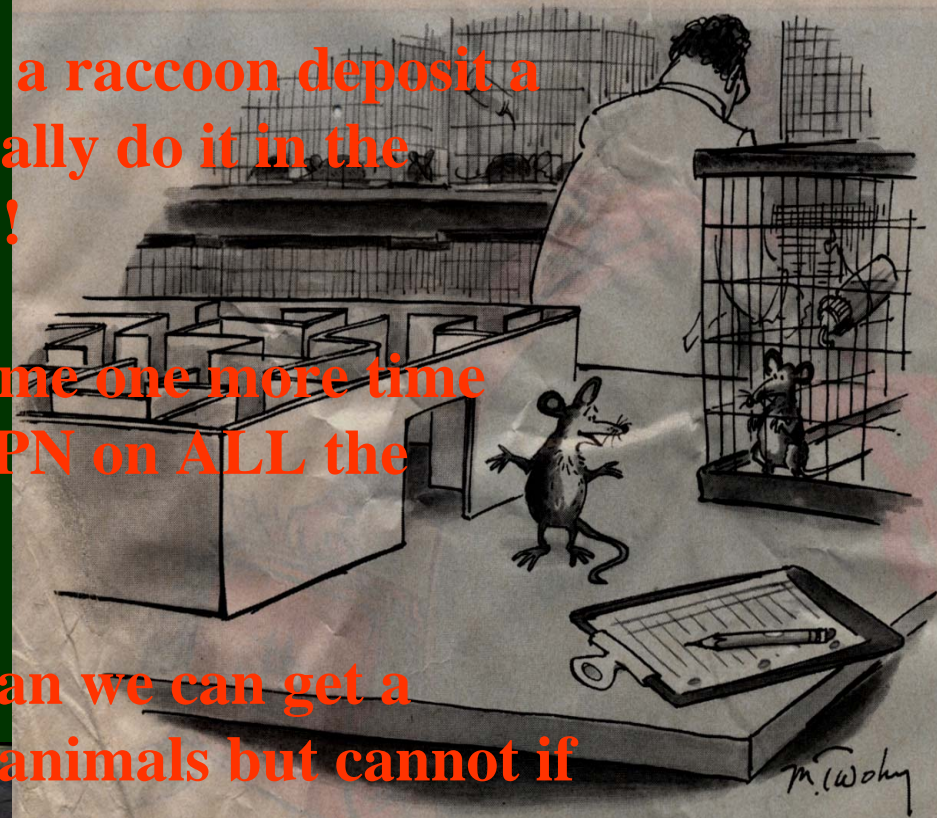
Collecting library samples—will a raccoon deposit a sample in a box? Does a bear really do it in the woods and why can't I find it!!!!

Linking disciplines-explain it to me one more time why you want me to measure MPN on ALL the samples . . . .

Paperwork and admin—you mean we can get a trapping permit if we KILL the animals but cannot if we leave them alive???? What do you mean there's no place to install the autoclave???

How many bureaucrats and how long does it take them to review a federal MOA???

On-going. . . .



*"I don't usually volunteer for experiments, but I'm kind of a puzzle freak."*

