Are Hydrologic Benchmark Network Watersheds Recovering From Acid Deposition?

An Update of Mike McHale's 2013 Presentation

Jason Siemion, Michael R. McHale, Gregory B. Lawrence, and Douglas A. Burns

USGS
science for a changing world

What does recovering mean?

- Not a return to original condition

- Statistically significant chemical changes?
  - decreasing acidity
  - increasing soil calcium

- Ecologically significant changes?
  - upper B horizon base saturation >12% (Sullivan et al , 2013)
  - A horizon Ca_{ex} > 2.5 $Cmol_c\ kg^{-1}$ (Sullivan et al , 2013)

USGS

What is HBN?

- 35 primarily undisturbed watersheds across the US
- Provides a long-term record of stream flow and water quality (since 1960s)
- Soil sampling of HBN sites began in 2011 (additional USGS reference sites as well)
- 3 sites sampled previously (Greg Lawrence)
- Deposition stations co-located in these 3 watersheds

USGS

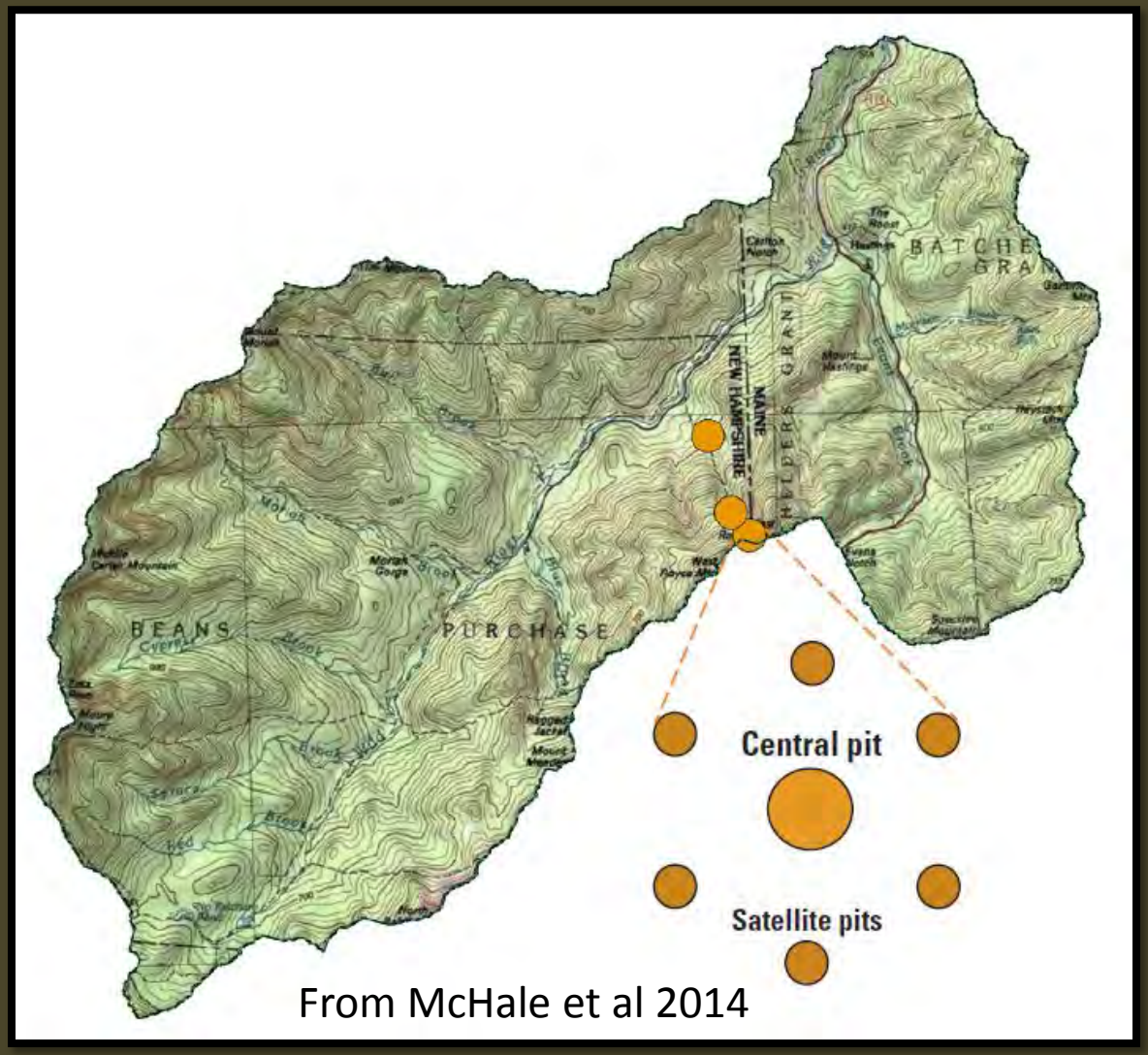
HBN Sites

USGS


78°W
76°W
74°W
72°W
70°W
46°N
44°N
42°N
40°N
80°W
CANADA
MAINE
White Mountain NF
Wild R.
VERMONT
Adirondack Park
NEW HAMPSHIRE
NEW YORK
Catskill Park
MASSACHUSETTS
Neversink R.
CONNECTICUT
RHODE ISLAND
Young Womans Cr.
PENNSYLVANIA
NEW JERSEY
0 50 100 Miles
0 50 100 Kilometers

USGS

Soil Sampling 2001 to 2011



From McHale et al 2014

USGS

Analysis

- Seasonal Kendal test for trends in deposition and stream water (Doug Burns and Mike McHale)
- Soil…lumped all central and satellite pits for either Oa or A and upper B at each site (n=10 to 15), t test or rank sum test for significant differences depending on normality
- Need to re-analyze archived samples

USGS

About the Watersheds

- Young Womans Creek (120 km^2)
  - sandstone, shale, siltstone, occasional calcareous lenses
  - unglaciated, ultisols and inceptisols
  - northern and mixed upland hardwoods

USGS

Upper Slope

USGS

About the Watersheds

- Neversink River (172 km^2)
  - sandstone, siltstone, and shale
  - glaciated, inceptisols and few spodosols
  - northern hardwoods, spruce-fir on ridge tops

USGS

Upper Slope

USGS

About the Watersheds

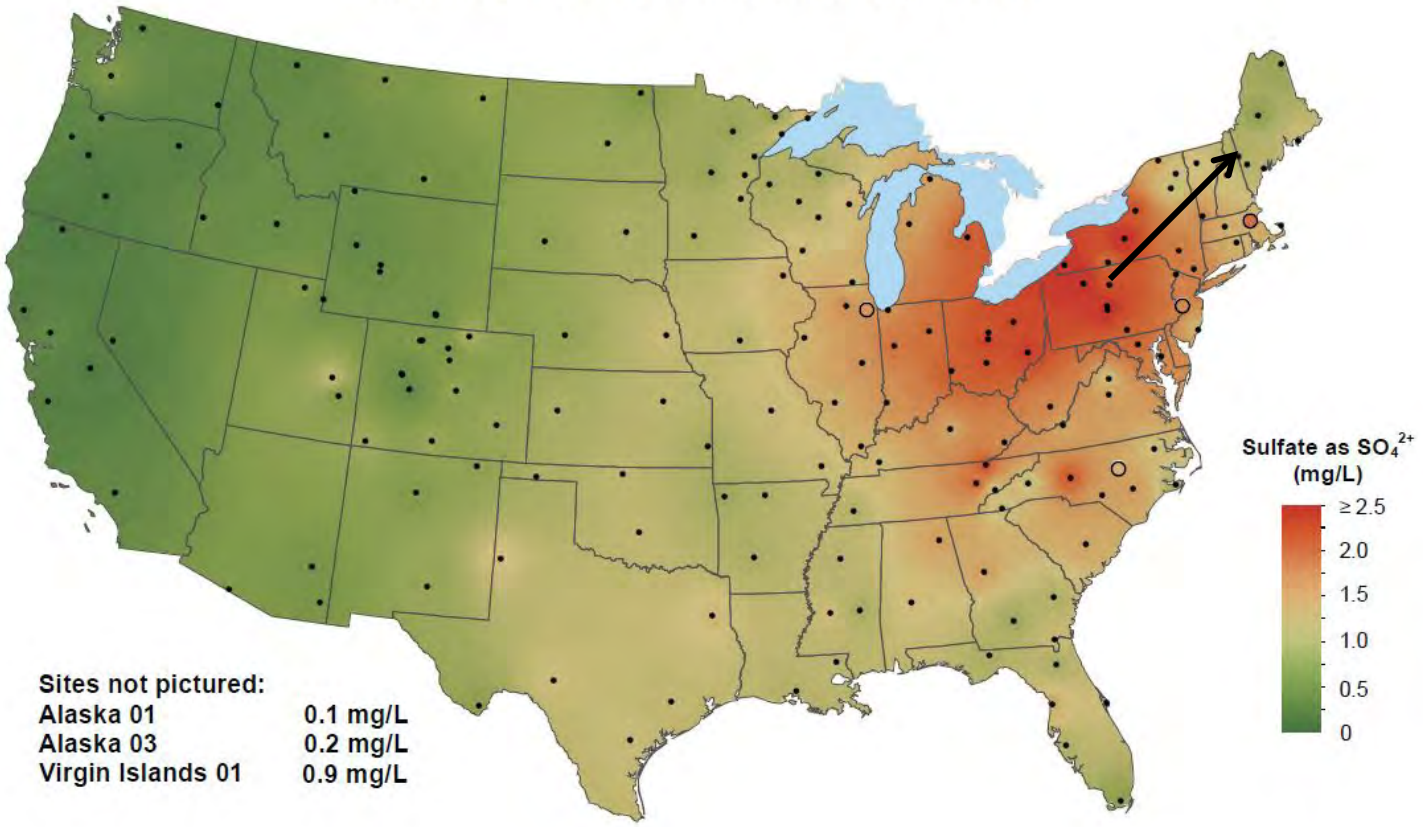
- Wild River (180 km^2)
  - metasedimentary and metavolcanic bedrock
  - glaciated, spodosols
  - northern hardwoods, spruce-fir at high elevations

USGS

Mid Slope

USGS

Sulfate ion concentration, 2000



National Atmospheric Deposition Program/National Trends Network
http://nadp.isws.illinois.edu

USGS

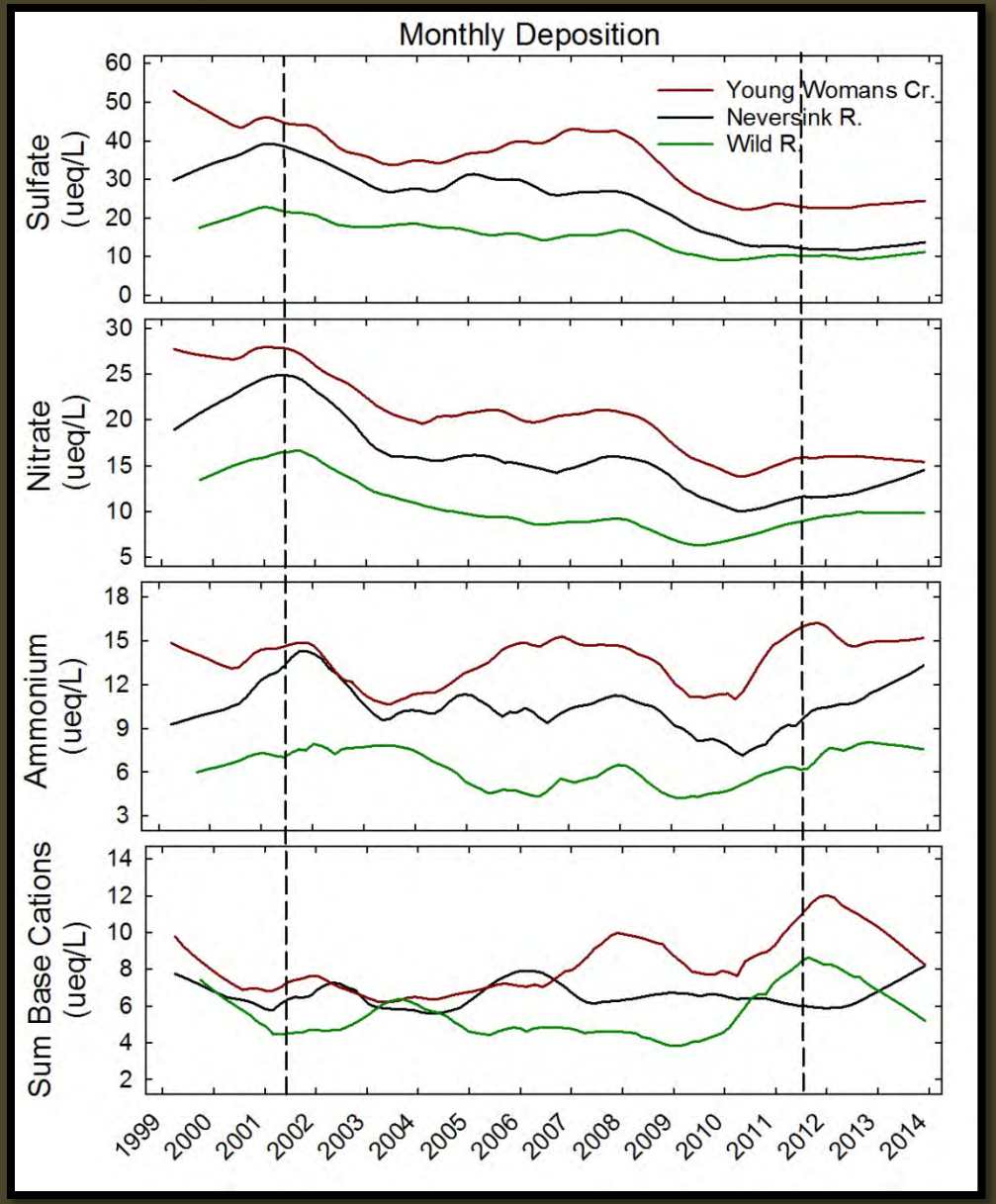
Trends in Deposition

- Sulfate:
  Young Womans = -2.1 $ueqL^{-1}Yr^{-1}$
  Neversink = -2.0 $ueqL^{-1}Yr^{-1}$
  Wild River = -1.0 $ueqL^{-1}Yr^{-1}$

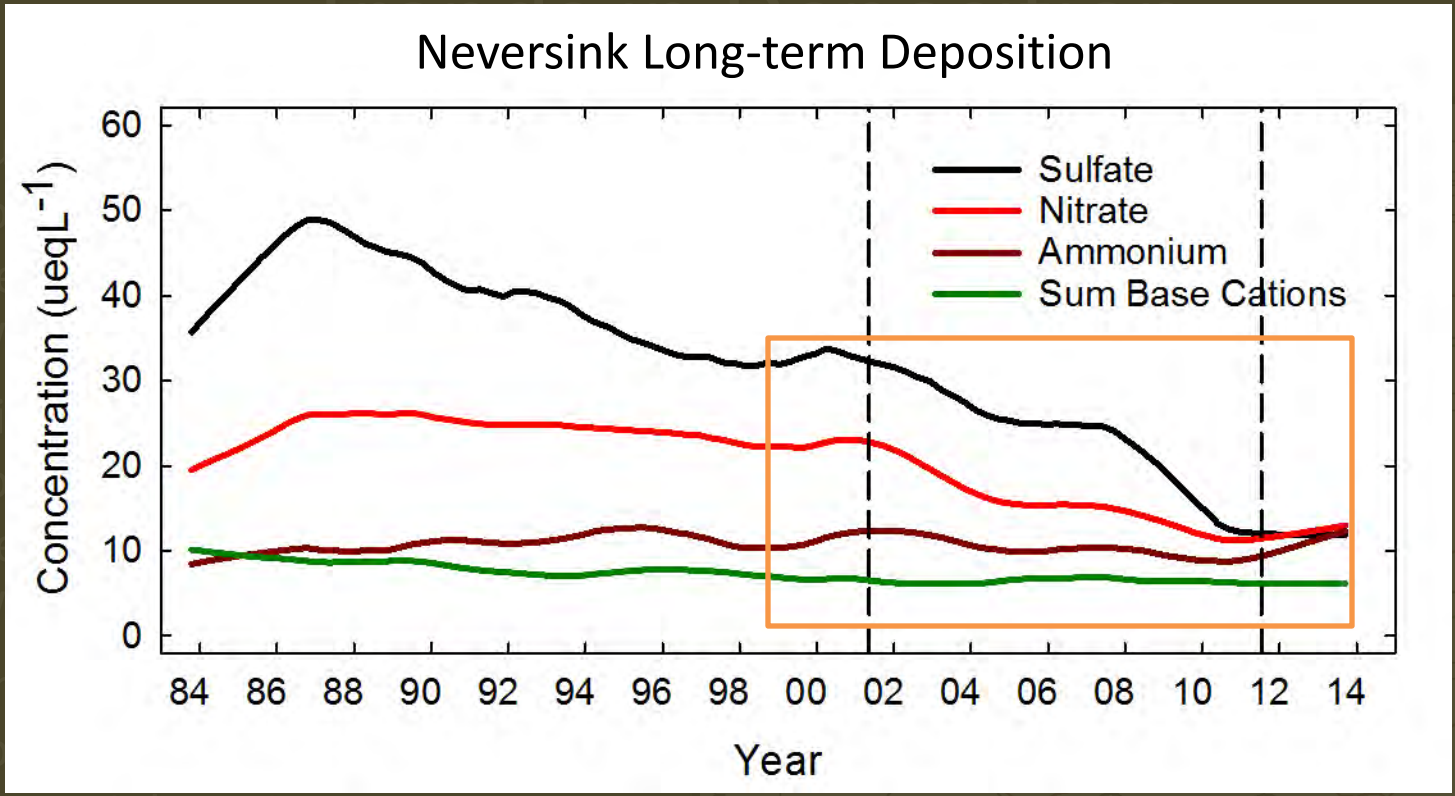
- Nitrate:
  Young Womans = -0.8 $ueqL^{-1}Yr^{-1}$
  Neversink = -0.8 $ueqL^{-1}Yr^{-1}$
  Wild River = -0.6 $ueqL^{-1}Yr^{-1}$

- Ammonium:
  No significant trends

- Sum Base Cations:
  No Significant Trends



USGS



Sulfate -1.3 $ueqL^{-1}yr^{-1}$

Nitrate -0.6 $ueqL^{-1}yr^{-1}$

Ammonium no significant trend

Base Cations < $-0.03ueqL^{-1}yr^{-1}$

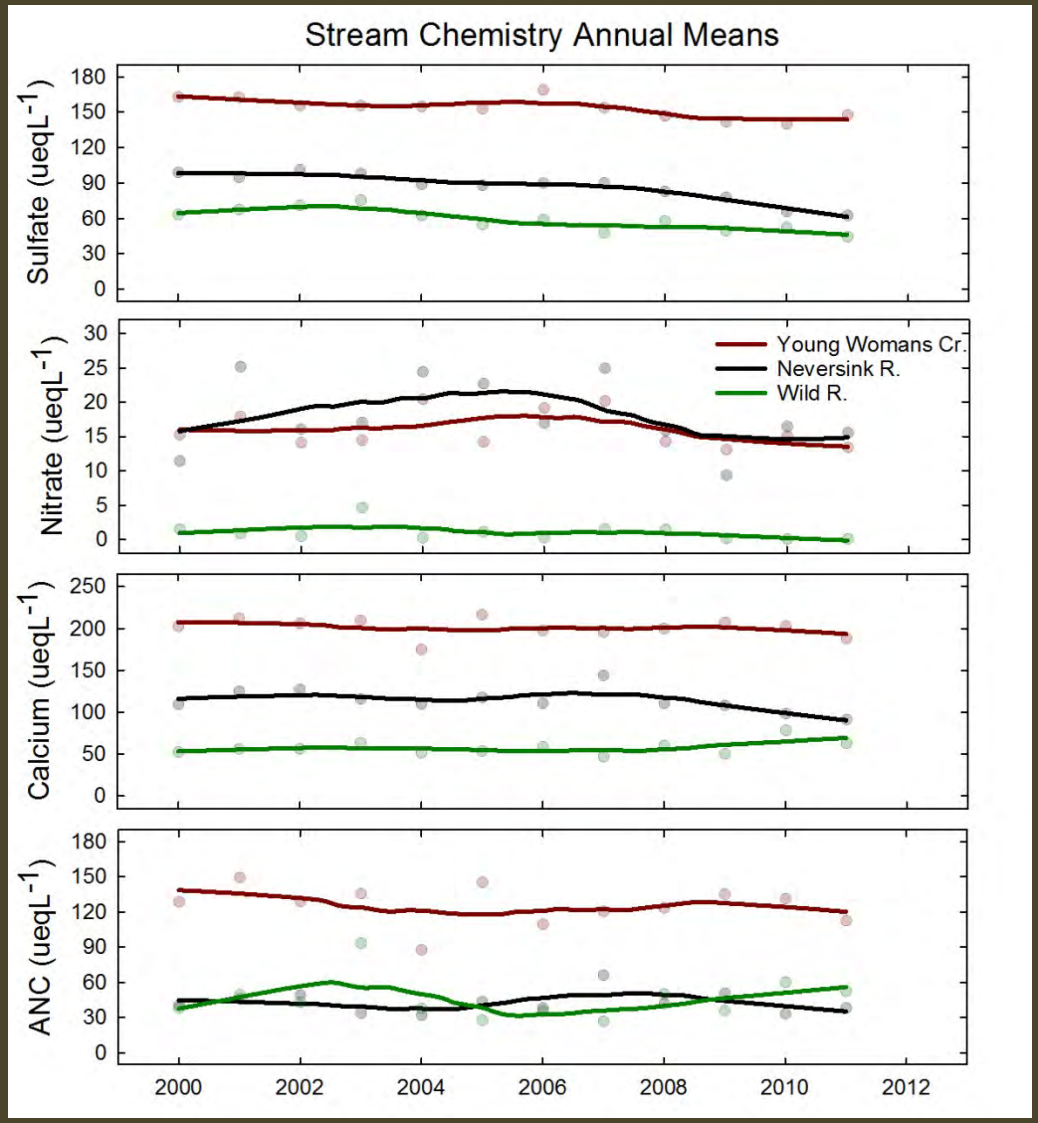
Similar results to Mast (2013)

Trends in Stream Chemistry From Mast (2013)

- Sulfate 1970-2010:
  Young Womans = -0.4 $ueqL^{-1}Yr^{-1}$
  Neversink = -2.0 $ueqL^{-1}Yr^{-1}$
  Wild River = -1.0 $ueqL^{-1}Yr^{-1}$

- Sulfate 1990-2010:
  Young Womans = -1.4 $ueqL^{-1}Yr^{-1}$
  Neversink = -2.3 $ueqL^{-1}Yr^{-1}$
  Wild River = -0.8 $ueqL^{-1}Yr^{-1}$

- Nitrate 1990-2010:
  Young Womans = -0.7 $ueqL^{-1}Yr^{-1}$
  Neversink = No Significant Trend
  Wild River = Insufficient Data

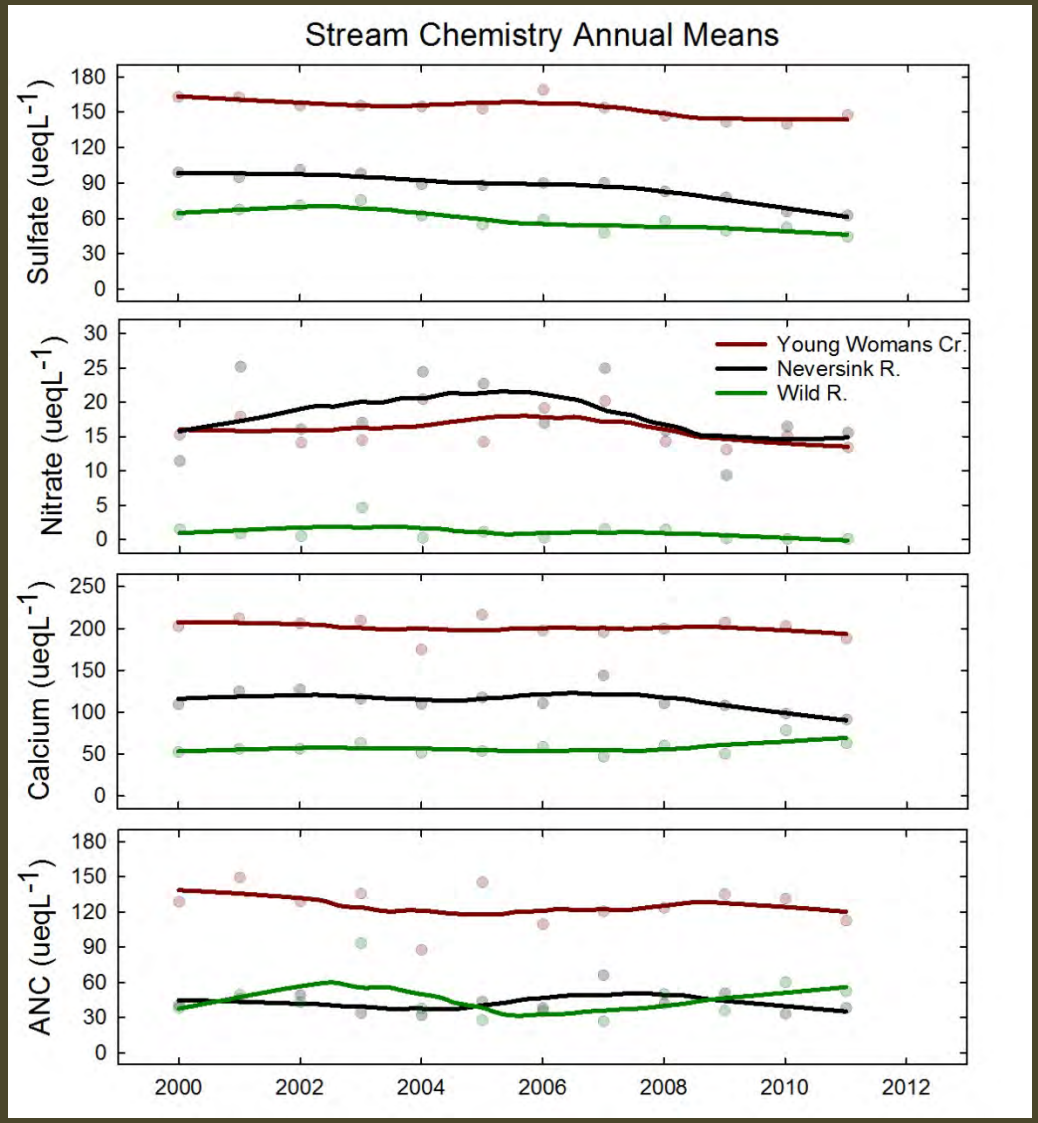


USGS

Trends in Stream Chemistry From Mast (2013)

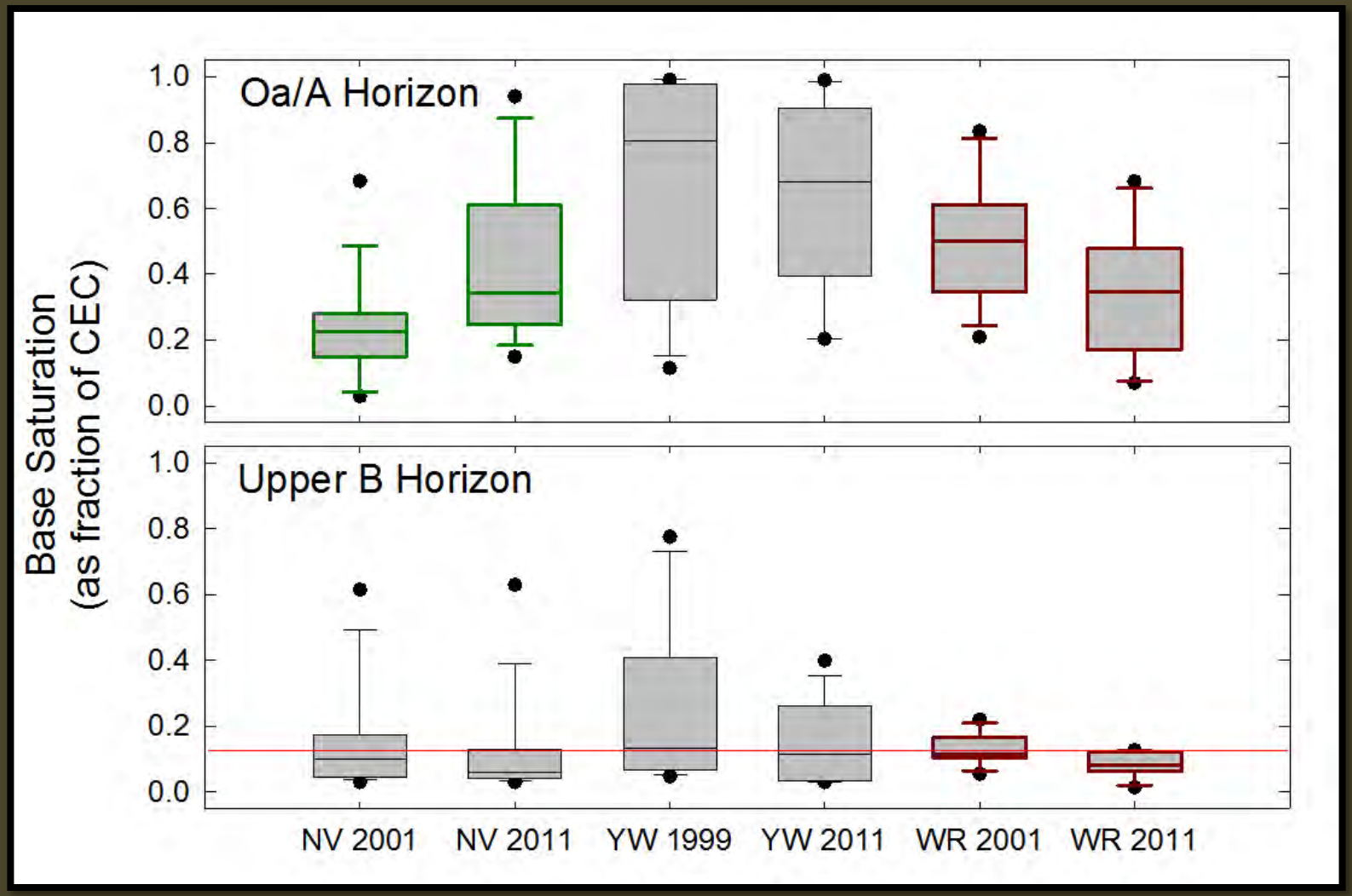
- ANC 1970-2010:
  Young Womans = -0.9 $ueqL^{-1}Yr^{-1}$
  Neversink = 0.1 $ueqL^{-1}Yr^{-1}$
  Wild River = -1.2 $ueqL^{-1}Yr^{-1}$

- ANC 1990-2010:
  Young Womans = 1.0 $ueqL^{-1}Yr^{-1}$
  Neversink = 0.7 $ueqL^{-1}Yr^{-1}$
  Wild River = -0.1 $ueqL^{-1}Yr^{-1}$



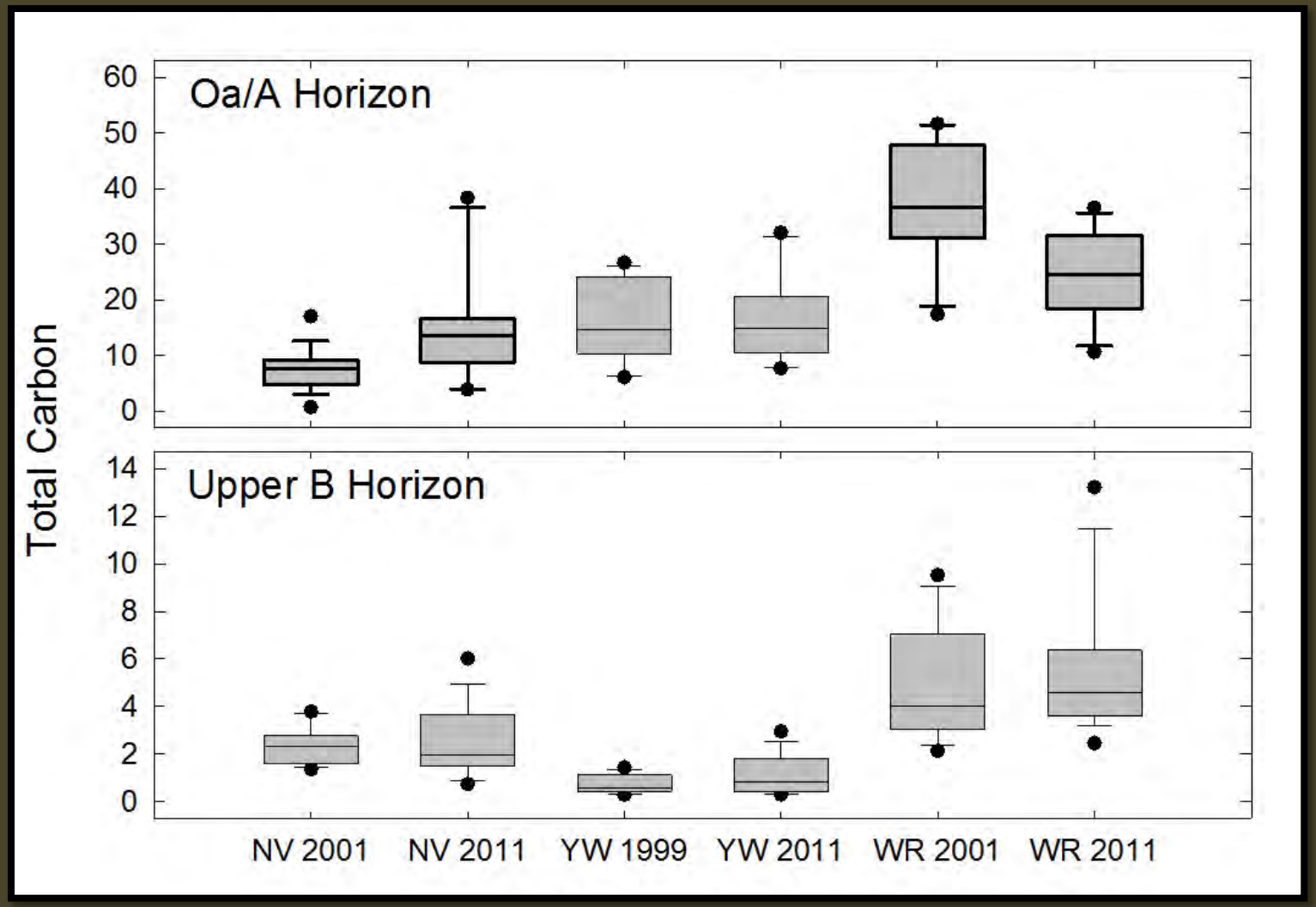
USGS

Changes in Soil Base Saturation



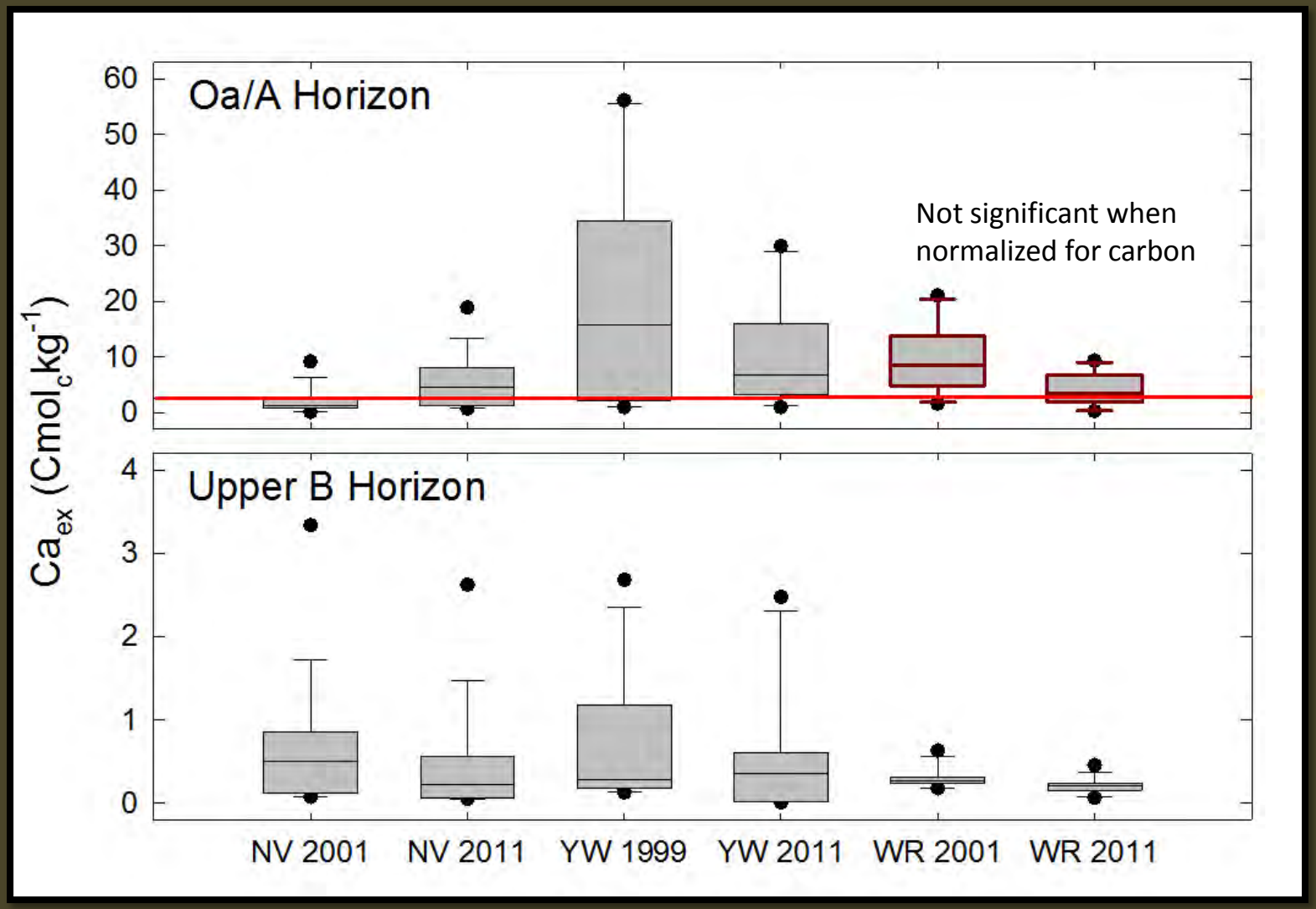
USGS

Changes in Soil Total Carbon



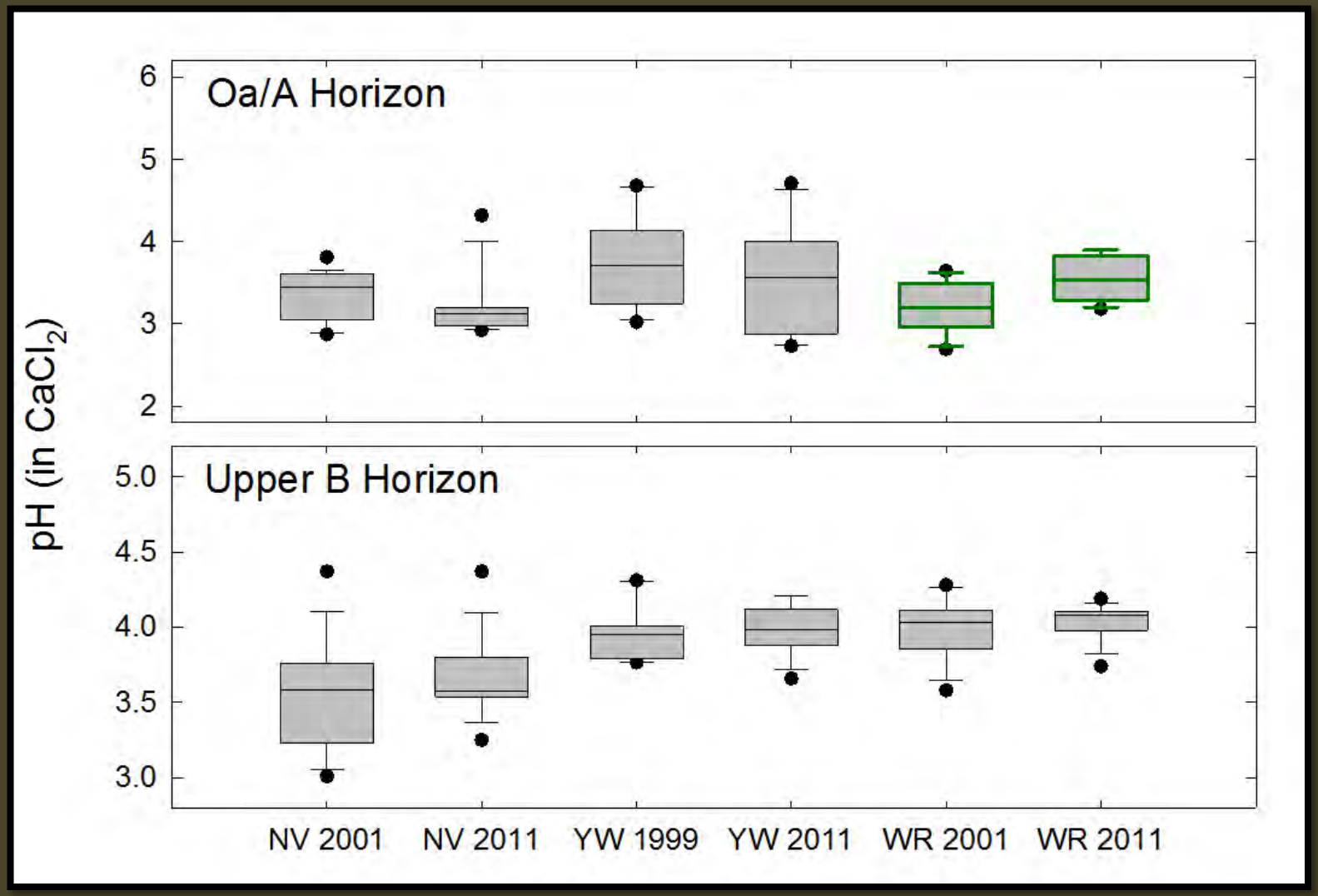
USGS

Changes in Soil Ca_{ex}



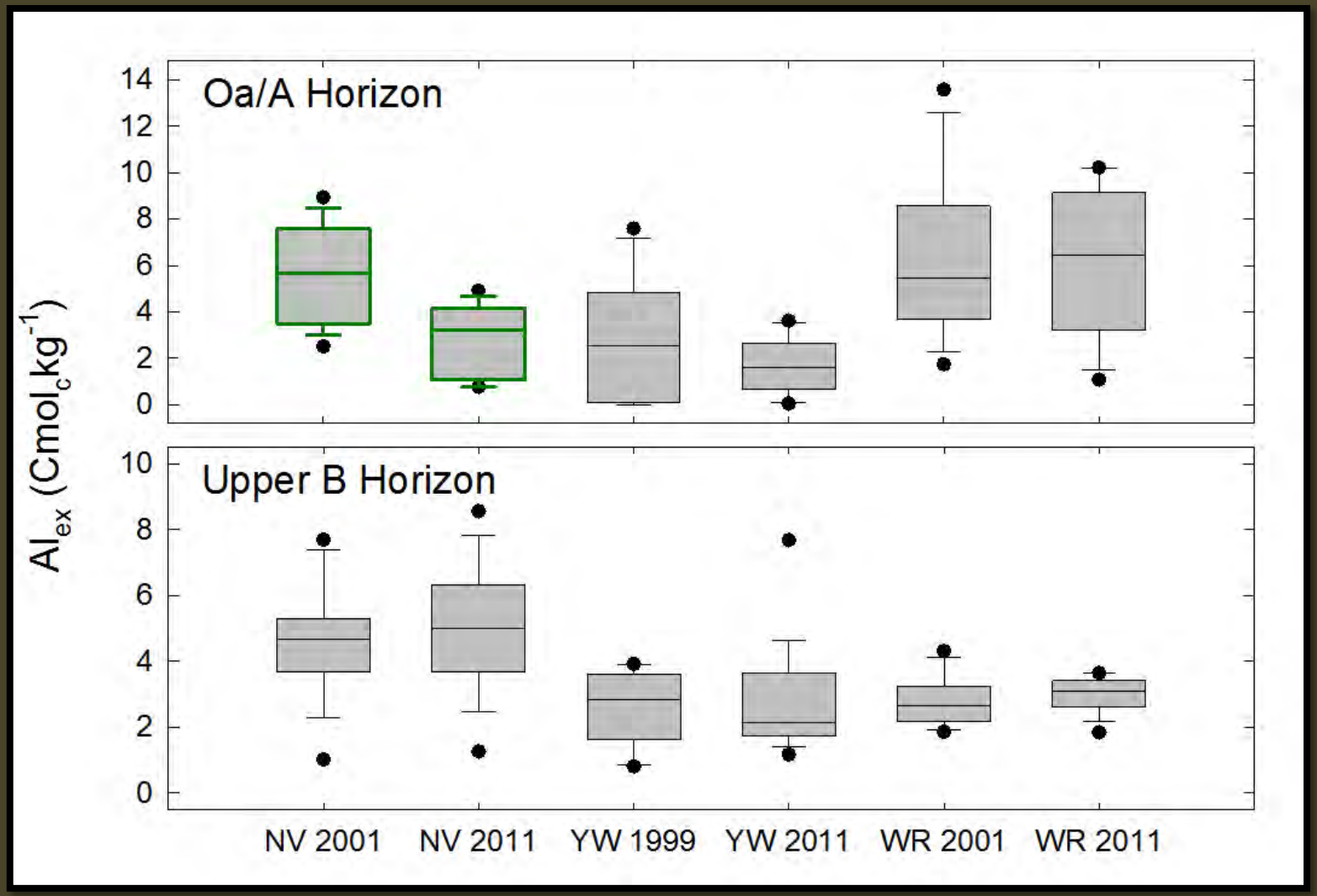
USGS

Changes in Soil pH



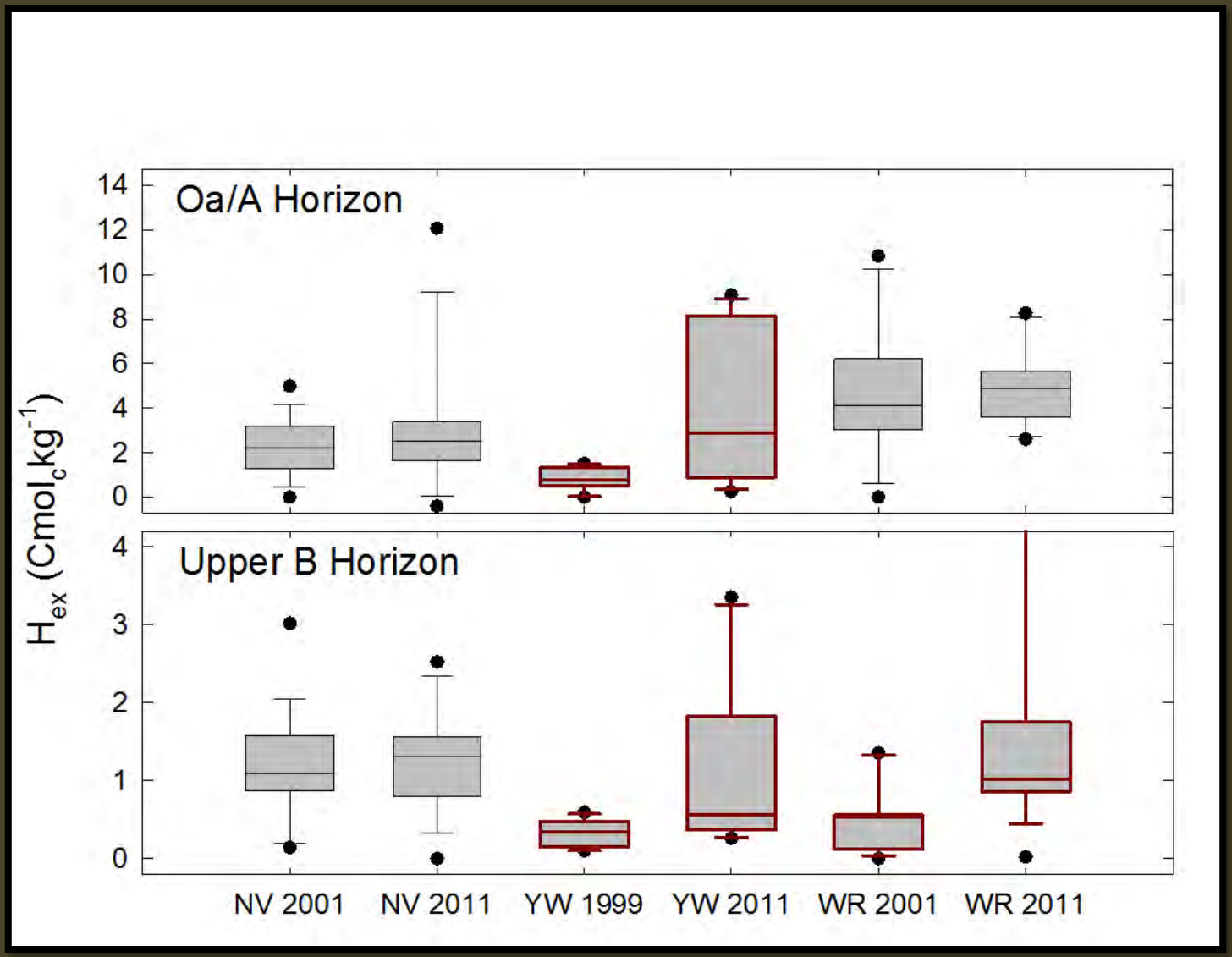
USGS

Changes in Soil Al_{ex}



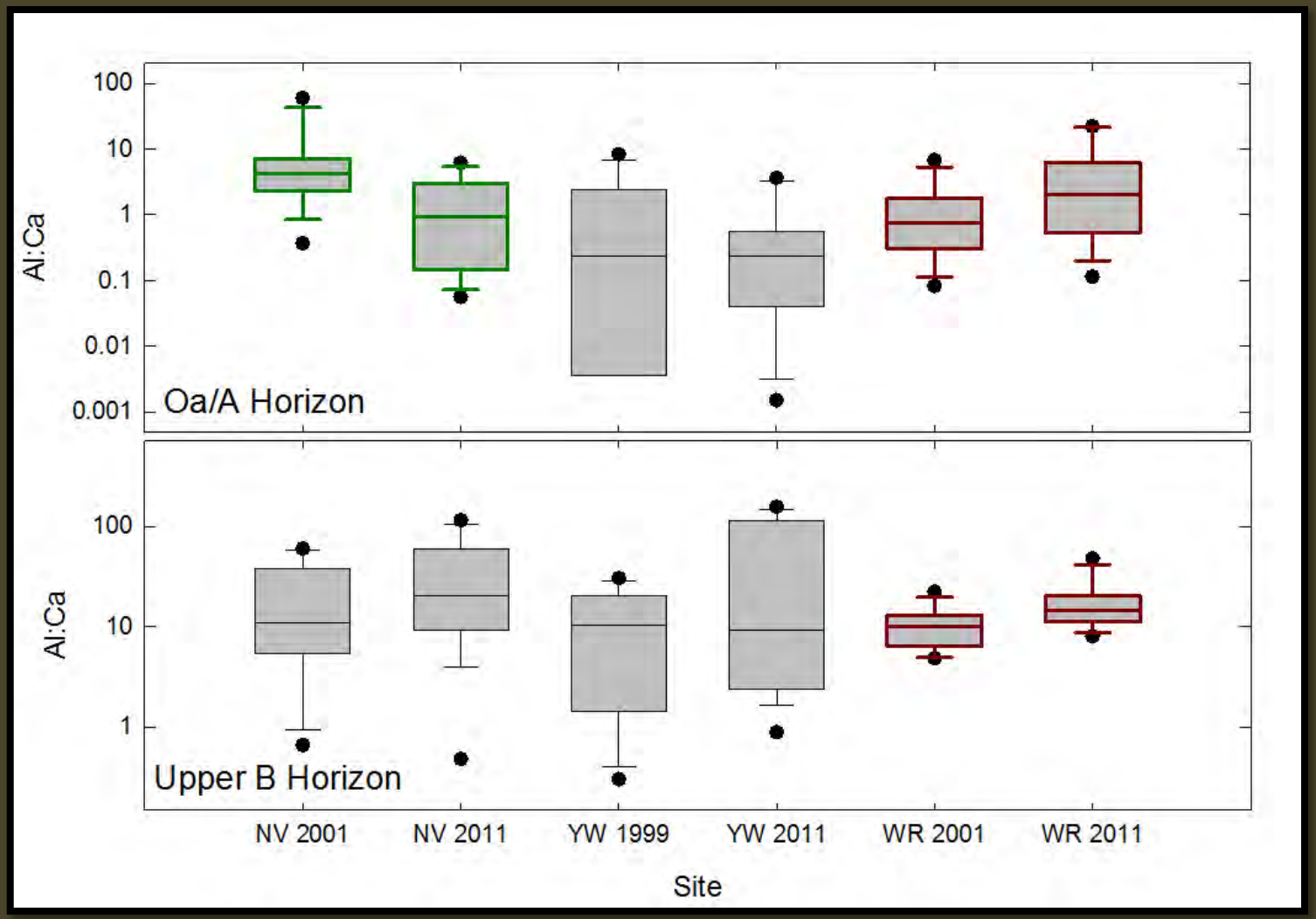
USGS

Changes in Soil H_{ex}



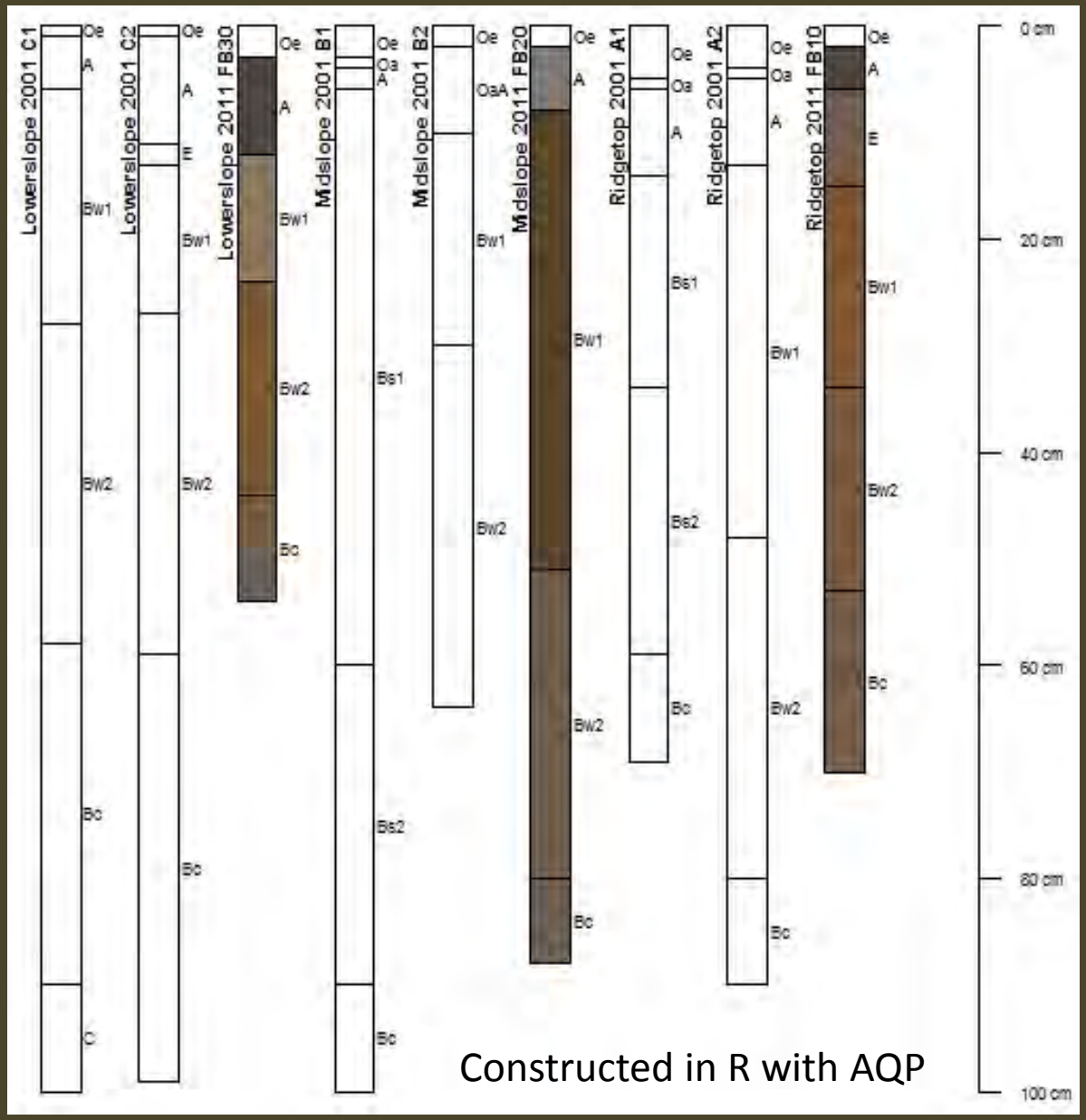
USGS

Changes in Soil Al_{ex}:Ca_{ex} Ratios



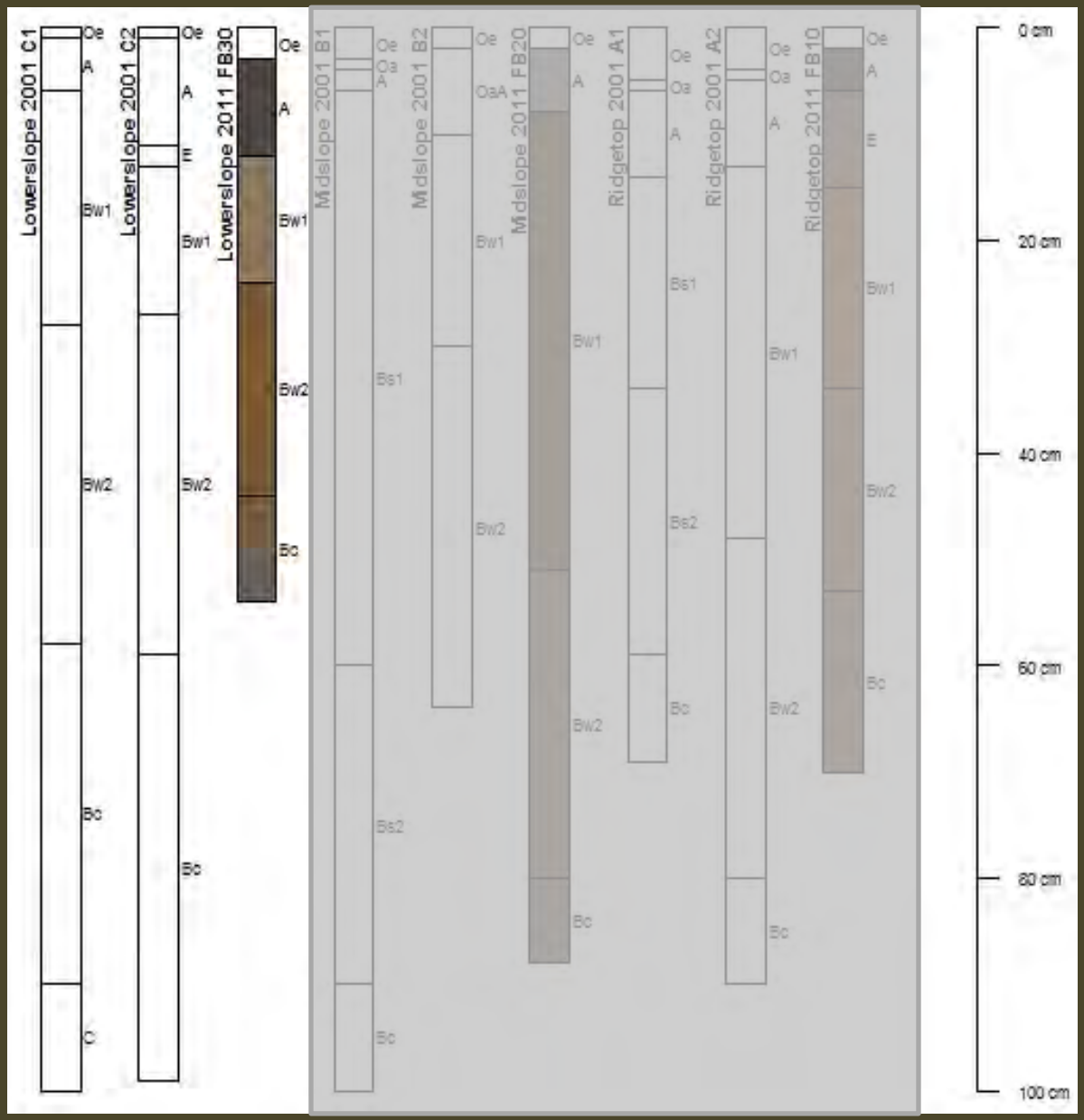
USGS

Central pits...what to compare?



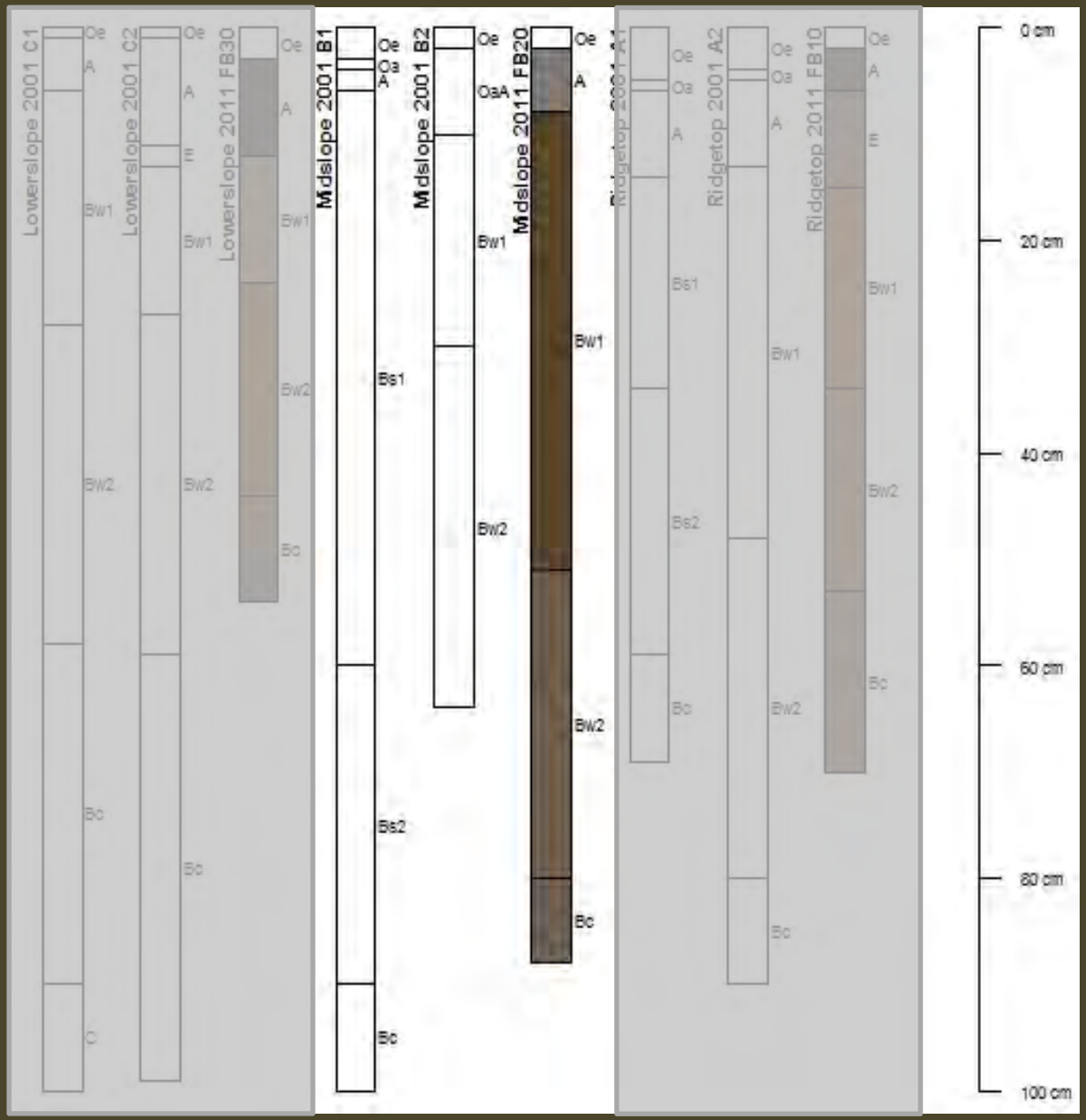
USGS

Central pits...what to compare?



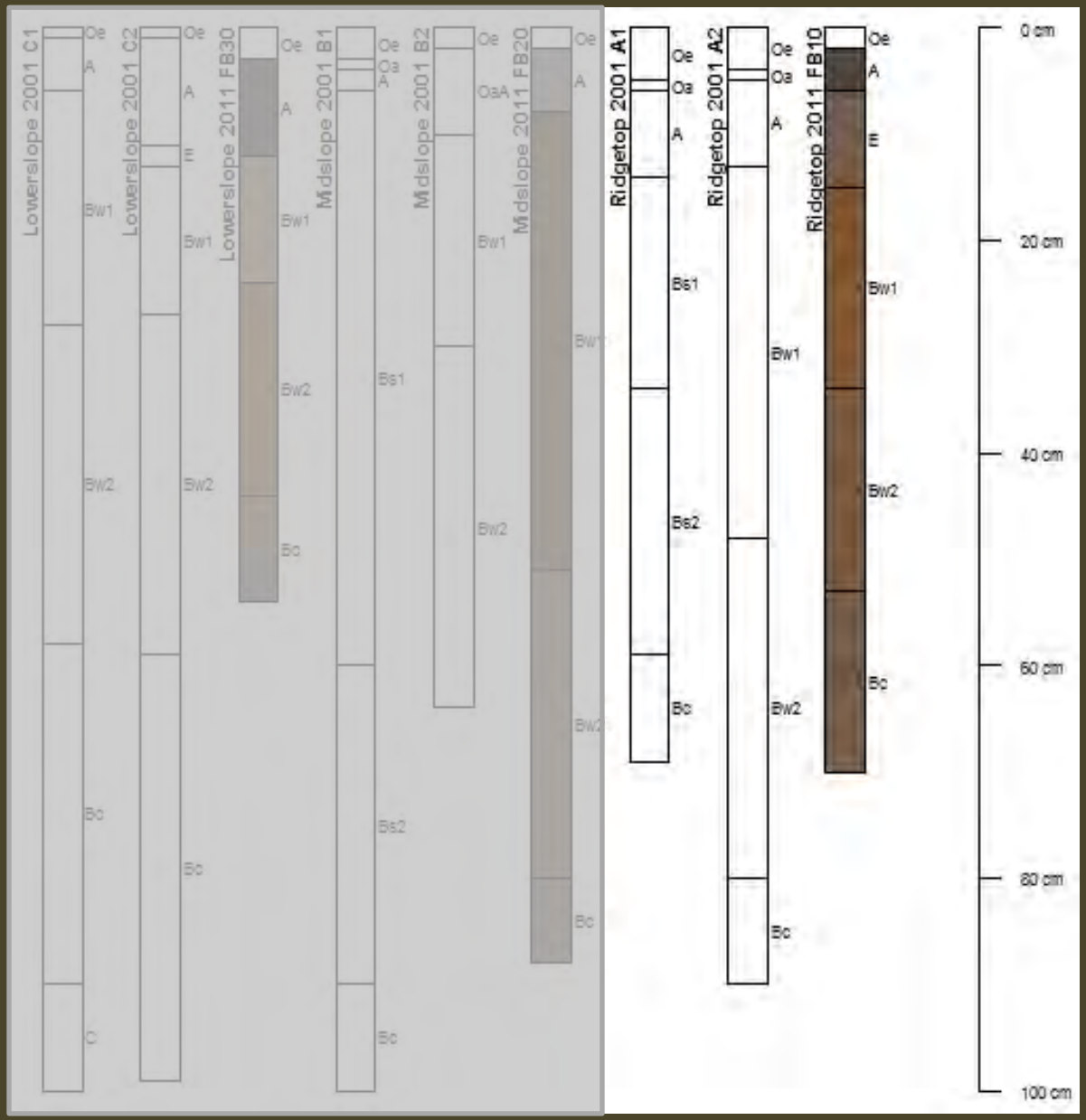
USGS

Central pits...what to compare?



USGS

Central pits...what to compare?



USGS

Significantly decreasing sulfate and nitrate deposition.

Are the HBN watersheds recovering?

USGS

Are the HBN watersheds recovering?

Sort of….

- Improving stream chemistry
- Start of soil recovery in the Neversink River?
- Soils in Young Womans Creek and Wild River not responding to decreased deposition

USGS

Summary

- Young Womans…highest deposition… soil not responding to declining deposition…but soil still base rich relative to other sites
- Neversink…moderate deposition…A horizon starting to respond to declining deposition…base poor B horizon
- Wild River…low deposition…soil not responding declining deposition… base poor B horizon

USGS