KEARNEY FOUNDATION OF SOIL SCIENCE

2006-2011 Mission

Understanding and Managing Soil-Ecosystem Functions across Spatial and Temporal Scales

Mission Overview

Soils on the landscape (soilscapes) are complex physical, chemical and biological systems that involve processes and interactions occurring within and between the atmosphere, hydrosphere, biosphere and geosphere. These systems are dynamic in space and time and involve a constant interaction with environmental drivers. Scale issues are at the heart of many environmental problems because different processes may be dominant at different spatial and/or temporal scales. Research across multiple spatial and temporal scales is necessary to fully understand the large-scale response and the underlying processes regulating the response. Few processes in nature operate in a linear fashion, but rather in a strong non-linear manner. While a system may initially resist changes from a forcing factor, a relatively small change at some point may push the system across a threshold that leads to an abrupt change in the response.

The focal point of this mission is to conduct multi-scale (spatial and/or temporal) basic and applied research that has clear relevance to land management decisions and policies. Research within the spatial continuum from molecular to regional scale (regional defined here as the state of California) and the temporal continuum from seconds to millennia are appropriate (Figure 1). Environmental management and decision making is often made at scales much larger than experimental plots, resulting in a great amount of uncertainty from the extrapolation of research results across scales. A large portion of the research supported by this mission will center on transitions between scales at which important ecosystem processes of interest occur and interact, as well as analyzing relationships between the scale of management decisions and the scale of assessment and monitoring. For example, mathematical models of flow and transport processes that best represent soil characteristics at the plot scale may not be the appropriate descriptors of the same processes at the larger watershed scale. By working at appropriate scales for management decisions and monitoring, the economic feasibility and social acceptability of potential management options and related policies can be more readily assessed.

Time Scales in Soil Ecosystems

Years	Time Scale	Soil Processes
10^5	100 Millennia	
10^4	10 Millennia	Soil development
10^3	Millennia	
10^2	Century	Org. matter response to disturbance
10^1	Decade	Acidification & salinization Erosion
10^0	Year	Mineralization
10^{-1}	Season/Month	Oxidation/reduction
10^{-2}	Day	Leaching Diel temp. excursions
10^{-3}	Hour	Nutrient uptake
10^{-4}	Minute	Sorption
10^{-5}	Second	Ion exchange

Spatial Scales in Soil Ecosystems

	Area (m^2)	Spatial Scale	
	10^{14}	Global	
	10^{12}	Continent	California
	10^{10}	Region/biome	
Typical management unit	10^8	Landscape	
Typical management unit	10^6	Ag. field/small watershed	
Typical management unit	10^4	Hillslope/stand	
	10^2	Plot/patch	
	10^0	Pedon	
	10^{-2}	Soil core/horizon	
	10^{-4}	Macro-aggregate	
	10^{-6}	Micro-aggregate	
	10^{-8}	Pore	
	10^{-10}	Colloids	
	10^{-12}	Molecular	

Figure 1. Representation of spatial and temporal scales in soil ecosystems. Most land management and policy decisions require knowledge of processes occurring within the hillslope to landscape spatial scales and within the day to decade temporal scales.

Goals of this mission are to:

- Investigate how ecosystem properties, processes, functions and services are controlled by soil biophysical and biochemical processes across spatial and temporal scales;
- Conduct multi-scale basic and applied research that demonstrates clear relevance to land management decisions and policies;
- Examine transitions between scales at which important soil-ecosystem processes occur and interact; and
- Examine the relationships between the scale of management decisions and the scale of investigation, assessment and monitoring.

Research Areas

Funding is available to support two year research projects beginning in January 2007. The scope of the mission is large and because of its interdisciplinary nature, multi-investigator proposals are encouraged. Many, if not all, traditional soil-ecosystem research topics are well suited for this mission, but funded research topics under this mission will be unique in that they will i) address multiple spatial and/or temporal scales and ii) provide information that is clearly relevant to land management decisions and policies. While numerical modeling efforts are encouraged as a component of research proposals, projects must demonstrate an experimental approach that will examine fundamental mechanisms to support model formulation, calibration and validation across multiple spatial and/or temporal scales. Priority will be given to research proposals that demonstrate a direct application to land management decisions and policies in California.

Examples of research central to the soil system that could be addressed under this mission are:

1) Spatial and temporal variability of greenhouse gas emissions across landscape- to regional-level greenhouse gas budget assessments.
2) Biogeochemical cycles across ecosystems and landscapes, i.e., carbon, nitrogen, pathogens, and other contaminant loads from atmospheric (e.g. acids, nutrients, dust), to terrestrial (e.g. irrigated agriculture, animal agricultural operations), to riparian, aquatic (surface and ground waters) and wetland systems.
3) The feedback between landscape-level edaphic variation and evolutionary response within both plant and soil communities.
4) The effects of changes in the nature of plant-animal-soil feedbacks over space and time on soil functions from the soil pore to the landscape scale.
5) Scaling of the genomic control of microbial processes that act upon nitrogen, carbon, other nutrients and contaminants to the fluxes of metabolic products that are essential nutrients for plant primary productivity or have negative impacts on the environment.
6) Short- and long-term effects of prescribed or wild fires on soils of contrasting landscape positions and plant communities.
7) Short- and long-term impacts of manure and/or organic waste applications on soil C, N, salt, and pathogen balances of agricultural landscapes.
8) Biological, chemical and hydrological soil processes at the interfaces between agriculture/urban, agriculture/wildland, and wildland/urban environments.
9) Scaling up of the interactive processes between air quality, soils, agricultural production, and water quality (surface and ground waters) that occur at the field scale.
10) Assessment of economic, policy and social implications/applications of proposed management options that involve different temporal and spatial scales.
11) Effects of pore to watershed scale hydrologic flowpaths on transport of environmental constituents within the vadose zone.
12) Examining soil and vegetation (including species invasion) developmental processes that control nutrient and toxin retention and release within the landscape.
13) Spatial/temporal dynamics of hydrological and biogeochemical processes within ecosystems that experience strong seasonal dynamics (e.g., vernal pools).
14) Assessment of spatial/temporal dynamics as related to soil-ecosystem restoration and remediation in natural and managed systems.
15) Assessment of changes in soil attributes across pedological sequences (e.g., chronosequences, toposequences, climosequences).
16) Up-scaling and down-scaling of soil survey information to quantify near surface processes in the field with uncertainty analysis to support resource management and policy decisions.