EVALUATION OF ABIOTIC AND BIOTIC RESPONSES TO BEST MANAGEMENT PRACTICES IN SMALL AGRICULTURAL STREAMS OF THE SPRING CREEK WATERSHED IN CENTRAL PENNSYLVANIA

Susan E. Yetter, Robert F. Carline, and Robert P. Brooks

Penn State Cooperative Wetlands Center
Pennsylvania Cooperative Fish and Wildlife Research Unit

PENNSTATE
1855
Department of Geography
Penn State Cooperative Wetlands Center
www.wetlands.cas.psu.edu

U.S. Department of Agriculture USDA

National Water Program
A Partnership of USDA CSREES & the Land Grant System

Applying knowledge to improve water quality

CSREES EDUCATION · RESEARCH · EXTENSION · USDA

NRCS Natural Resources Conservation Service

- CEAP Watershed Studies
  http://www.nrcs.usda.gov/technical/nri/ceap

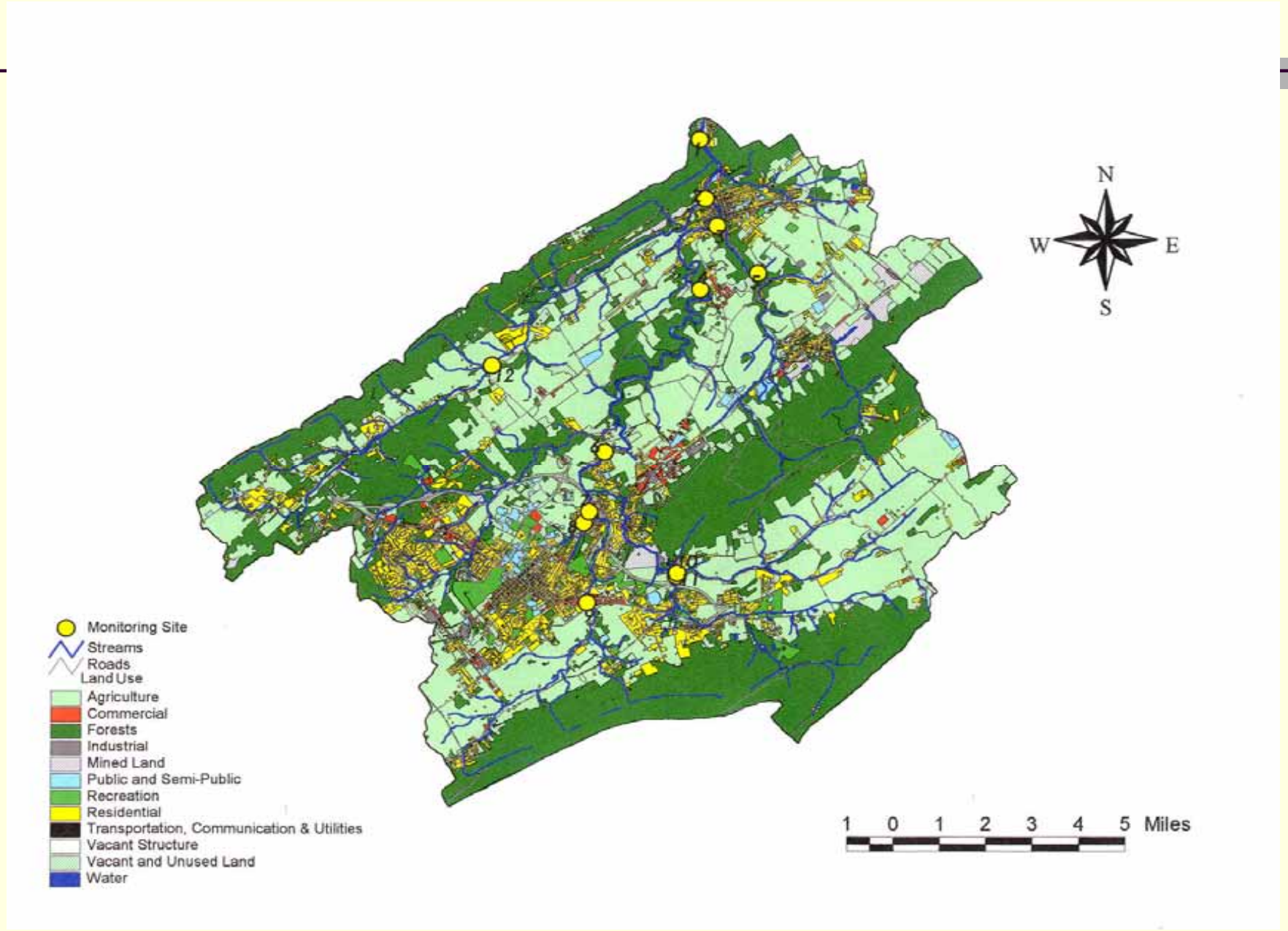
- CSREES-NRCS Competitive Grants Watersheds

- Project Team: Pennsylvania State University
  Smithsonian Environmental Research Center
  Canaan Valley Institute
  Cornell University

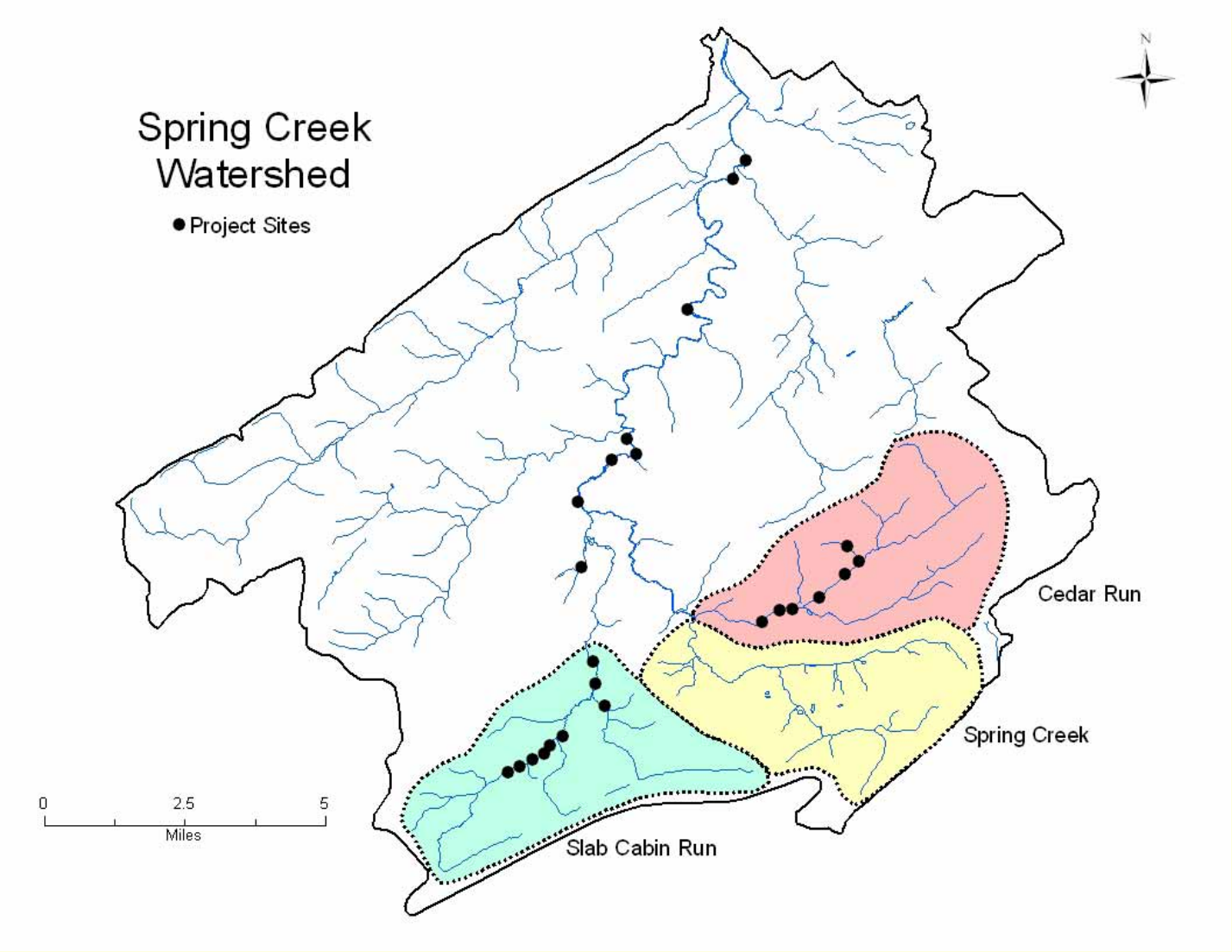
- Objective 3: Ground-based monitoring and ecological analyses

Spring Creek Watershed Land Use

SOURCE - Base map and land use information; Centre County Planning Office, Geographic Information System (GIS) data.



RIPARIAN RESTORATION IN SPRING CREEK



BEST MANAGEMENT PRACTICES IN SPRING CREEK WATERSHED

Pre-treatment monitoring

(1991-1992)

Treatments (1992 – 1998):

streambank fencing

stream crossings

bank stabilization

Post-treatment monitoring

(selected years 2001-2007)

BEST MANAGEMENT PRACTICES IMPLEMENTED

Slab Cabin Run

Treatment: 2740 m streambank fencing

26 stream crossings

1875 m bank stabilization

Post-treatment: 61% of unfenced stream pastures

Cedar Run

Treatment: 2000 m streambank fenced

14 stream crossings

245 m bank stabilization

Post-treatment: 98% of unfenced stream pastures

ECOLOGICAL ANALYSIS

OBJECTIVES:

- Are BMPs effective in reducing sediment loading and stream bank erosion in streams with livestock grazing?

- Are substrate composition, macroinvertebrates, and fish useful water quality surrogates for evaluating BMP performance?

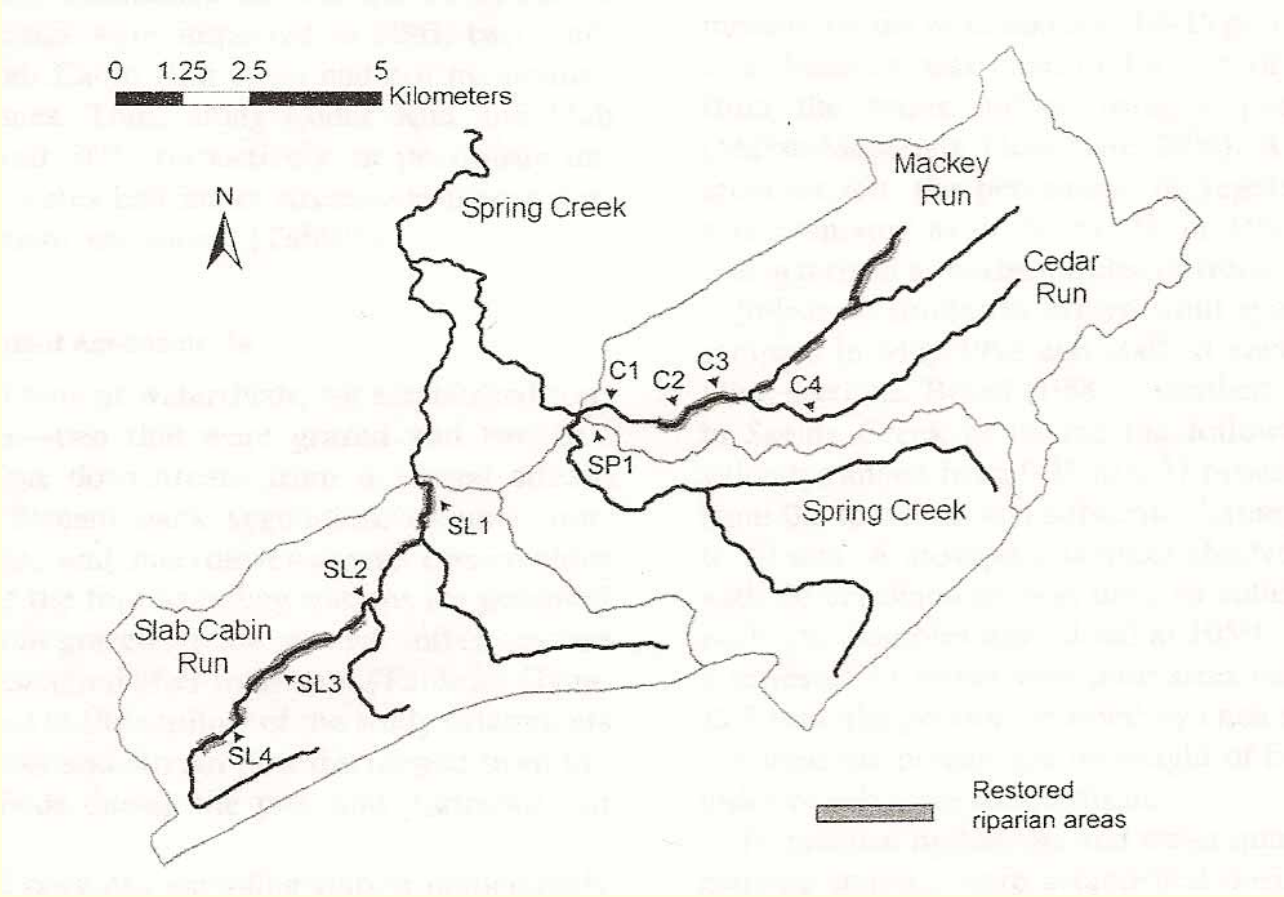
- What is the optimal time for post-construction monitoring?

STUDY DESIGN

- 2 Treatment subbasins;
1 reference subbasin

- 2 grazed, 2 ungrazed

- Compare substrate, macroinvertebrate, and fish data pre- vs. post-restoration



Source: Carline and Walsh. 2007. Responses to riparian restoration in the Spring Creek Watershed, Central Pennsylvania. Restoration Ecology 15(4):731-742

METHODS

SUBSTRATE →

- Brown trout redds
- Stovepipe sample
- Percent fines

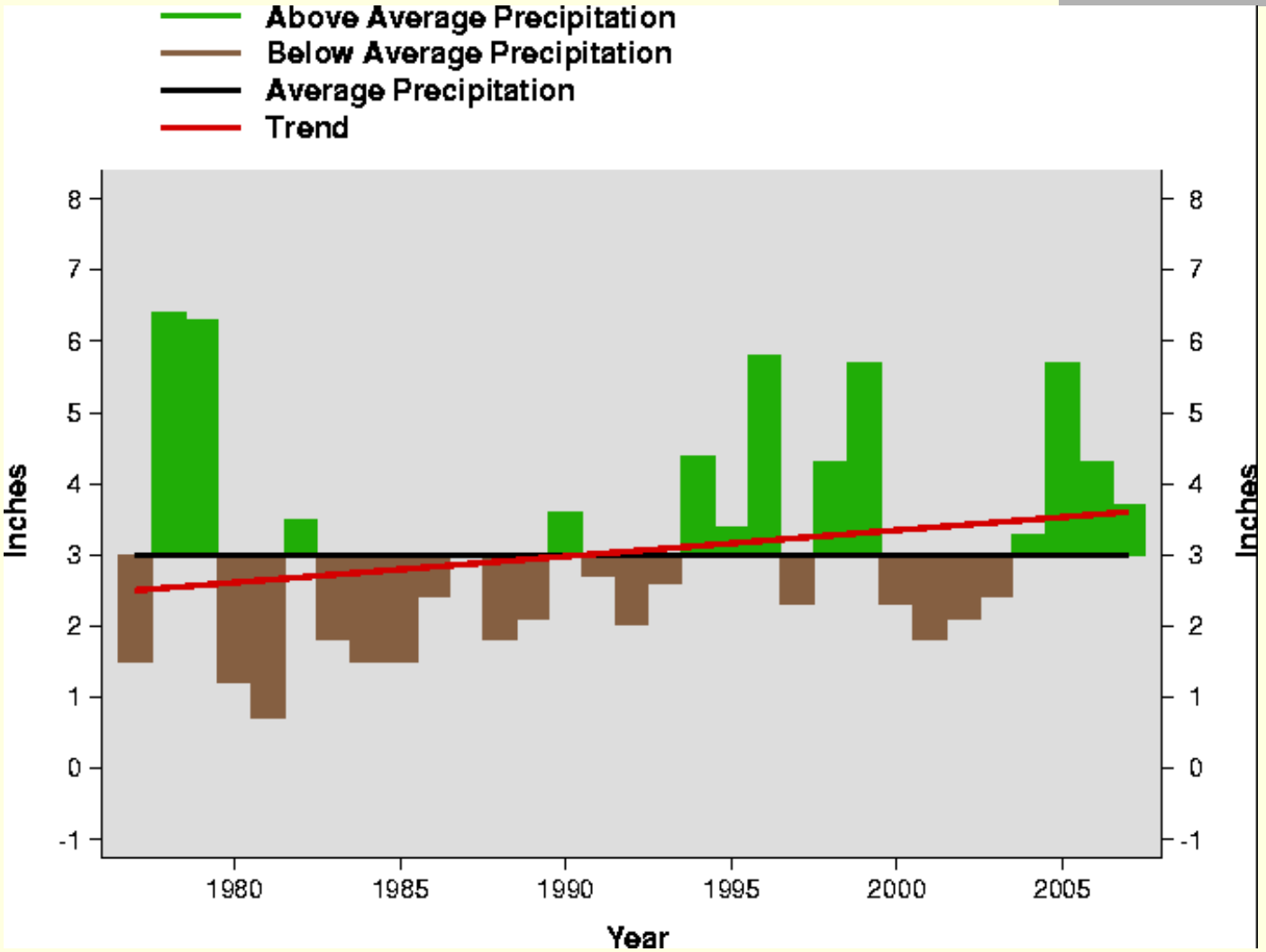
FISH →

- May and August
- Successive removal method
- Electrofishing
- Brown trout density

MACROINVERTEBRATES →

- May and August
- Riffle habitats
- Triplicate surber samples
- Density and richness measures

Statewide Precipitation Trends Since 1977

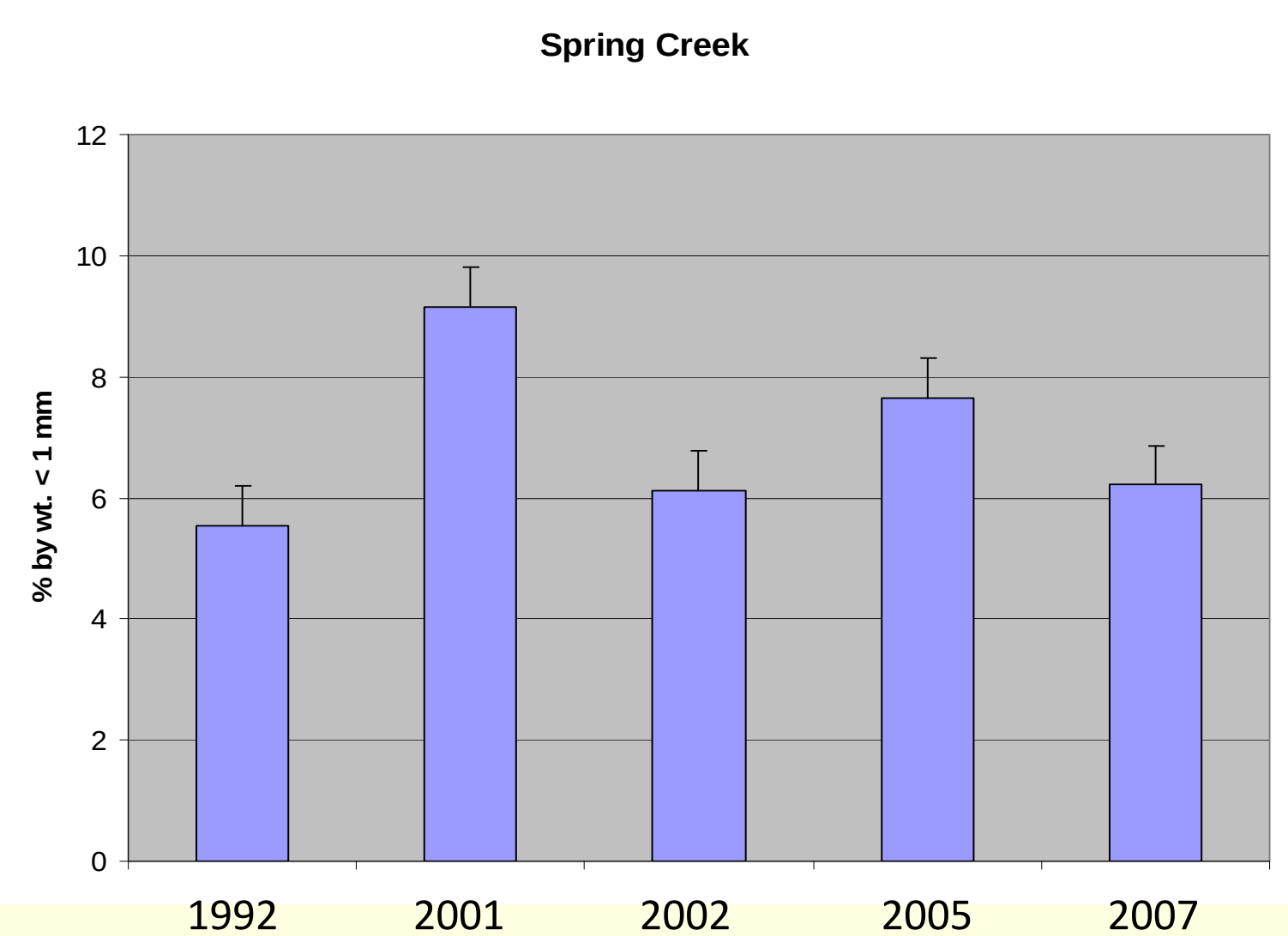


Source: http://www.erh.noaa.gov/ctp/hydro/drought/

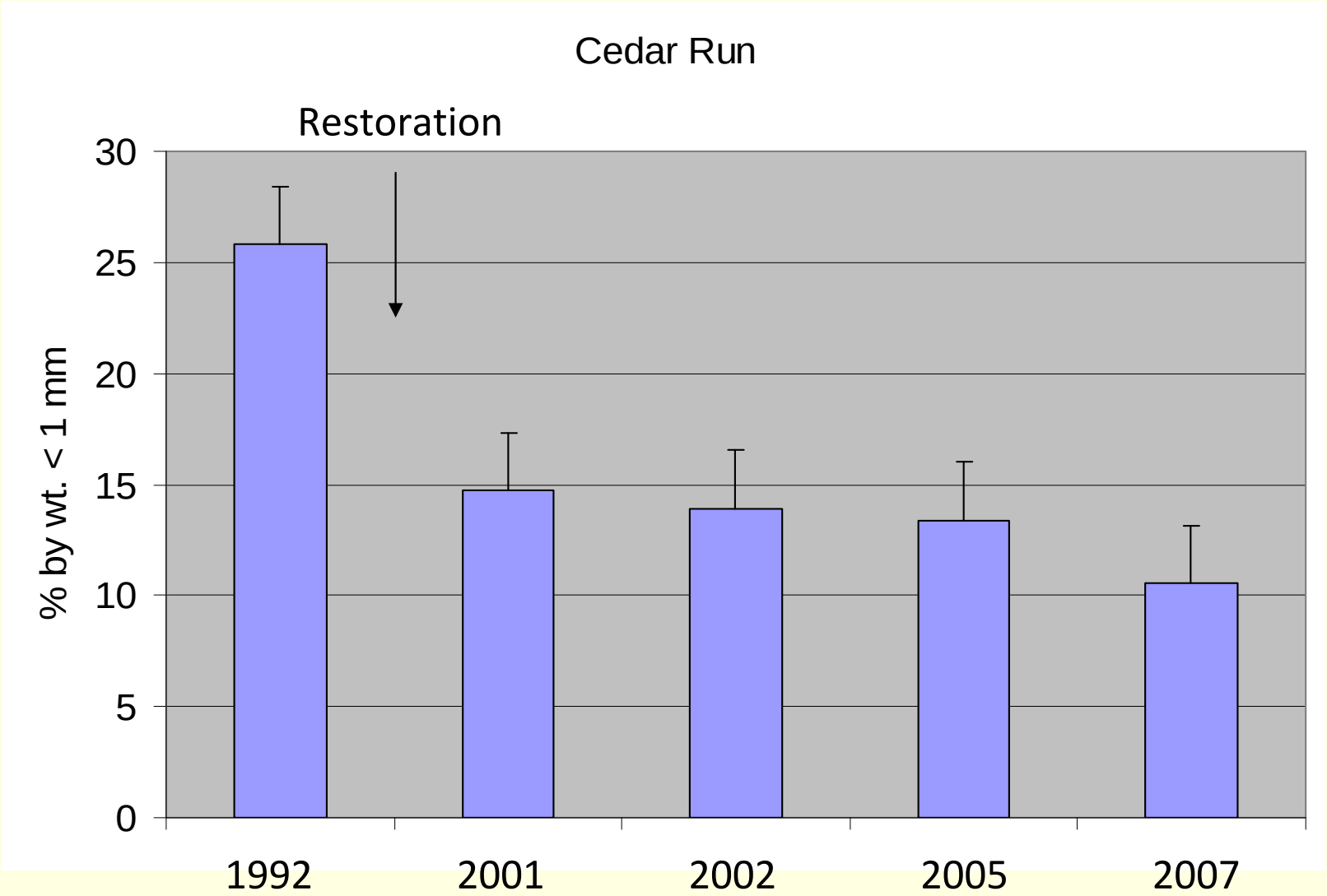
RESULTS

SUBSTRATE

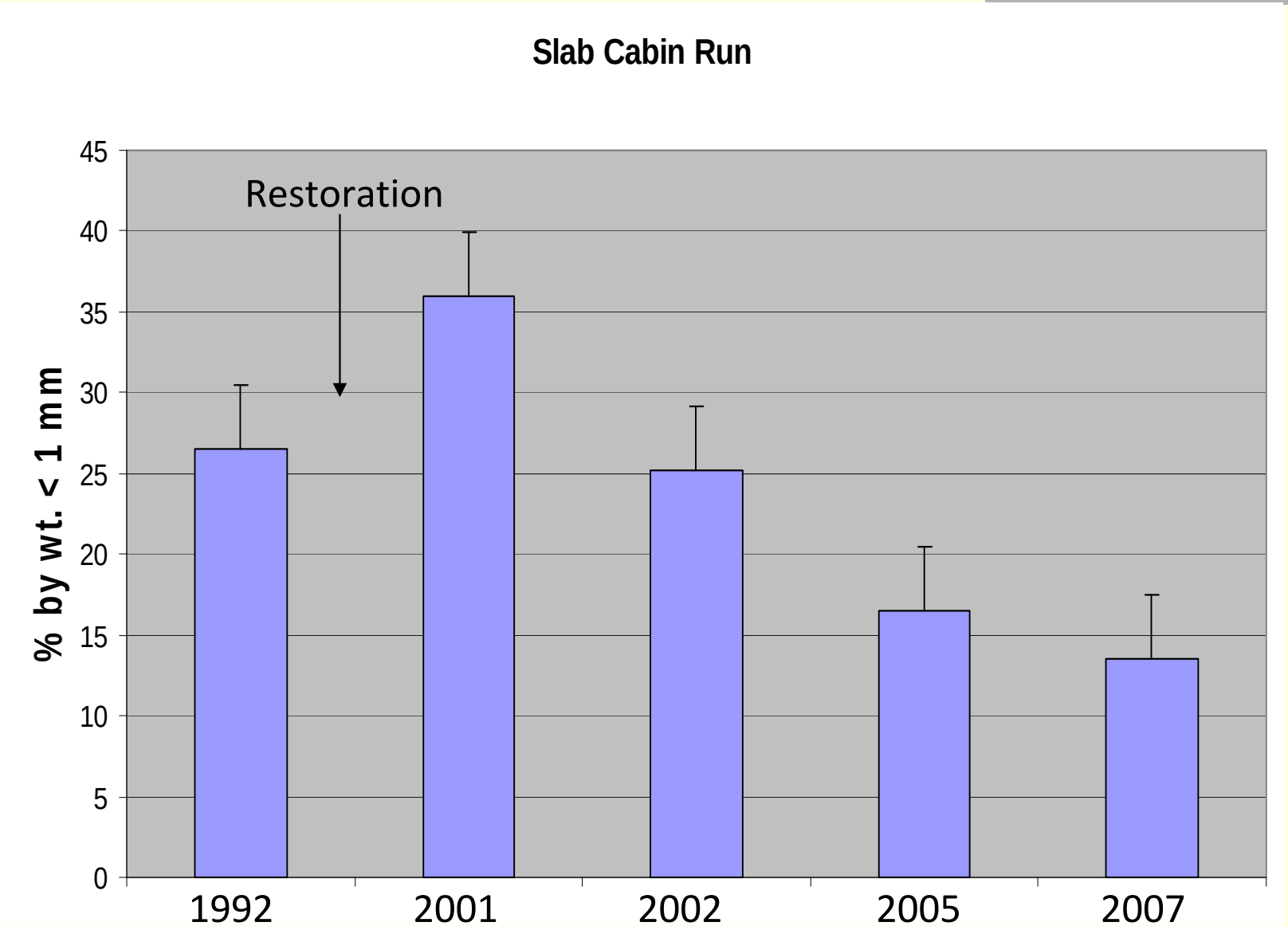
% Fines Upper Spring Creek



% Fines Cedar Run



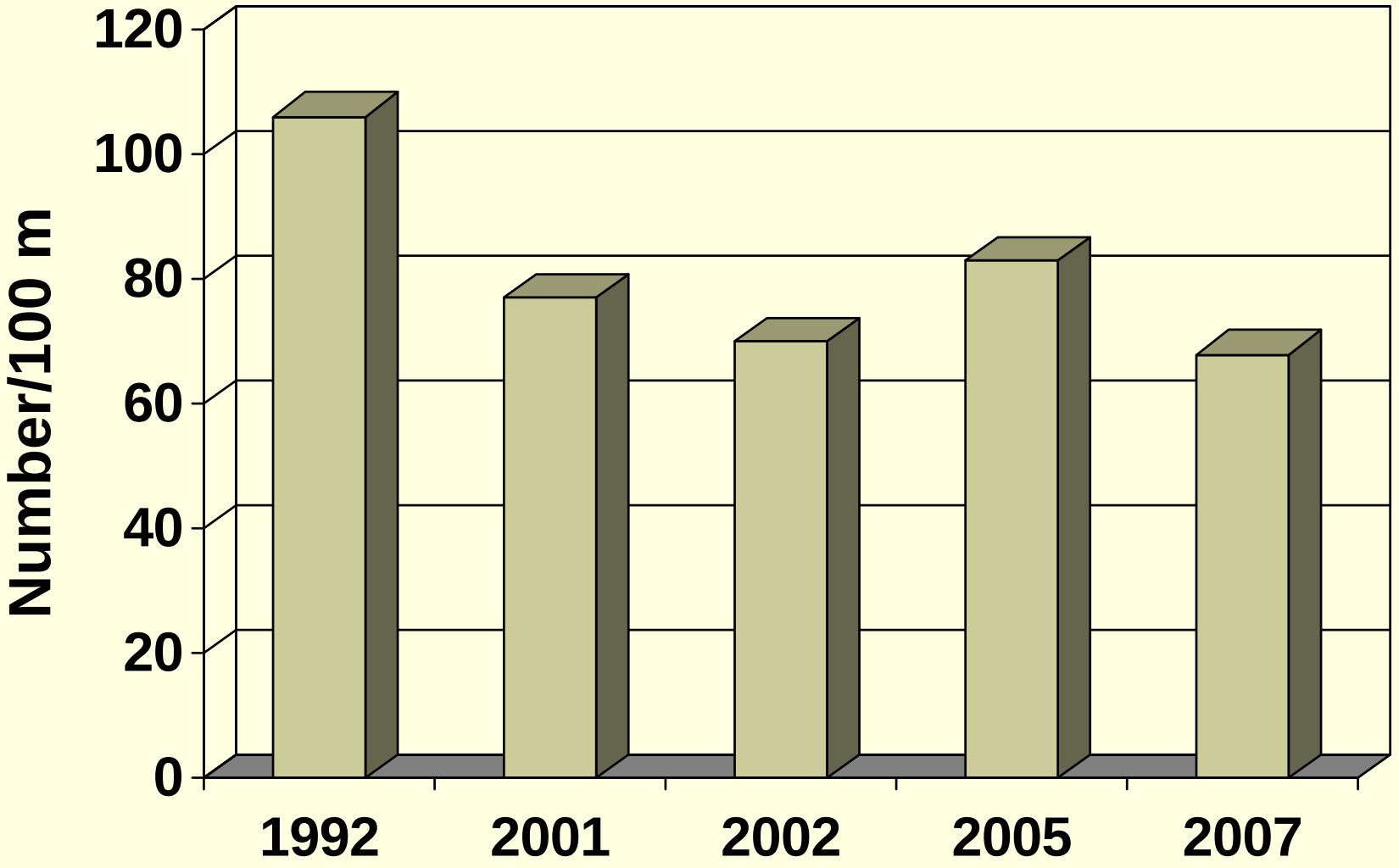
% Fines Slab Cabin Run



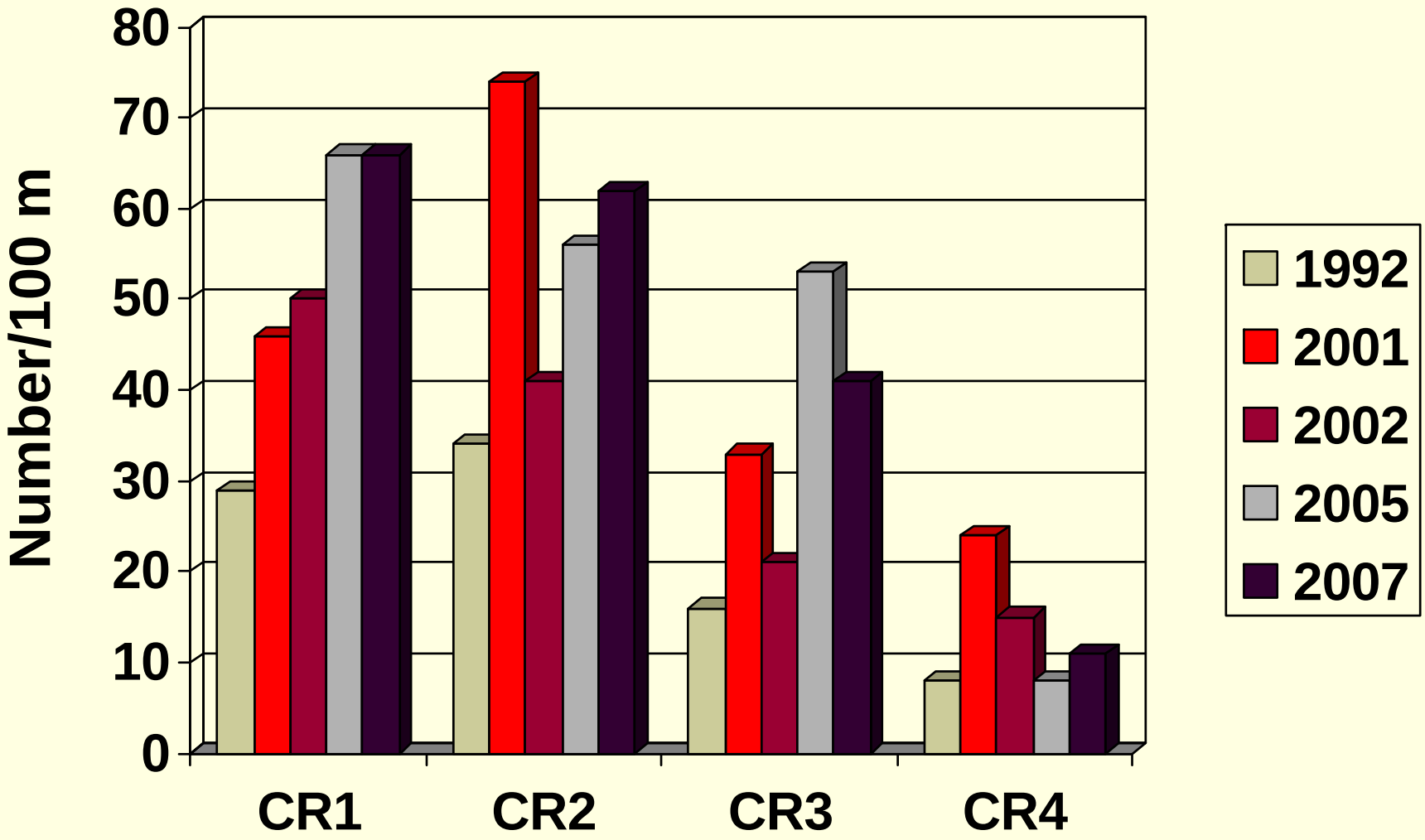
RESULTS

FISH

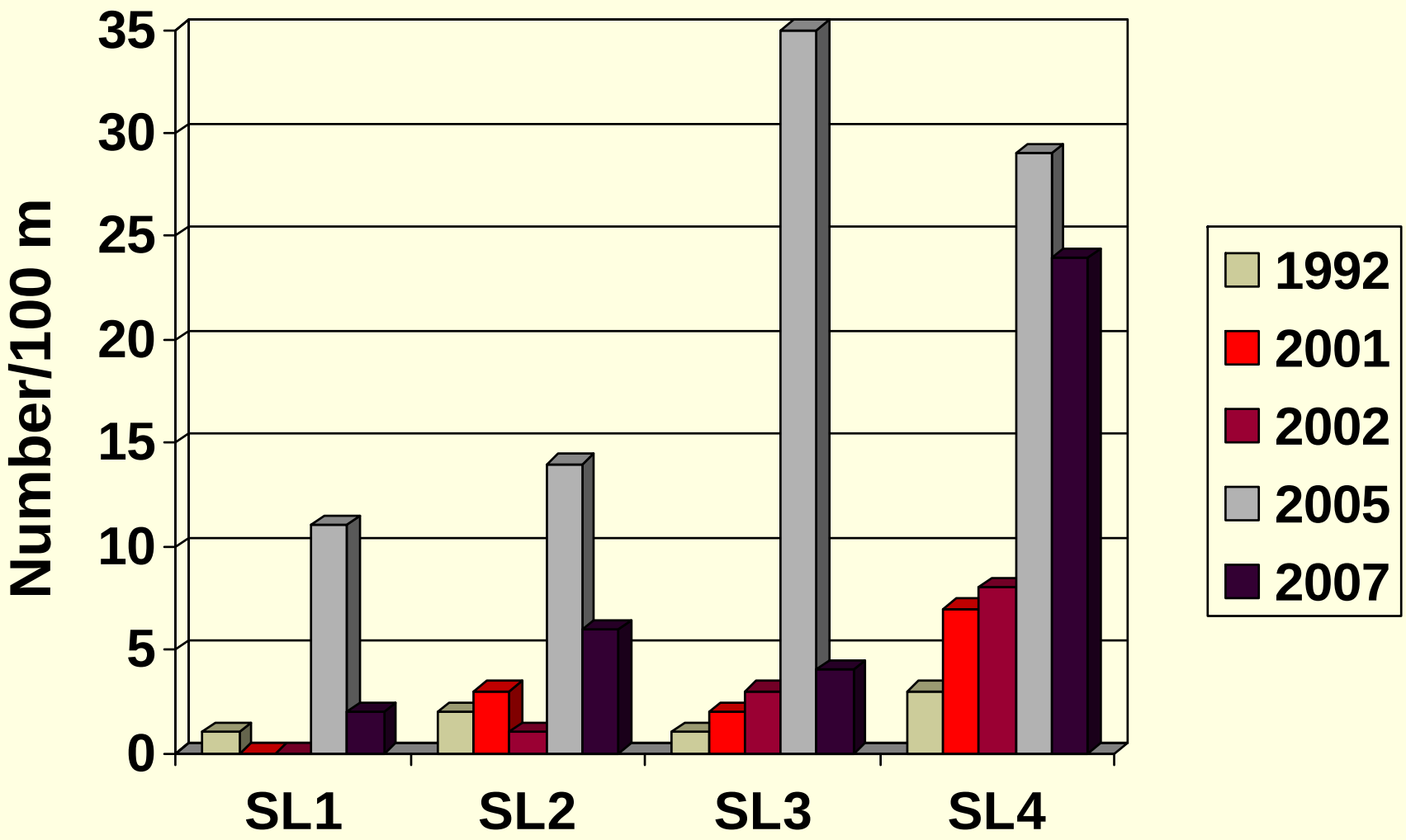
Spring Creek age-1 and older brown trout – May



Cedar Run, age-1 and older brown trout, May



Slab Cabin Run, age-1 and older brown trout, May



RESULTS

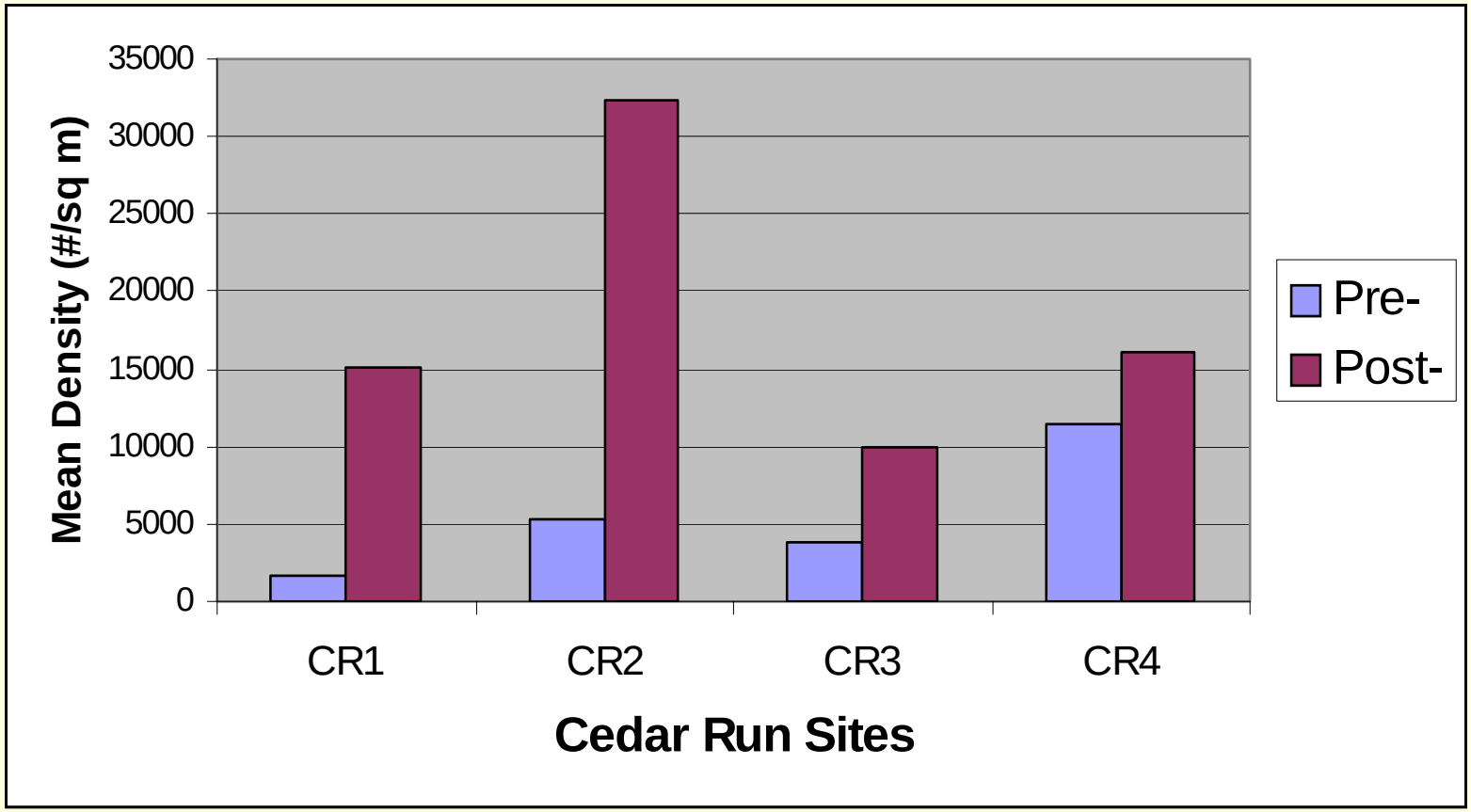
MACROINVERTEBRATES

Macroinvertebrate Community Metrics

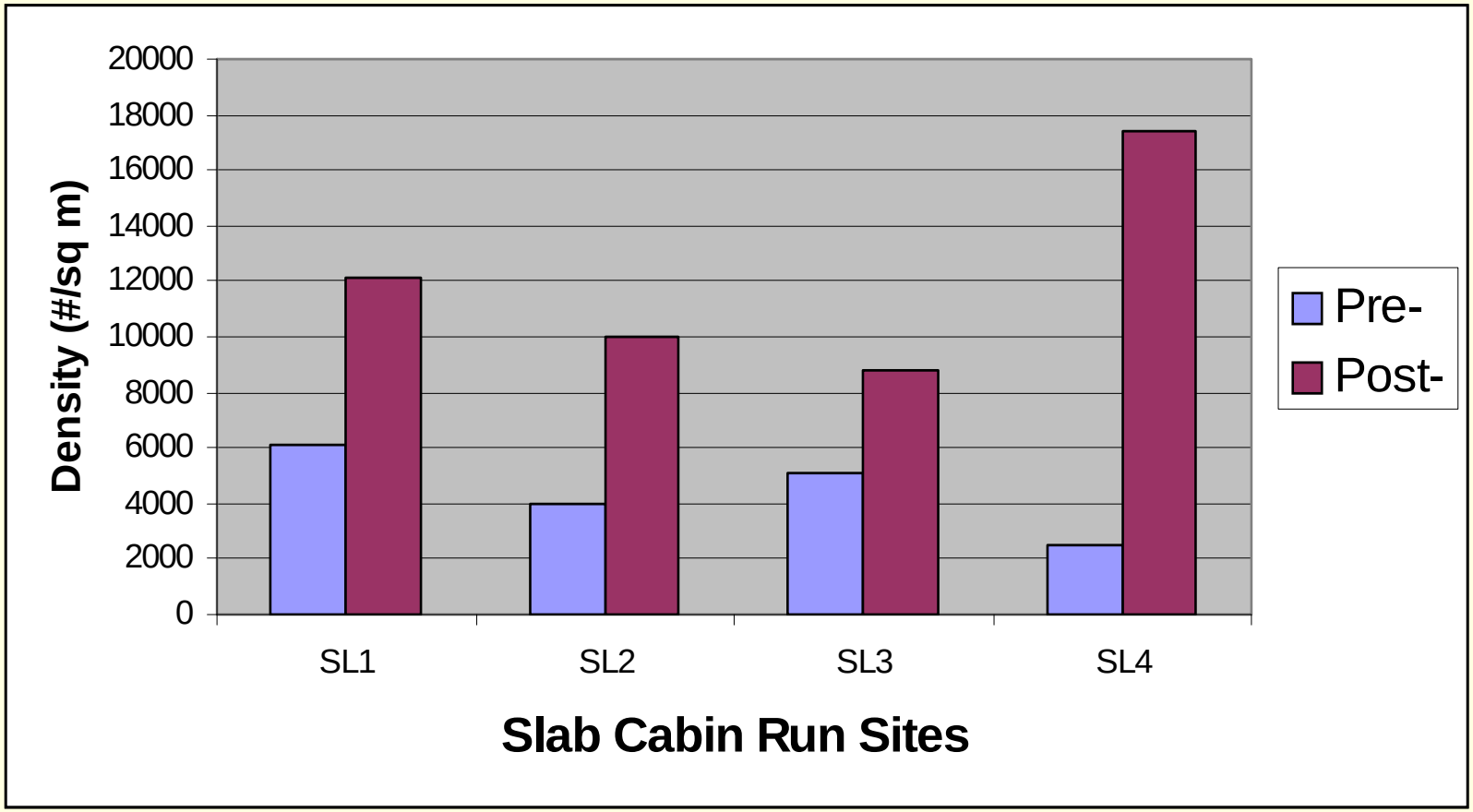
- Density
  - -- Total individuals per square meter
  - -- Ratio of total individuals for reference stream to treatment stream

- Community Composition
  - -- Taxa richness and EPT richness between pre-restoration vs post-restoration
  - -- Mean difference in taxa richness and EPT taxa between treatment stream and reference stream

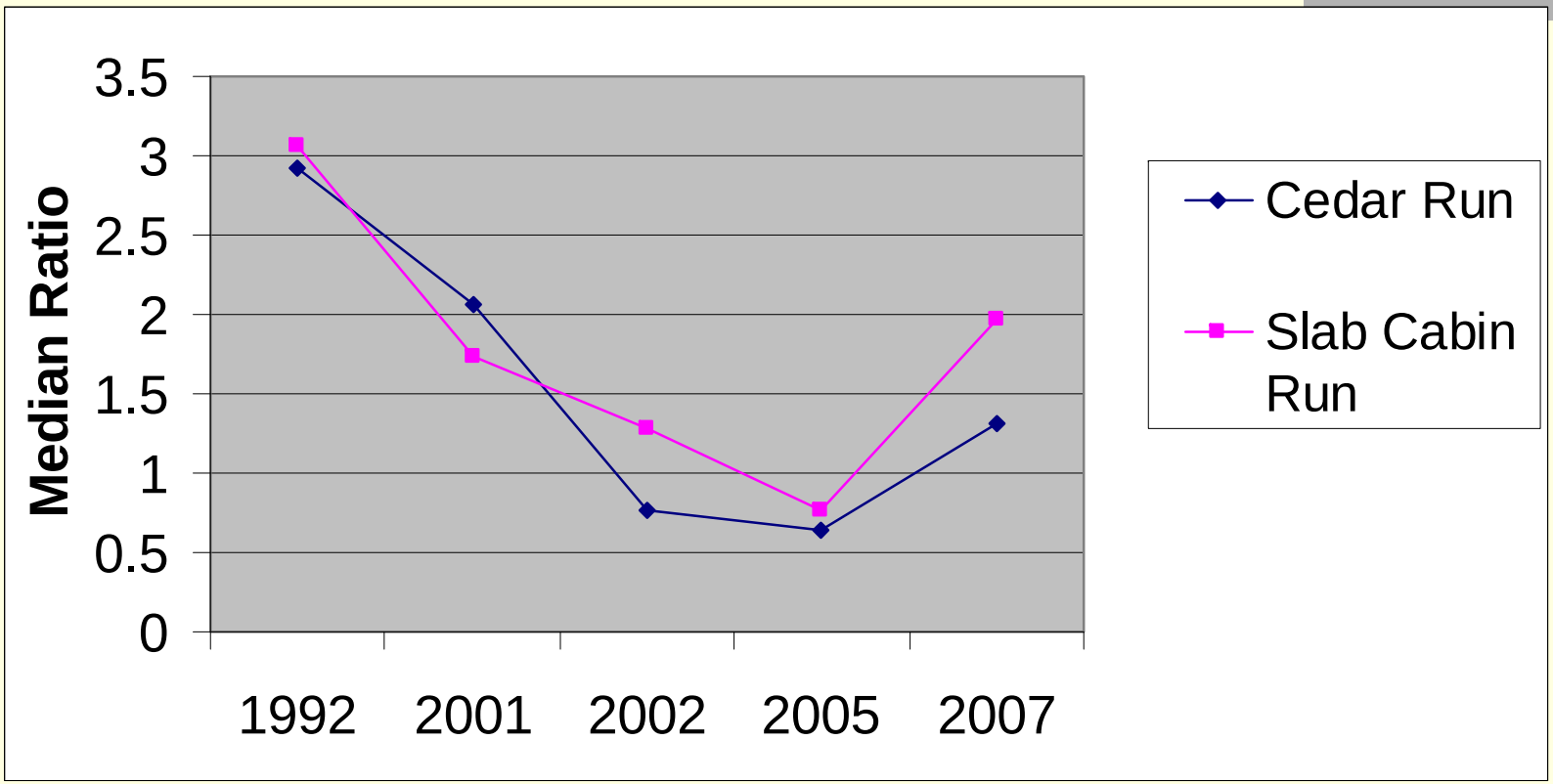
Cedar Run
Stream Macroinvertebrate Densities



Slab Cabin Run
Stream Macroinvertebrate Densities

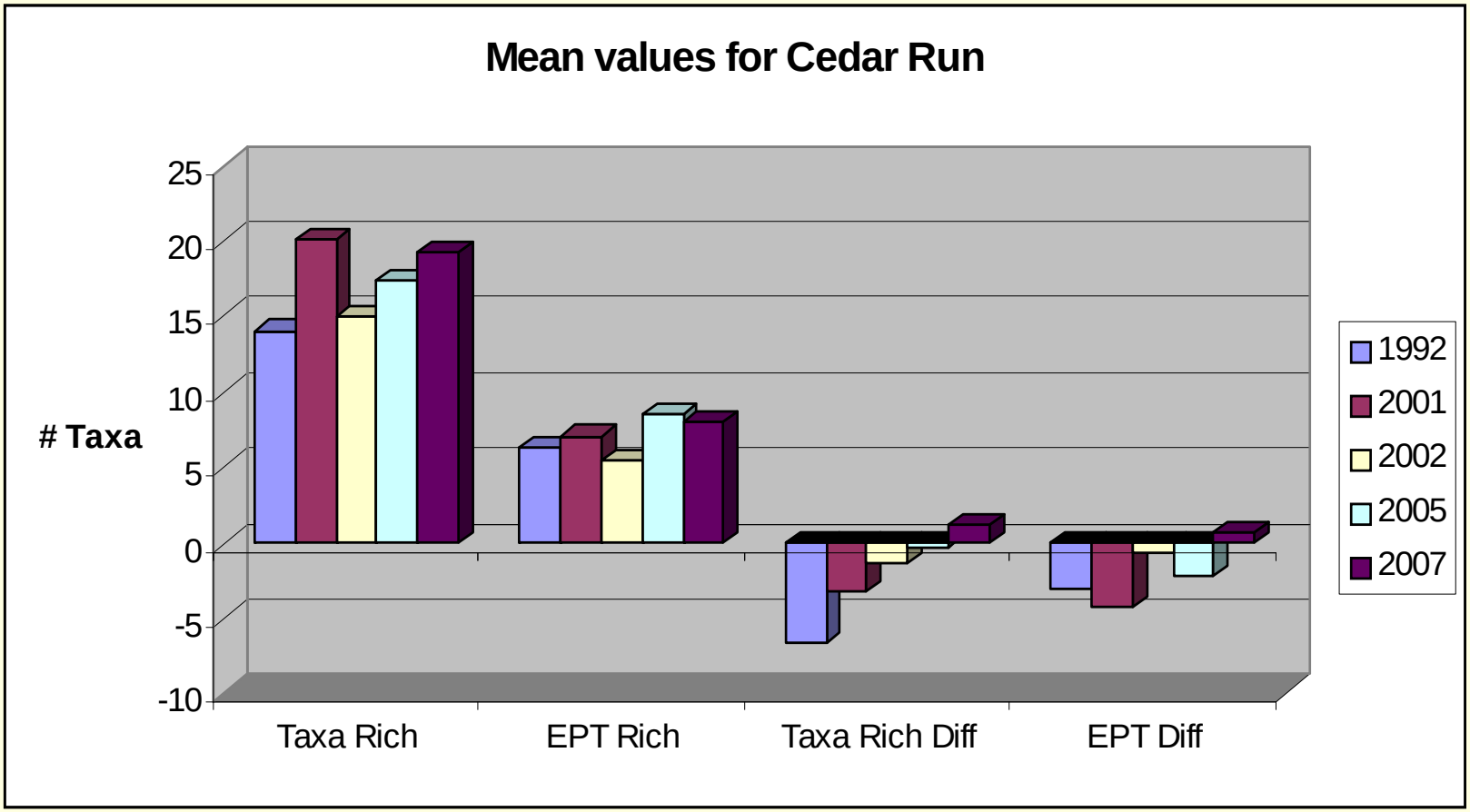


Ratio of Macroinvertebrate Density Reference Stream to Treatment Stream

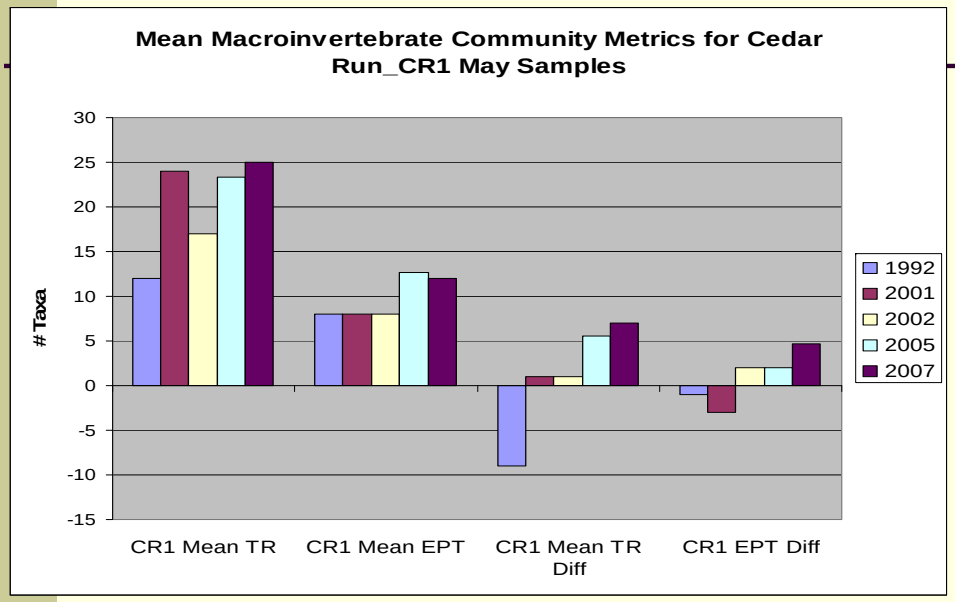


Changes in reference/treatment ratios pre-treatment to post-treatment period:	Cedar Run 2.92 to 0.84 (p = 0.047)	Slab Cabin Run 3.07 to 1.10 (p = 0.019)

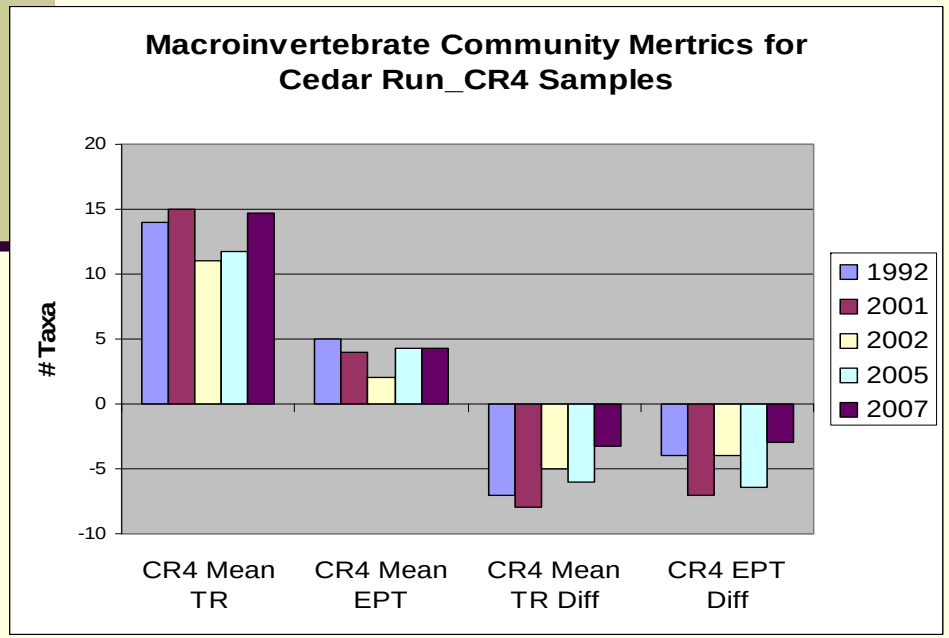
Cedar Run – Macroinvertebrate Community Composition Metrics



Cedar Run Reach Level

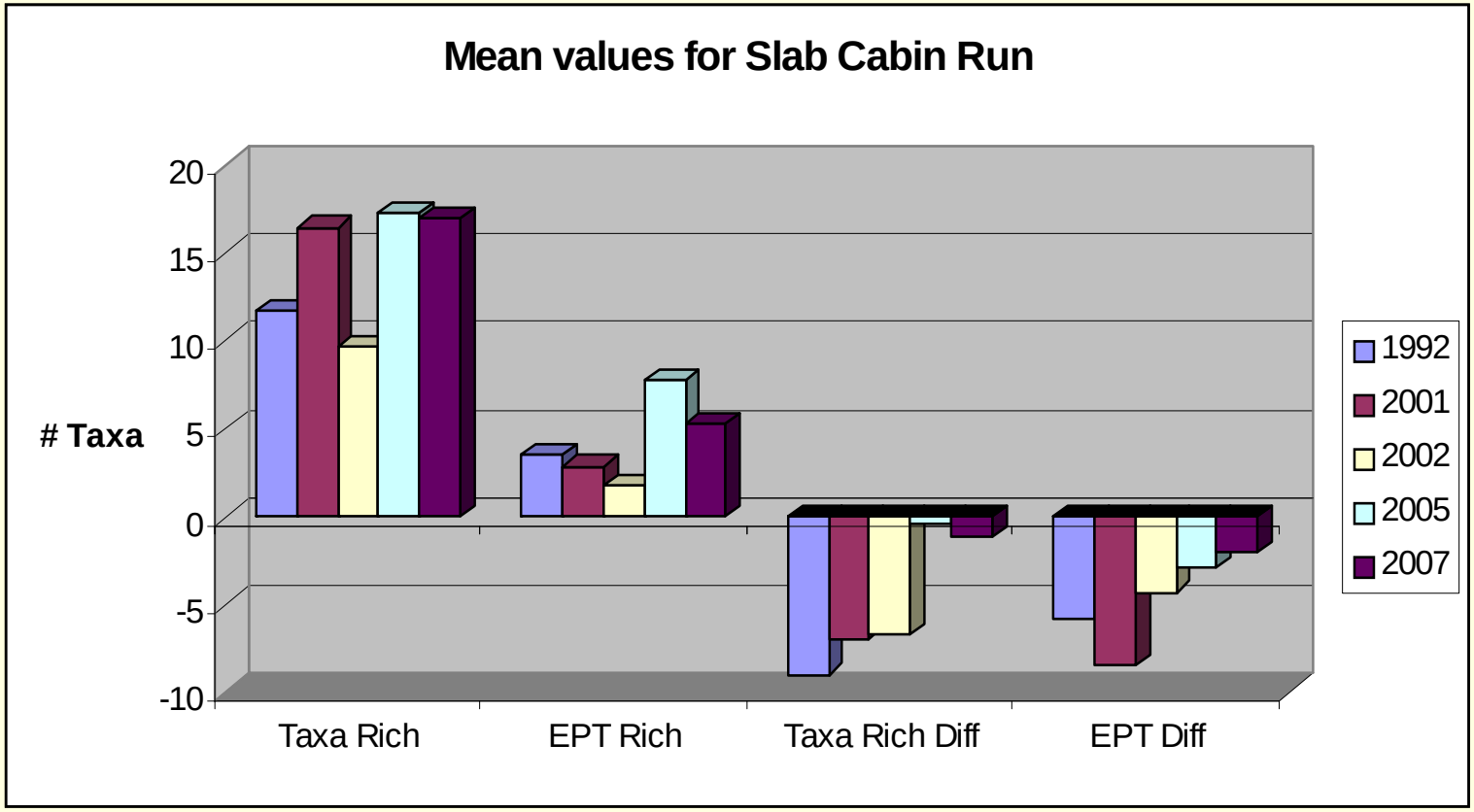


CR1	
Metric	R-sq (adj) (*p*-value)
Taxa Richness	63.8% (*p*=0.000)
EPT Taxa	40.6% (*p*=0.007)
Taxa Rich Diff	84.9% (*p*=0.000)
EPT Diff	34.1% (*p*=0.013)



CR4	
Metric	R-sq (adj) (*p*-value)
Taxa Richness	0.0% (*p*=0.656)
EPT Taxa	0.0% (*p*=0.376)
Taxa Rich Diff	0.0% (*p*=0.354)
EPT Diff	0.0% (*p*=0.941)

Slab Cabin Run – Macroinvertebrate Community Composition Metrics



RESULTS: Summary of Pre-restoration to Post-restoration Changes

- SUBSTRATE: Percent fines declined significantly but response in Slab Cabin Run delayed by drought.
- FISH: Density of age-1 and older brown trout increased but magnitude of the response small for Slab Cabin Run where brown trout densities were lower than Cedar Run and Spring Creek.
- MACROINVERTEBRATES: Densities increased after restoration; community metric responses not as strong. Cedar Run displayed significant improvement in reaches downstream of treatment areas but responses in Slab Cabin Run obscured by drought.

CONCLUSIONS

- Narrow grass riparian buffers, stream crossings, and bank stabilizations appear to be effective in reducing sediment loading in Cedar Run and Slab Cabin Run.

- Percent fines, densities of brown trout and macroinvertebrates are most likely good water quality indicators for evaluating BMP performance, but the magnitude of their responses can be affected by drought. Macroinvertebrate richness measures either do not respond to these specific BMPs or may require more time to produce a consistent and significant response.

- Monitoring of BMP performance should include sufficient time for tracking the effects of dry and wet years on stream abiotic and biotic components.

ACKNOWLEDGMENTS

Thanks to CEAP for funding this project!

- Dr. Robert P. Brooks, Director, Penn State Cooperative Wetlands Center (Riparia), Professor of Geography and Ecology

- Dr. Robert F. Carline, Unit Leader (retired), Pennsylvania Cooperative Fish and Wildlife Research Unit, Adjunct Professor of Fisheries