Long-term Soil Monitoring at USGS Reference Watersheds

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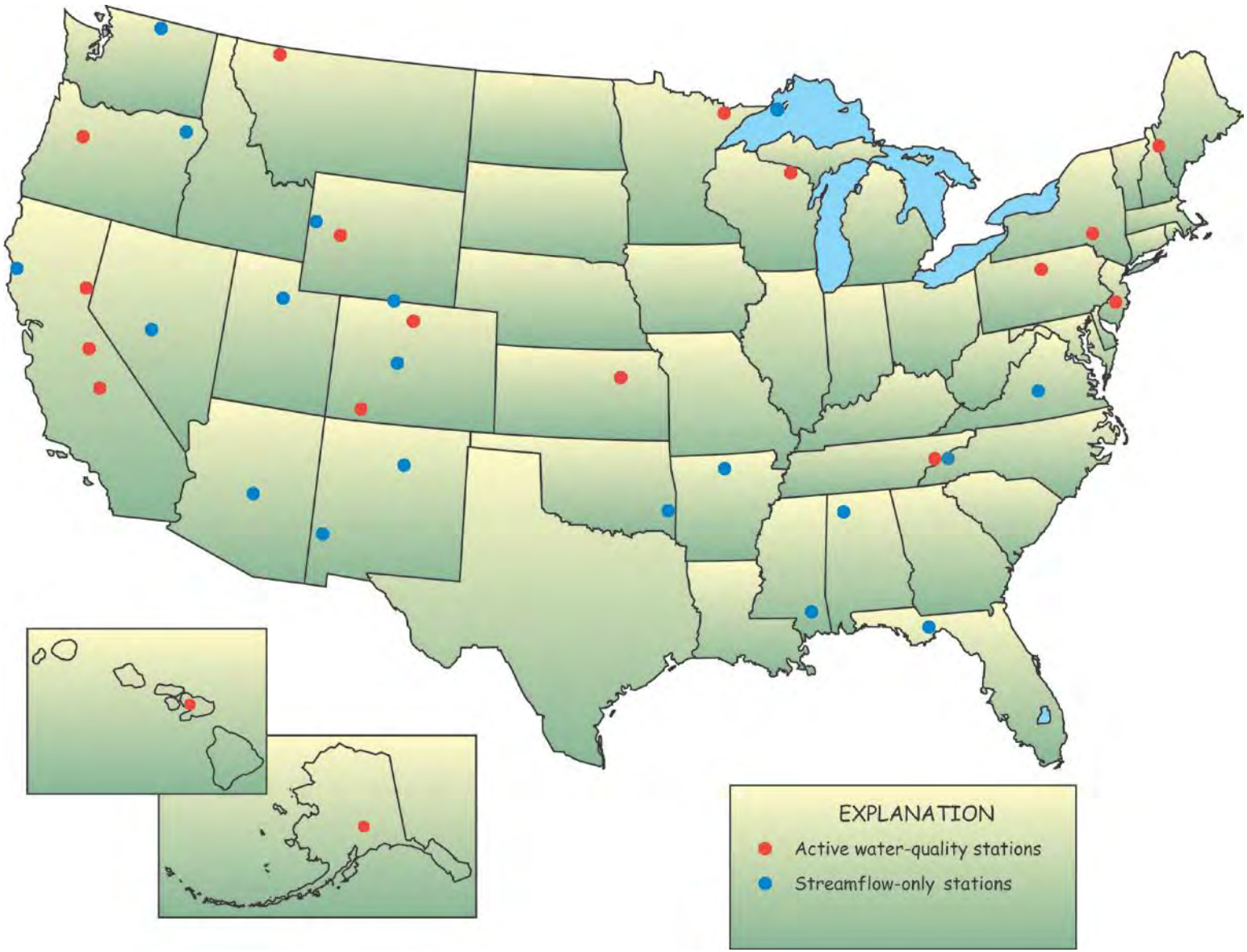
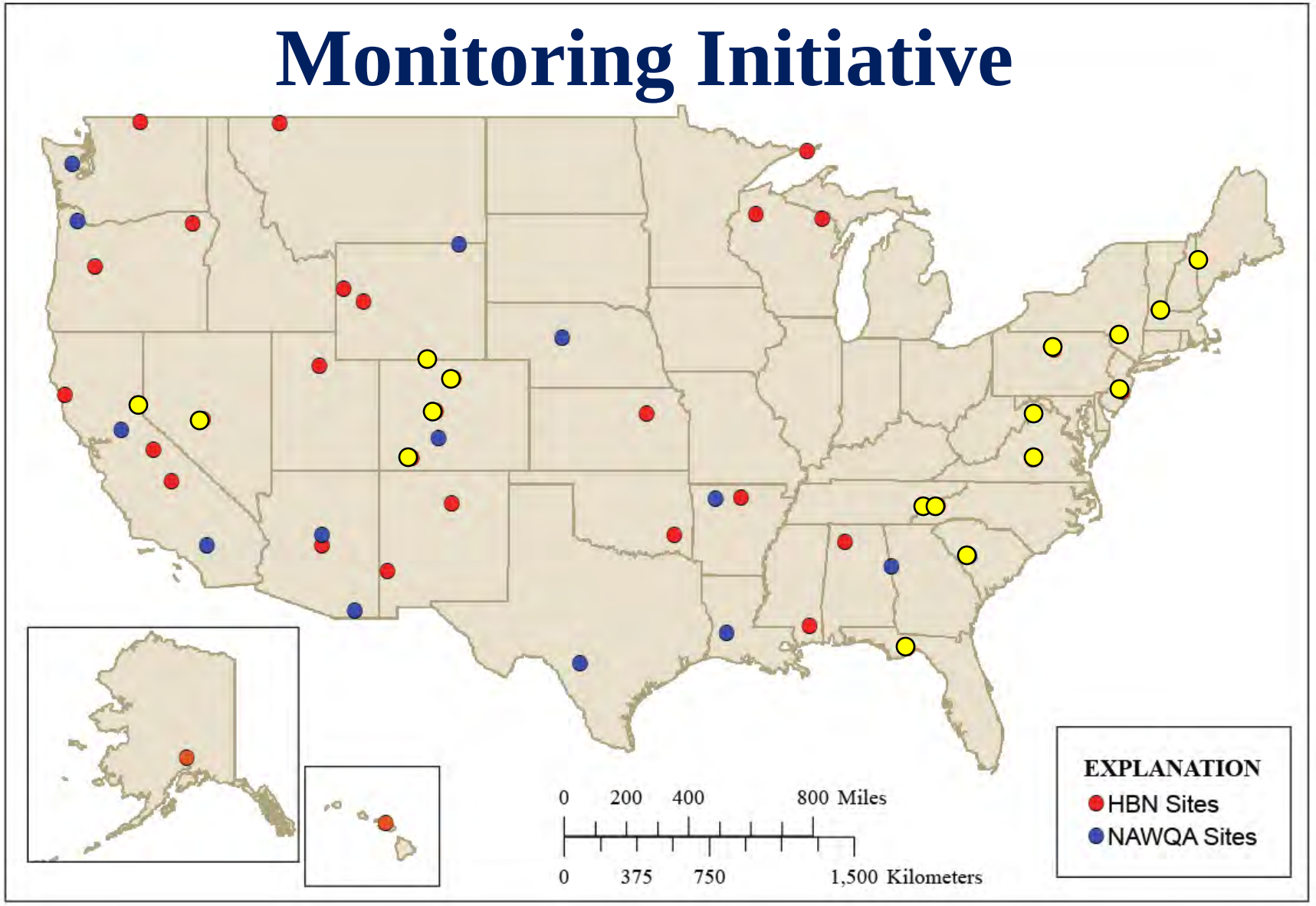
The Hydrologic Benchmark Network



USGS Reference Site Soil Monitoring Initiative



What do we mean by Reference Watershed?

Hydrologic Benchmark Network

- No manmade storage, regulation, or diversion was to exist in the basin
- Ground water in the basin was not to be affected by pumping from wells
- Conditions favorable for accurate measurement of streamflow and water quality
- Small potential for special natural changes, such as beaver activity, overgrazing, or extensive fire.
- Little or no chance of human disturbance possible (e.g., National and State parks) were favored.
- Medium sized watersheds were targeted, not so small that they would be affected by localized climatic conditions and not so large as to be affected by human activity, the mean basin area was 50 square miles.

What do we mean by Reference Watershed?

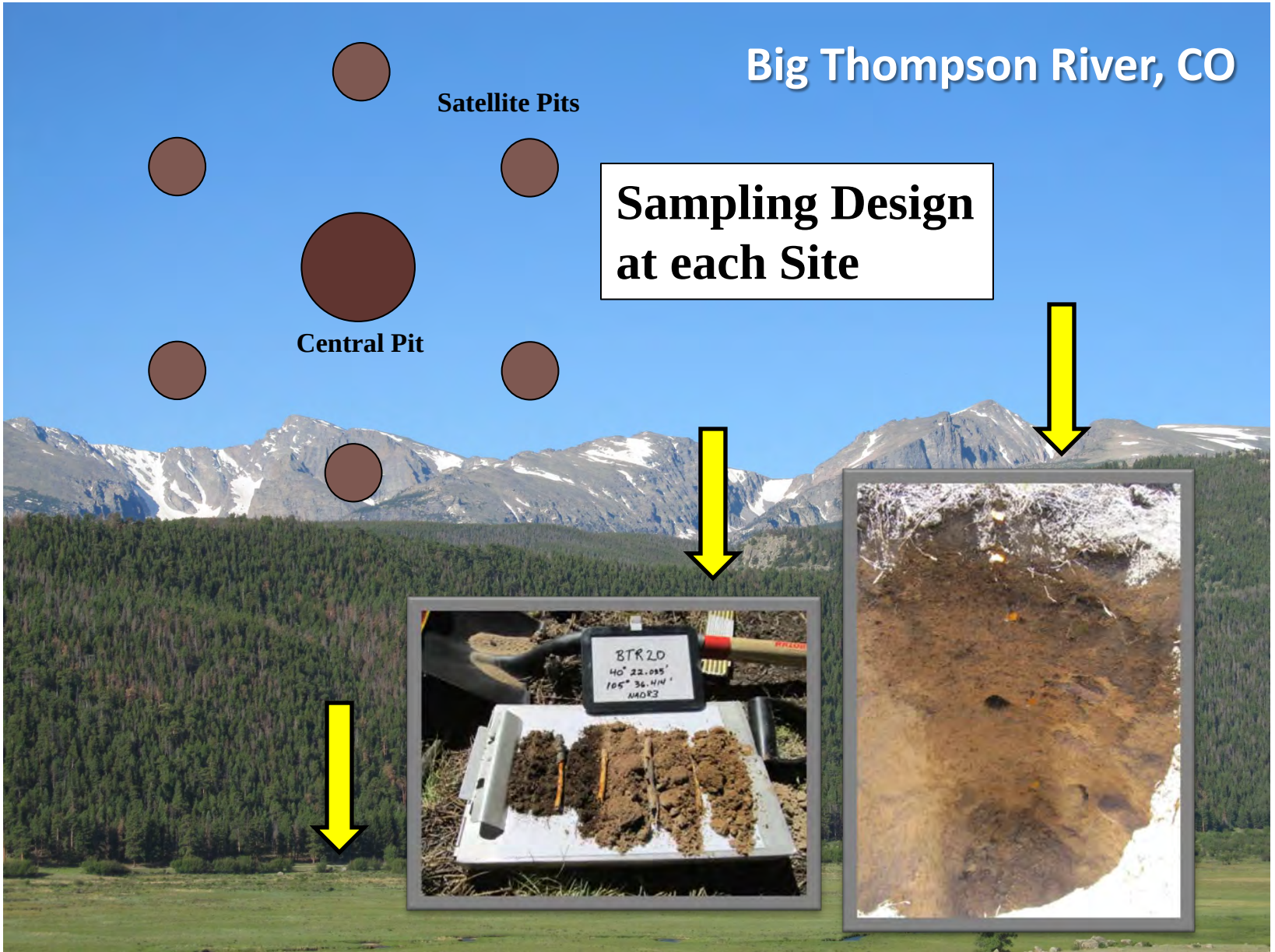
NAWQA

- Less than 5% urban land cover in basin
- Generally less than 50% agricultural land cover in the basin (this was relaxed in the Midwest, where riparian undeveloped land cover was considered the most useful way to identify the "least disturbed" sites.
- Sites downstream from unique natural areas.
- Best professional judgment of local science center and other agency personnel (often confirmed by their knowledge of the species present and not the specific samples collected).

Network Goal

The goal of the collaborative HBN – NAWQA soil monitoring initiative is to track changes in representative soils within each reference watershed - rather than characterize the soils throughout each watershed (which is not possible for us to do).

Methods

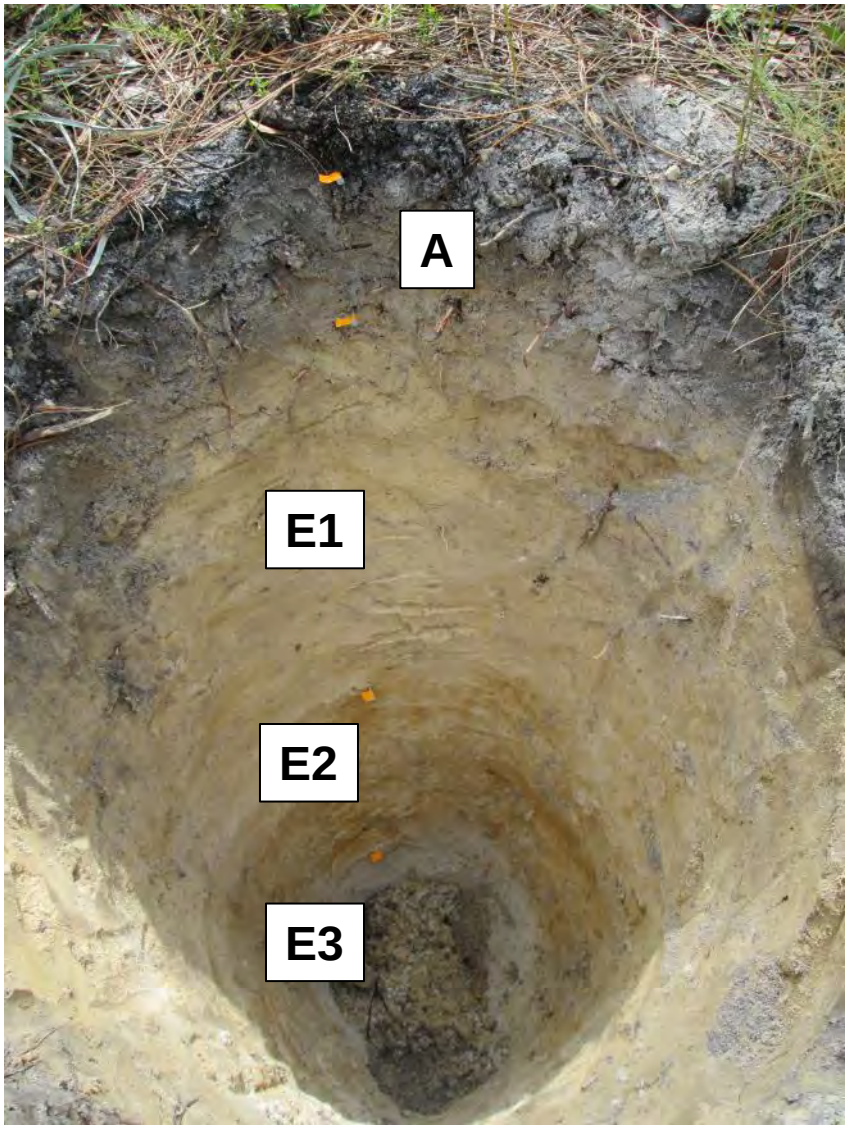

Big Thompson River, CO
Satellite Pits
Central Pit
Sampling Design at each Site
BTR20
40° 22.035'
105° 36.414'
NAD83

Green River, VT
Ridgetop Soil Pit

Young Woman's Creek, PA
Ridgetop Soil Pit

Young Woman's Creek, PA
Midslope Soil Pit

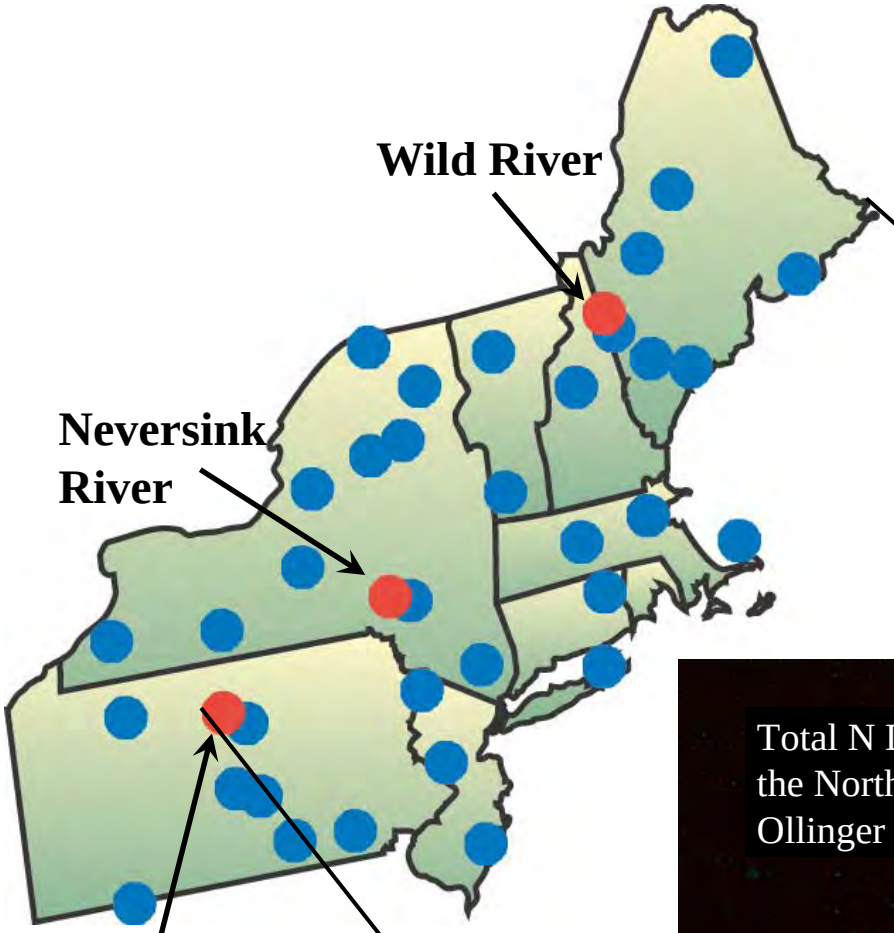
Lutterloh Series
Sopchoppy River, Florida
30° 14’ 9.3” N; 84° 34’ 4.8”



Laboratory Analyses

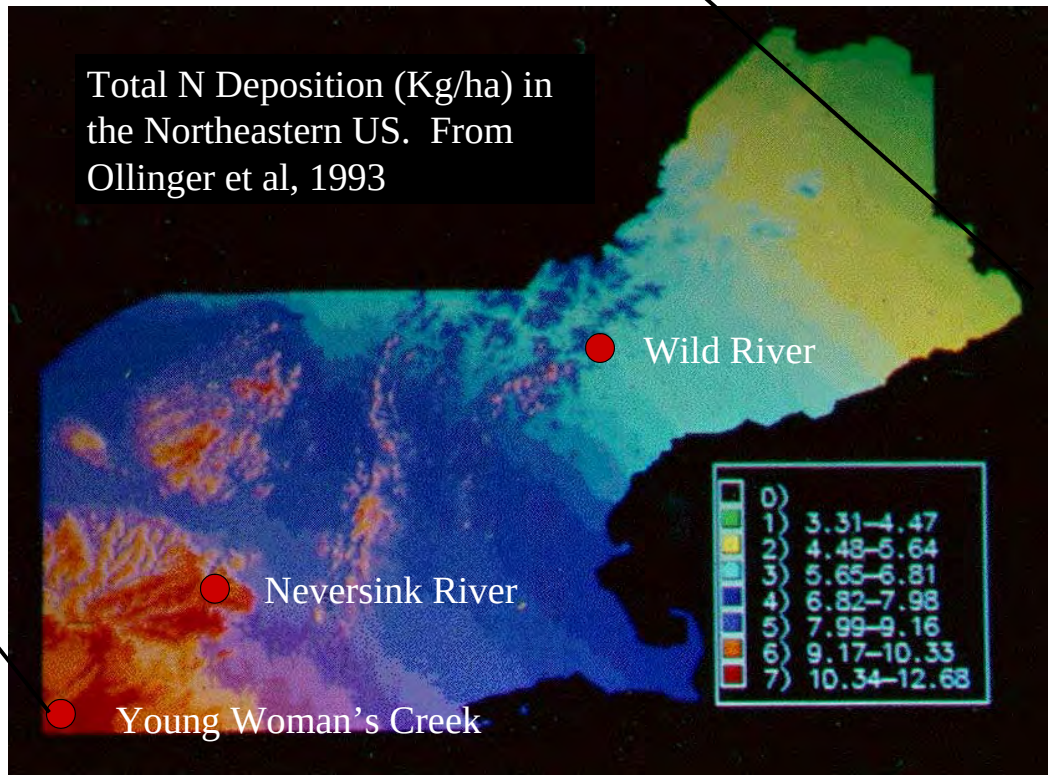
- **Soils are air dried and sieved - 4 mm sieve (organic samples) or a 2 mm sieve (mineral samples).**
- **Moisture content of the air-dried samples is determined by oven drying at 65^{o}C for organic samples and 105^{o}C for mineral samples.**
- **Soil samples are analyzed for exchangeable acidity and exchangeable aluminum (Al_{ex}), by KCl vacuum extraction and titration. Exchangeable bases are determined by NH_4Cl vacuum extraction, and measurement by inductively coupled plasma-emission spectrometry.**

HBN Study in the Northeast



National Atmospheric Deposition Program Site

HBN Gaging Station



Preliminary Results

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The soil chemical response to decreases in atmospheric sulfate deposition across the Northeastern United States

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'USGS Colorado WSC, Denver Federal Center, Lakewood, CO

Introduction

The Hydrologic Benchmark Network was established in 1963 to provide long-term measurements of streamflow and water quality in areas that are minimally affected by human activities. The network has consisted of as many as 57 streamflow and water-quality monitoring stations and one lake level station in 39 states. Currently, there are 37 streamflow monitoring stations in 28 states of which 17 also include water-quality monitoring. In 2011, through collaboration with the USGS National Water Quality Assessment (NAWQA) Program, measurements of aquatic biology were added to each HBN watershed and soil chemistry monitoring was added to all HBN and NAWQA Reference watersheds.

Nearly all precipitation and the chemicals deposited by wet and dry deposition interact with soil before reaching streams and lakes. This is particularly true in natural ecosystems where soil chemistry can strongly influence the chemical signature of surface water and groundwater recharge. Monitoring soil chemistry helps us to interpret the relation between changes in atmospheric deposition and changes in surface and shallow groundwater chemistry. Nevertheless, changes in soil chemistry have often been thought to occur too slowly or be too difficult to measure to be a useful indicator of environmental change.

U.S. Geological Survey Hydrologic Benchmark Network and NAWQA Reference Site Soil Monitoring Initiative

Figure 1. Hydrologic Benchmark Network (Red) and NAWQA Reference Site (Blue) soil monitoring network.

Methods

Within each watershed 3 sites are selected in soil types that are representative of soils throughout the watershed. The sites are located along a hillslope gradient if possible.

Sampling Design

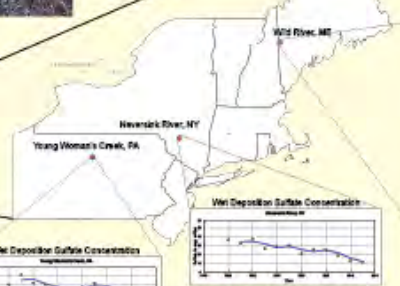
At each location a central pit is dug to the C horizon and fully described. In each of the cardinal compass directions a satellite pit is dug and the organic and top of the mineral soil are sampled.

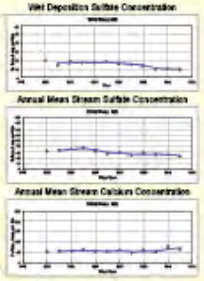
Figure 2. Young Woman's Creek near Ramova, PA and NRCS soil map. The gaging station is shown in red and the soil sampling locations are shown in green.

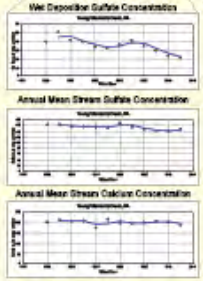
A spodosol from the Green River Watershed in Vermont

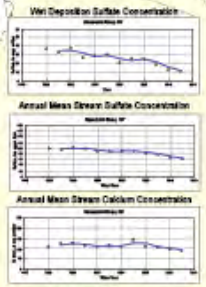
Trends in Sulfate Deposition and Stream Chemistry

During 2011, the first year of the soil monitoring initiative, three sites were sampled across the northeastern US. These sites were targeted because they had been sampled a decade earlier as part of a project to characterize soil chemistry across a gradient of acid deposition from high concentrations in Pennsylvania to low concentrations in western Maine. As a result we were able to quantify a decade of changes in soil chemistry across this same gradient during our first year of sampling.









Young Woman's Creek, PA
Forest Type: Northern Hardwoods
Surficial Geology: Thin soils overlying bedrock
Bedrock Geology: sandstone, conglomerate, siltstone, and a few calcareous lenses

Neversink River, NY
Forest Type: Northern Hardwoods
Surficial Geology: Thin glacial till
Bedrock Geology: sandstone, conglomerate, siltstone, and shale

Wild River, ME
Forest Type: Northern Hardwoods, spruce/fir at upper elevations
Surficial Geology: Thin glacial till
Bedrock Geology: metamorphosed sandstone, siltstone, and shale

Preliminary Results

- Soil total carbon and calcium decreased in Wild River and Young Woman's Creek, the sites with generally lower Ca soil concentrations.
- In the Neversink watershed soil total carbon generally increased in the A- and B-horizons at all hillslope positions, calcium increased in the A-horizon, but decreased slightly in the B-horizon.
- Greater sample numbers at each hillslope position would provide more statistical power. The current schedule for the HBN soil monitoring initiative is to sample every site once every 6 years. We recommend lengthening the sampling interval in order to increase the number of samples collected without increasing the budget.
- These generally calcium poor soils have not shown a substantial recovery in response to the decrease in atmospheric sulfate concentration which may explain the slow recovery in stream water SO_4 and Ca.

Acknowledgements

The authors would like to thank the staff of the USGS Soil and Water Quality Laboratory in Troy, N.Y. for all of the chemical analyses.

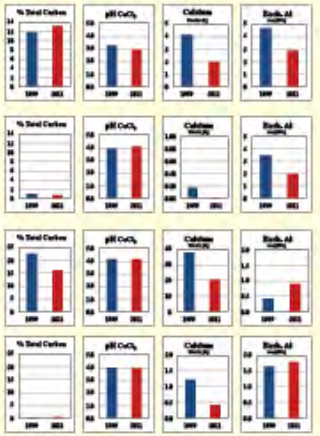
2001 to 2011
10 Years of Soil Change in the Northeastern United States

Young Woman's Creek, PA

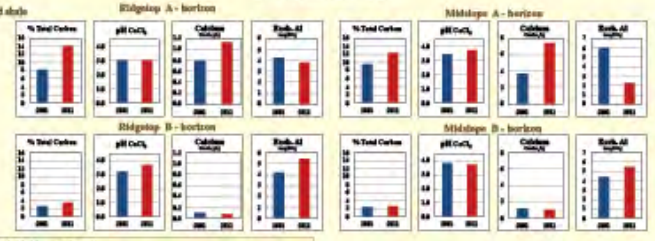
Ridgetop (flat)

Midslope (steep)

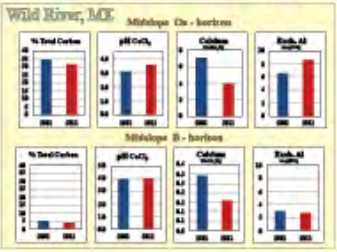
Low slope (moderately steep)

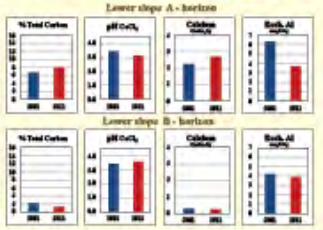


Neversink River, NY

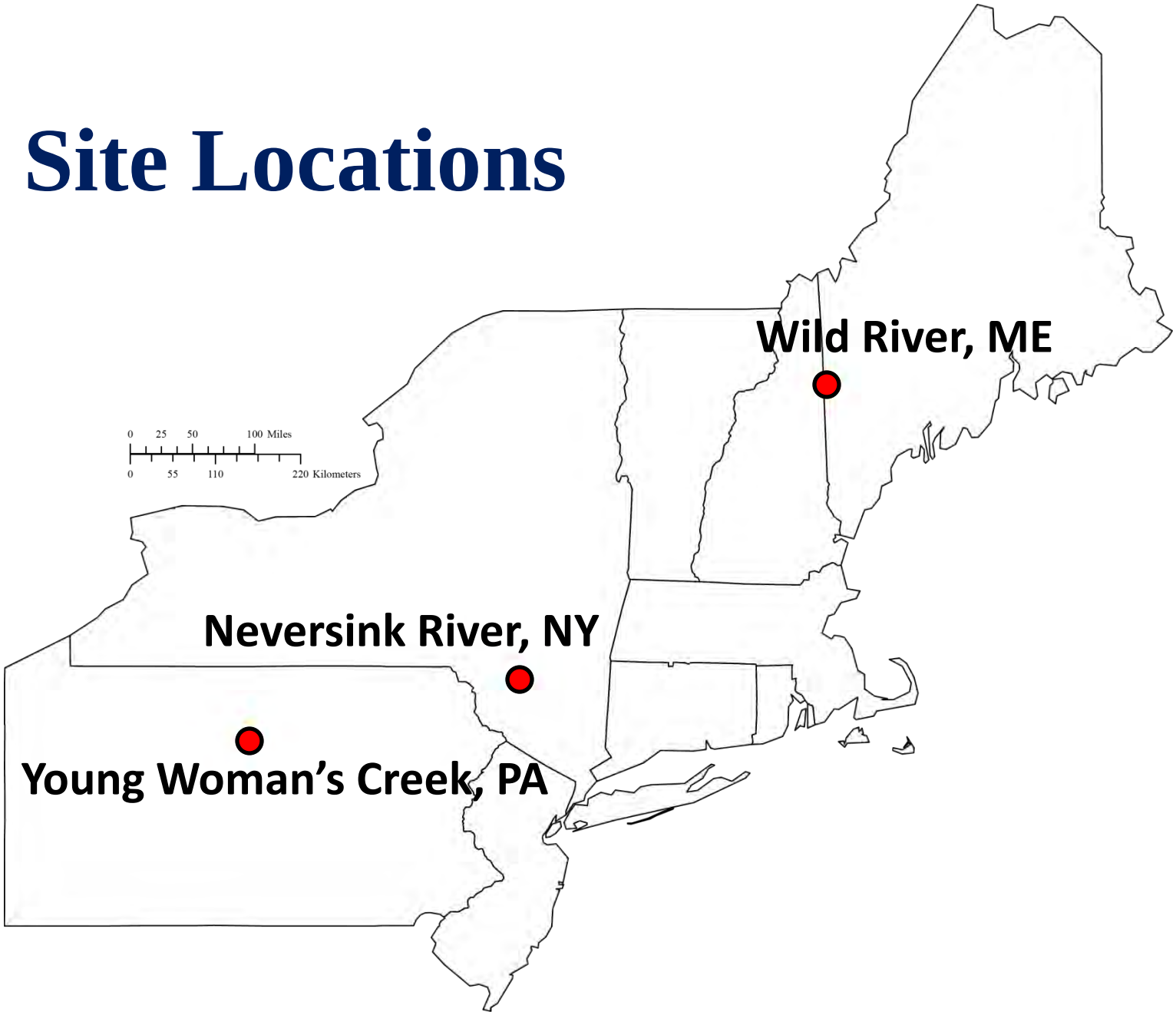


Wild River, ME



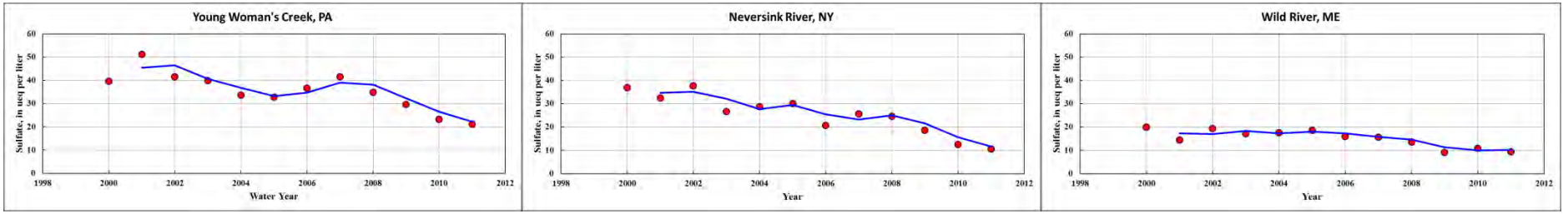


Site Locations

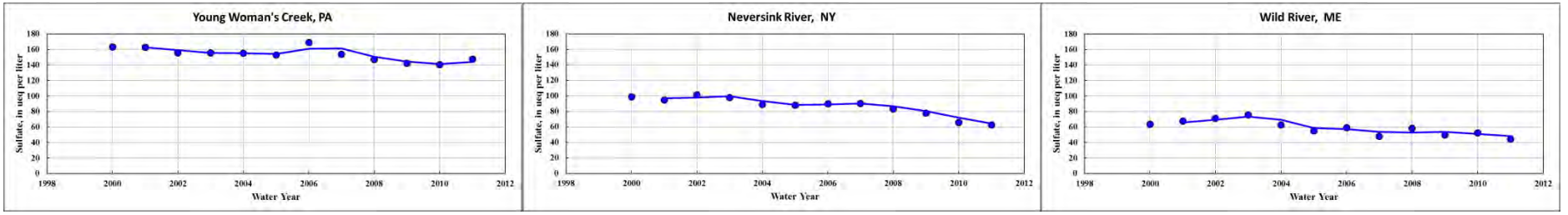


Precipitation and Stream Chemistry

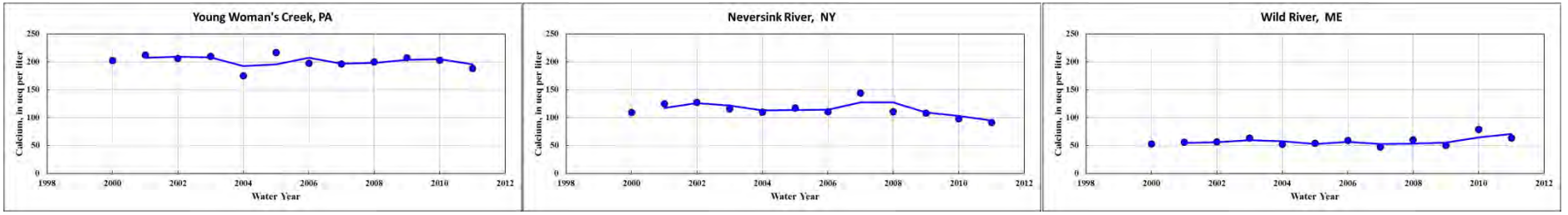
Young Woman's Creek, PA **Neversink River, NY** **Wild River, ME**



NADP Annual Mean Wet Precipitation Sulfate Concentration



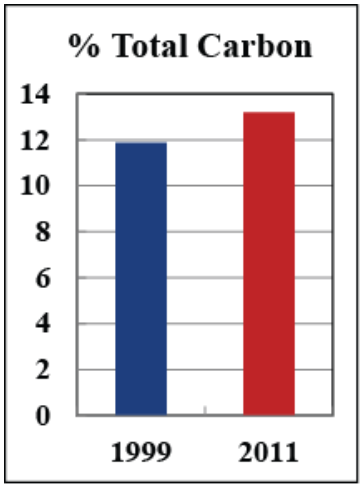
Annual Mean Stream Water Sulfate Concentration

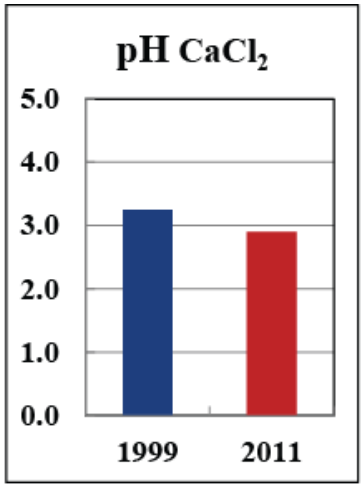


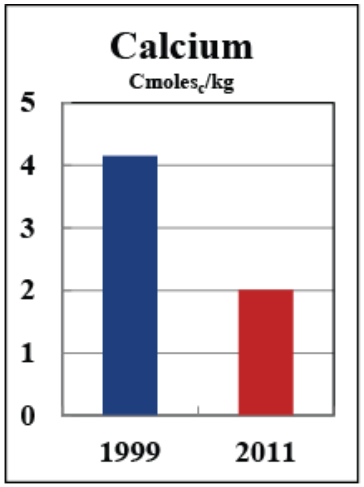
Annual Mean Stream Water Calcium Concentration

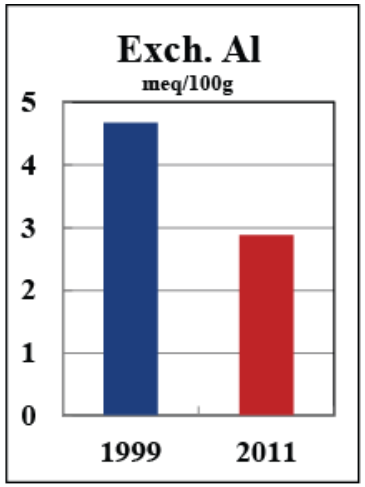
Young Woman's Creek, PA

Ridgetop Oa horizon

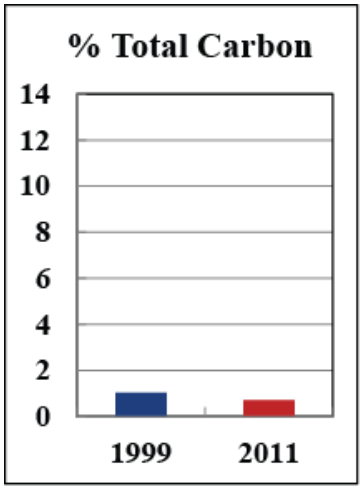


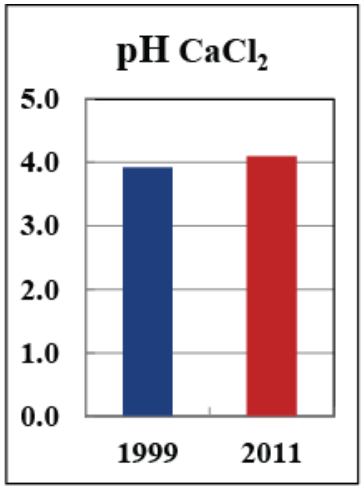


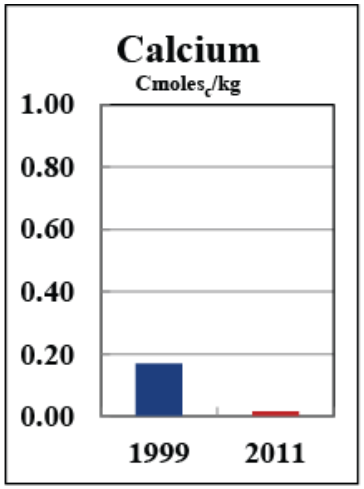


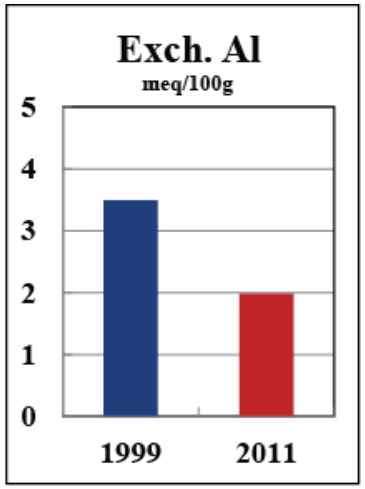


Ridgetop B horizon



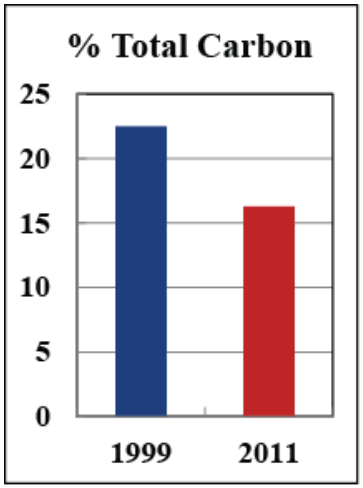


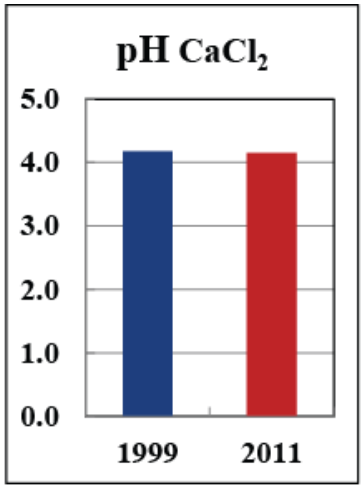


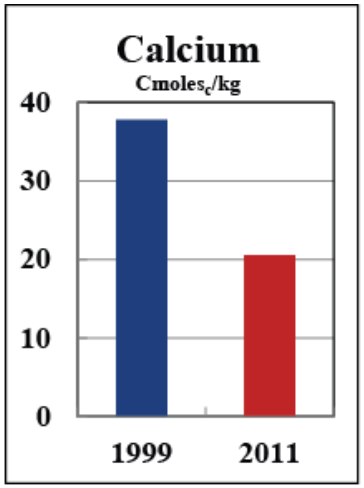


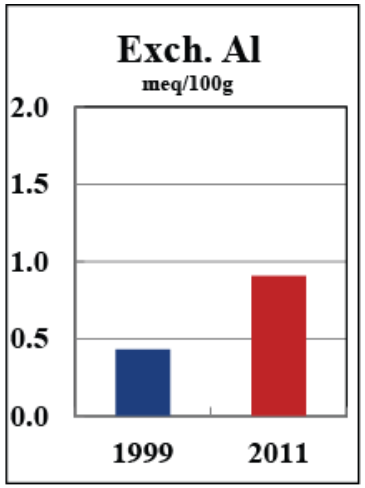
Young Woman's Creek, PA

Midslope Oa horizon

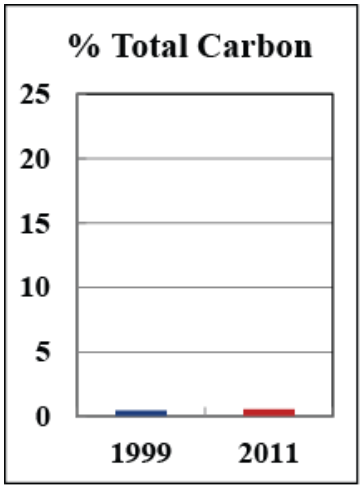


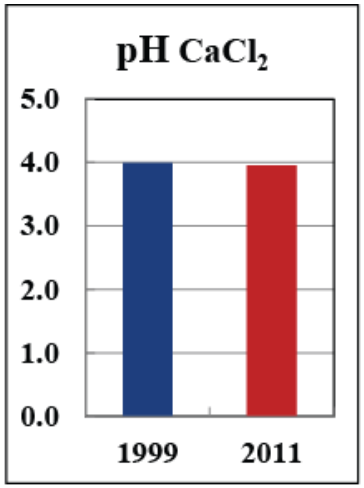


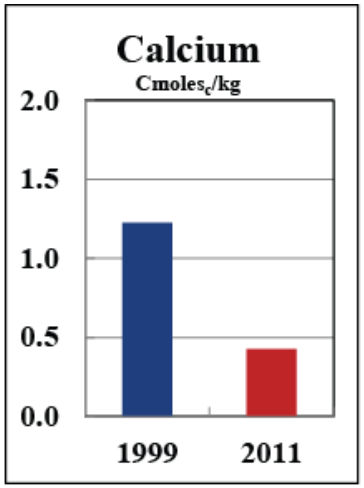


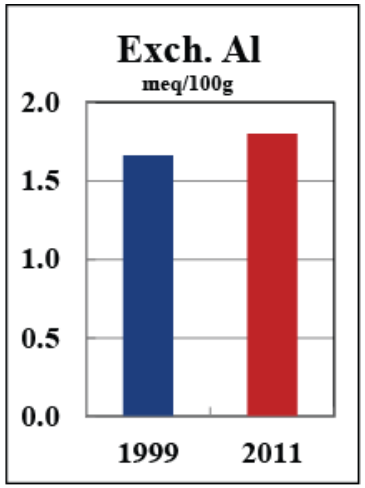


Midslope B horizon



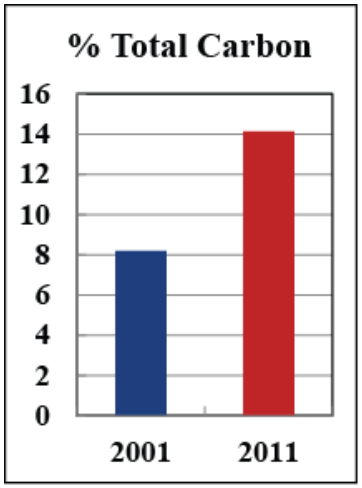


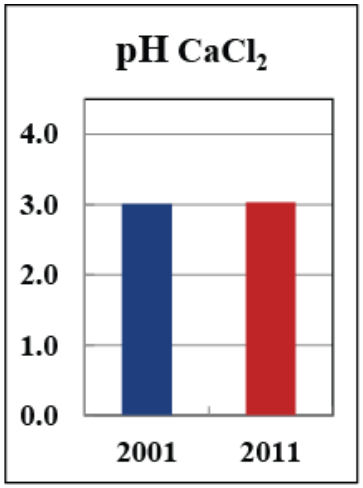


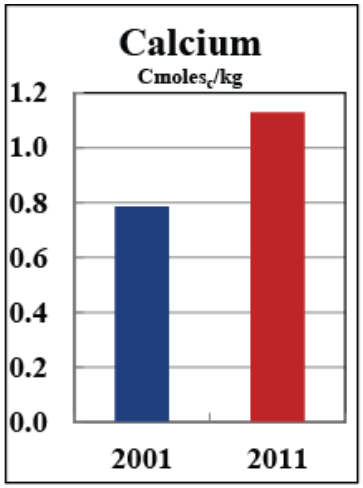


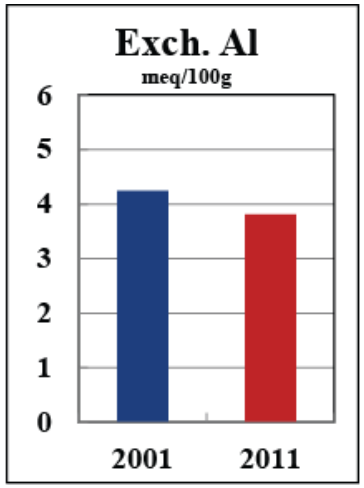
Neversink River, NY

Upperslope A horizon

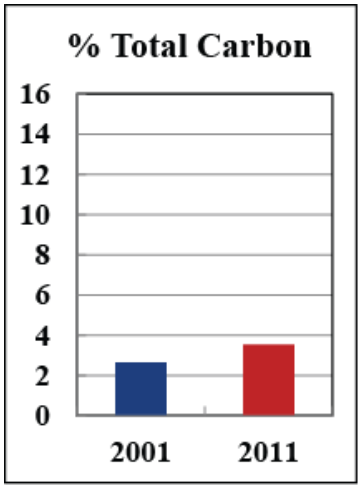


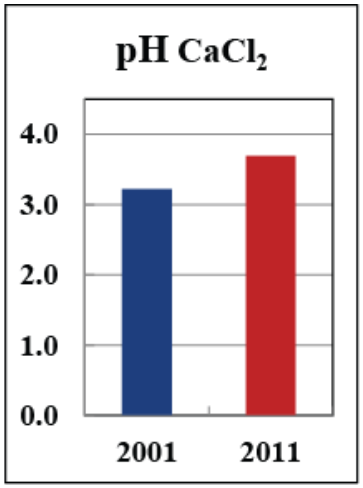


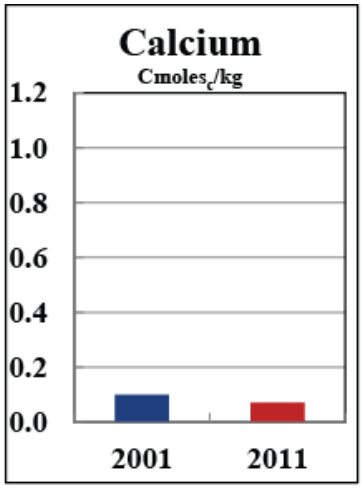


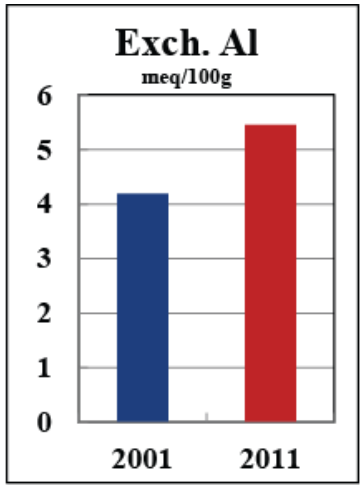


Upperslope B horizon



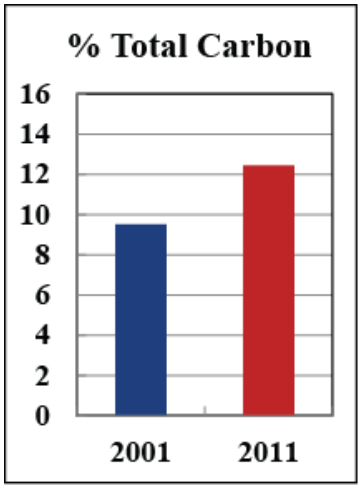


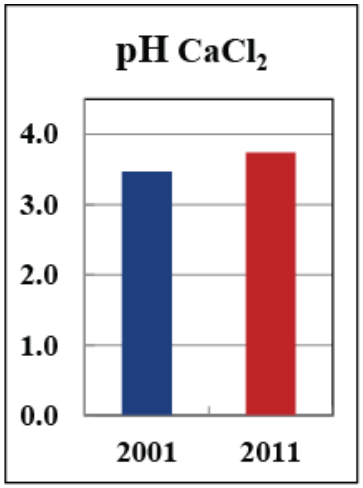


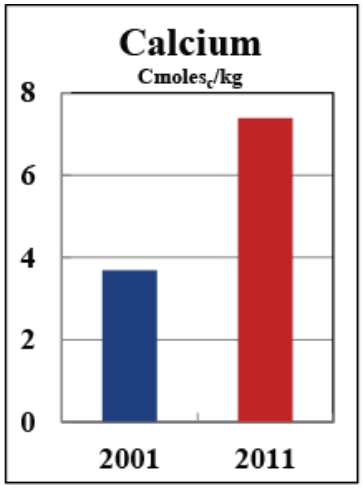


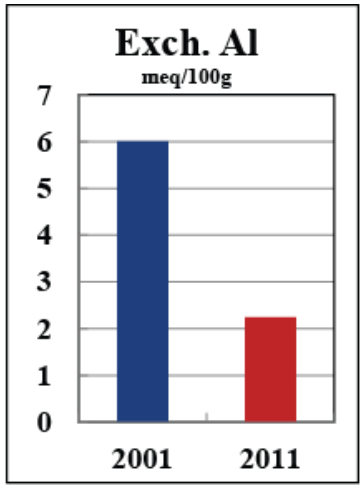
Neversink River, NY

Midslope A horizon

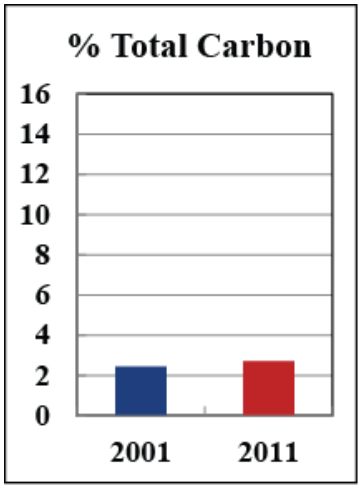


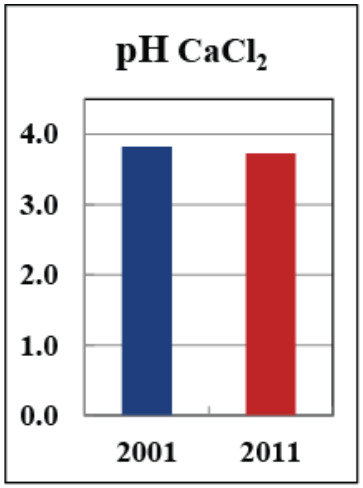


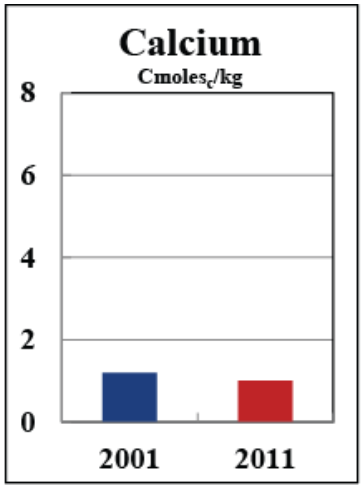


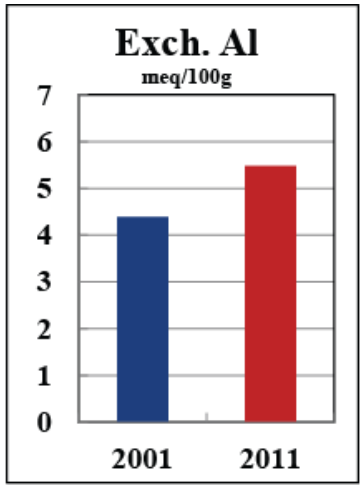


Midslope B horizon



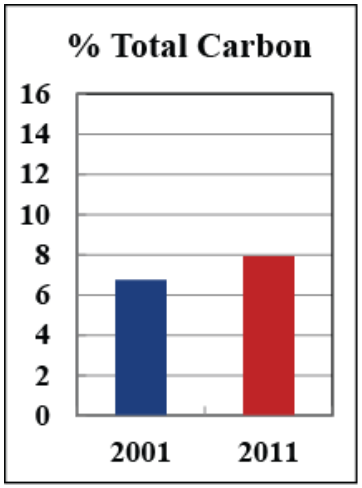


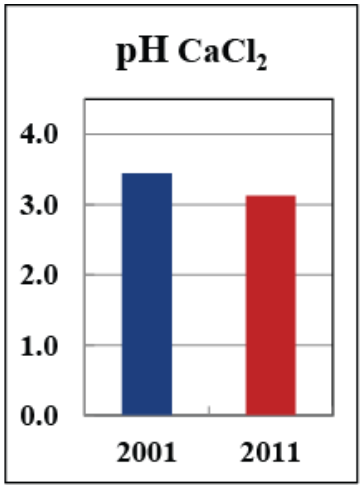


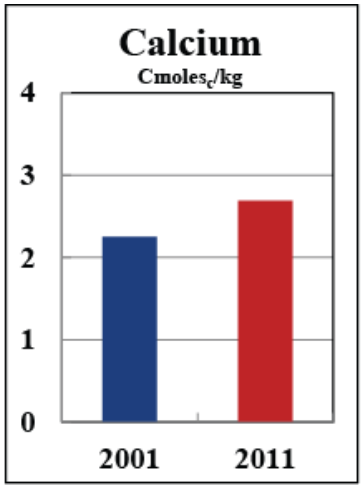


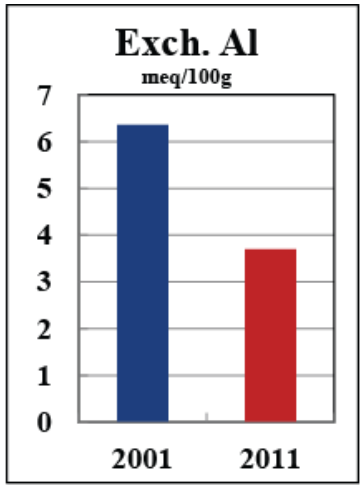
Neversink River, NY

Lowerslope A horizon

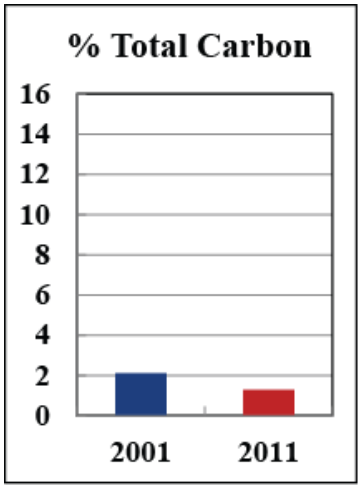


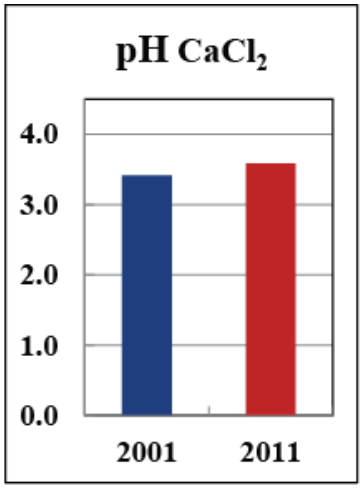


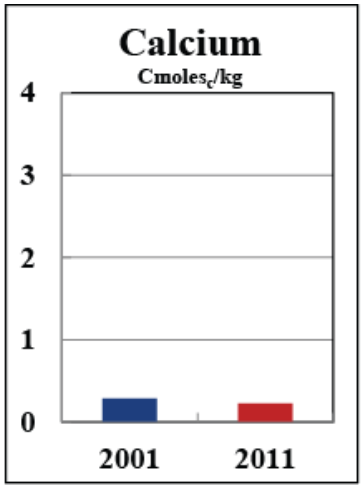


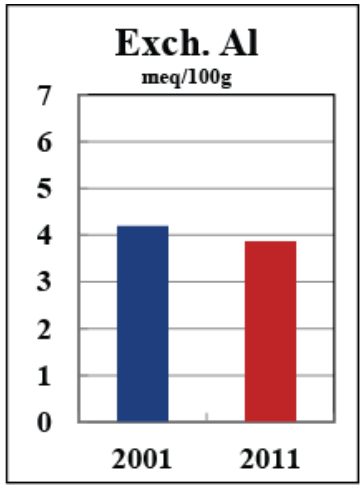


Lowerslope B horizon



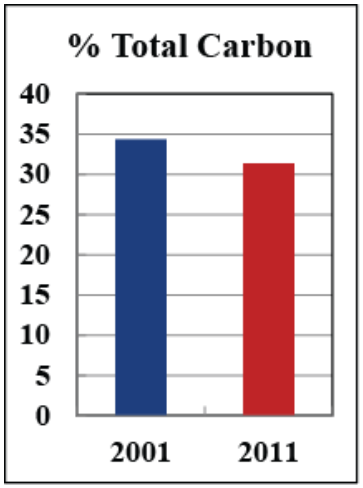


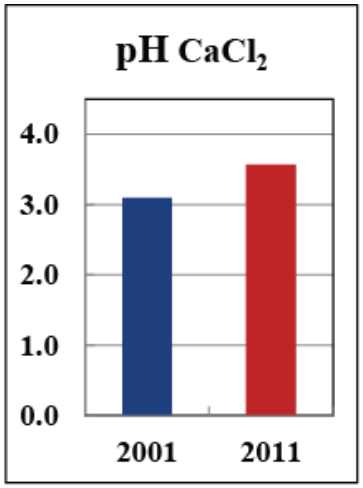


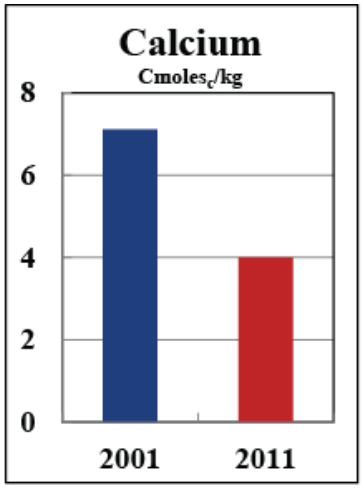


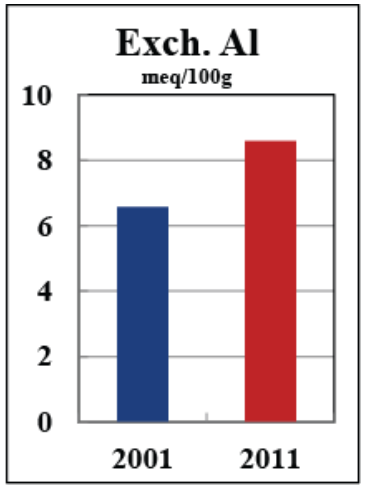
Wild River, ME

Midslope Oa horizon

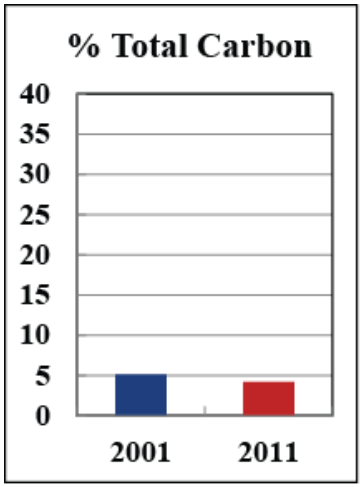


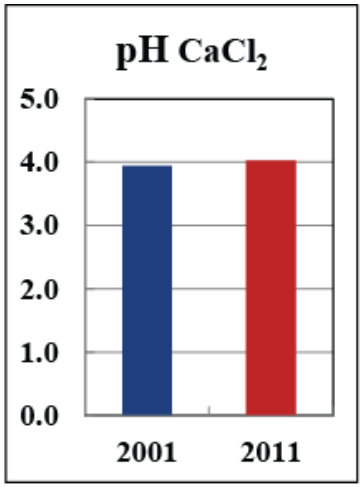


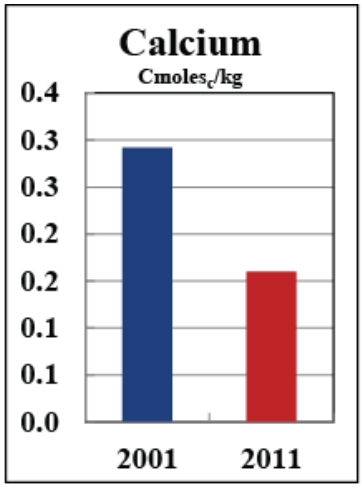


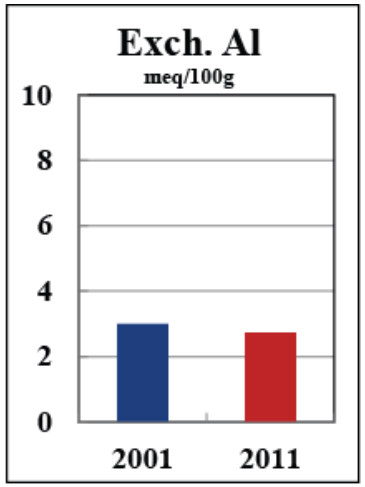


Midslope B horizon









Preliminary Results

- **Soil total carbon and calcium decreased in Wild River and Young Woman's Creek, the sites with generally lower Ca soil concentrations.**
- **In the Neversink watershed soil total carbon generally increased in the A- and B-horizons at all hillslope positions, calcium increased in the A-horizon, but decreased slightly in the B-horizon.**
- **Greater sample numbers at each hillslope position would provide more statistical power.**
- **These generally calcium poor soils have not shown a substantial recovery in response to the decrease in atmospheric sulfate concentration which may explain the slow recovery in stream water SO_4 and Ca.**

Preliminary Results

- **Stream water Total Al at Young Woman's Creek has increased during the past 10 years from about 0.5 umol/L to 3.5 umol/L.**
- **At the other sites Al has remained generally constant though with a lot of annual fluctuations.**