Exploring and understanding patterns of biological diversity in Oklahoma soils

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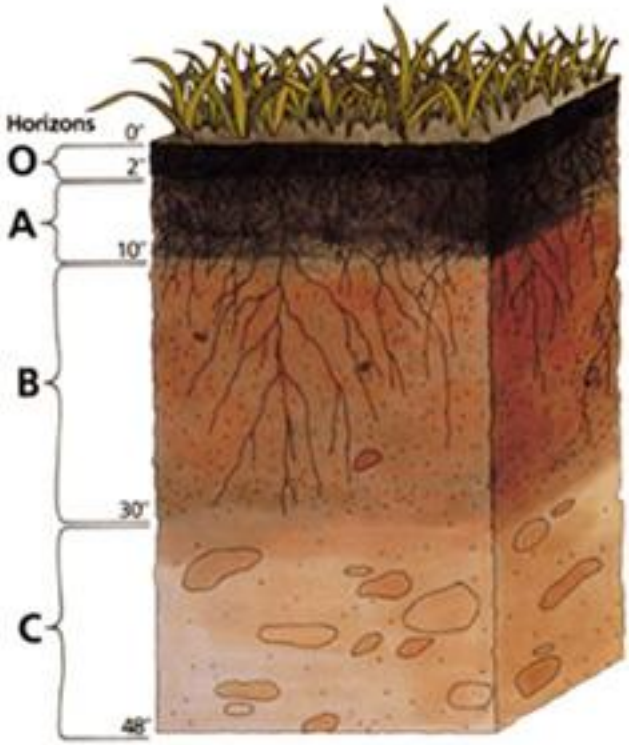
Soil: an amazing reservoir of biological Diversity

- Soil
  - The unconsolidated layers on the immediate surface of earth, consisting of mineral and organic matters.
  - Formed when minerals from rocks and organic matter from plants and animals combine.
- Soil is an extremely important ecosystem:
  - Economically: Agricultural, pasture, flood control, water filtration and purification.
  - Ecological cycling: Carbon sequestration, nitrogen cycling, photosynthesis.
  - Management, processing and detoxification of a variety of wastes, both natural and man-made through the activity of soil microorganisms.

The diversities of soil types within Oklahoma and beyond

- Parent material, climate, topography, biological factors, and time determines the type of soil.
- According to the USDA soil classification system, soil is classified into **Orders, Suborders, Great Groups, Subgroups, Families, and Series**.
- Soil is classified into 12 different orders, with 64 suborders.
- Each type of soil often have multiple diagnostic horizons.
- Within similar types of soil, differences in land usage, topography, climate, geographic location, exist.

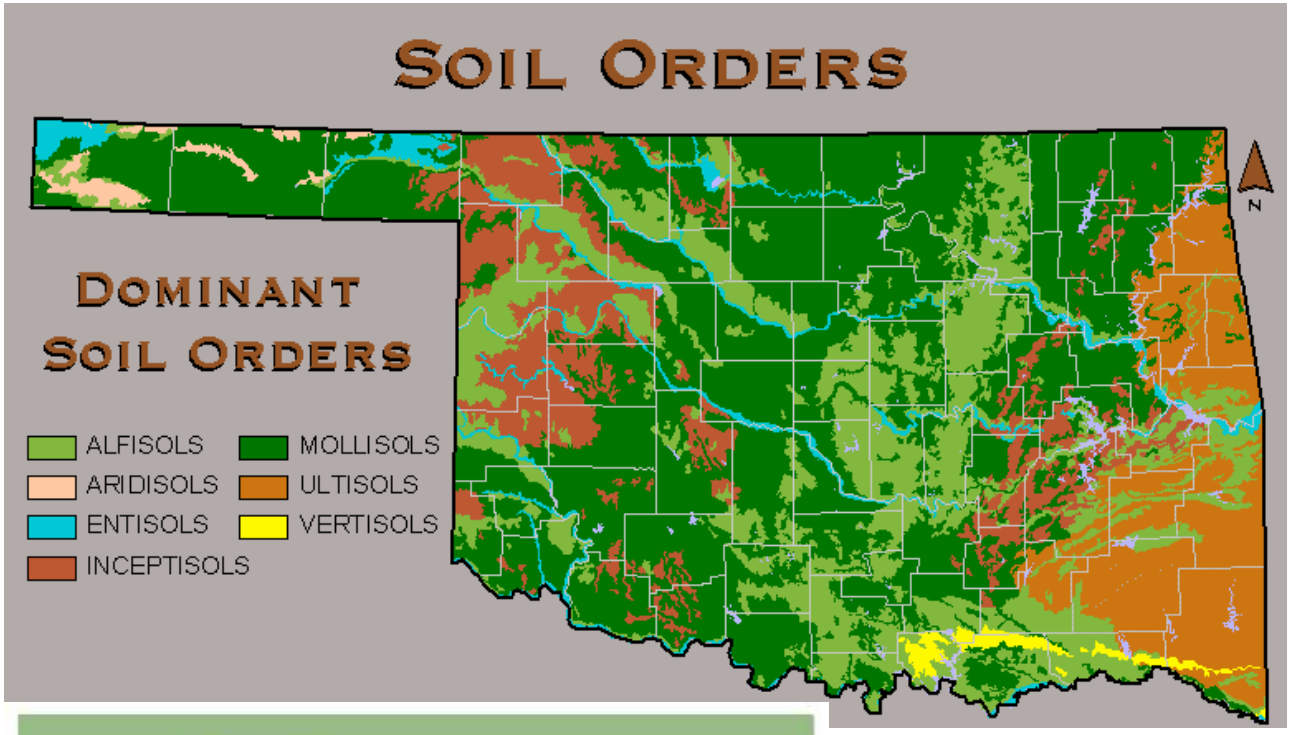


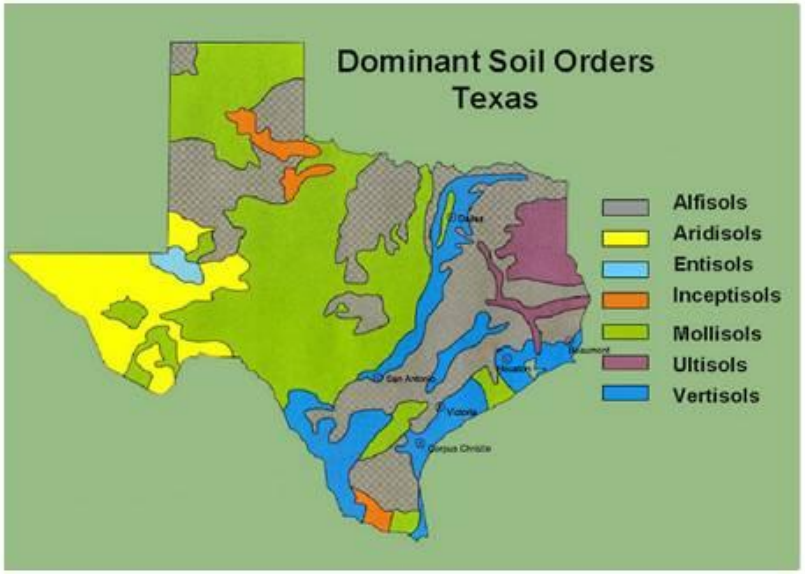
➢No two soil samples are exactly the same

➢No two soil samples have a similar microbial community

Soil is an inexhaustible reservoir of microbial diversity

Soil orders within the state of Oklahoma





- Within Oklahoma and Texas Panhandle 7 soil orders are present

Project Goals

I. Exploring and documenting biological diversity within OK soils

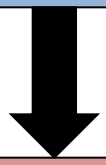
A. Phylogenetic diversity

B. Genomic diversity

C. Functional diversity

II. Elucidation of factors influencing microbial diversity and community structure in soils

New technical improvements in high throughput "–omics" approaches have greatly improved our capabilities to address these questions in highly diverse ecosystems such as soil



Now is the time

I. Exploring and documenting biological diversity within Oklahoma soils –A. Phylogenetic diversity

- ***Rationale:***
  - Multiple novel bacterial lineages are present in soil.
  - Documenting such diversity in multitude of soils will greatly expand (double, Triple, or even Quadruple) microbial diversity on earth.
- ***Goal:***
  - Complete documentation of soil phylogenetic diversities in Oklahoma Soils (and beyond).
- ***Approaches:***
  - High throughput sequence approaches and analysis to characterize microbial communities in Oklahoma Soils.
  - Implementation of novel approaches to access, examine, and document soils rare biosphere.
  - Does a shadow biosphere of unidentified, undetected microorganisms exist?

I. Exploring and documenting biological diversity within Oklahoma soils –B. Genomic diversity

- ***Rationale:***
  - –A large fraction of microorganisms in soil are uncultured, or have extremely few cultured representatives.
  - –Metabolic capabilities, ecological roles of these microorganisms are unknown.
  - –Access to their genomes of such lineages could greatly enhance our understanding of their importance, ecological role in soil.
- ***Goal*:**
  - –Targeted genomic and metagenomic analysis of novel yet-uncultured, and poorly characterized bacterial lineages in soil.
- ***Approaches*:**
  - –A single cell genomics approach to access genomes of novel uncultured lineages in soil.
  - –Novel, creative high-throughput strategies to isolate novel microbes.
  - –Targeted metagenomic approaches to resolve complexity, and improve binning of microbial metagenomes.

I. Exploring and documenting biological diversity within Oklahoma soils –C. Functional diversity

- ***Rationale***
  - –Metagenomic soil studies have found a large fraction of novel, unknown genes.
  - –Extensive functional redundancy within microorganisms and metagenomes.
- ***Goals***:
  - –Understanding functions of genes with yet-unknown functions?
  - –Understanding factors govern gene evolution in soil microorganisms?
- ***Approaches***:
  - –Metagenomic analysis for partial genomic reconstruction using few selected soil samples.
  - –Coupling metagenomics to Structure activity relationship studies to gain novel insights into protein activity, folding, and evolution of key protein families (Genomic biophysics).

II. Elucidation of factors influencing microbial diversity and community structure in soils

- ***Rationale***:
  - Various edaphic, climatic, or land usage factors shape microbial diversities.
  - Correlations between microbial community structure/diversity and abiotic factors are unclear.
  - Multiple correlations of factors could effect specific aspects of diversity and community structure.
  - Prior studies were simplistic, usually assessing the effect of single factor on microbial community structure/diversity.
- ***Approach***:
  - Temporal and spatial investigations of soil samples across all soil types, habitats and climates, and soil usages.
  - Detailed analysis of soil properties, characteristics, activities, compositions.
  - Detailed phylogenetic and functional analysis of communities per samples.
  - Statistical approach to correlate specific factor or combination of factors to observed community structure.

Outreach

- ***Active involvement*** of regional universities at different geographic locations in the state in sampling, investigation of soil properties, laboratory experiments, and analysis.

- Active participation of undergraduates through REU opportunities.

- Opportunities for high school students to join research laboratories in the summer.

- Developing summer and intersession courses.

- Annual soil scientists meetings, hosting international meeting of microbiology/ecology/soil sciences.

This project is…….

A multi-University

OSU, OU, UT, Cameron University, Northeastern State University (and potentially ALL Regional Oklahoma Universities.

multidisciplinary effort

Microbiologists, Soil scientists, Ecologists, Bioinformaticians, Computer scientists, Biophysicists, Statisticians, and Meteorologists.

with a focused theme

Exploring and understanding biological diversity in Oklahoma soils.

that leverages existing capacity, capabilities

DNA sequencing capacity, Cyber and computational capacity, strong nucleus of soil microbiologists/microbial ecologists.

while adding new expertise

Biostatistician, single cell biology, systems biology, genomic biophysics, and soil mycologist.

Thank you!

For a copy of the presentation, please email me:

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