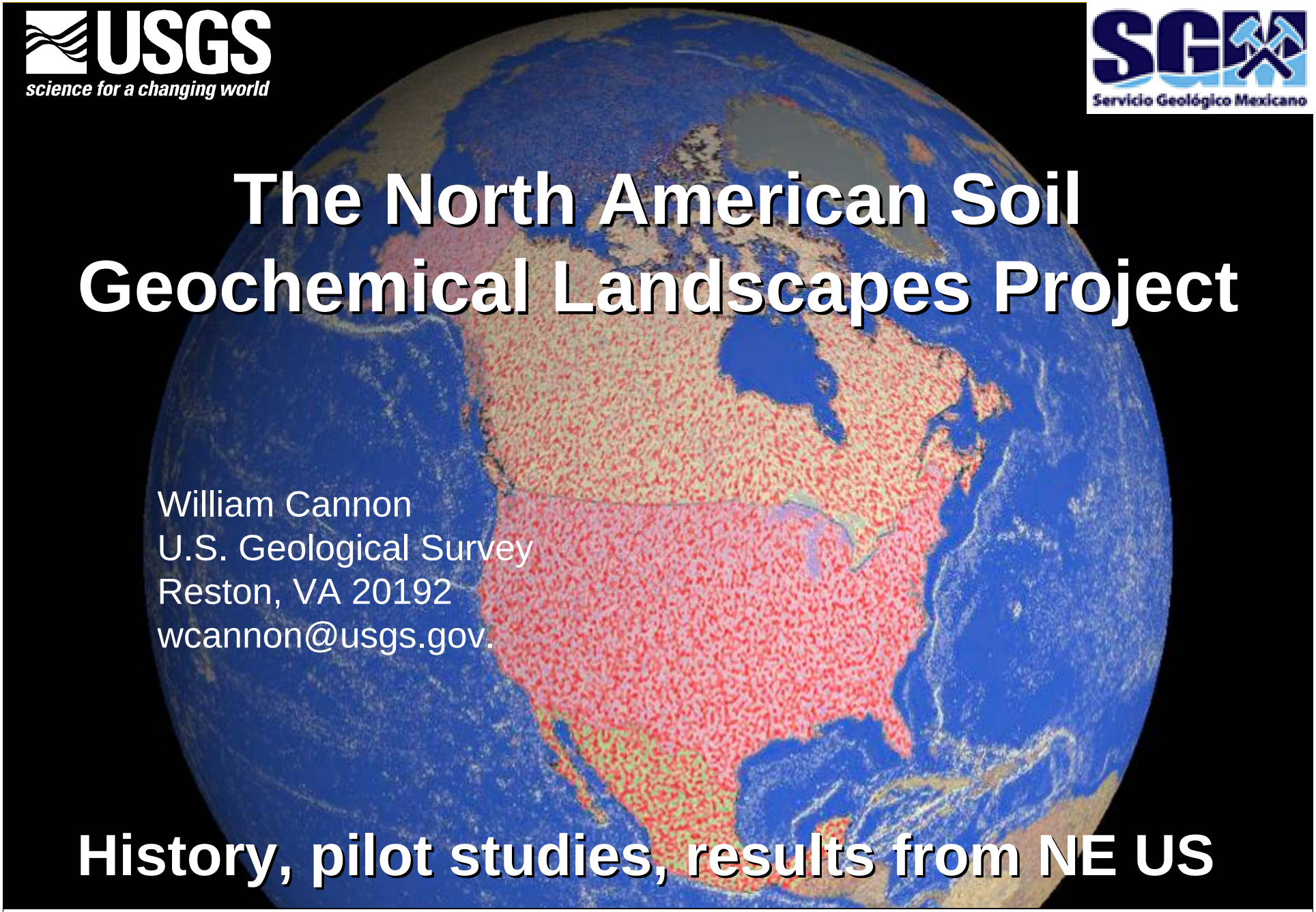

The North American Soil Geochemical Landscapes Project

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Reston, VA 20192
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History, pilot studies, results from NE US

Natural Resources Canada Ressources naturelles Canada

Canada

NASGLP Timeline

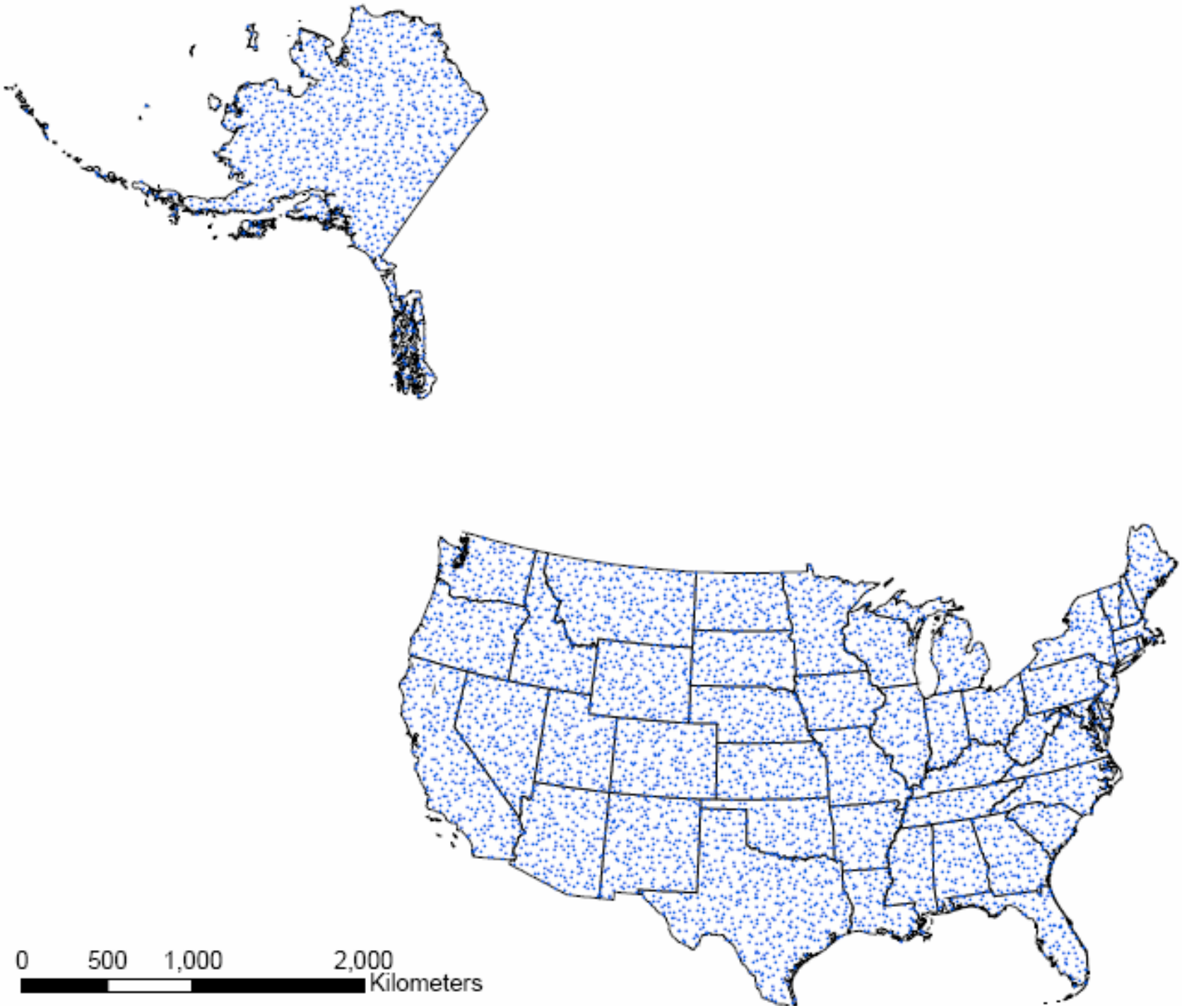
- 2001: Directors of SGM, GSC, USGS identify soil geochemistry as subject of mutual concern
- 4 workshops held (2002, 2003, 2004, 2006)
- 2004-2006 Pilot phase in Canada and US
- 2006-2007 Pilot phase in Mexico
- 2007 Sampling begins for full continental-scale survey
- Sampling for conterminous US may be done in 2010

USGS

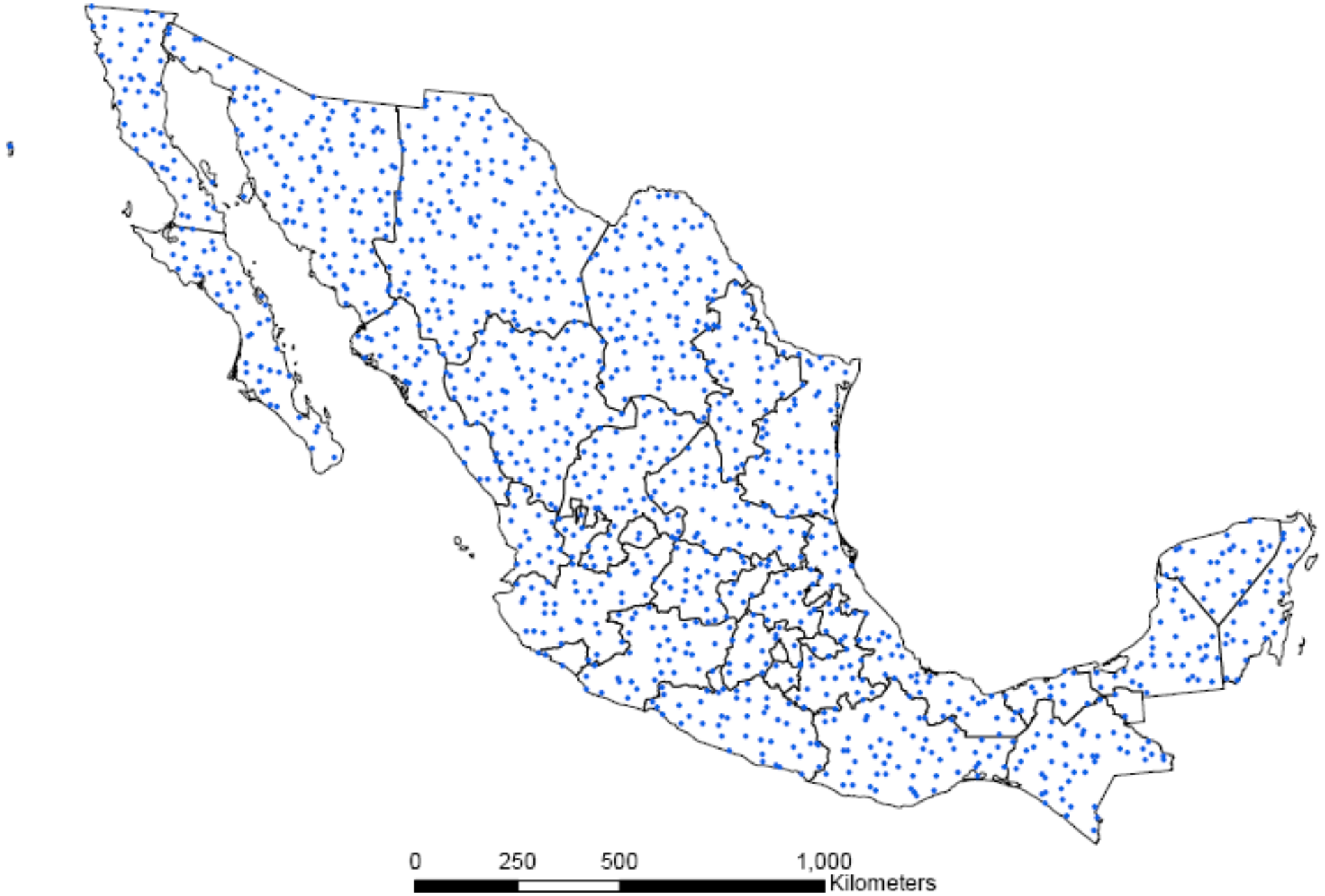
Sample Design

- Generalized Random Tessellation Stratified (GRTS) design
  - Spatially balanced throughout N.A.
  - Widely published
  - Routines available online
  - Flexibility: Allows increased sample density in areas of interest
- 13,215 sites for North America (about 1 per 1,600 km^2)
  - US = 5,813; Canada = 6,183; Mexico = 1,219

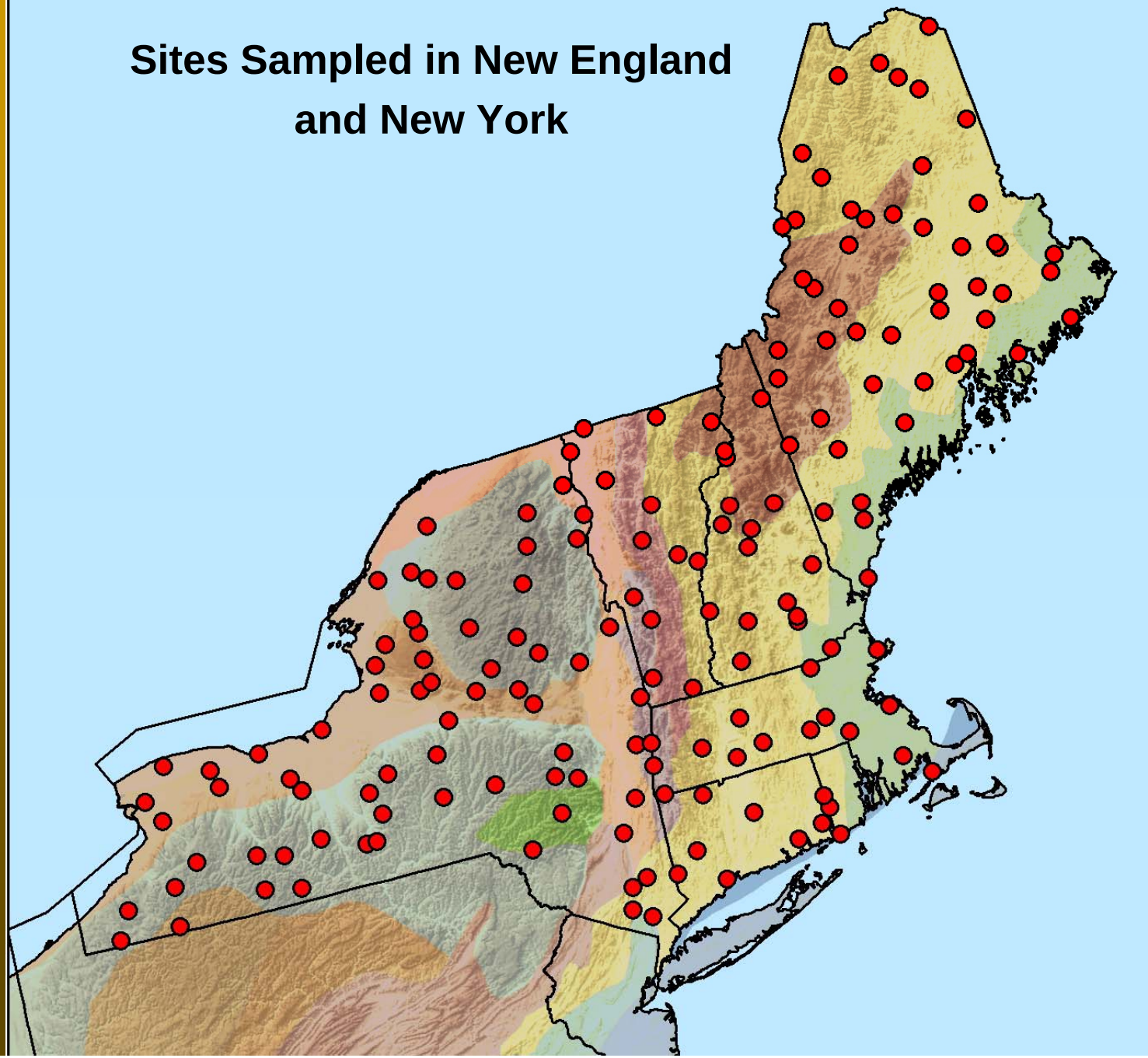
USGS


0
500
1,000
2,000
Kilometers


0
500
1,000
2,000
Kilometers


0
250
500
1,000
Kilometers

Sites Sampled in New England and New York



Current Status of National-Scale Soil Geochemistry

- Two data sets of national scale in US
  - 1 by U.S. Geological Survey (USGS)
  - 1 by Natural Resources Conservation Service (NRCS)

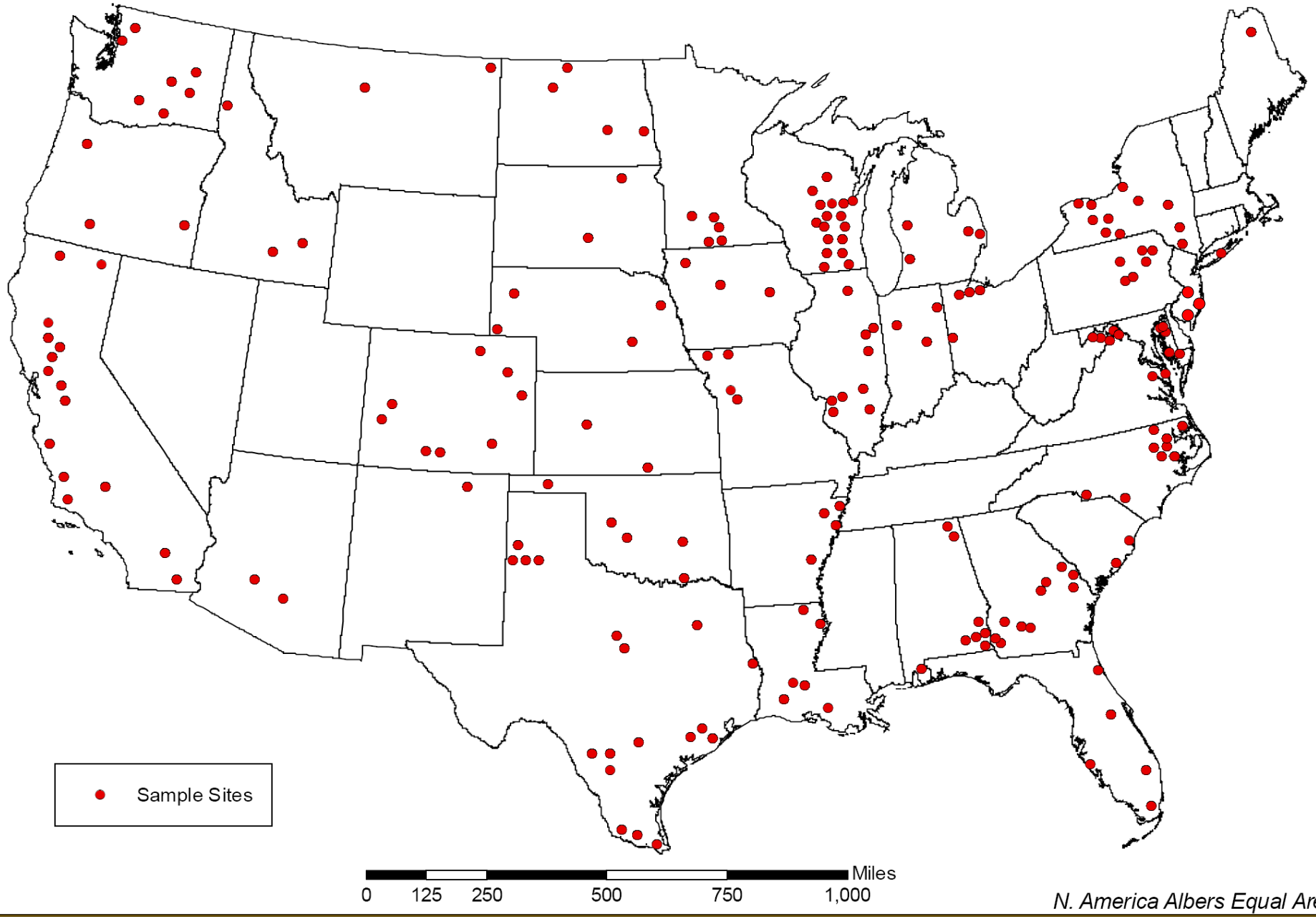
USGS

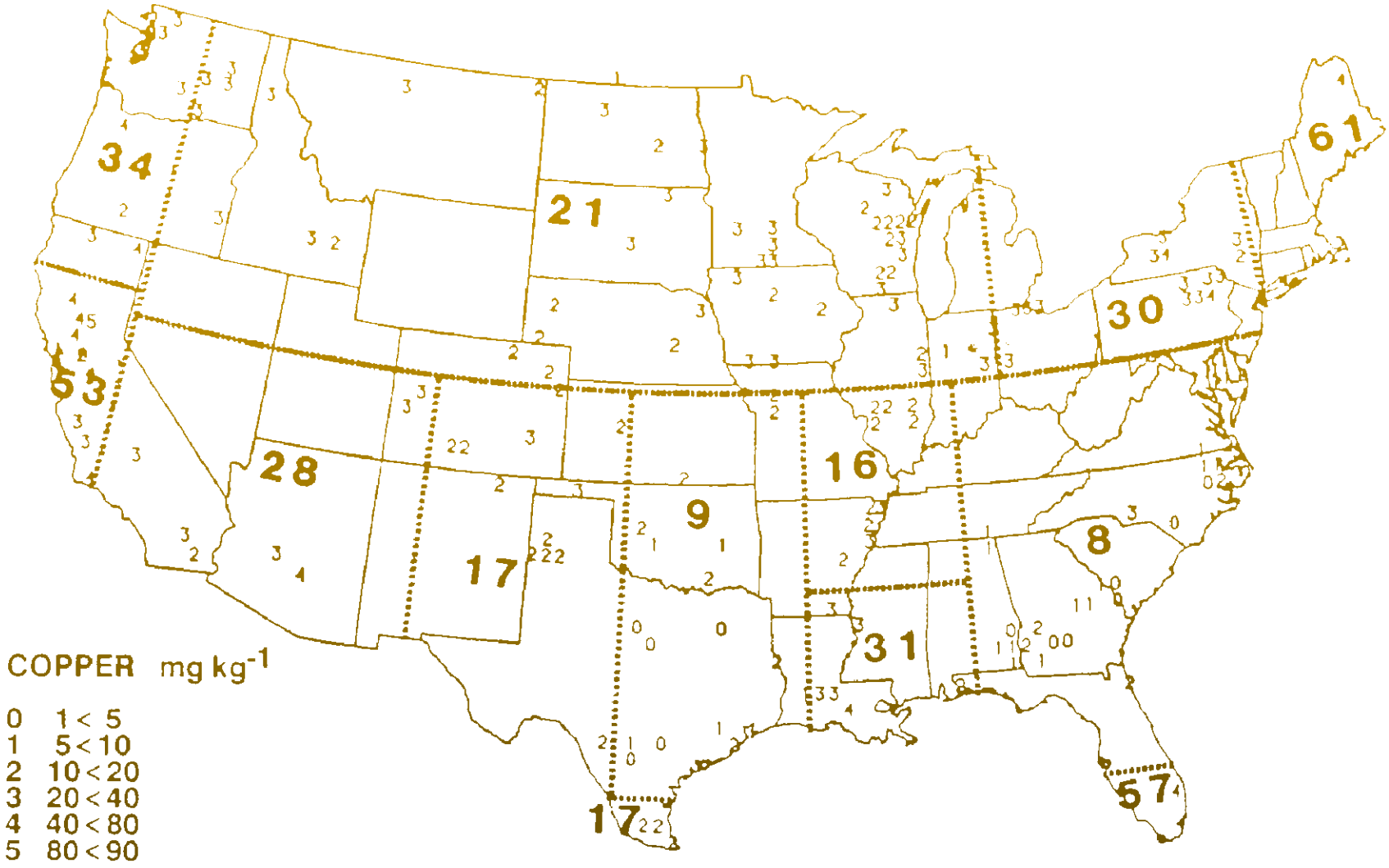
NRCS National-Scale Data (Holmgren et al., 1993, *J. Environ. Qual.)*

- 3,045 samples collected from agricultural fields in major crop producing areas
- Analyzed for Cu, Pb, Zn, Cd, and Ni
- Collected from 1978 to 1982

USGS

Sample sites of Holmgren et al.





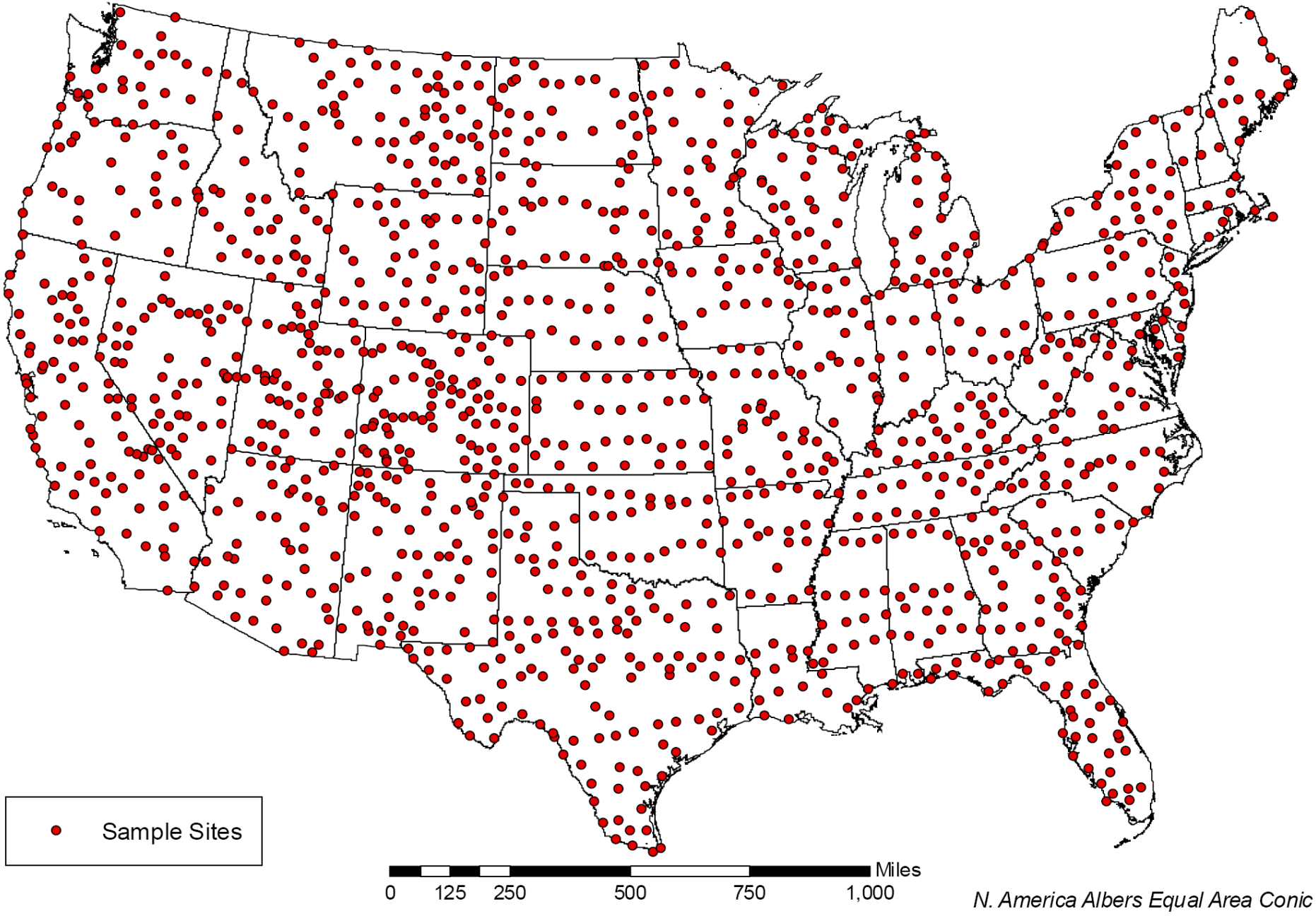
Map for copper based on NRCS national-scale data set. Bold numbers: Mean in selected area. Small numbers: codes for county average

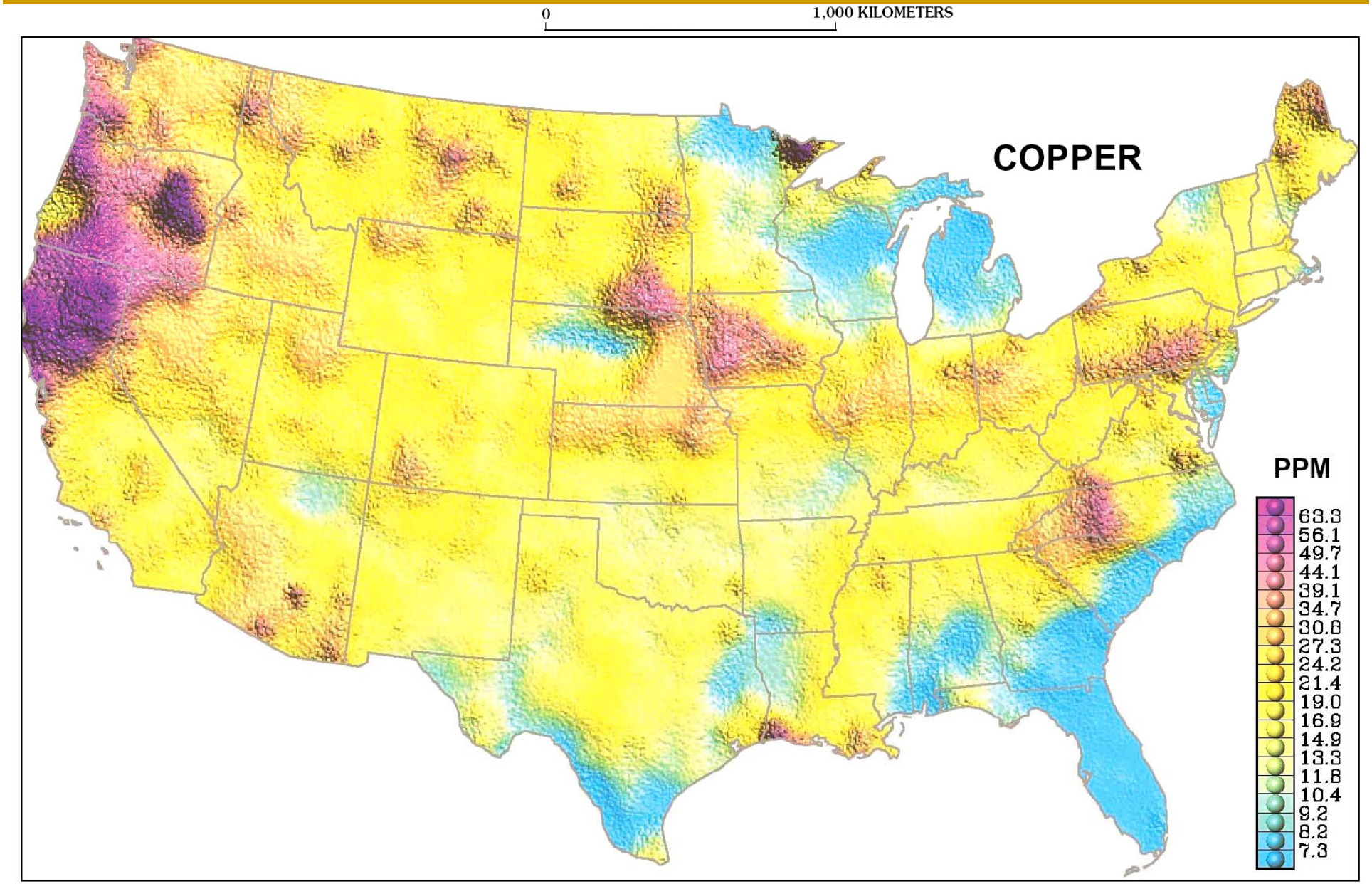
USGS National-Scale Soil Data (Shacklette Data)

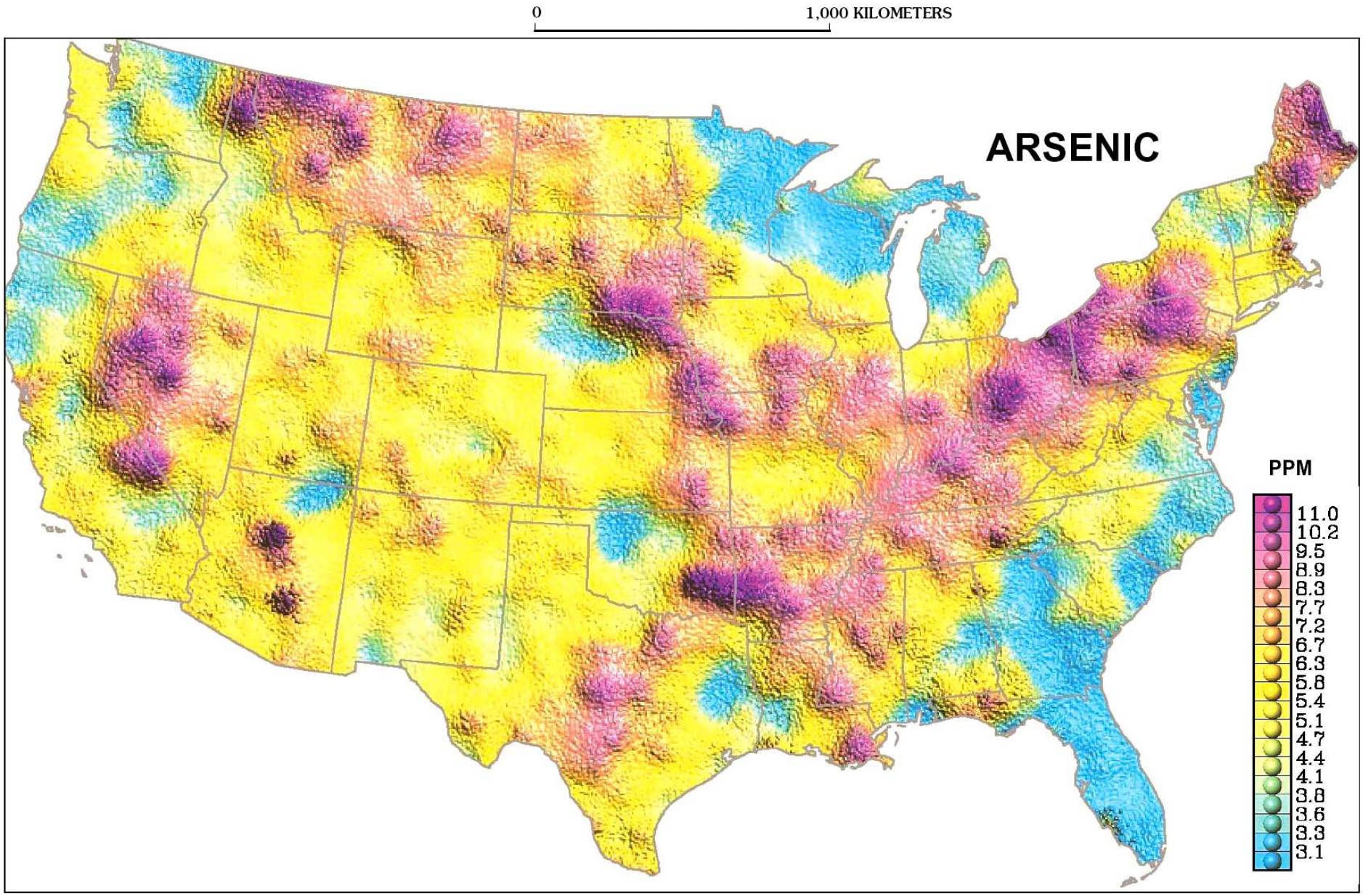
- 1,323 samples (1 per 6,000 sq. km.) collected from areas with native vegetation
- Collected from 1960s to late 1970s
- 40+ elements analyzed
- Still the most-often-quoted data for “background” values of trace elements in soil
- Similar data set for AK (Gough et al.)

USGS

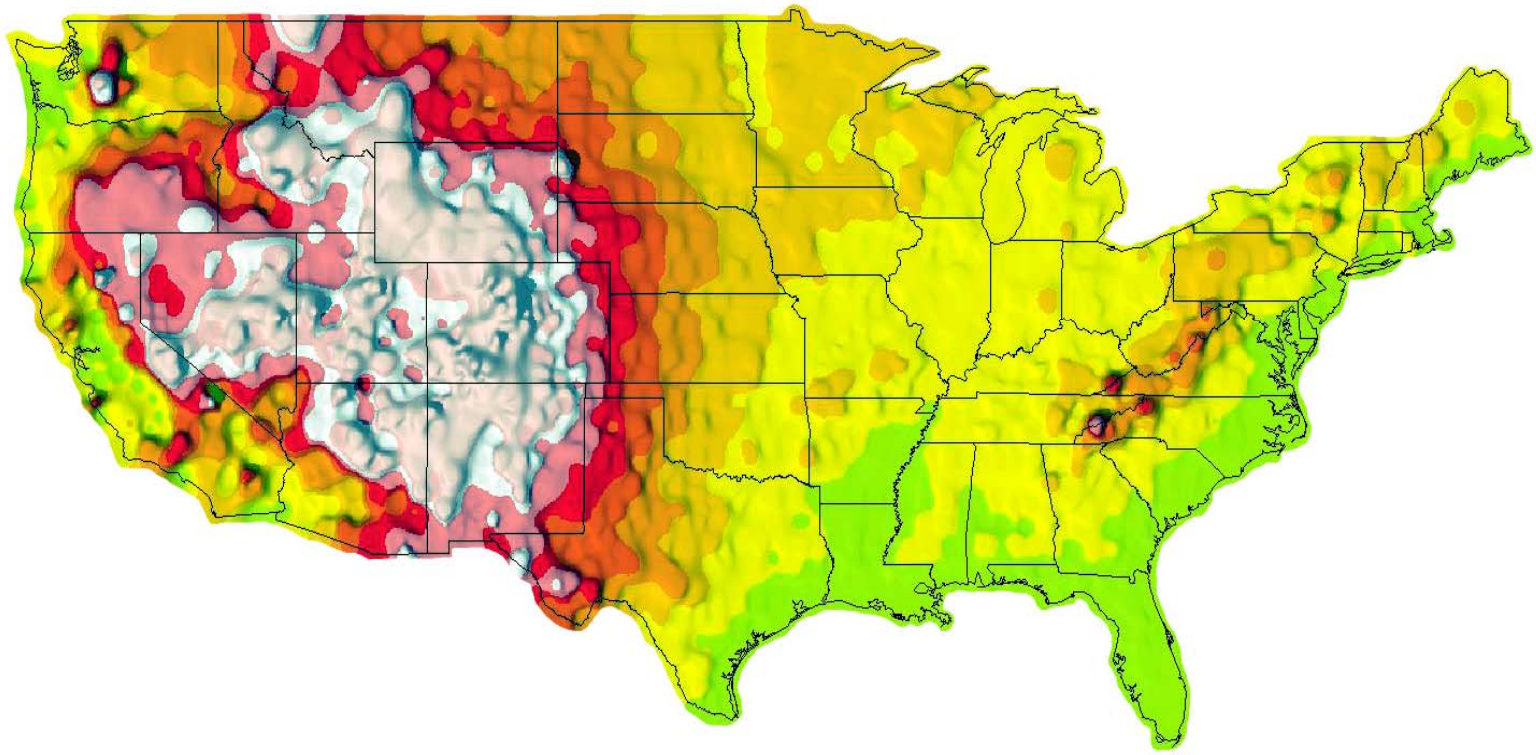
Shacklette sample sites



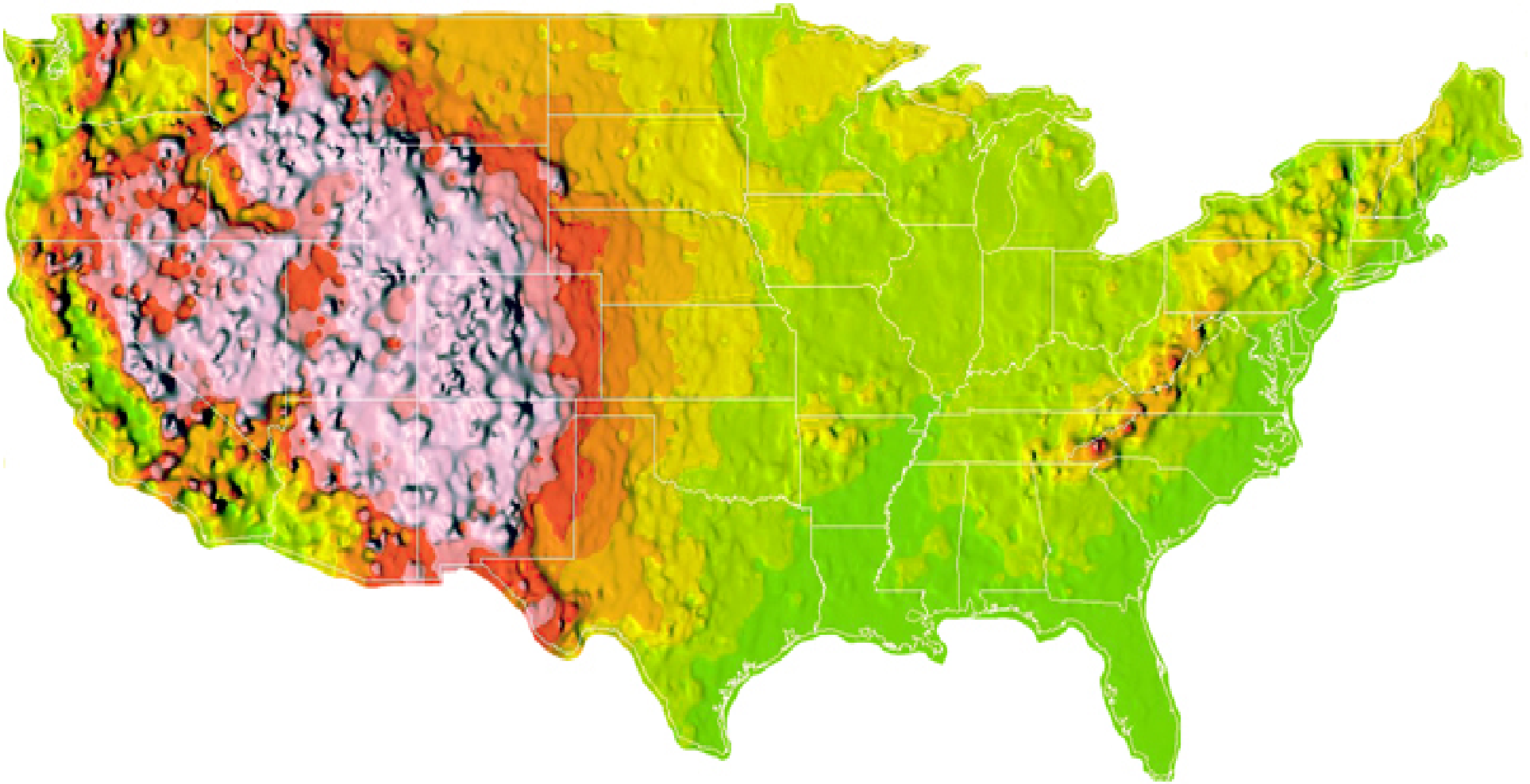

0
1,000 KILOMETERS
COPPER
PPM
63.3
56.1
49.7
44.1
39.1
34.7
30.8
27.3
24.2
21.4
19.0
16.9
14.9
13.3
11.8
10.4
9.2
8.2
7.3

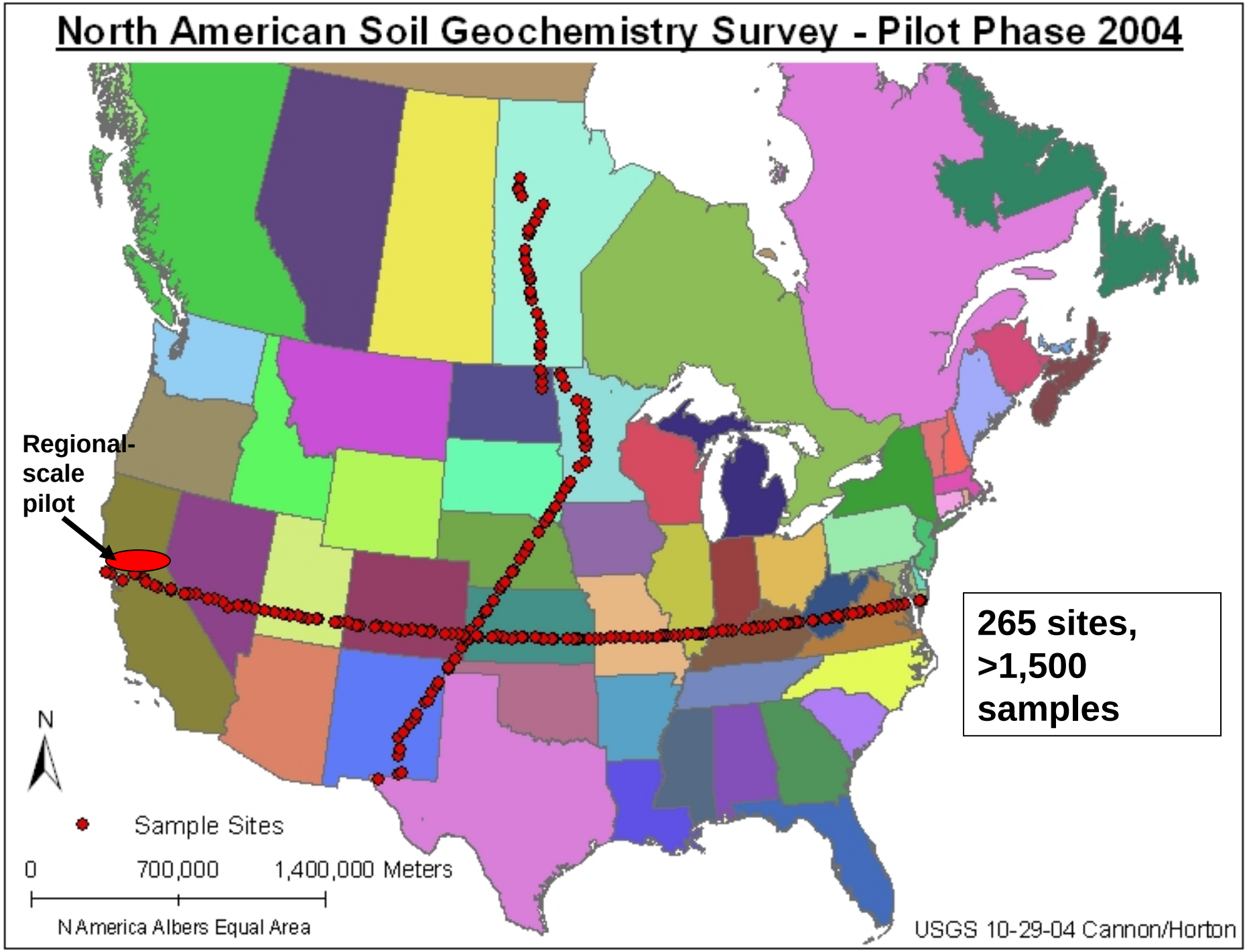

0
1,000 KILOMETERS
ARSENIC
PPM
11.0
10.2
9.5
8.9
8.3
7.7
7.2
6.7
6.3
5.8
5.4
5.1
4.7
4.4
4.1
3.8
3.6
3.3
3.1

TOPOGRAPHY OF THE CONTERMINOUS US INTERPOLATED FROM SHACKLETTE DATA POINTS



Topography of conterminous US interpolated from 4,000 sample points (approximate density of proposed continental-scale survey)




North American Soil Geochemistry Survey - Pilot Phase 2004
Regional-scale pilot
265 sites, >1,500 samples
N
Sample Sites
0
700,000
1,400,000 Meters
N America Albers Equal Area
USGS 10-29-04 Cannon/Horton


USGS

Sample types collected at each site

- 0-5 cm (265 samples)
  - Separate sample for organic compounds
- O horizon (38 samples)
- A horizon (244 samples)
  - Separate samples for microbial characterization
- C horizon or closest approximation (258 samples)

USGS

Sample Analysis

- Near-total extraction for major and trace elements (ICPMS/ICPAES) – USGS
- Forms of carbon, total sulfur - USGS
- Water extraction (A horizon) – GSC
- Gastric fluid and lung fluid extraction (0-5 cm) – USGS
- Gamma-ray spectrometry – GSC
- Phospholipid fatty acid analysis – UC Davis
- Enzyme assays – Oregon State University

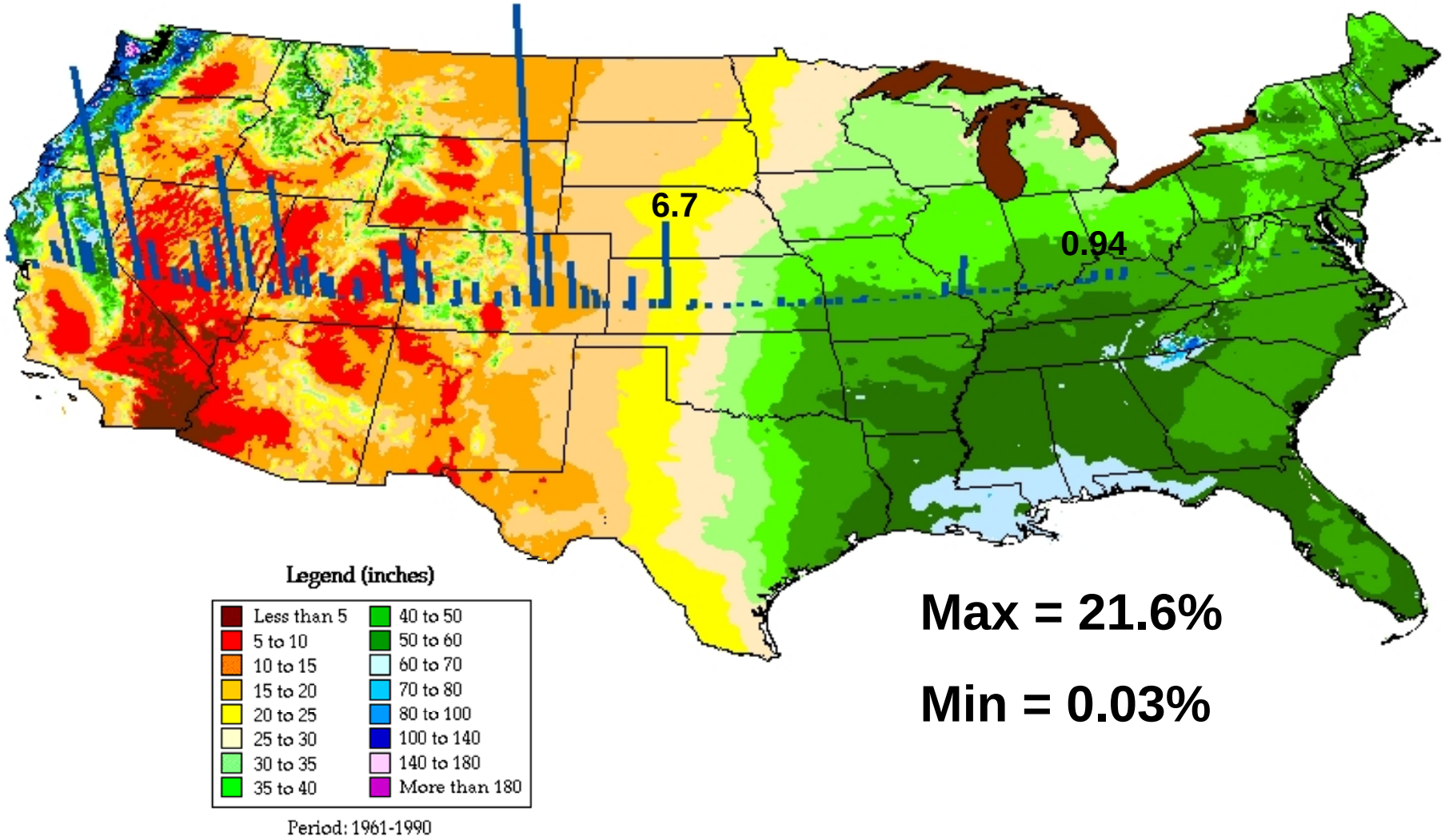
USGS

Sample analysis (continued)

- BioLog community profiling – USGS
- Human and agricultural pathogen screening – USGS
- Quantitative XRD (A and C horizon) – USGS
- Screen for 22 organochlorine pesticides – contract laboratory

USGS

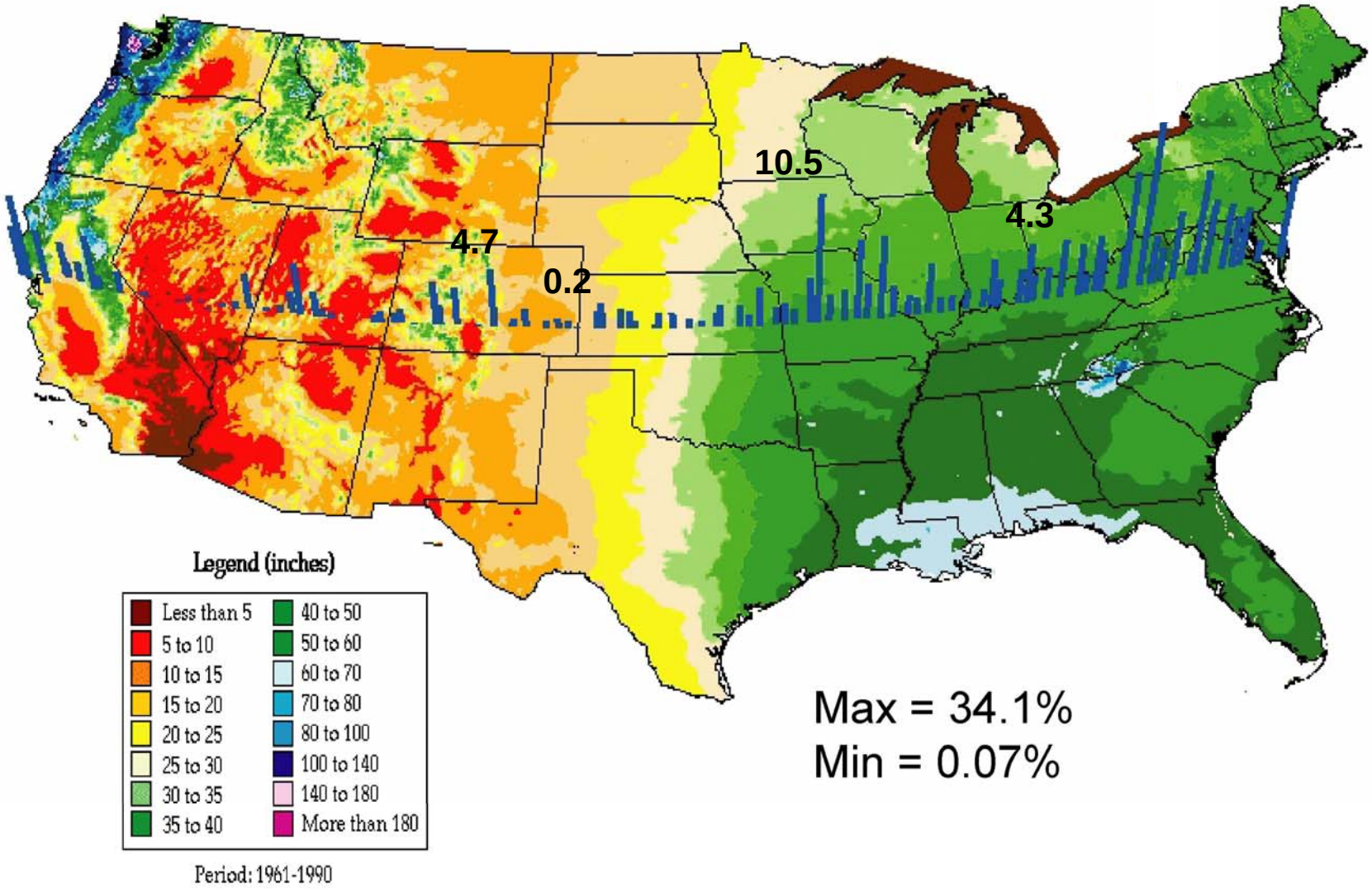
Calcium in A-horizon soils



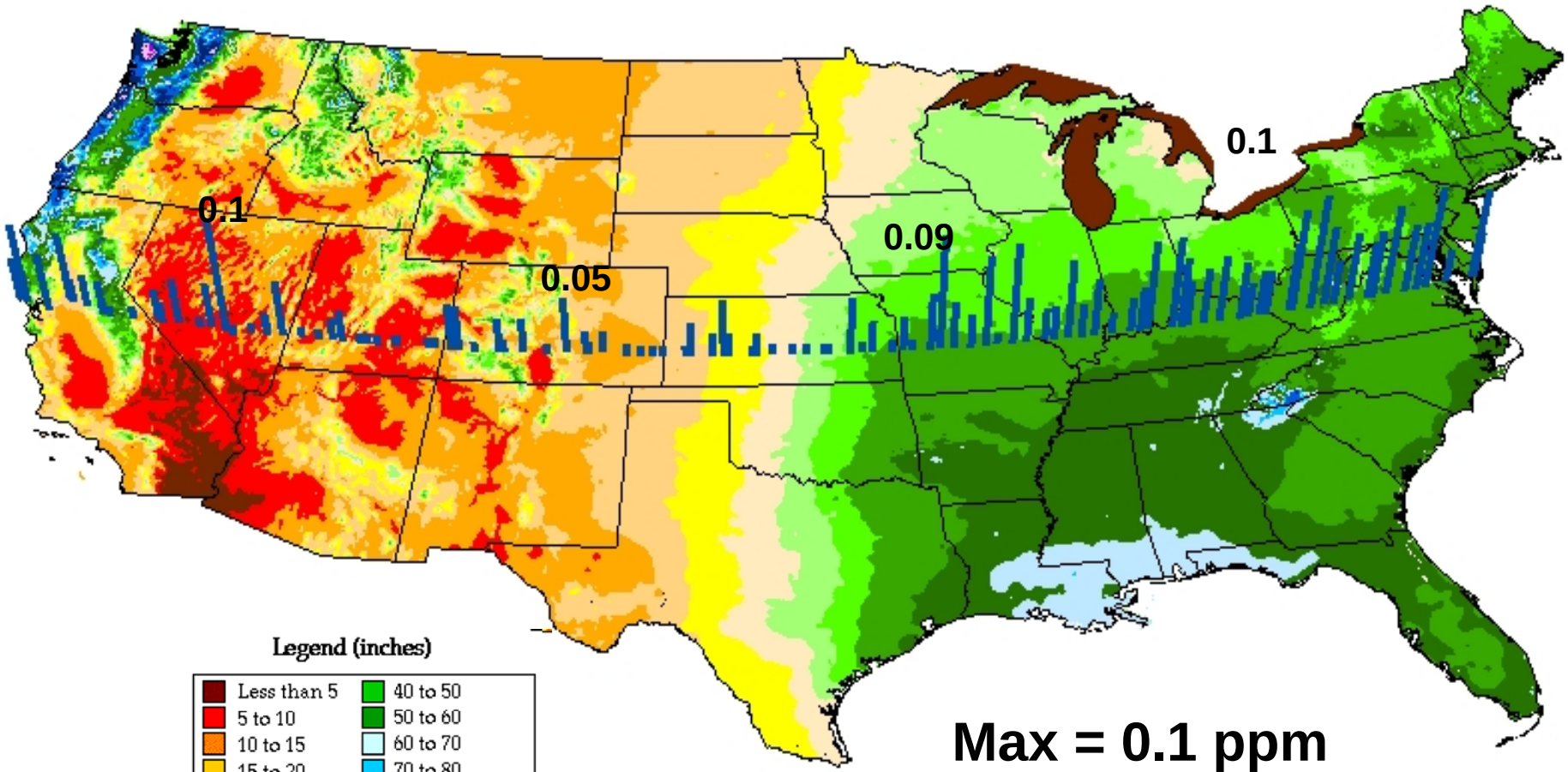
Max = 21.6%

Min = 0.03%

Organic carbon in A-horizon soils



Mercury in A-horizon soils



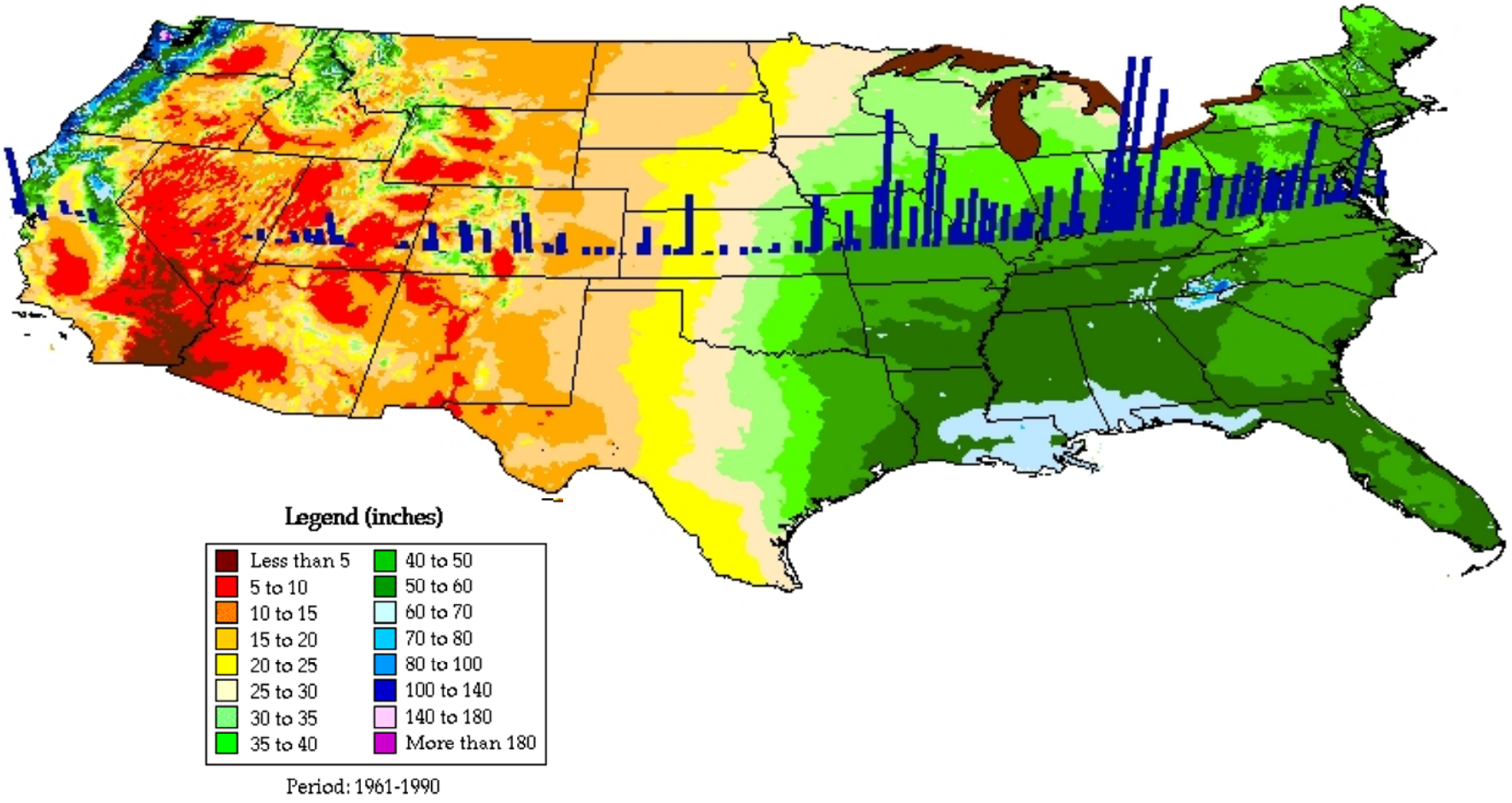
Max = 0.1 ppm

Min <0.02 ppm

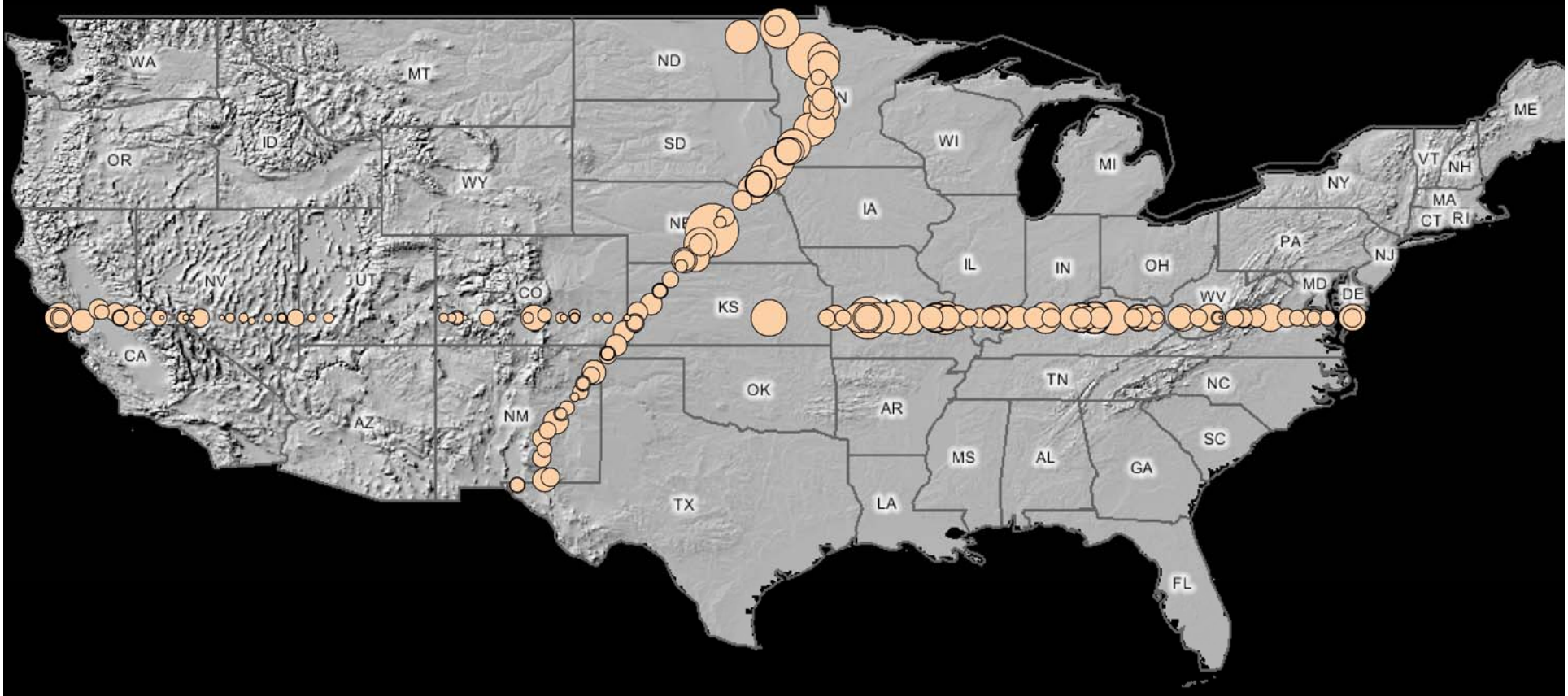
Arylsulfatase in A-horizon soils

Max = 750 mg *p*-nitrophenol per kg soil per hour

Min = 0.3 mg *p*-nitrophenol per kg soil per hour



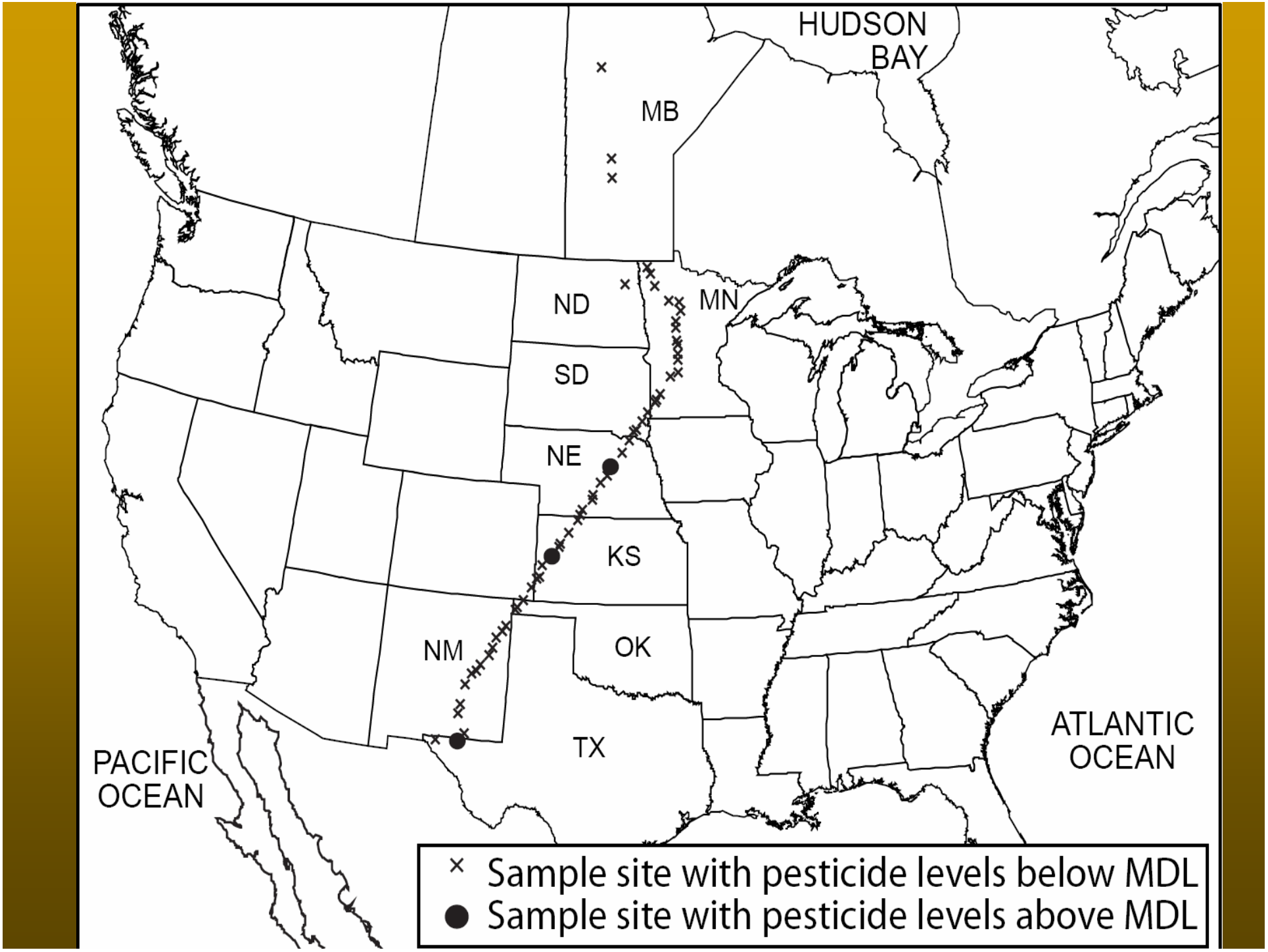
PLFA Biomass



Organochlorine pesticides analyzed (73 US samples from N-S transect)

- Aldrin
- Alpha-BHC
- Beta-BHC
- Gamma-BHC (Lindane)
- Chlordane
- 4,4’-DDT
- 4,4’-DDD
- 4,4’-DDE
- Dieldrin
- Endrin
- Endrin aldehyde
- Endrin ketone
- Endosulfan I
- Endosulfan II
- Endosulfan sulfate
- Heptachlor
- Heptachlor epoxide
- Methoxychlor
- Toxaphene

Red indicates persistent organic pollutants (POPs)


HUDSON BAY
MB
ND
MN
SD
NE
KS
NM
OK
TX
PACIFIC OCEAN
ATLANTIC OCEAN
Sample site with pesticide levels below MDL
Sample site with pesticide levels above MDL

Lessons Learned from Pilot Study

- Time on site: ~1 hour
- Average sites per day ~4-5 per team
- Collection/preservation protocols for organic compounds and microbial characterization add time on site and $$ for analysis
- Mostly non-detects for organic compounds
- Seasonal variation may affect some methods of microbial characterization

USGS

Lessons applied to NASGLP

- No specialized sampling for organic compounds
- Only anthrax for microbial characterization
- No O horizon collected

USGS

SO – THE CURRENT SAMPLE SUITE CONSISTS OF:

0-5 CM

A-HORIZON COMPOSITE

UPPER C-HORIZON

ANTHRAX SAMPLE (0-5 CM)

MICROBIOLOGY AT 10% OF SITES

WHAT WE ARE GOING TO DO

For sure:

- 42 element-ICP-MS for near-total digestion; A,C, 0-5cm
- Forms of carbon: A, 0-5cm
- Single element techniques for Hg, Se
- Quantitative XRD mineralogy; A and C horizon
- Anthrax screening; 0-5 cm

Contract laboratory

In-house

WHAT ELSE WILL WE PROBABLY DO?

Water leach 42-element

Aqua regia digestion 42 element

Radiometric scan

PLFA

PERMANENT SAMPLE ARCHIVE

In addition to the immediate analyses, a permanent archive of each sample, consisting of at least one kilogram, will be maintained by the USGS in Denver, CO and will be available for additional studies and analyses in the future.

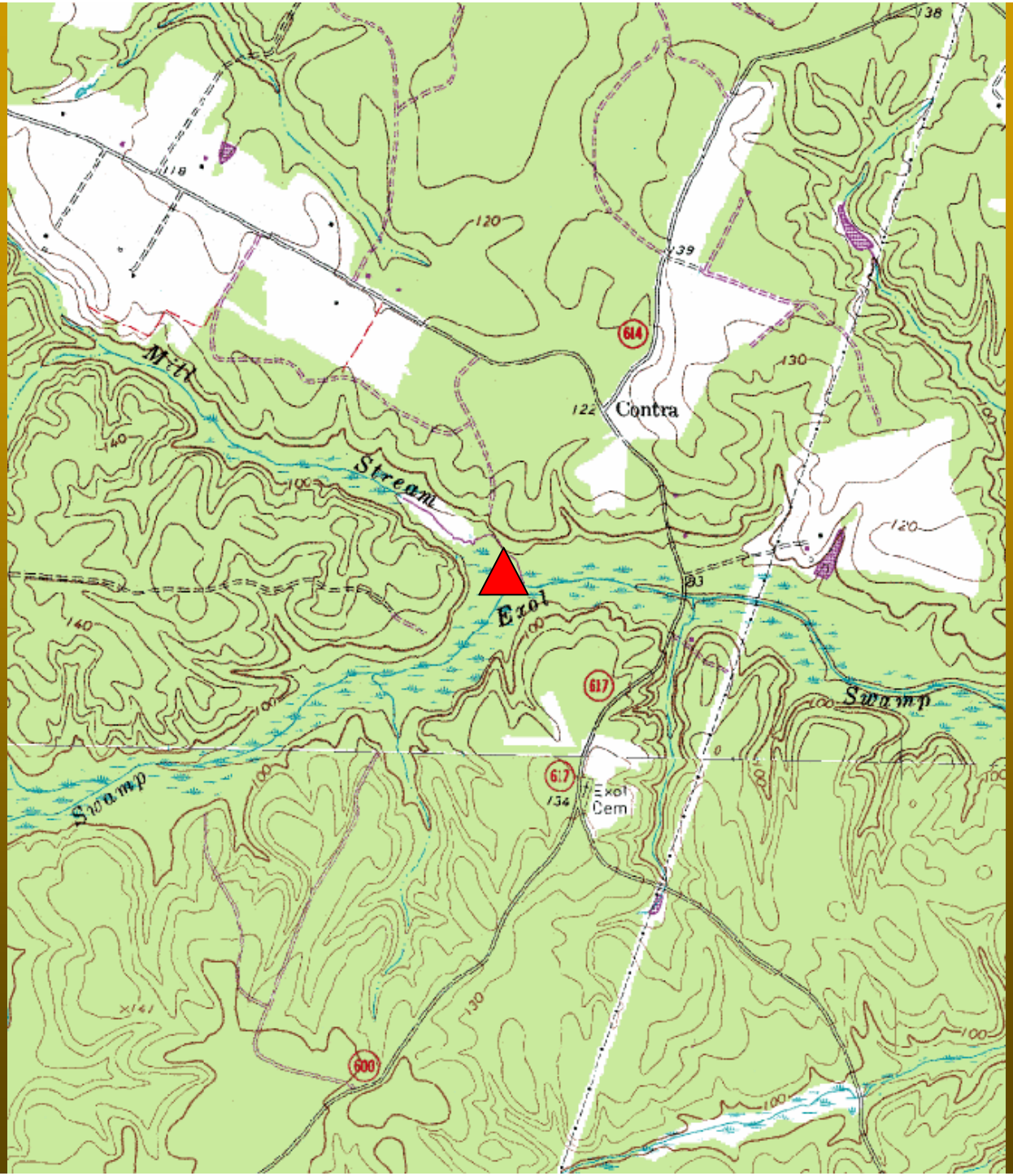
FIELD OPERATIONS

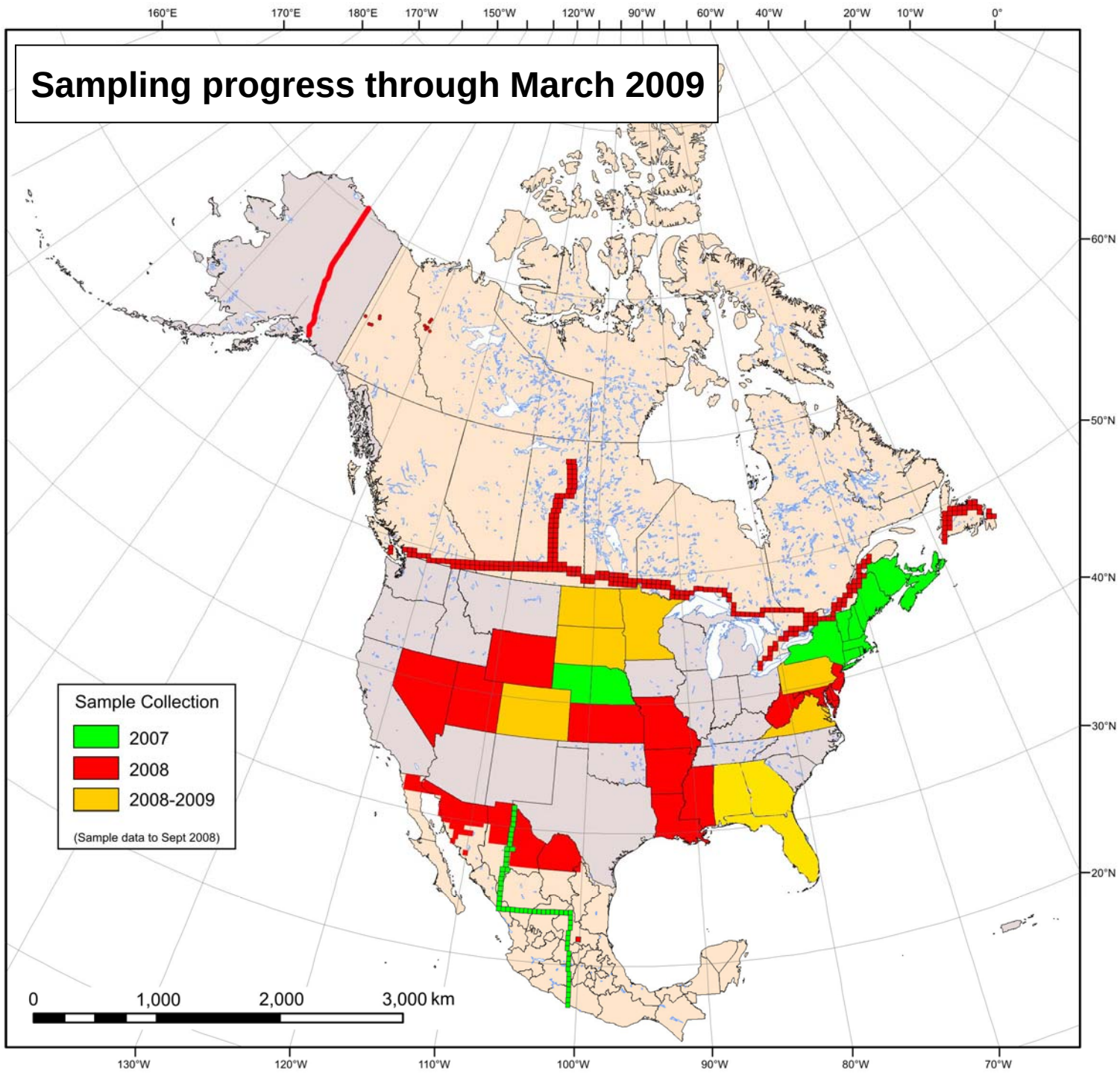
Site selection—exactly where should we dig a hole?

Make some judgments before going in the field using readily available data---but be flexible and practical.

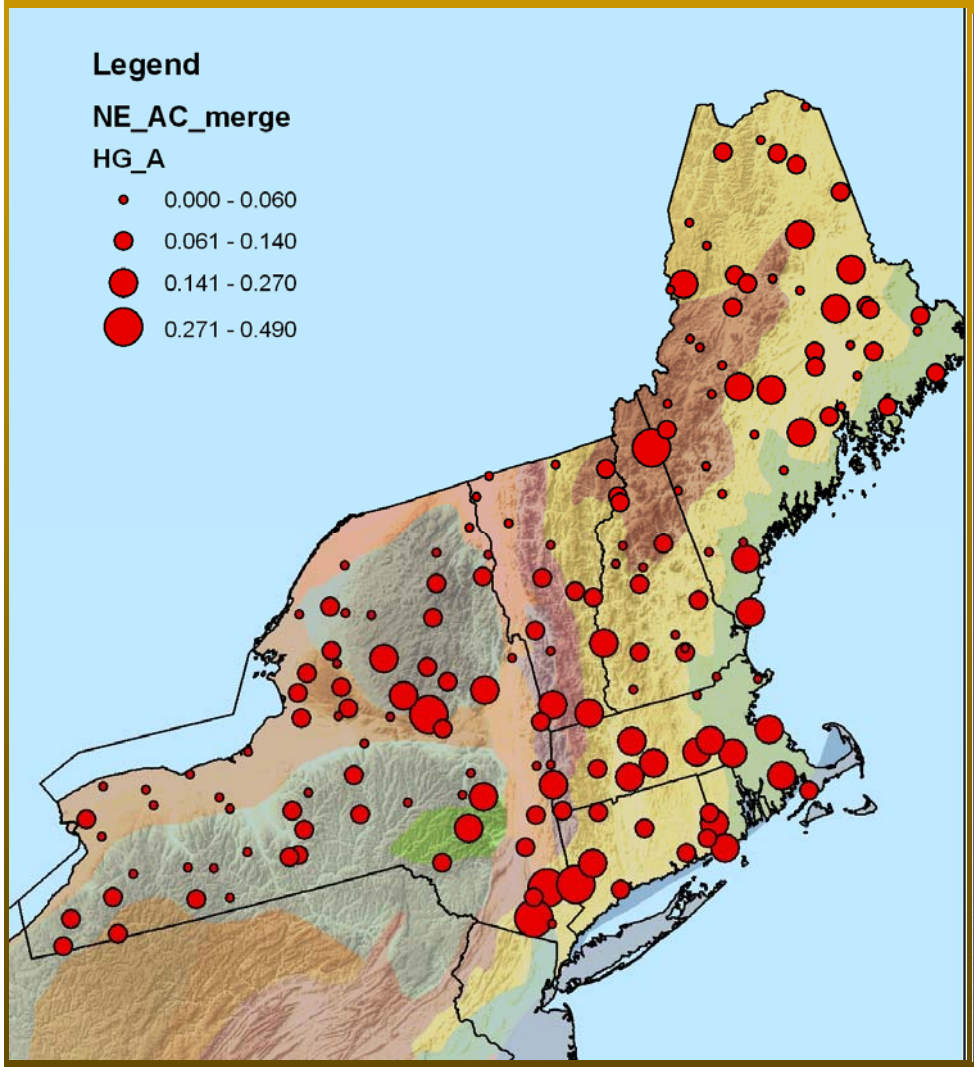
- **Topozone maps**
- **NRCS on-line soil maps**
- **NRCS on-line soil series descriptions**
- **Google Earth images**

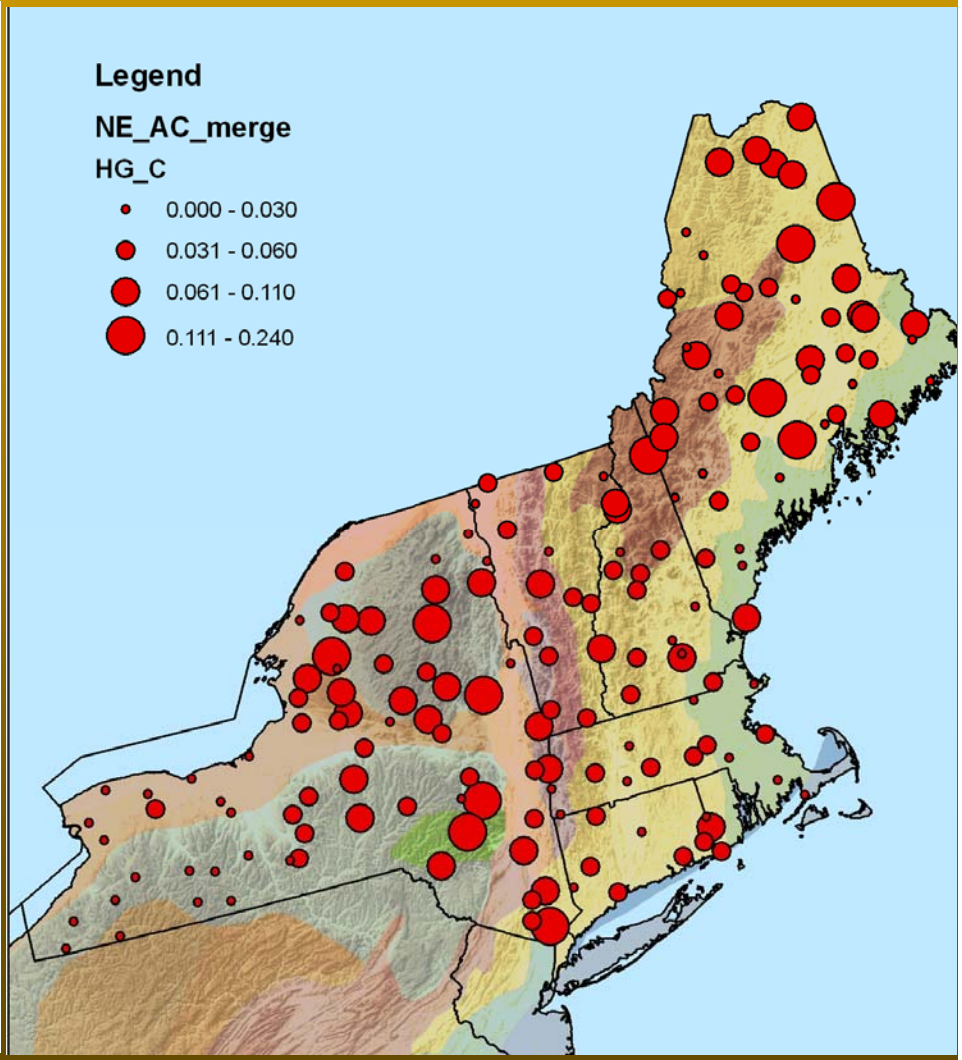
Then the hard part----find the landowner

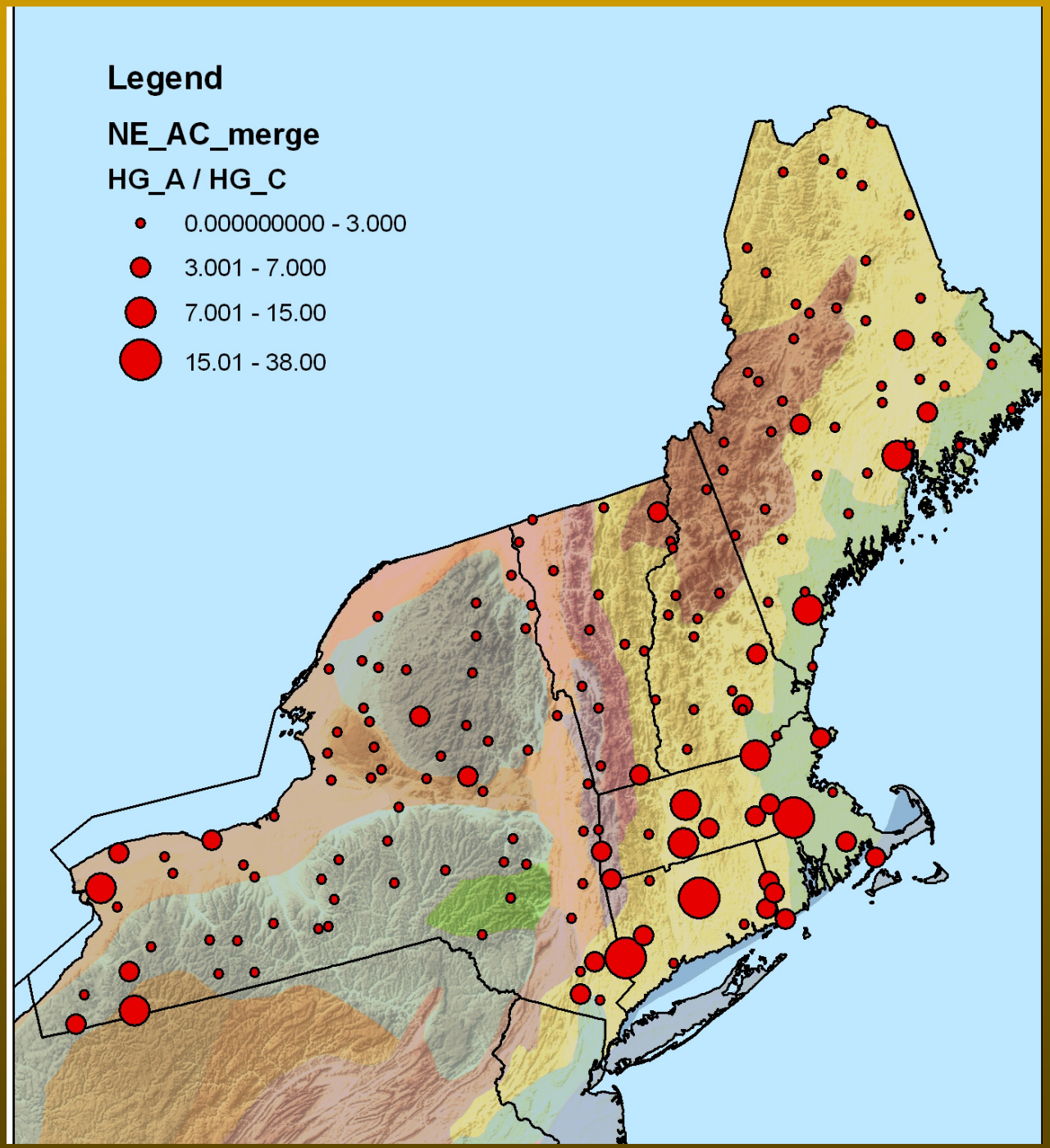

Contra
Stream
Exol
Swamp
Swamp
Exol
Cem
614
617
617
600
M&R

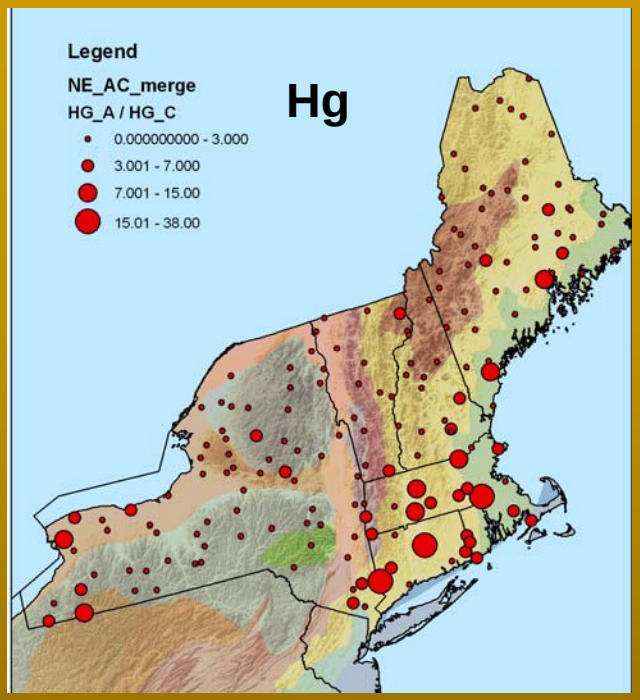

Sampling progress through March 2009
160°E
170°E
180°E
170°W
150°W
120°W
90°W
60°W
40°W
20°W
10°W
0°
60°N
50°N
40°N
30°N
20°N
130°W
120°W
110°W
100°W
90°W
80°W
70°W
Sample Collection
2007
2008
2008-2009
(Sample data to Sept 2008)
0
1,000
2,000
3,000 km

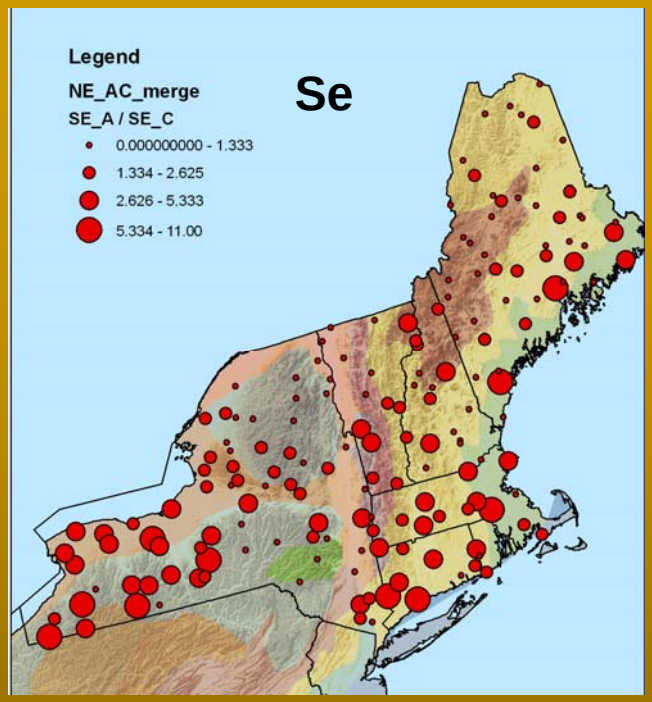
Total Mercury in A and C Horizons

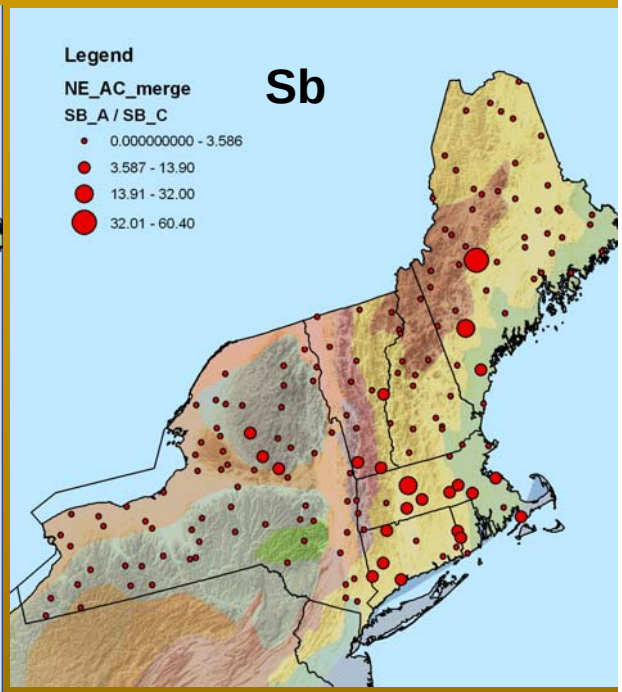


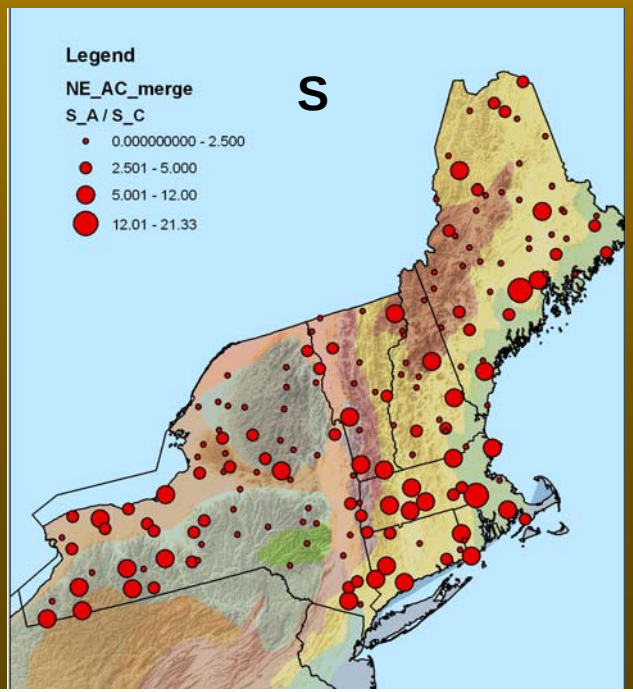


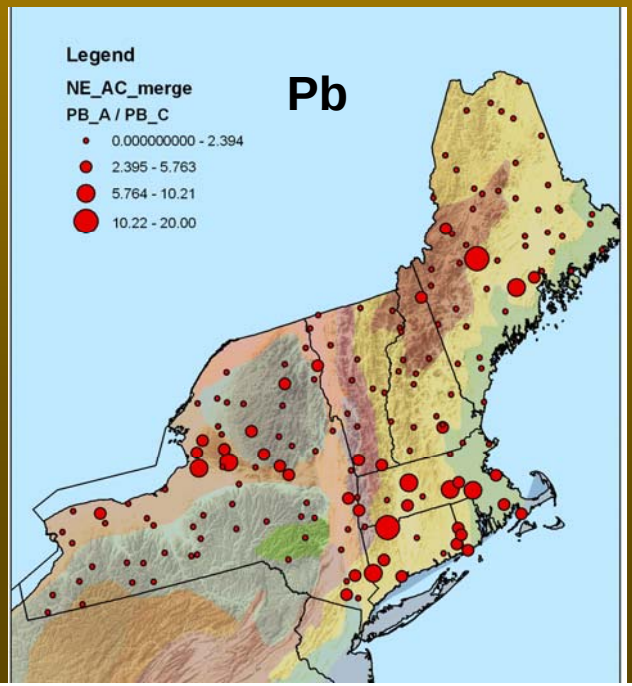

Legend
NE_AC_merge
HG_A / HG_C
0.000000000 - 3.000
3.001 - 7.000
7.001 - 15.00
15.01 - 38.00







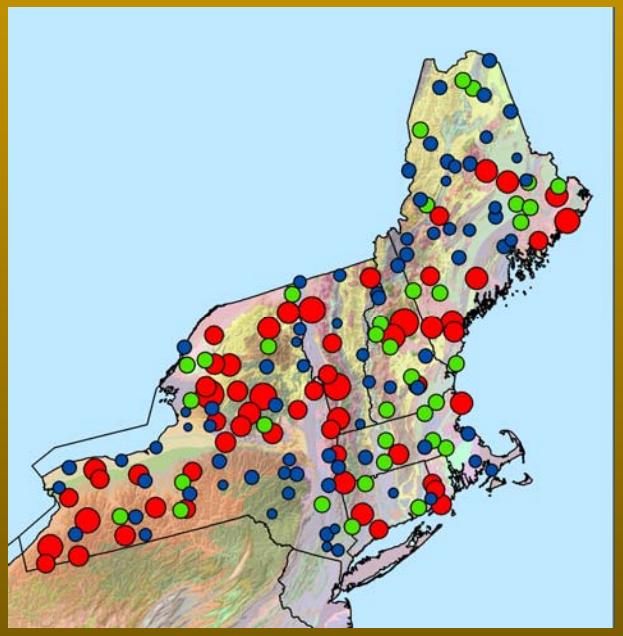




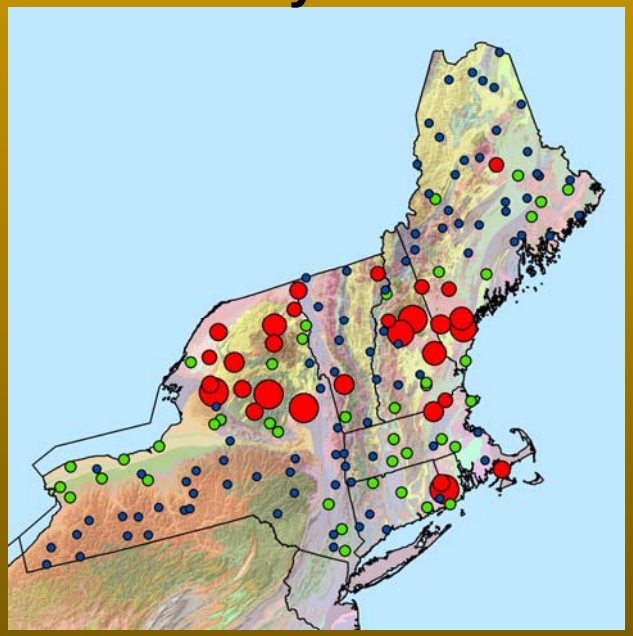
Enrichment patterns in A-horizon soil relative to C-horizon soils for 5 elements

Use of mineralogy to map mineralogic residence of potassium in C-horizon

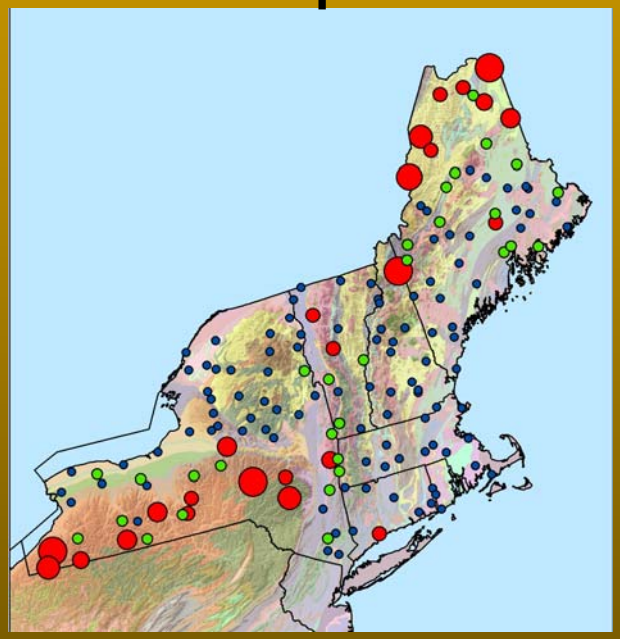
K



K normalized by total clay minerals

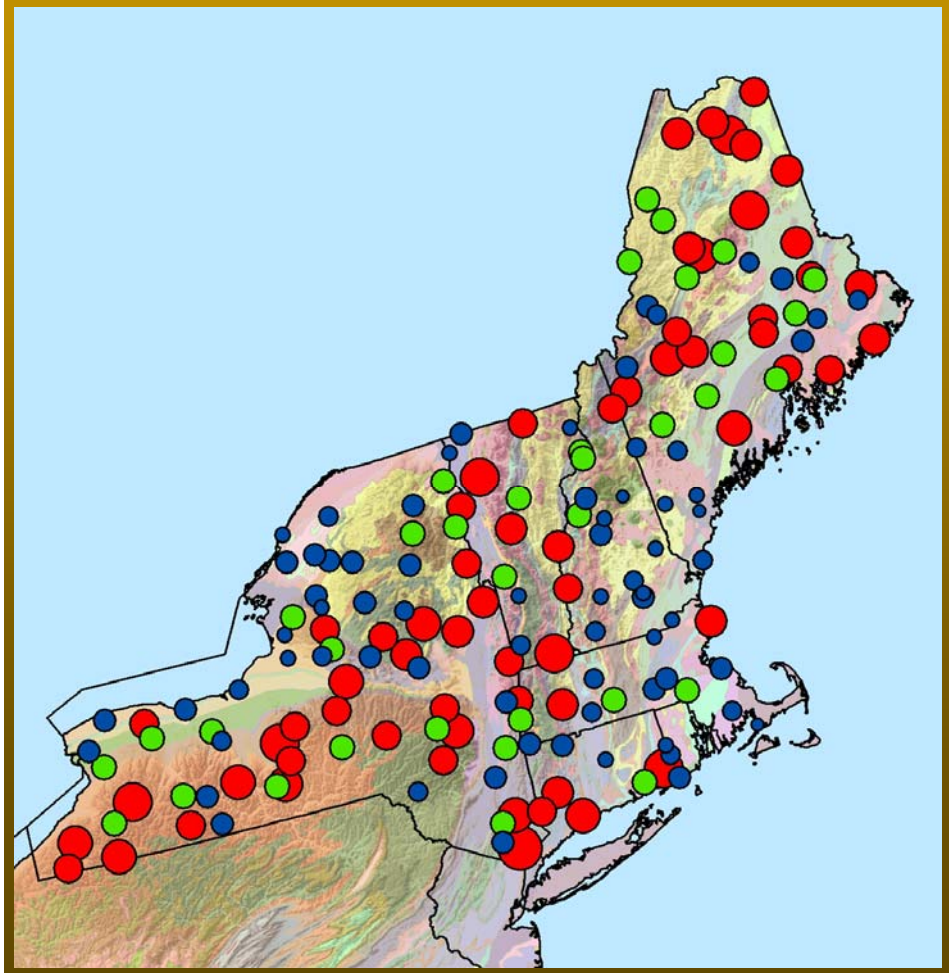


K normalized the K-feldspar



Using mineralogy to map the mineralogic residence of vanadium in C-horizon

V



V normalized by total clay