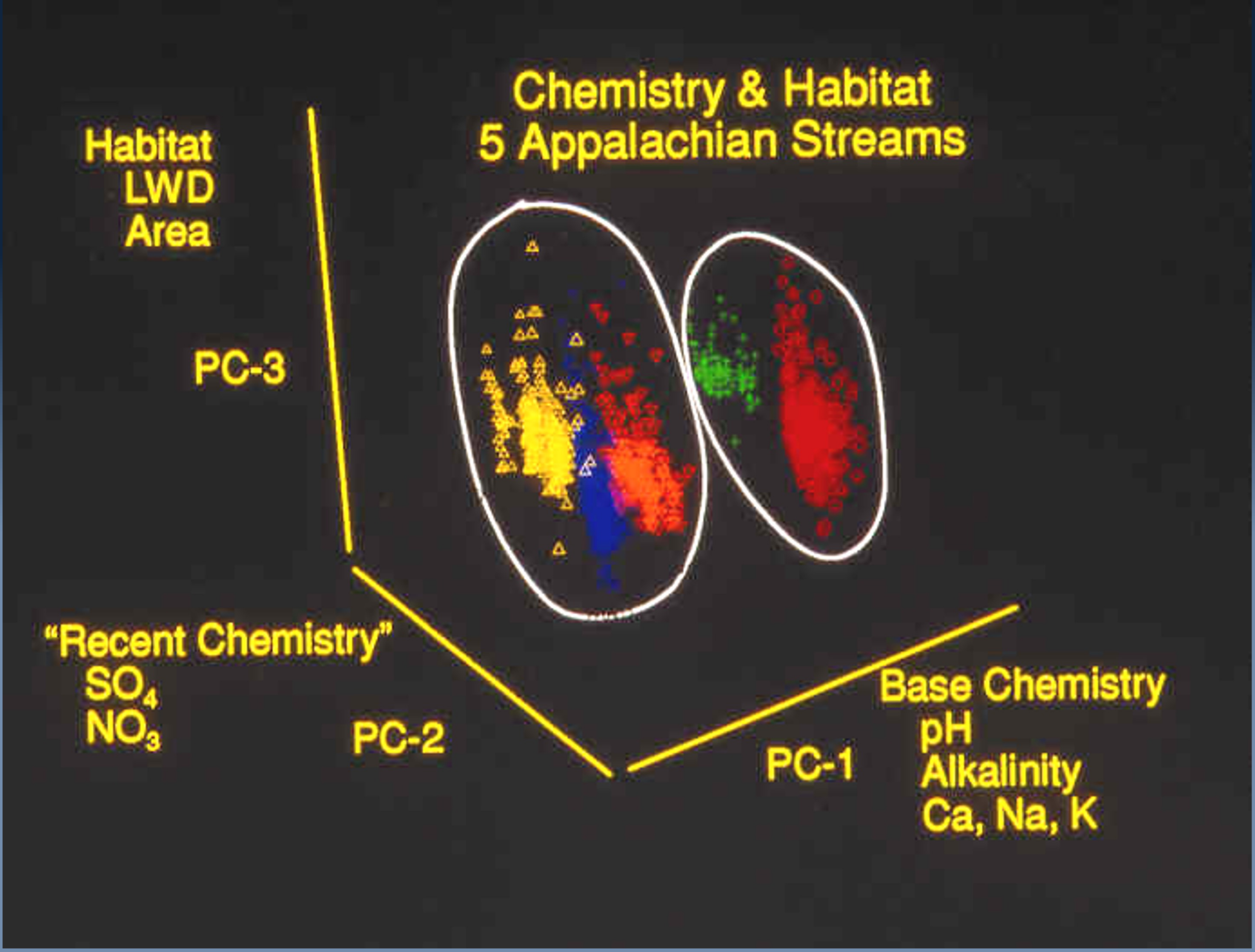
Stream Restoration with Large Wood
-Monitoring-

Klawock & Craig, Prince of Wales Island
September 2023

- Andy Dolloff, Fish Head
- USDA Forest Service
- Southern Research Station, retired

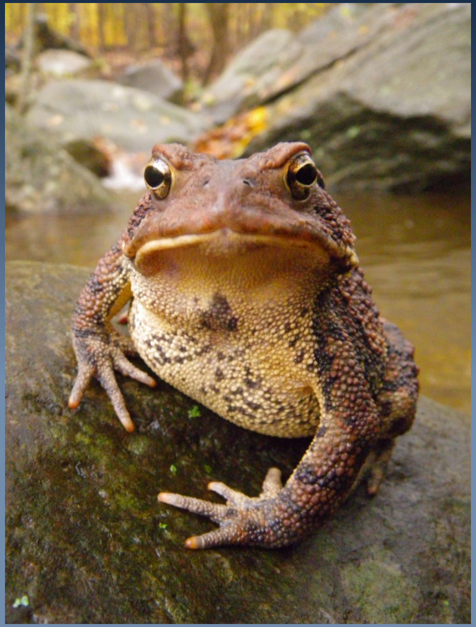
First step in restoration is triage, establish purpose, watershed context

- Water quality is the Conditio sine qua non
  - Temperature
  - Conductivity
  - pH (Alkalinity)
  - “Appropriate” concentrations of base cations and anions dissolved oxygen
  - Absence of Toxic substances


Chemistry & Habitat
5 Appalachian Streams
Habitat
LWD
Area
PC-3
"Recent Chemistry"
SO4
NO3
PC-2
PC-1
Base Chemistry
pH
Alkalinity
Ca, Na, K

Watershed Management of any kind must account for Risk:

"If you don't want it in the water, keep it out of the watershed"



Monitoring helps address risk

Monitoring
spend time formulating the right questions

Goals

- Document progress
- Communicate to stakeholders
- Inform and prioritize future actions

Monitoring*

The four monitoring levels:

(1) "implementation" monitoring,

(2) "effectiveness" monitoring,

(3) "validation" monitoring,

(4) "trend" monitoring.

In general, approaches move from **qualitative and simple** to **complex** as the level changes from **implementation to validation**. **Implementation** and **effectiveness** monitoring can be viewed as short-term whereas **validation** and **trend** are typically comprehensive and longer-term.

*excerpted directly from: Solomon, R. 1989. Implementing non-point source control: Should BMPs equal standards? Pages 155-162 *in:* Hook, D. D.; Lea, R., eds. 1989. Proceedings of the symposium: The forested wetlands of the Southern United States; 1988 July 12-14; Orlando, FL. Gen. Tech. Rep. SE-50. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 168 pp.

<u>Implementation Monitoring</u>

- Implementation is the most common form of monitoring. It is (should be!) accomplished to document whether project plans and prescribed practices were implemented as designed. The basic question is: <u>*"Did we do what we said we were going to do?"*</u>

- Although documentation need not be extensive, it should be available to decision makers and regulators.

- Implementation monitoring provides the basic information necessary for fine tuning of current and future project plans and practices.

Effectiveness Monitoring

- Determine if the plans, practices, measures, etc., were effective in meeting management objectives, particularly where the efficacy of practices and techniques are new, unknown, or highly variable. After the basic question: "Did we do what we said we were going to do?" we ask: *"Did it work?"*

- May be quantitative or qualitative. Specific measurements must be related to habitat, water quality, or biotic objectives and appropriate to and calibrated for local spatial and temporal scales.

- Coordinated with adjacent landowners and appropriate Agencies; can be used to adjust prescription standards and guidelines, BMPs, and management objectives.

Validation Monitoring

- Determine if our prescriptions or S&Gs protect beneficial uses and/or if model relationships are valid. Validation monitoring is used to determine: (1) whether the criteria limits are sufficient to protect beneficial uses, or (2) if a criterion is an appropriate surrogate to protect the beneficial use. Think of the basic question as*: "So what?" ….or who should care and why…*

- **Validation monitoring is data intensive and requires long-term commitments** Validation monitoring results may be used to adjust model coefficients, water quality standards, minimum requirements, goals, policy, and laws and regulations. Example: Shepard et. al. (1998) "monitored" Bull Trout embryo survival and fry emergence, finding negative correlation between fine sediments (<6.4mm) and survival.

- **Validation monitoring should be closely coordinated with - or conducted by - researchers via "Administrative Studies."**

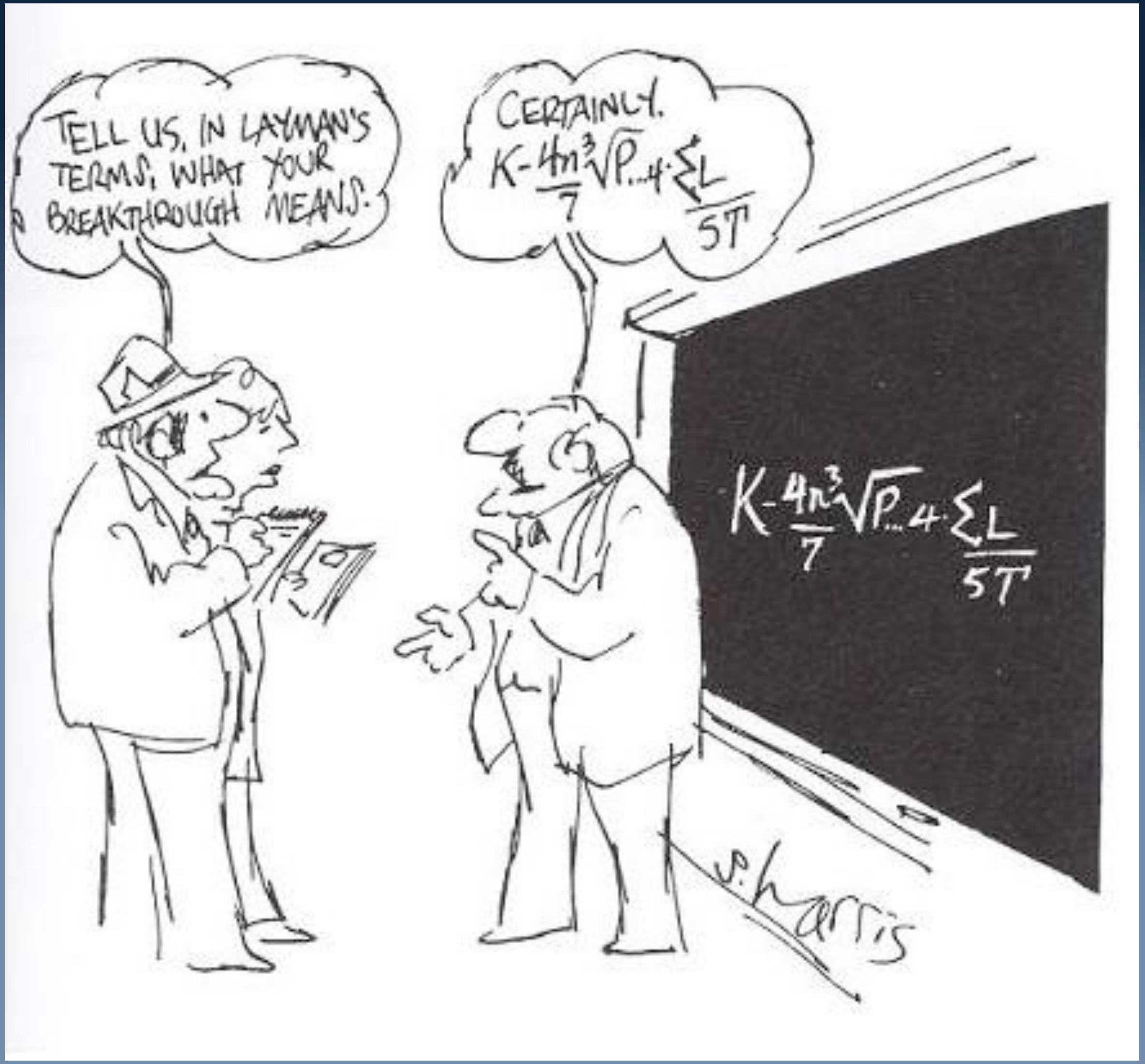
Trend Monitoring

Establish long-term trends in physical, chemical, and biological characteristics. May naturally derive from appropriately designed effectiveness or validation monitoring.

Validation and trend monitoring typically involve empirical design, model development and higher-order statistical analyses.

The accuracy, consistency, and repeatability of data and data collection methods used in monitoring is critical; managers, researchers and data analysts need to coordinate during all phases of the design, implementation, and interpretation of monitoring outputs.

Be clear!


TELL US, IN LAYMAN'S TERMS, WHAT YOUR BREAKTHROUGH MEANS.
CERTAINLY.
S. Harris

Be SMART!

Specific – What are you going to do?

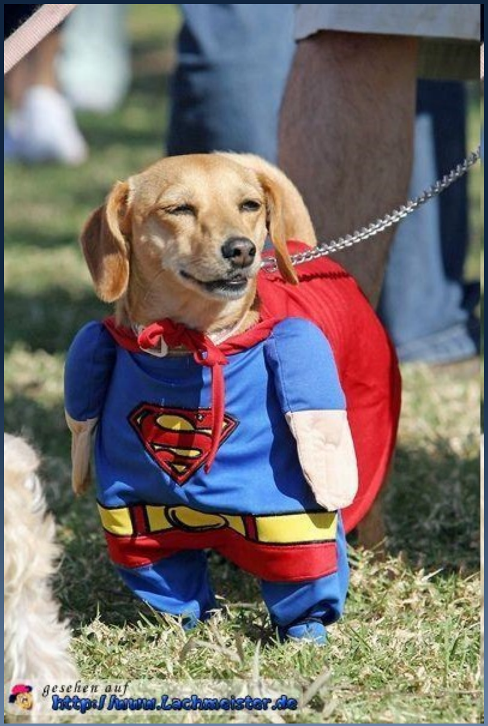
Measurable – Is it measurable?

Achievable – Can it be done in a timely manner?

Relevant – who cares and why?

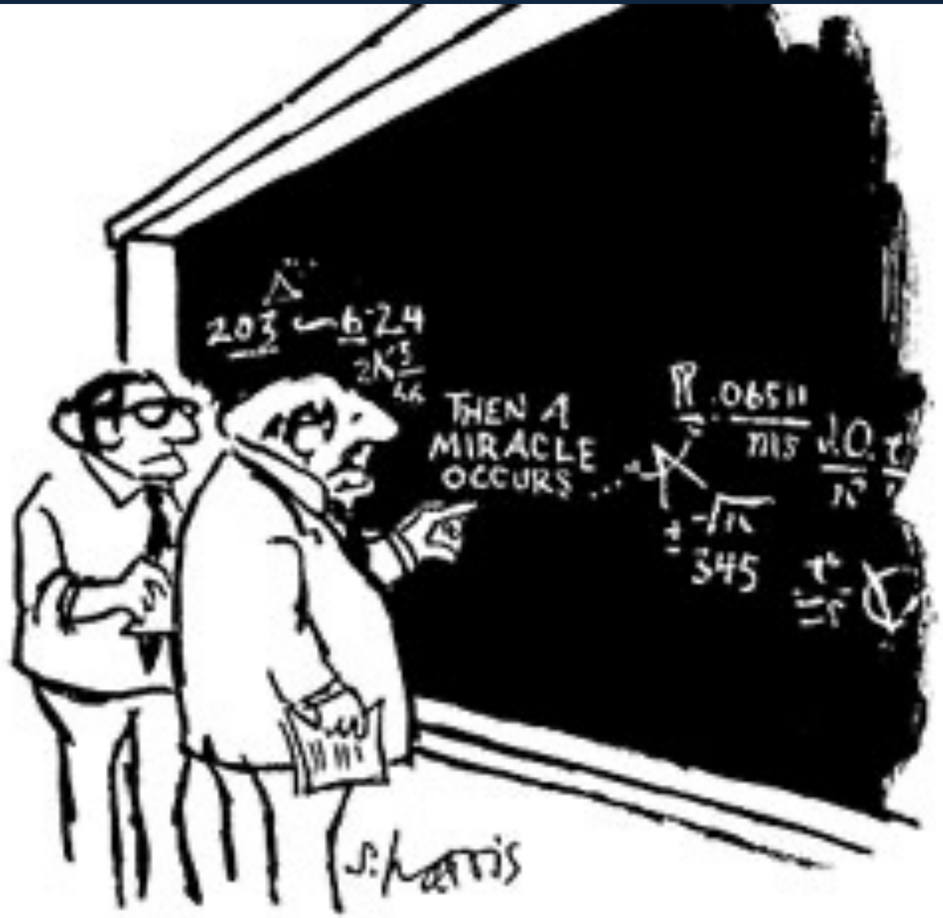
Timely – When and how often?

Don’t try to do everything!



Far better to provide ‘conclusive,’ focused answers to one or two key questions than to inadequately address several questions.

Be concise but don't oversimplify!



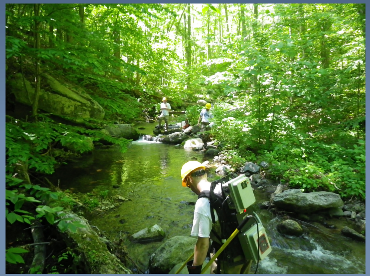
"I think you should be more explicit here in step two."

Monitoring

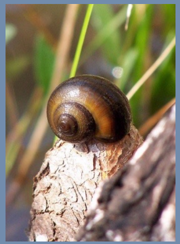
Must choose appropriate:

- Targets
- Scale
- Methods








Think like a fish (or whatever critters someone cares about)

Knowledge of natural history is essential

Scale: the age old conundrum:

– If we build it will they come?

- For aquatic biota: If they come did we simply redistribute from the existing population/community or did our project increase productive capacity?

Wood Additions

1993 Jefferson NF SRS partnership
3 @ 250 m reaches two streams,
'150 structures' 2-weeks

Minimize non-wood impacts
*(canopy and bank)

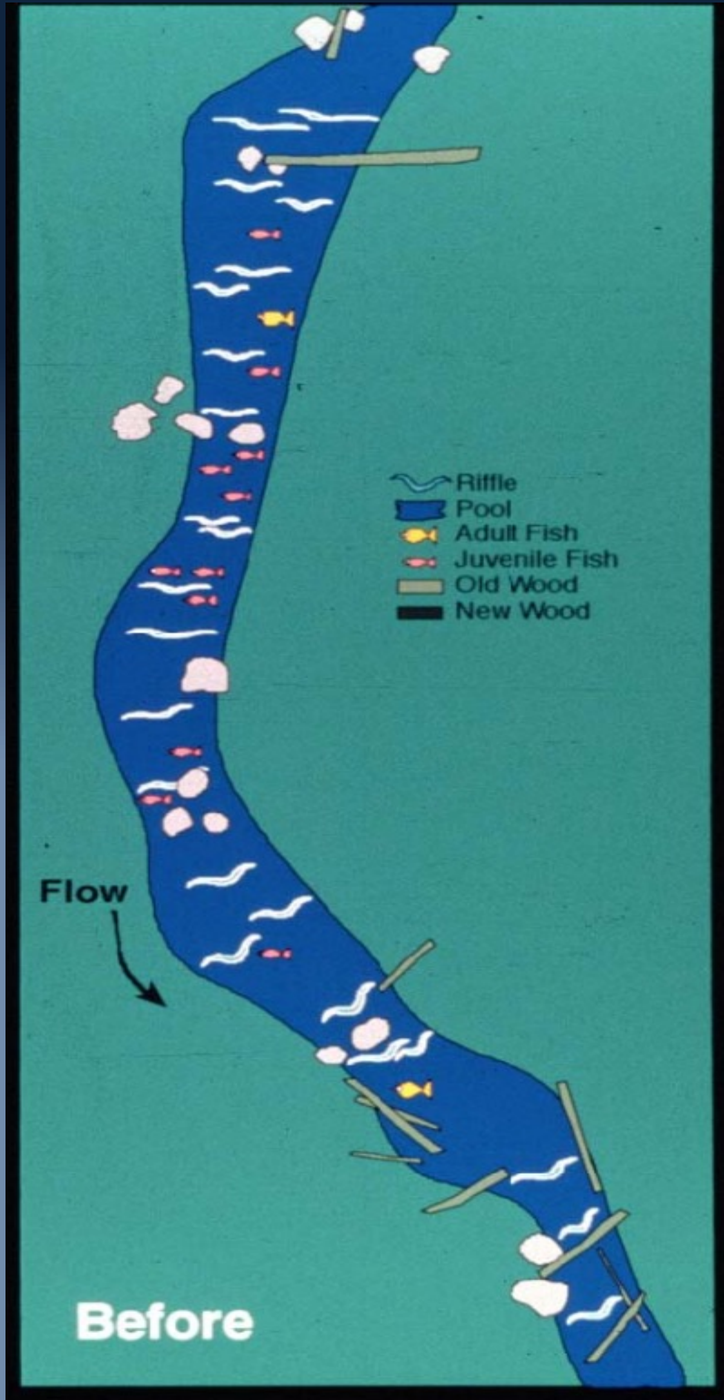
7 tree species
Min 30 cm d small end
1-1.5x channel width length
30 m^3 of wood/stream
No roots, limbs, anchors

Peaveys & log tongs
Chain saw winch

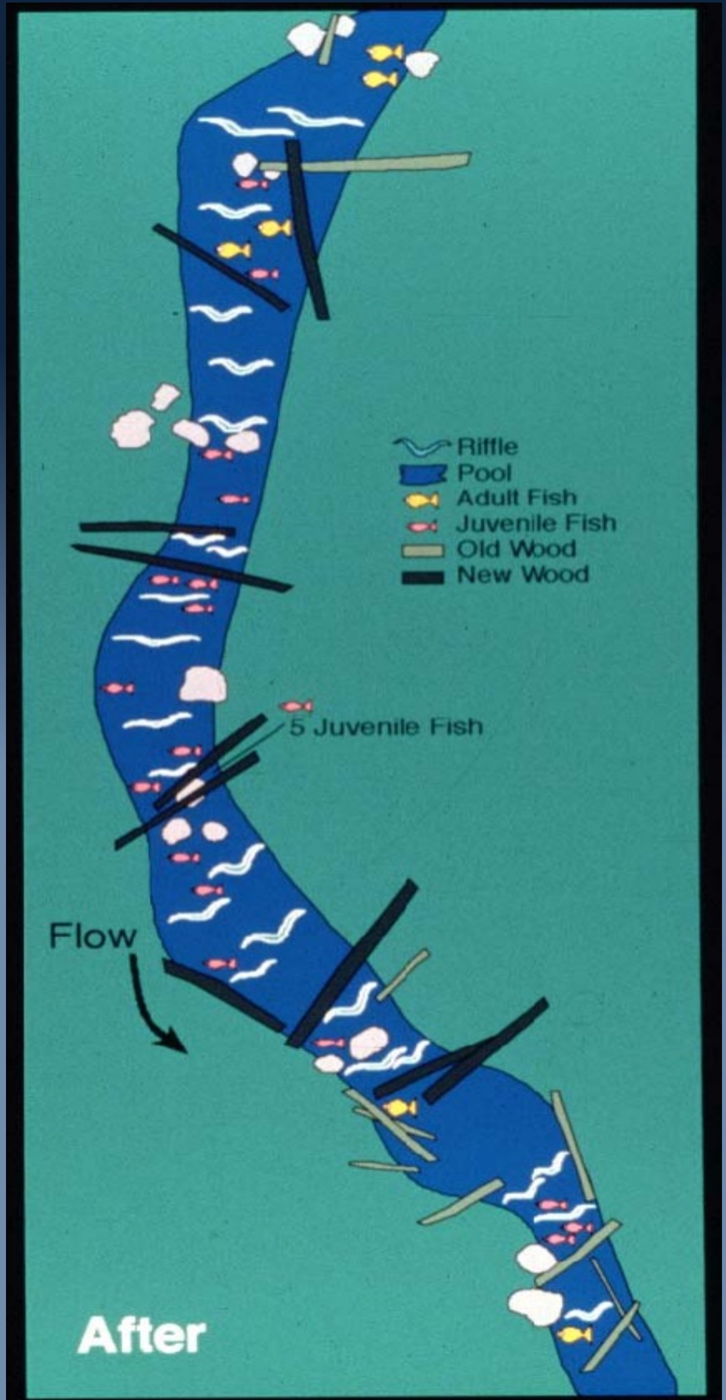
Match tools & skill-set
to the job!


Tag and locate all wood

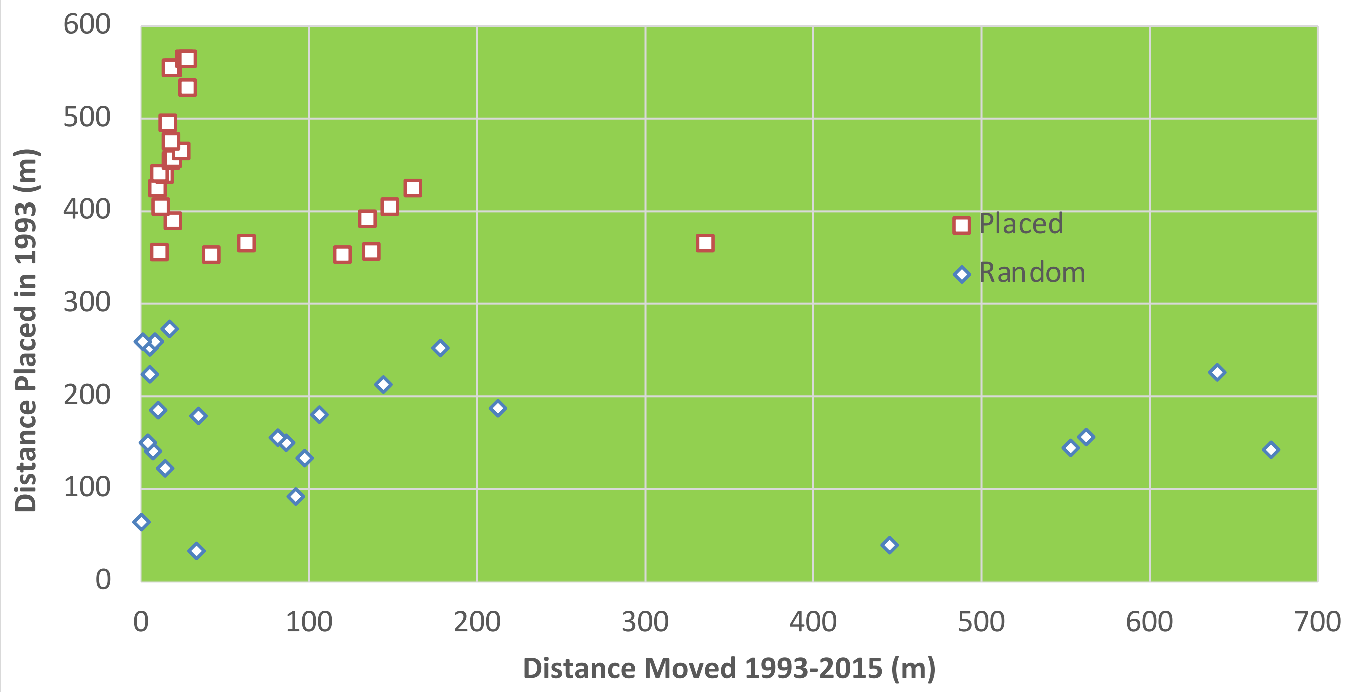
Relocate and evaluate all pieces at least annually
1993-2023 (so far…)



Riffle
Pool
Adult Fish
Juvenile Fish
Old Wood
New Wood
Flow
Before

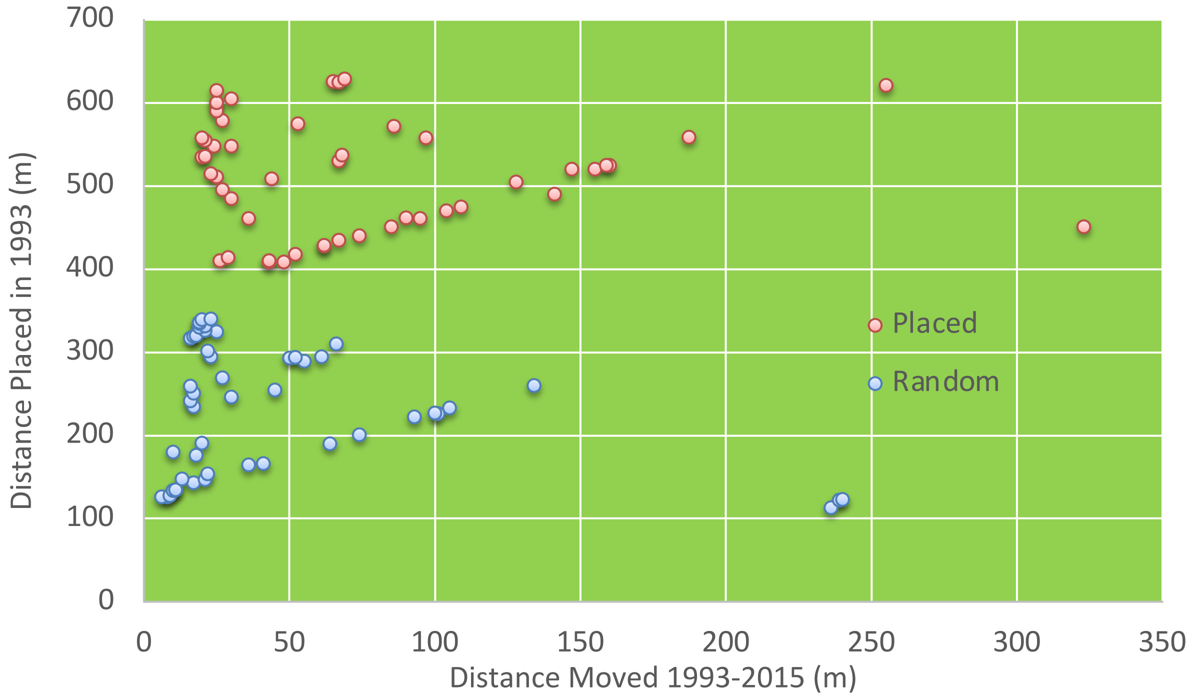


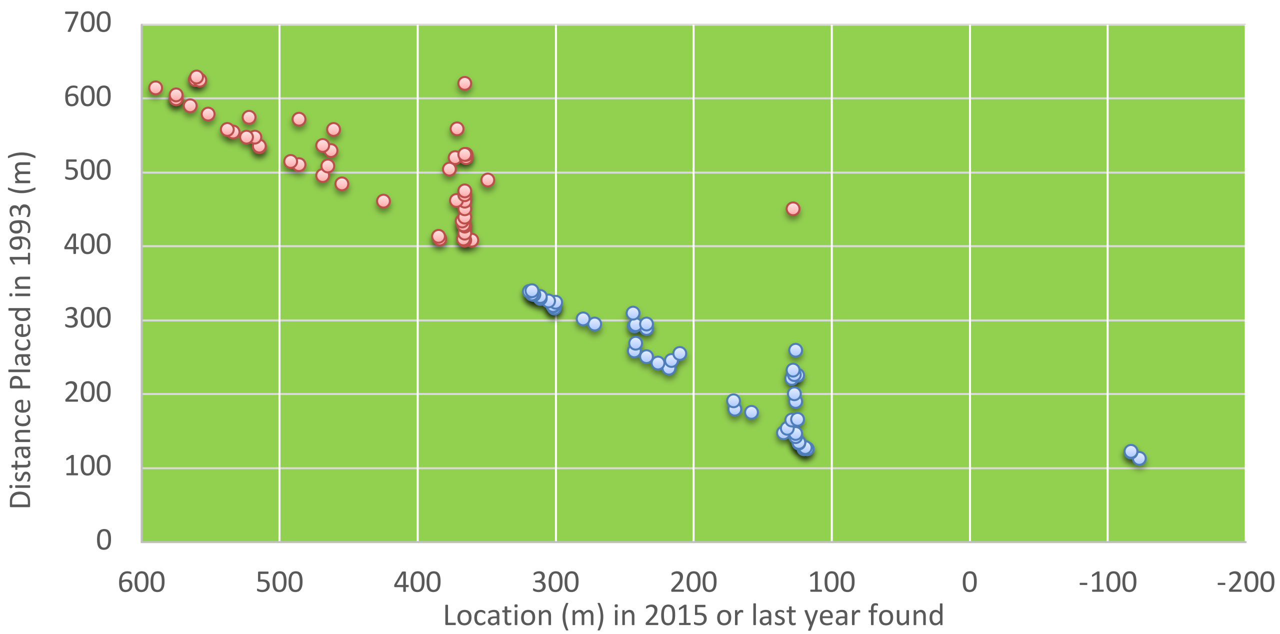
Riffle
Pool
Adult Fish
Juvenile Fish
Old Wood
New Wood
5 Juvenile Fish
Flow
After



Barbour's Creek (High gradient)

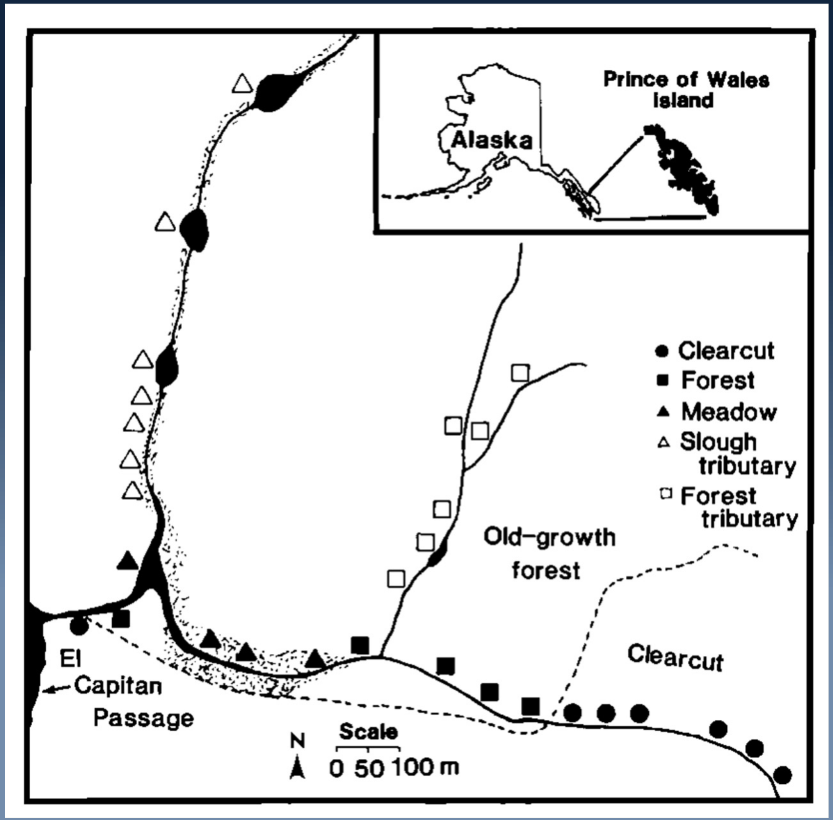
North Fork Stoney (low gradient)

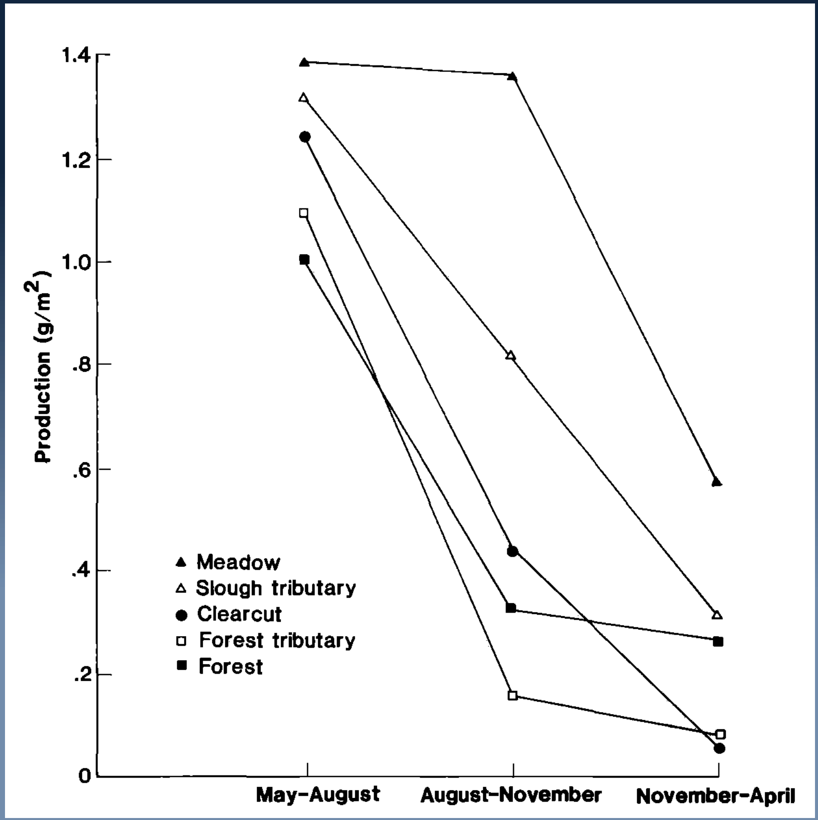




Short-term Results

- Channel complexity greater in low gradient stream
- Boulders function like wood in forming habitat
- Macroinvertebrate biomass unchanged, either stream
- Limiting factors other than large wood must be considered if desired result is increased fish numbers or size





Habitat characteristic or fish statistic	Clear-cut	Forest	Meadow	Slough tributary	Forest tributary
Number of sites	7	5	4	4 (7)	3 (6)
Water surface area (m^2)	702	390	626	148	105
Surface area in pools (%)	29.6	33.1	88.5	32.3	31.6
Average maximum depth (cm)	36.7	60.6	83.3	51.7	39.3
Undercut bank (m^2)	2.4	2.1	7.6	3.9	5.7
Large woody debris (m^2)	3.8	1.4	3.9	0.9	0.4

Ecological Targets

Target Species

– Detecting Effects on Occupancy and Abundance

presence/absence (occupancy), mark/recap., depletion

- Probability of Capture/Detection
- Spatial Variability (basinwide vs. non-random site specific)
- Temporal Variability (season…)

Species Targets – Appropriate Scales

- Difficult to scale up from individuals at specific life-history stages in specific sites/contexts to long-term effects on population size
- Standard methods tend to be expensive, difficult, and imprecise

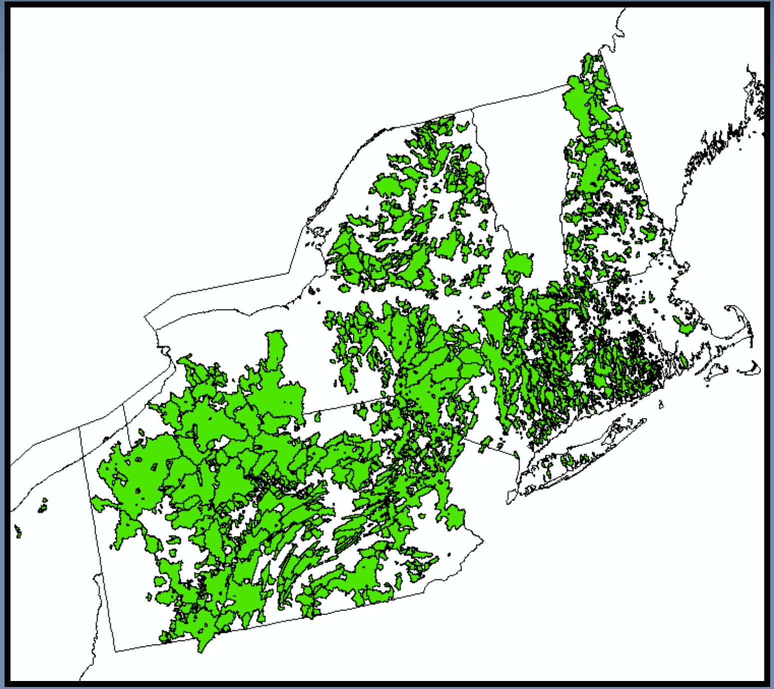
$ COST $?

Ecological Targets

Target Species – New Methods

Effective Population Size (N_e)

- Use genotypes of a representative sample to estimate the number of individuals responsible for producing a cohort (~ # breeders)
- Less variable than census size, more relevant to population viability
- USFS/UMASS Conservation Genetics Lab



Ecological Targets

Target Species – New Methods

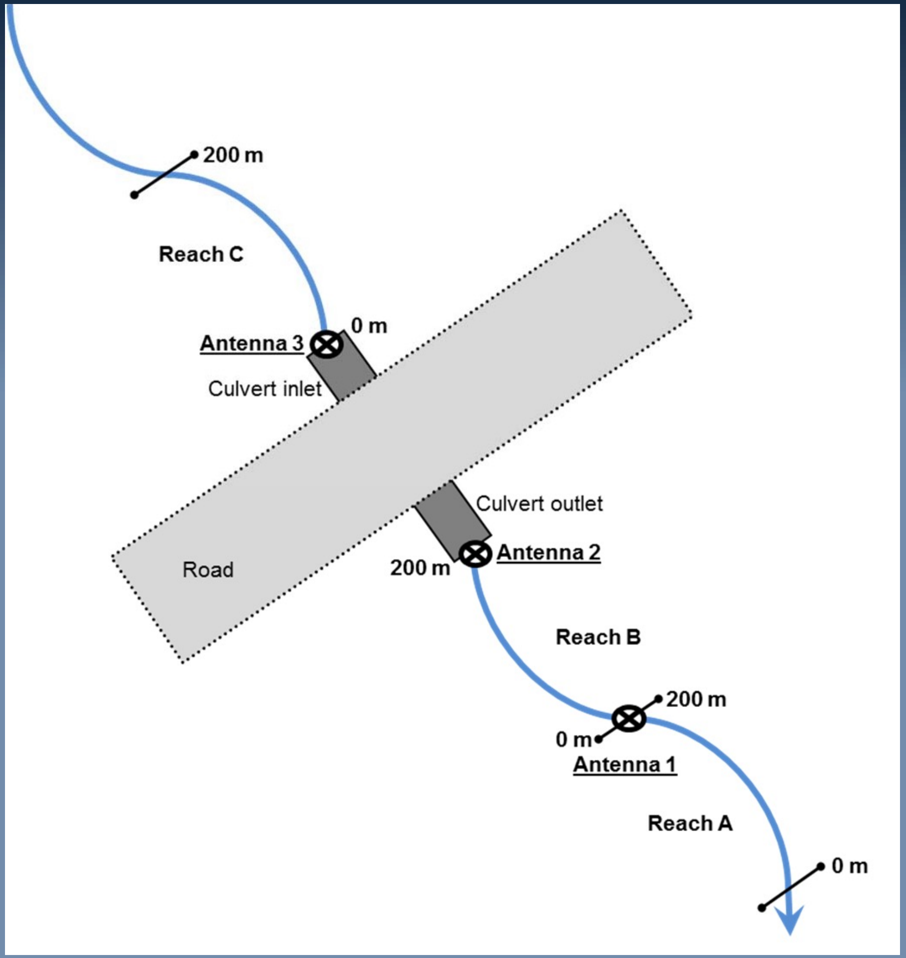
Environmental DNA (eDNA)

- Particularly for species with low capture probabilities and/or difficult to sample
- Presence/absence, not abundance (yet…)
- Species richness across multiple taxa
- USFS-led National Genomics Center (RMRS/Missoula)
    - But; still $, lack of profiles for many species


Ecological Targets

Target Species – New Methods

RFID (PIT) tags



Proven technology for salmonids and many species >= 70mm TL [e.g. chubs, adult dace, darters]

But: Time and labor cost, vandalism

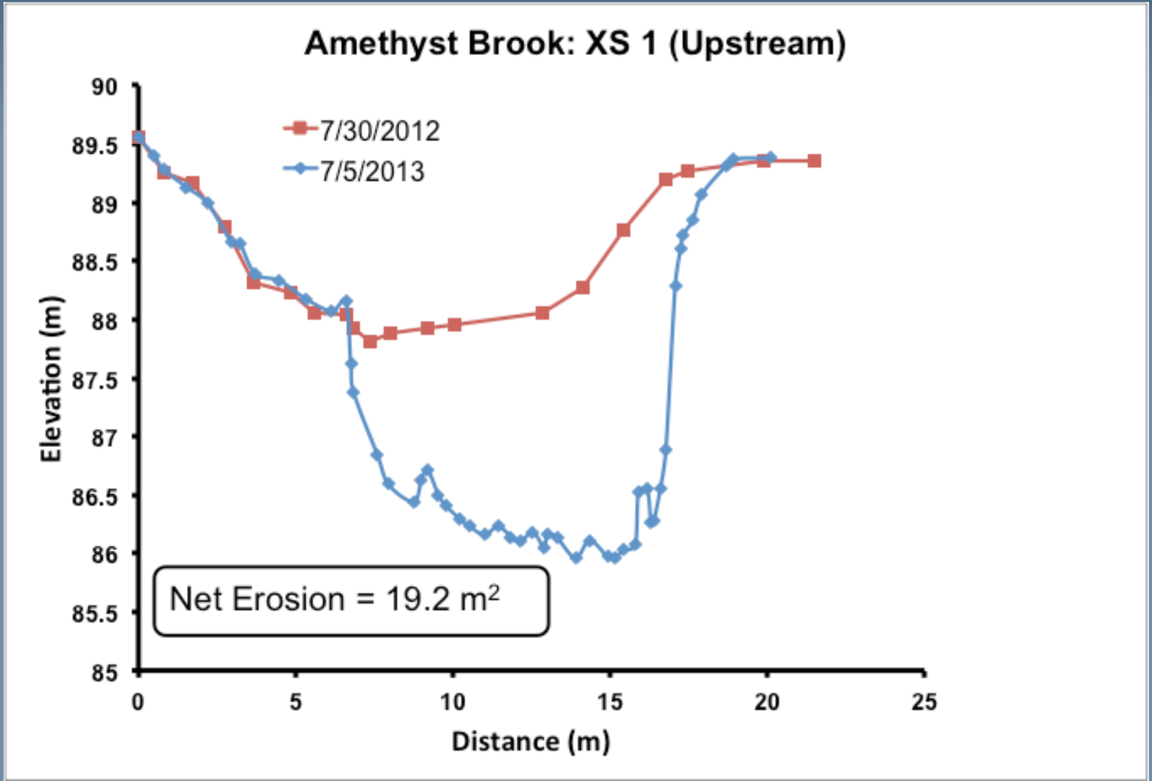
Geophysical Targets

- Habitat Quality/Complexity
- Storage/Sequestration of Water, Sediment, Nutrients

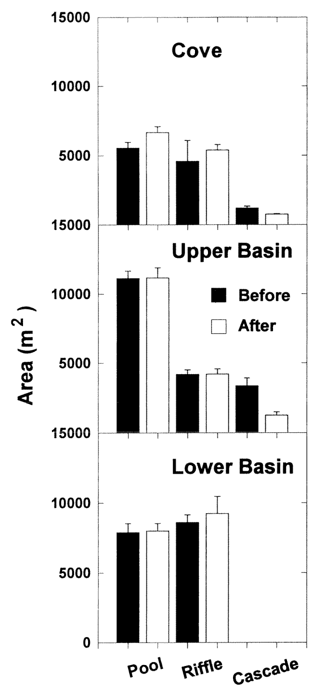
Geophysical Targets – Methods (Standard)

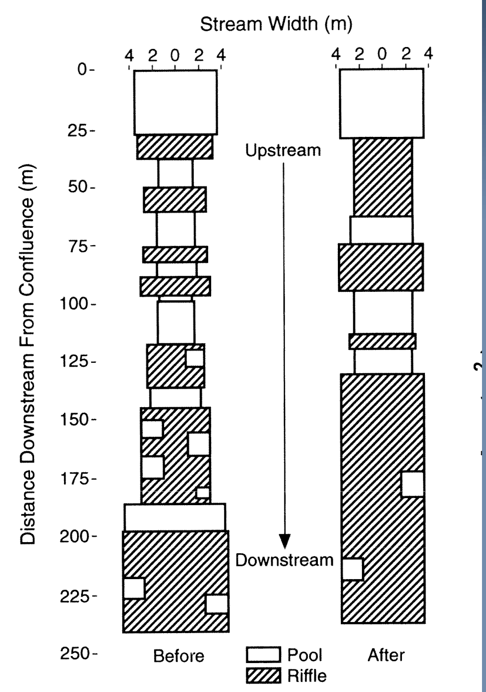
- Habitat Mapping
- Surveyed cross-sections, longitudinal profiles, plan view sketches
- Pebble counts

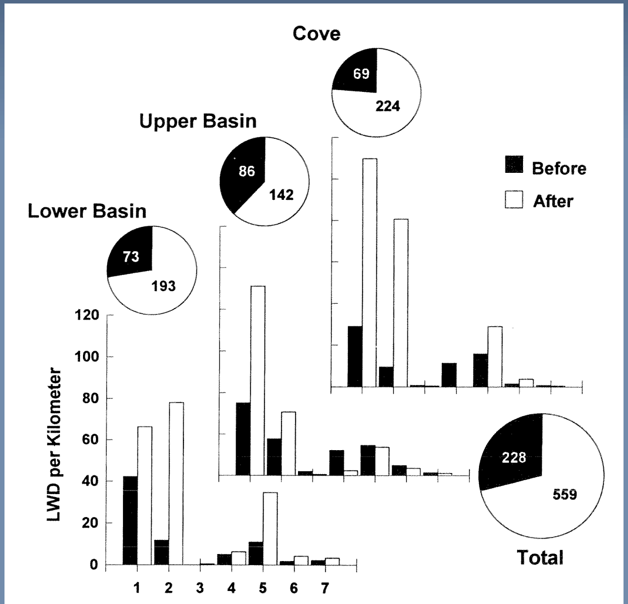
Ex$pensive, time consuming, spatially-limited

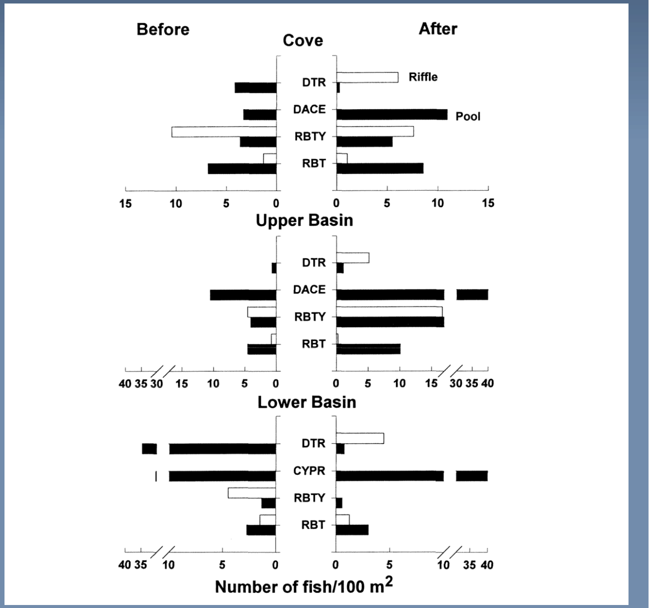


Habitat, Large wood and Fish pre & post Hugo









Dolloff, Flebbe, & Owen 1994

Geophysical Targets – Methods (State-of-the-Art)

- Conservative (passive) tracers

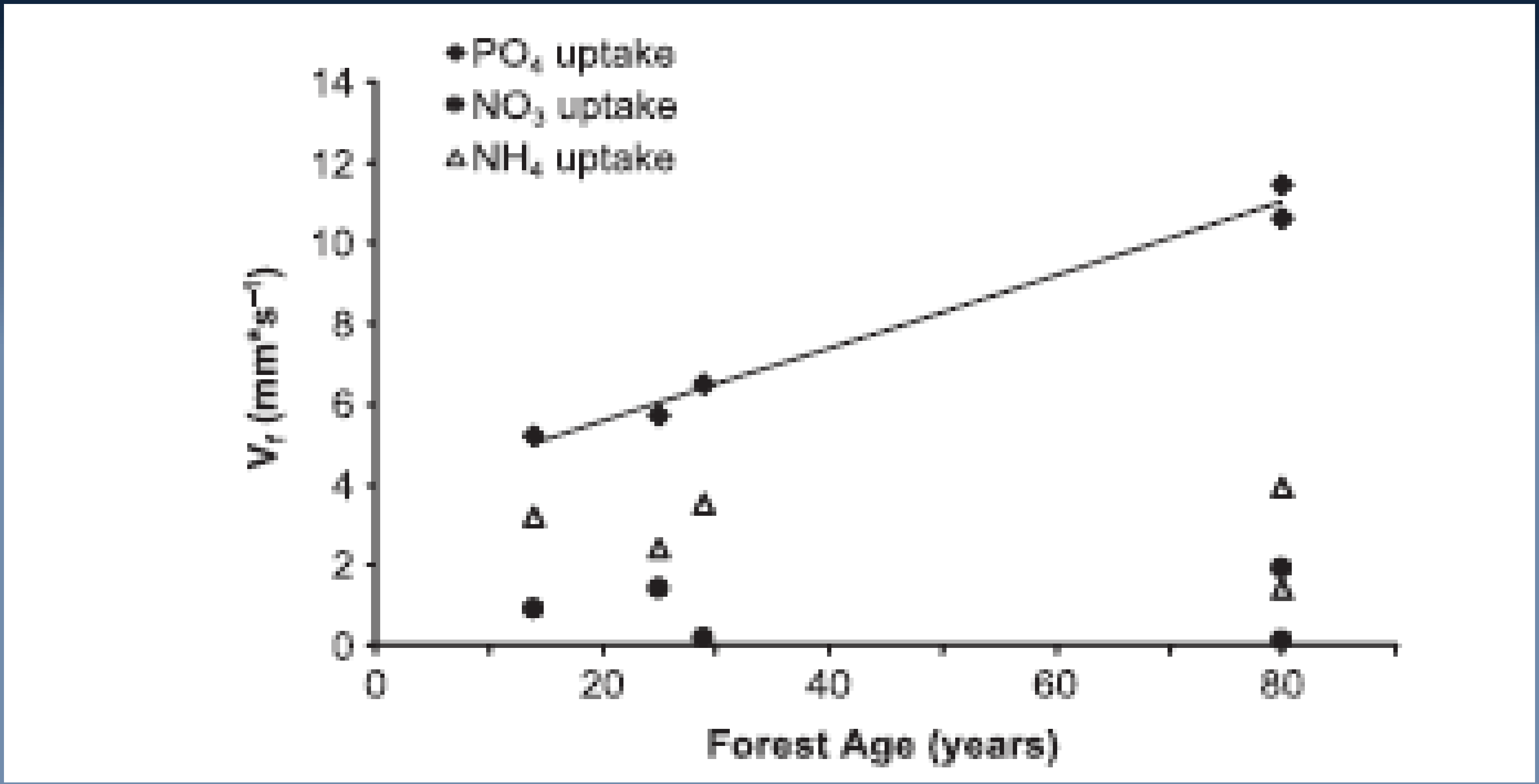
  Transient hydrologic storage (fluorescent dyes, sodium chloride)

- Isotopic tracers

  Nutrient uptake and sequestration (Indicators of habitat complexity and biological activity)

- -Rare earth element oxide tracers
  - (praseodymium, cerium, lanthanum, neodymium, samarium, gadolinium).

- Increased transient storage = tighter spirals = higher uptake velocities = longer retention (reduced export rates) in older forests with more LW



Warren et al. 2008

Geophysical Targets – Methods (State-of-the-Art)

- Hi-Resolution Imaging
  - Aerial Photography (Drones)
  - Standard Lidar
  - Ground-Based Lidar
  - ForWarn II, etc.

Accurate, high-resolution DEMs quickly and at low-cost

Major increases in power to detect channel change at a wide range of scales

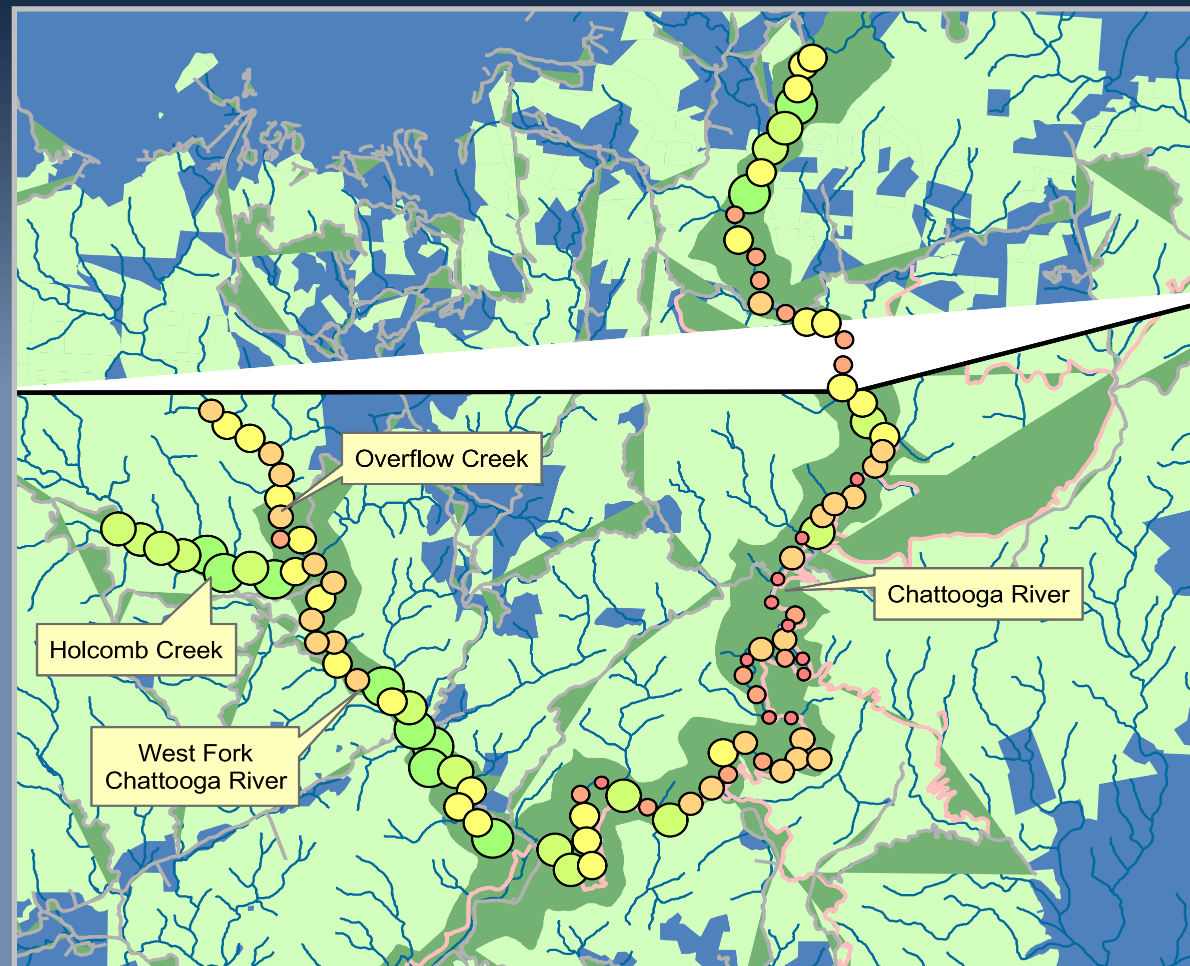
Leveraging 'Disasters'

- Hemlock Wooly Adelgid
  - Chattooga Wild & Scenic
  - 2013: Thousands of dead, standing hemlocks
  - Kayaks/rafts vs. Fish

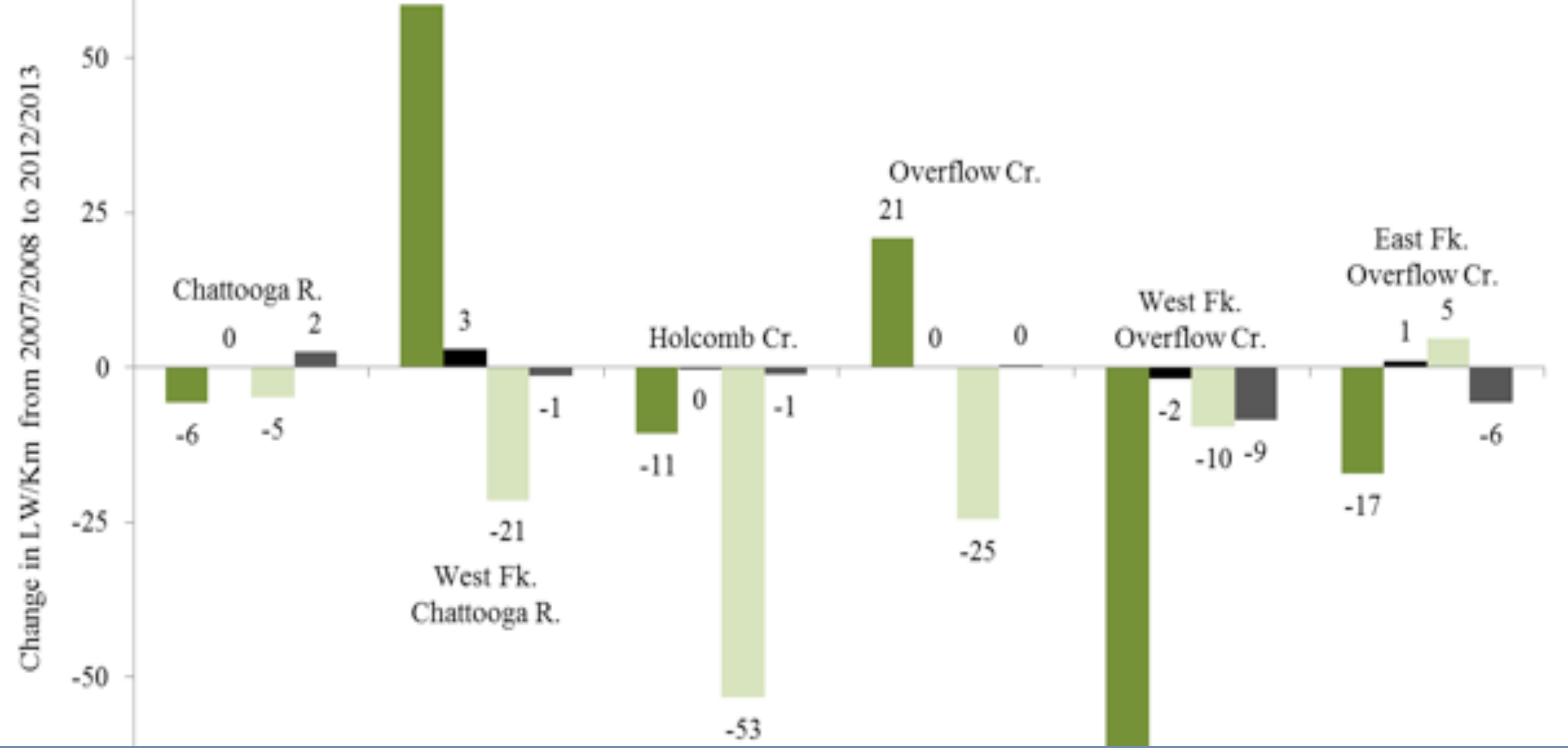
- Catastrophe or once in a lifetime opportunity?

Recreation


Southeastern Expeditions


Overflow Creek
Holcomb Creek
West Fork
Chattooga River
Chattooga River

Change in LW 2007/8 2012/13

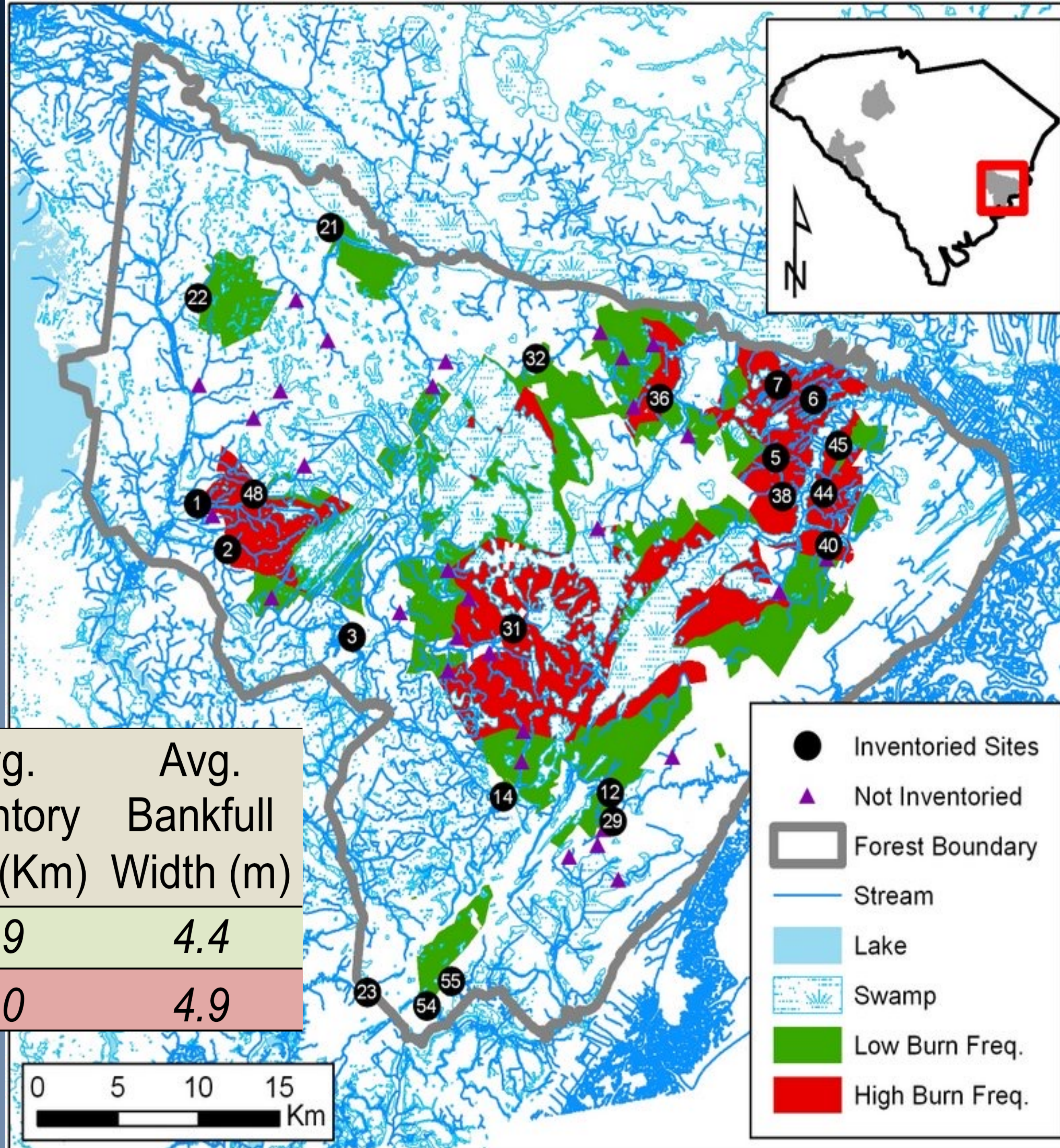


Leveraging ‘Disasters’

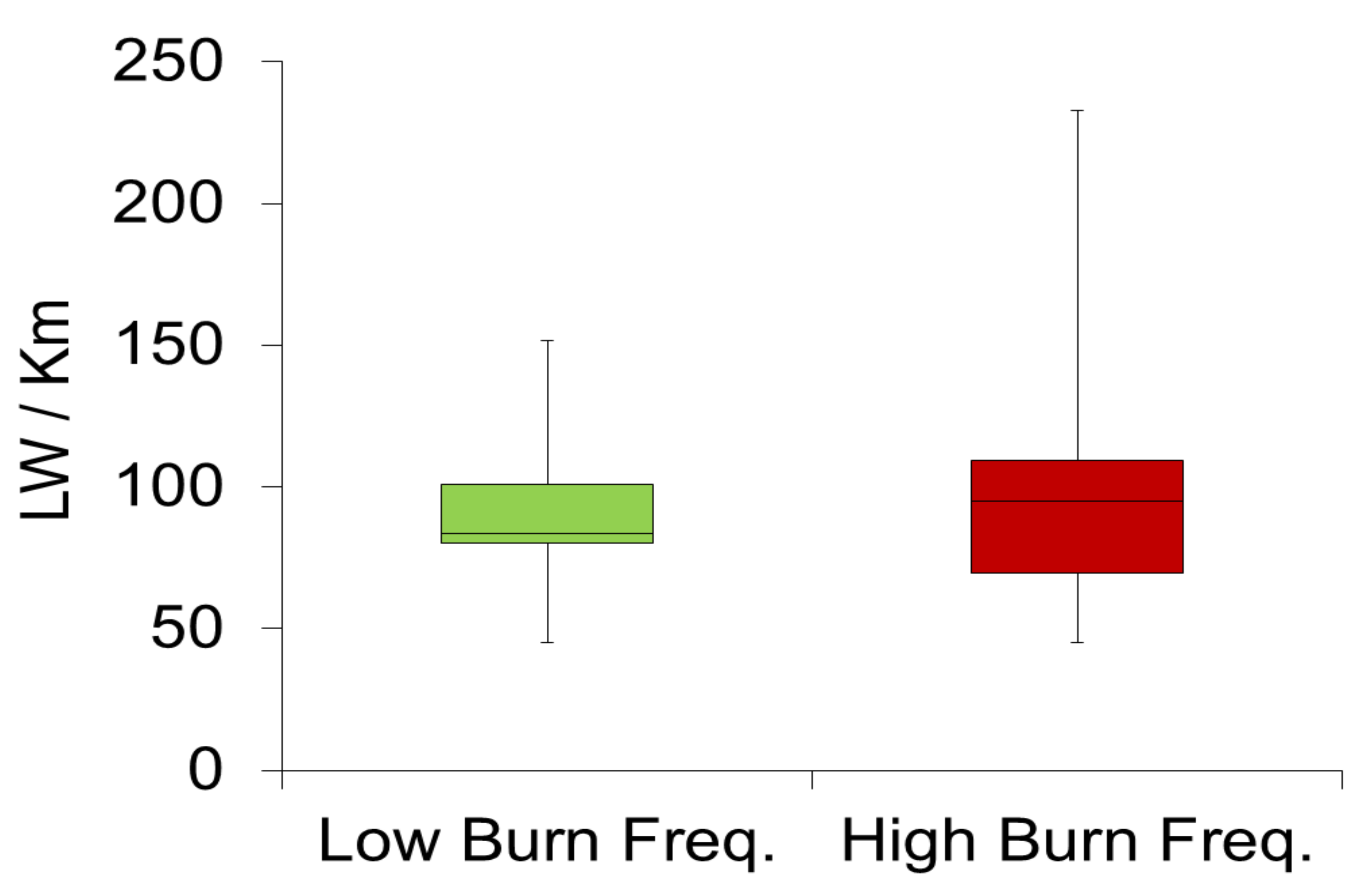
- Hurricane Hugo
  - Francis Marion, SC
  - 1993: many sites impossible to sample because of LW
  - Salvage operations
  - 2013: worried about lack of LW & prescribed fire effects
- Opportunity lost?

Francis Marion: LW and Prescribed Fire

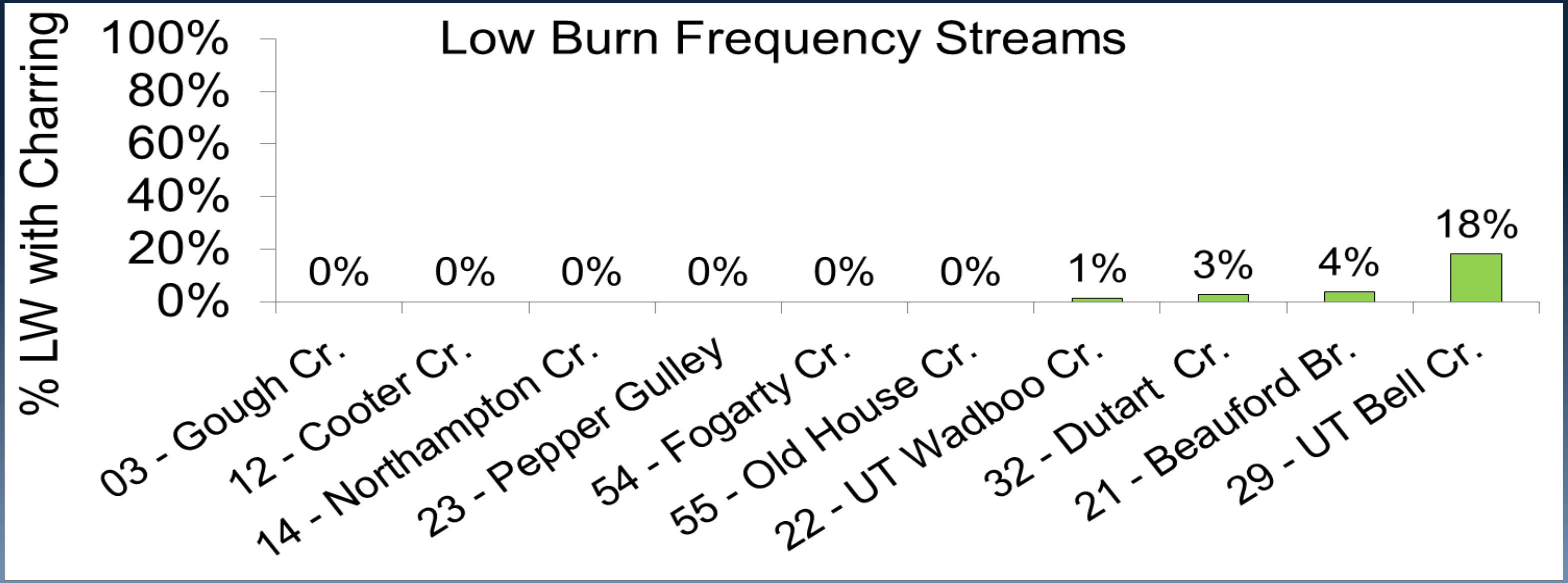
Burn Freq.	# Sites	Avg. Times Burned (2006-2013)	Avg. Inventory Dist. (Km)	Avg. Bankfull Width (m)
Low	10	*1*	*0.9*	*4.4*
High	12	*4*	*1.0*	*4.9*



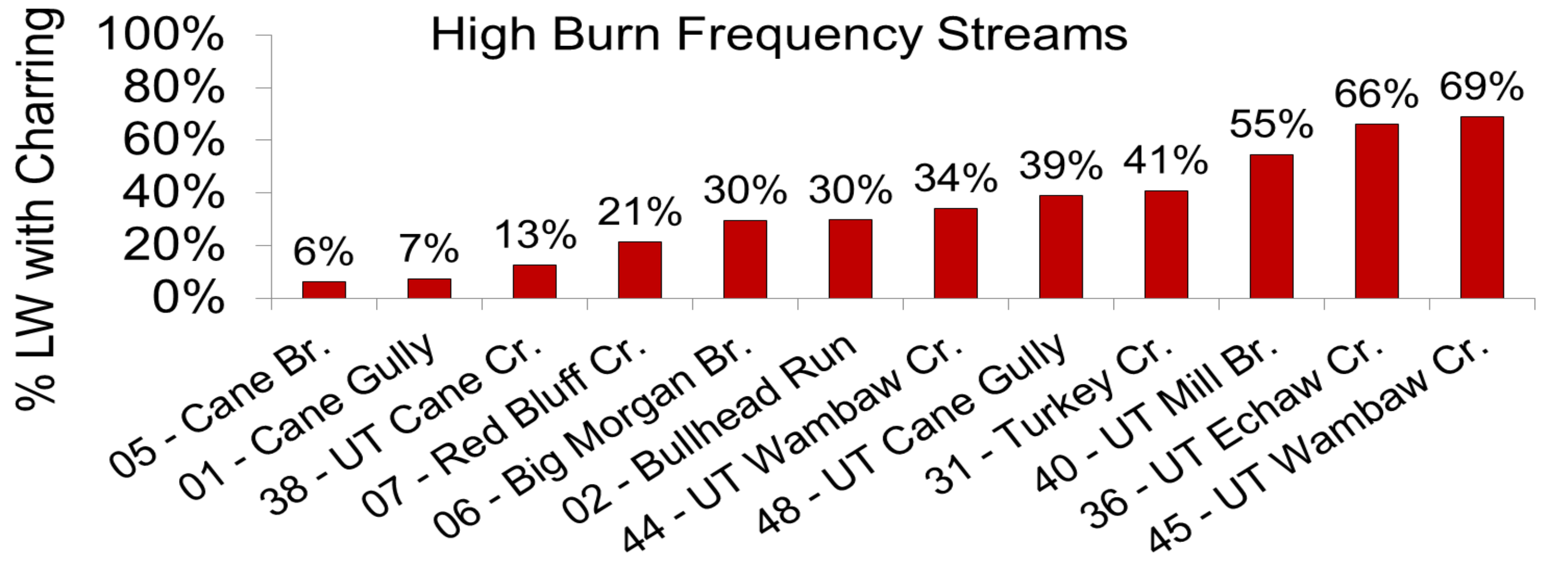
Quantity (LW/Km)



Charred LW



Low Burn Frequency Streams
% LW with Charring
100%
80%
60%
40%
20%
0%
0%
0%
0%
0%
0%
0%
1%
3%
4%
18%
03 - Gough Cr.
12 - Cooter Cr.
14 - Northampton Cr.
23 - Pepper Gulley
54 - Fogarty Cr.
55 - Old House Cr.
22 - UT Wadboo Cr.
32 - Dutart Cr.
21 - Beauford Br.
29 - UT Bell Cr.



High Burn Frequency Streams
% LW with Charring
100%
80%
60%
40%
20%
0%
6%
7%
13%
21%
30%
30%
34%
39%
41%
55%
66%
69%
05 - Cane Br.
01 - Cane Gully
38 - UT Cane Cr.
07 - Red Bluff Cr.
06 - Big Morgan Br.
02 - Bullhead Run
44 - UT Wambaw Cr.
48 - UT Cane Gully
31 - Turkey Cr.
40 - UT Mill Br.
36 - UT Echaw Cr.
45 - UT Wambaw Cr.

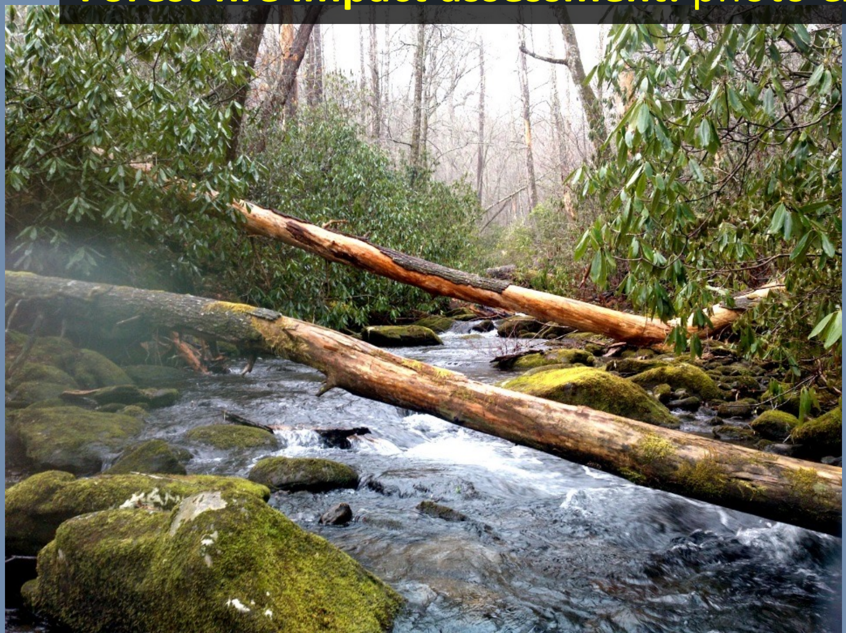
Fire Effects?

- % charred LW greatest in high burn frequency, *but*
  - Lack of difference in quantity, volume, or position of LW in Low and High burn frequencies, *and*
- Prescribed fire not consuming all LW, *but*
  - Few trees recruited by fire
- Long term prognosis for LW under current fire regime:

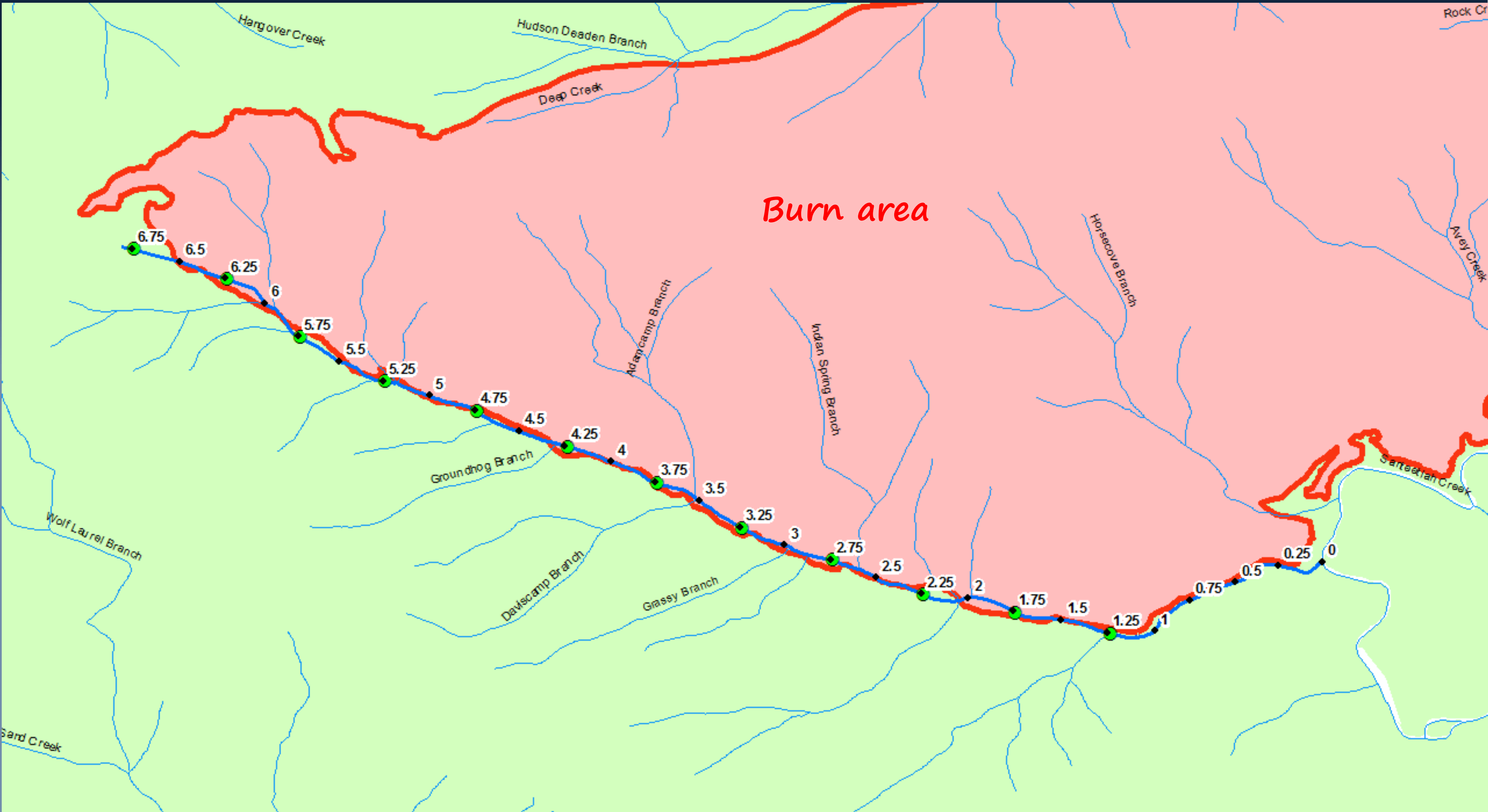
Decline without replacement

Little Santeetlah Creek Joyce Kilmer-Slickrock

Forest fire impact assessment: photo examples of low and medium fire intensity



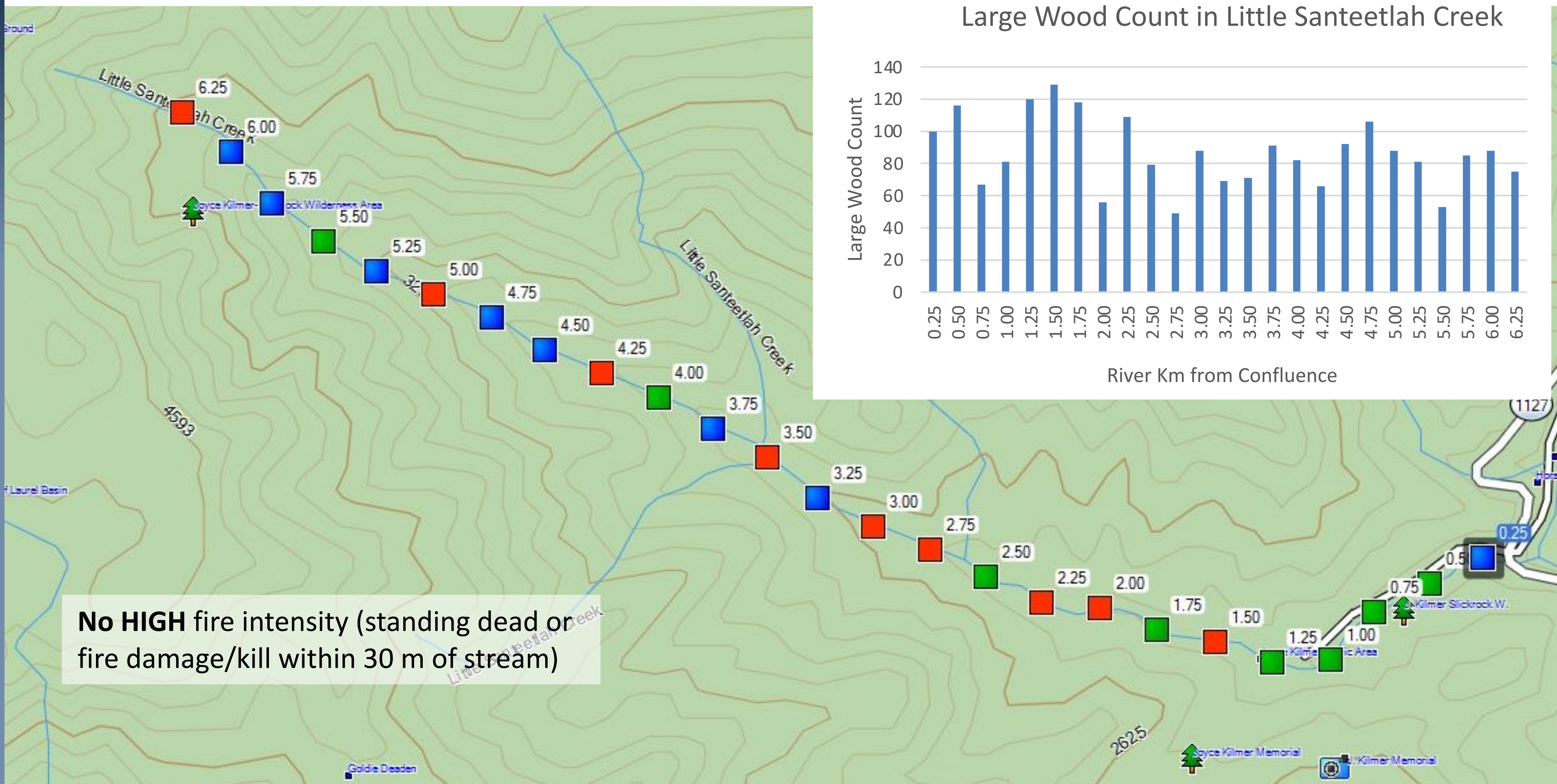

BELDING COAL
BELDING TRACT
GRAHAM COUNTY
SNOWBIRD TRACT
WELCH
JUDSON
GRAHAM COUNTY, NORTH CAROLINA.
This special map shows the timber holdings of the Whiting Manufacturing Company in Graham County, North Carolina. Particular attention is directed to the location of the streams which form a natural right of way for the logging roads and will enable the company to log all of its timber at a low cost.
Practically all of the timber illustrations were taken on the Belding, Snowbird and Long Creek tracts.



Burn area
Hargover Creek
Hudson Deaden Branch
Deep Creek
Rock Cr
Adamcamp Branch
Indian Spring Branch
Horsecove Branch
Avey Creek
Santeetlah Creek
Groundhog Branch
Wolf Laurel Branch
Daviscamp Branch
Grassy Branch
Sand Creek
6.75
6.5
6.25
6
5.75
5.5
5.25
5
4.75
4.5
4.25
4
3.75
3.5
3.25
3
2.75
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0

Fire intensity along north streambank:

- **Green squares = no evidence** of fire within 30 m of stream
- **Blue squares = low**
  - charring of leaf litter, light charring of rhododendron trunks or lower leaves, light charring on tree trunks within 30 m of stream
- **Red squares = medium**
  - fire damage into canopy of rhododendron within 30 m of stream



No HIGH fire intensity (standing dead or fire damage/kill within 30 m of stream)

Brook Trout Distribution & eDNA

- Brook Trout found upstream of cascade at 5.25 km; only Rainbow Trout downstream
- eDNA samples 8 locations Little Santeetlah Creek and 3 tributaries

Hemlock Mortality and Aquatic Habitat

- Hemlock wooly adelgid [HWA] infestation 1st observed ~ 2003
- Hemlock mortality rates along the Chattooga > 90%
- Hemlock uprooting has potential to increase near-stream erosion and sedimentation

Perception that sediment in the Chattooga River and its tributaries has increased and is a direct result of mortality from HWA


Dead hemlocks will break or topple over

Questions

- What is the extent of hemlock decline and associated windthrow in riparian areas?
- How much soil (present and future) from hemlock uprooting is or will reach stream channels in the Chattooga Wild and Scenic River and tributaries?


Toppled hemlocks pull up roots and expose soil

Soil Erosion from tip ups

- The average 63.9; median 19.6 lbs/yr
- The maximum 450.3; minimum 0.2 lbs/yr
- The erosion rate 19.7 lbs/ac/yr
- Normal erosion undisturbed forest 100 lbs/ac/yr
- Skid trail erosion potential up to 17.2 tons/ac/yr (Worrell et al.2011)
- The average distance from tip-up to stream 9.18 ft
- 25 ft. SMZ traps sediment effectively (Lakel et al. 2010).

Conclusions

- Erosion from uprooted hemlock is minimal, < erosion rates in undisturbed forest (100-200 lbs/ac/yr)

- Sediment delivery to waterway from hemlock is certain at 9.8 ft. average, but likely insignificant

- Standing dead & dying hemlock may pose safety hazard for recreationists but are not a major contributing factor to sediment load

Large wood loading from hemlock benefits aquatic habitat in the Chattooga River watershed

Fallen trees provide valuable in-stream structure

Leveraging 'Disasters'

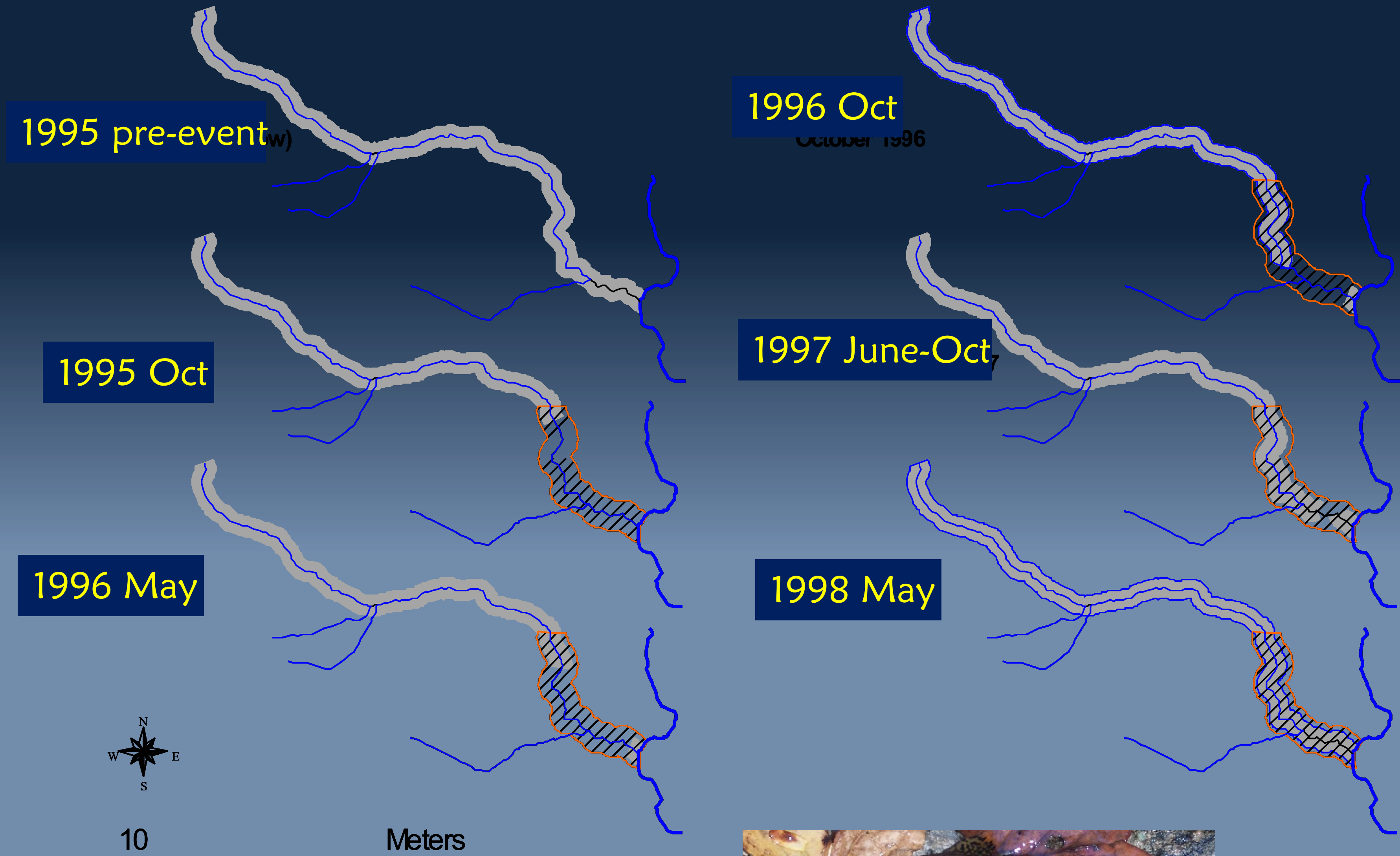
Before

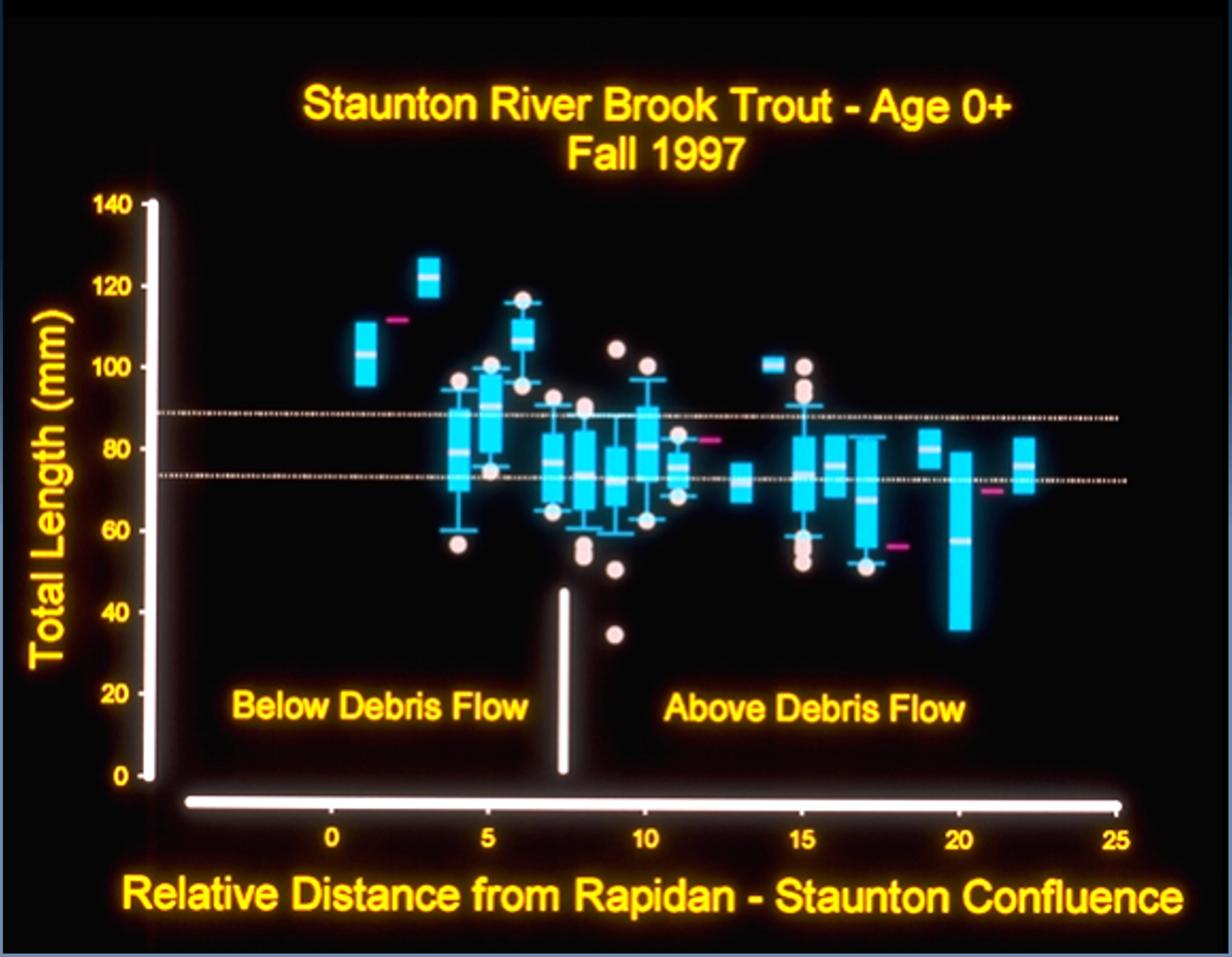
After

Staunton River, Shenandoah NP

Millenial flood & debris flow





1995 pre-event
1996 Oct
1995 Oct
1997 June-Oct
1996 May
1998 May
N
W
E
S
10
Meters


Staunton River Brook Trout - Age 0+
Fall 1997
Total Length (mm)
140
120
100
80
60
40
20
0
Below Debris Flow
Above Debris Flow
0
5
10
15
20
25
Relative Distance from Rapidan - Staunton Confluence

Conclusions

- ‘It’s only catastrophic if you’re in the way’
- Within 3 years: more and larger fish than before event

(Roghair and Dolloff 2002, 2005)

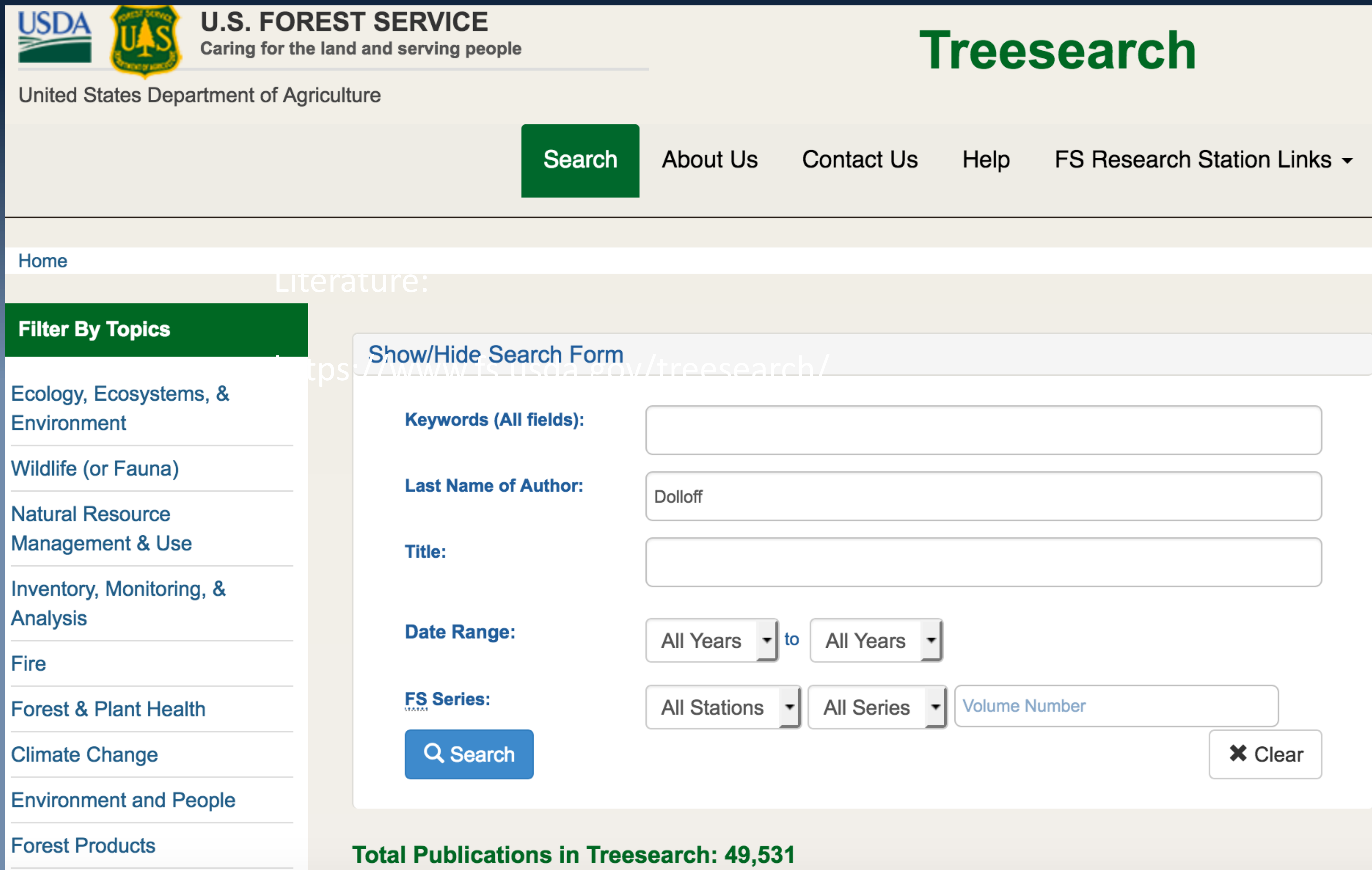

That's all Folks!


S
O L
O N G
A N D T
H A N K S
F O R A L L
T H E F I S H

https://www.srs.fs.usda.gov/blacksburg/

Literature:

https://www.fs.usda.gov/treesearch/



Monitoring:

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