GEOCHEMICAL ANALYSIS PROGRAM IN USDA-NRCS

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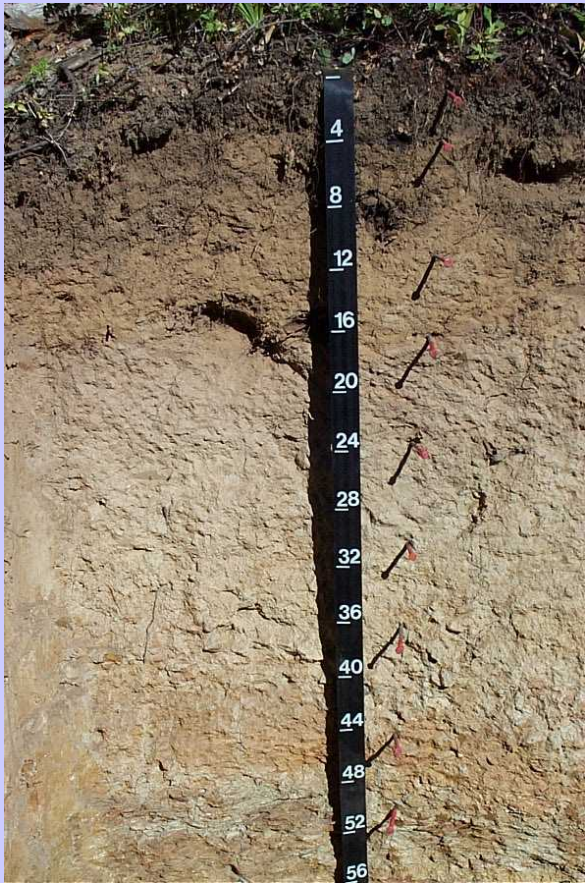
USDA-NRCS-NSSC

SOIL SURVEY LABORATORY



OBJECTIVES

- **Trace Elements - background and importance**
- **Present work in the NRCS Soil Survey Laboratory**
- **Future directions/cooperation**

ELEMENTAL SOURCES IN SOILS

Systematic variability: Attributed to a cause, predictable

- ***Lithogenic* - *from parent materials***
- ***Pedogenic* - *redistribution by soil-forming processes***

ELEMENTAL SOURCES IN SOILS

- **Random / Unpredictable variability:**

***Anthropogenic* - result of man's activities (urban, industrial, agricultural, mining)**

ANTHROPOGENIC CONTAMINATION

- **Residential** – biosolids (e.g., Zn, Cu, Ni, Cd)
- **Agricultural** – fertilizers, manures, limestone, gypsum (e.g., Cd, Zn, Ni)
- **Industrial** – manufacturing processes (e.g., Cr, Zn, Pb, Hg, As)
- **Metal Mining and smelting** – MT, OK, TN (e.g., Zn, Cd, Cu, Pb)
- **Fossil Fuels** – emissions (e.g, Pb, V)

Elemental Analysis
APPLICATIONS TO SOIL SURVEY

Soil quality and health-

- ***assessment of soils***
- ***background/baseline information***
- ***evaluation crop/forage/livestock production suitability***

Environmental protection

- ***Determine safe levels for waste application***
- ***Monitor waste management practices***
- ***Evaluating possibility/degree/source/risk of contamination***

Elemental Analysis
APPLICATIONS TO SOIL SURVEY

Defining soils, mapping units.

-ranges of properties

Pedon and Landscape Processes

-Direction/extent of weathering

-Determining types/origins of source materials

IONIC FORMS OF TRACE ELEMENTS

- **Cations** - Cd^{+2}, Co^{+2}, Cr^{+3}, Hg^{+2}, Ni^{+2}, Pb^{+2}, Zn^{+2}
- **Oxyanions** - AsO_4^{-3}, $B(OH)_4^{-1}$, CrO_4^{-2}, MoO_4^{-2}, $HSeO_3^{-1}$, SeO_4^{-1}
- **Halogens** - F^{-1}, Cl^{-1}, Br^{-1}, I^{-1}

OXIDATION STATES OF ELEMENTS

- Fe = +2, +3
- Mn = +2, +4
- As = -3, 0, +3, +5
- Se = -2, 0, +4, +6
- Cr = +3, +6
- V = +3, +4, +5
- Others: C, N, S, Cu, U

FORMS OF TRACE ELEMENTS IN SOILS

- **Aqueous species**
- **Sorbed onto surfaces of soil materials (diffuse ion, outer sphere complex, inner sphere complex)**
- **Structural elements in solids**

  (polymer, co-precipitate, or homogenous precipitate)

BIOAVAILABILITY

Essential or toxic element is <u>bioavailable</u> if:

- **in a chemical form, plants can readily absorb it;**
- **once absorbed, it affects life cycle of plant.**

(*Sposito, G. 1989. The Chemistry of Soil.*)

METHODS TO DETERMINE BIOAVAILABILITY

- Sequential Fractionation
- Speciation - e.g., As, Cr
- Animal testing - e.g., soil consumption
- Blood from indigenous human population
- Soil chemical extraction - 1M $CaCl_2$, 0.1 M $Ca(NO_3)_2$
- Plant uptake/tissue concentrations

QUESTIONS ABOUT METAL CONTAMINATION

- **How can significant risks be accurately evaluated?**

- **How to remediate contaminated soils effectively (e.g., adjust pH, add organic material, phosphates, Fe oxides).**

SOIL PROPERTIES RELATED TO METAL DISTRIBUTION

- Carbon/organic matter
- Clay
- Oxides
- Cation Exchange Capacity
- pH
- Redox potential (Eh)

The Pedon Concept--

Extending limited point data to geographic coverage

NATIONAL SOIL GEOCHEMICAL DATABASES

- ***USGS - Shacklette***
- ***1960s to late 1970s***
- ***1,323 samples***

- ***NRCS - Holmgren***
- ***1978 to ~1990***
- ***3,045 samples***

- ***NRCS - Wilson and Burt***
- ***1993 to present***
- ***>1903 samples***

STATUS - NRCS TRACE ELEMENT PROGRAM

- 486 pedons (Benchmark, anthropogenic, other important soils)
- 1903 samples (major horizons, satellite samples)
- 50 states, Puerto Rico, Virgin Islands, Guam
- Morphological description, characterization data, georeference location
- Two digestions/sample: Major, Trace

Reported Elements

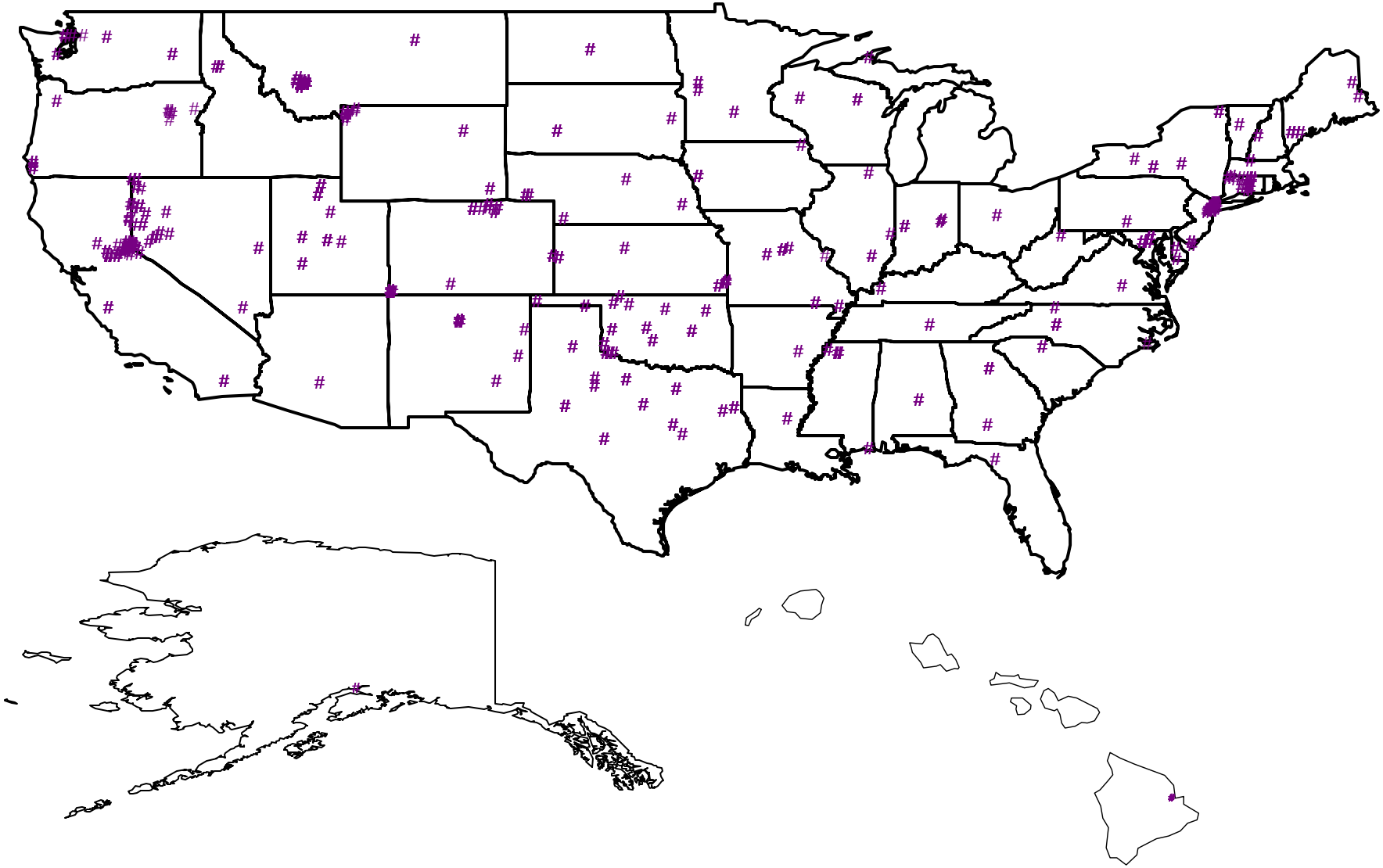
- **HF + Aqua Regia:** ***Si, Al, Fe, Mn, Ca, Mg, Na, P, K, Zr, Ti***

- **Aqua Regia:** ***Cu, Zn, Cd, Pb, Ni, Cr, Co, Hg, Mn, P, Fe, (Ba, Be, Sr, Sb, Ag, As, Se)***

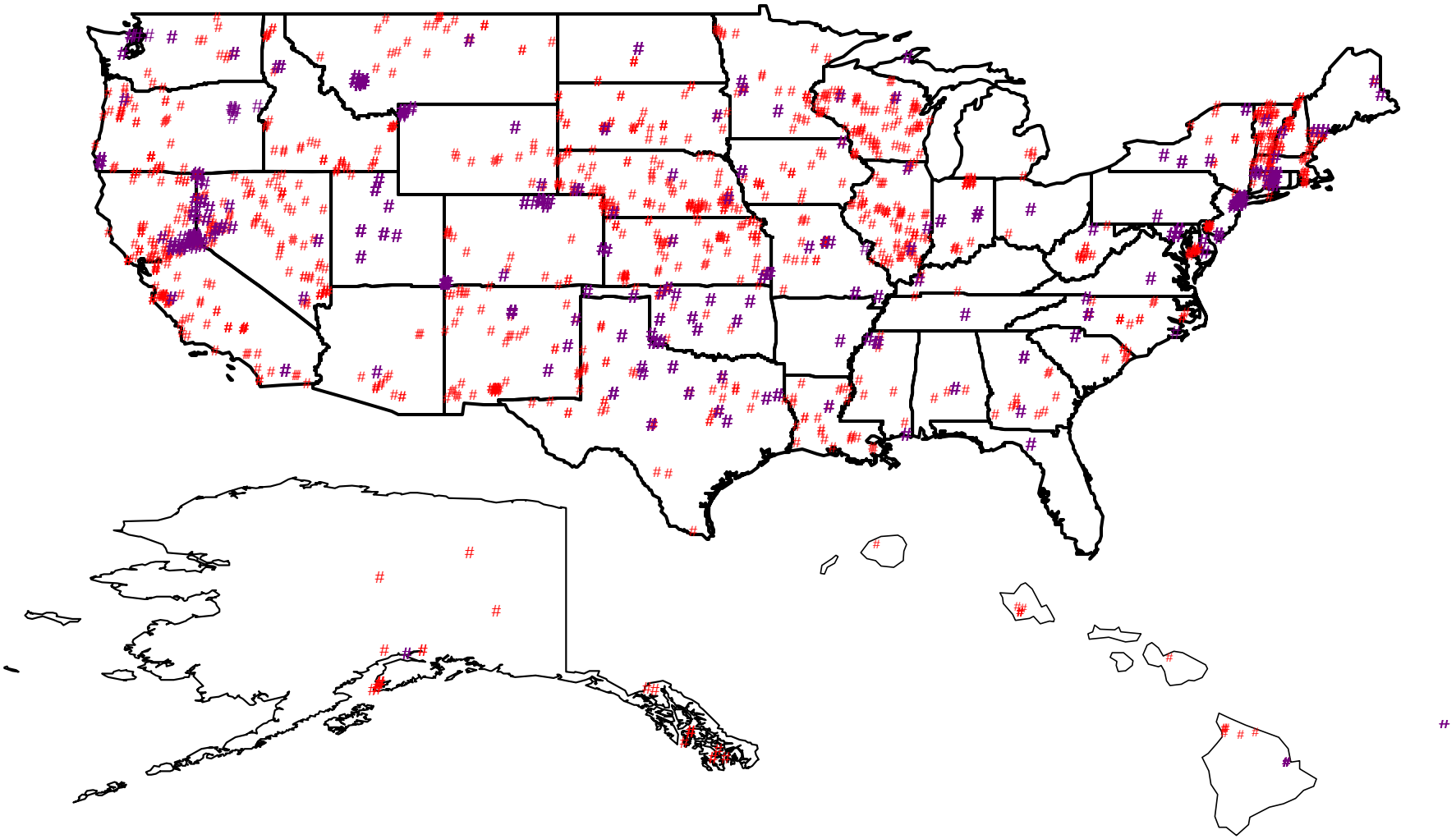
DATA DISSEMINATION

- Project reports to states and MLRA offices
- Presentations, Publications
- Database/data warehouse
- Website

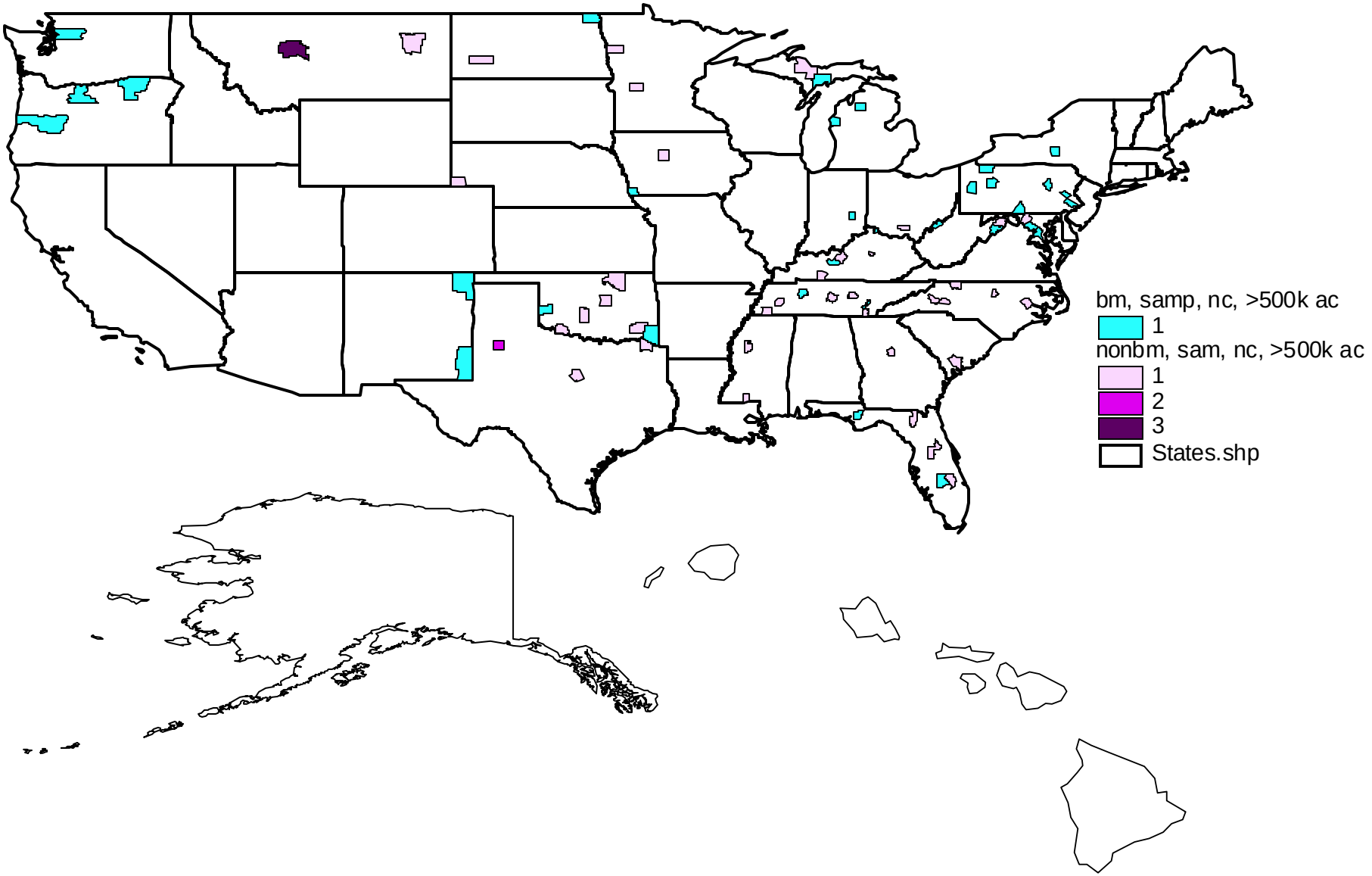
Pedon Locations for Trace Element Data



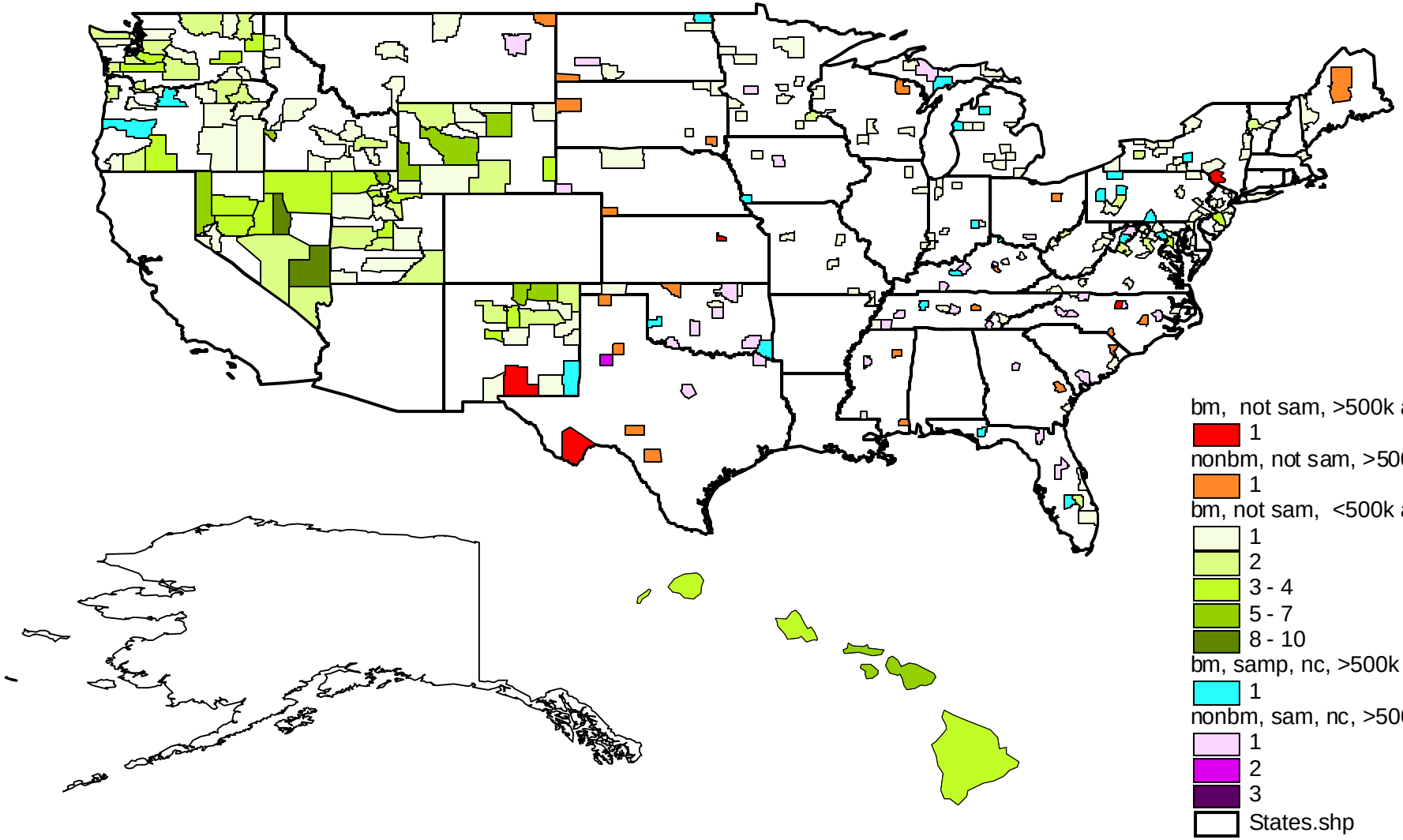
Benchmark pedon samples Available (red)



Counties with benchmark and other extensive Series, sampled and needing correlation in DB



Counties with benchmark and other extensive Series, sampled and not sampled



Evaluation Required for Additional Data Collection

- Basis for sampling - geographical vs. statistically random concepts
- Benchmark pedons and soils of significant acreage
- LRR, parent materials, and/or landforms in an MLRA or state

MINIMUM FIELD DATA SET
(based on current approach)

- ***Choose representative site***
- ***Identify soil type***
- ***Georeference location***
- ***Sample (minimum) 3 major horizons; possibly satellites***
- ***Site and Morphological documentation***

MINIMUM LABORATORY DATA SET

- ***Major and Trace elements***
- ***pH***
- ***Particle Size Analysis***
- ***Total C***
- ***Selective dissolution (e.g., citr. dith, acid ox.)***
- ***Cation exchange capacity***

USGS Collaboration

- ***Initial contact - March 2001***

- ***Project: Soil Geochemical Landscapes (Funding beginning FY 2003)***

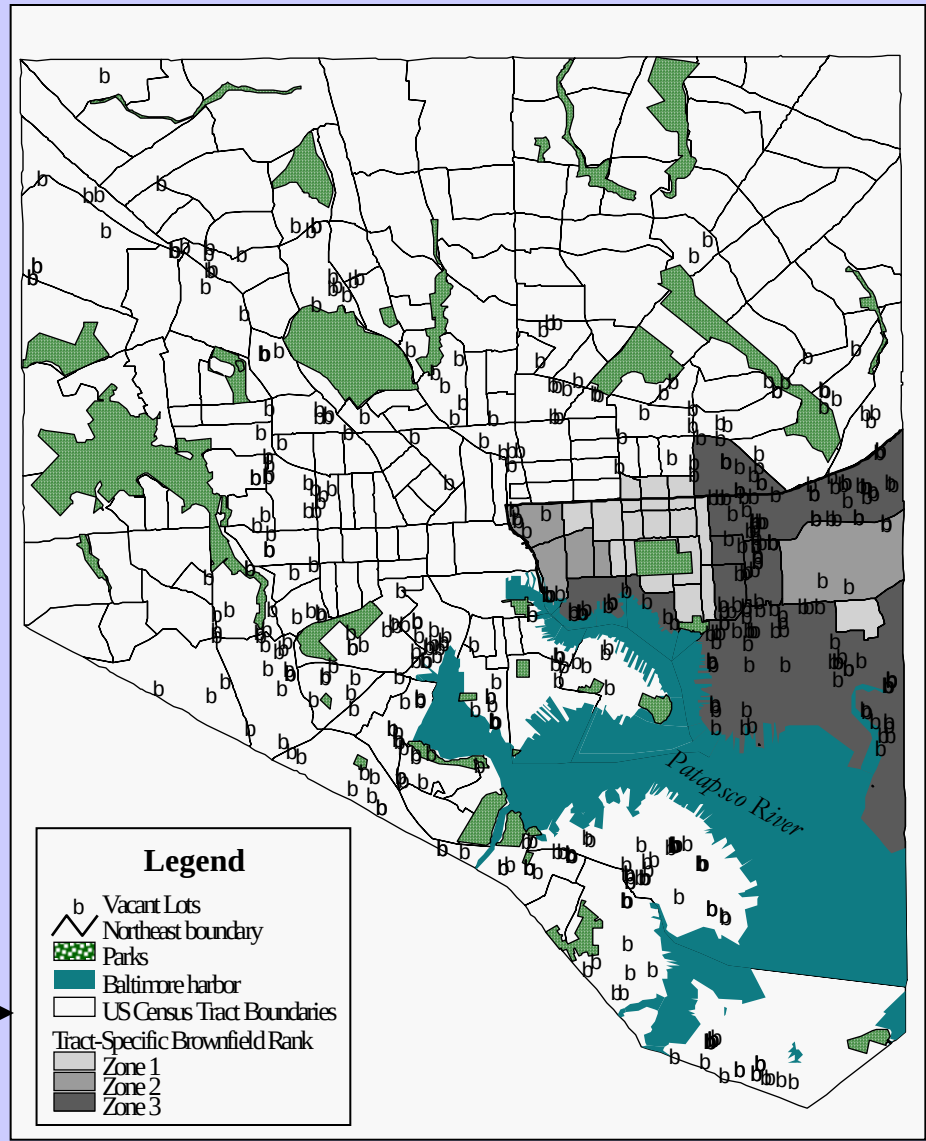
USGS Collaboration

- ***Objectives: Evaluate local and regional spatial distribution***
- ***Projects (on-going and new) of limited geographic area, followed by nation-wide survey***
- ***Components: trace elements, organic contaminants, microbial ecology***

Current Cooperative Efforts

Collecting 1000 lbs soil for laboratory trace element standard. Pawnee County, NE

Correlate geochemical data with epidemiological research (John Hopkins Univ.) of Baltimore residents near abandoned industrial brownfield sites



FUTURE COOPERATION

- Geochemical Map of North America
- Cooperatively managed website for trace element data repository/links
- Projects of limited scale
- Nationwide survey??

CONCLUSIONS

- **Elemental analysis provides data to address multiple needs of NRCS.**
- **NRCS SSL produces these data for site-specific or regional applications.**
- **Current approach is based on geo-reference pedons of major soils.**

CONCLUSIONS

- **Elemental data needs to be complemented with field documentation and additional lab analyses.**
- **We (Burt, Wilson) are willing to work with individual states/MLRA offices to provide data.**
- **If a cooperative program is developed with USGS, it should be tailored to the needs of the NCSS.**