Benchmark Soilscapes to Predict Effects of Climatic Change in the Western USA

Toby O'Geen
Department of Land, Air and Water Resources
University of California, Davis

Background

Multistate Research Projects are administered by State Agricultural Experiment Station Directors and Cooperative State Research, Education and Extension Service USDA CREES.

Limited funds, regional problems, proof of concept for grants

In the past western pedologists were funded to support NCSS with no specific research question required.

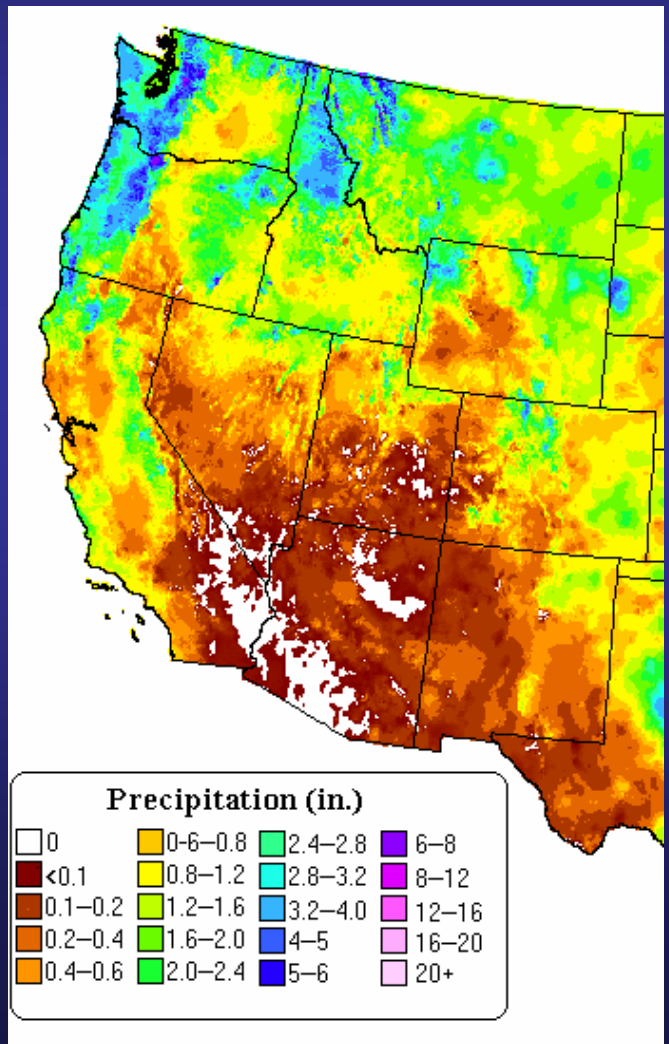
New Multistate Project for Western Pedologists

Project criteria recognized from Western Regional CSS meetings in 2004:

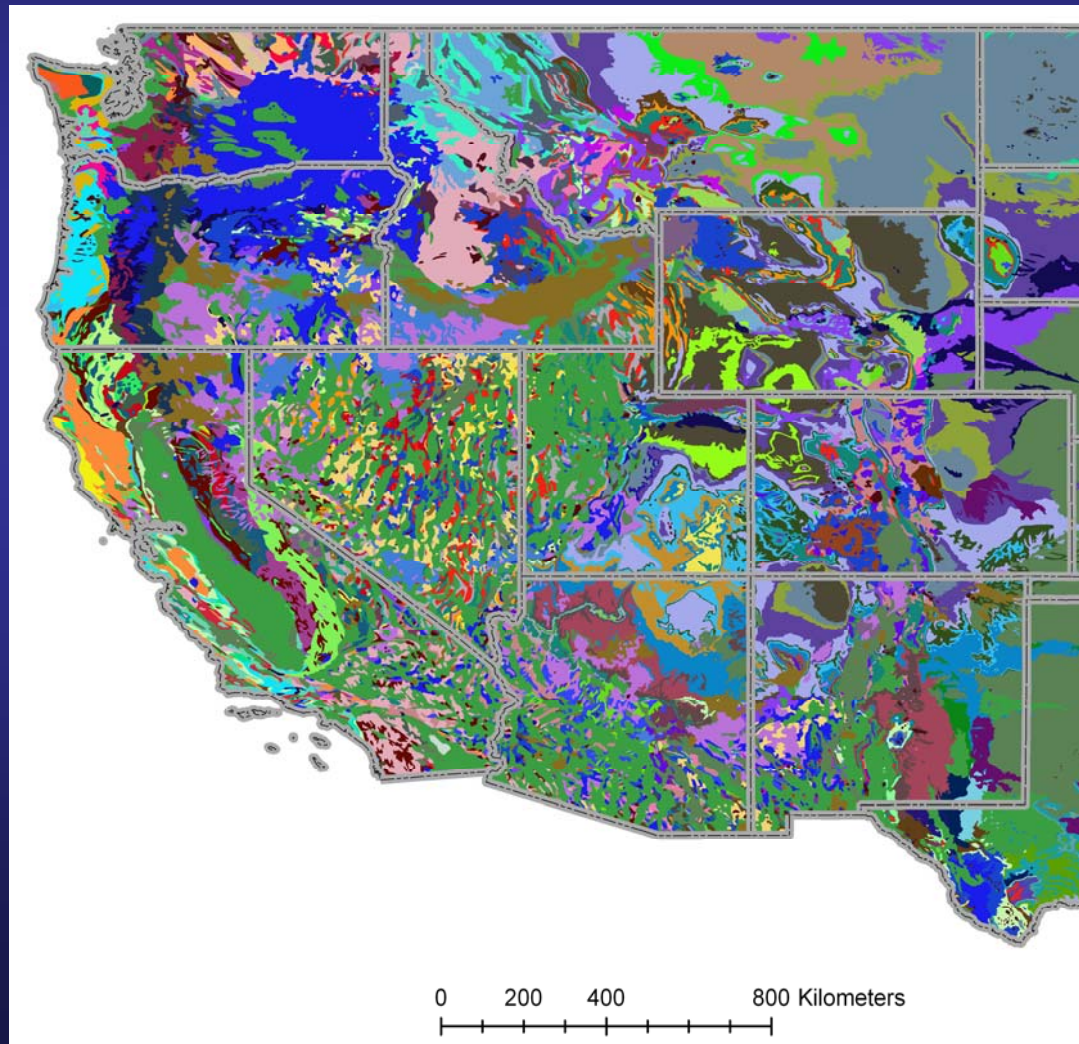
1) **Addresses a specific research question**
2) **Addresses current needs of NCSS**
3) **Select a study that appeals to several western pedologists**
4) **Has incentives for AES cooperators, will result in publications and attract funding**

Use the variation in climate and parent materials in the west as a natural laboratory to study the impacts of climate change on soil.

Precipitation in March



Geology of Western US



Mean Annual Maximum Temperature

2000

2099

°C

3

7

11

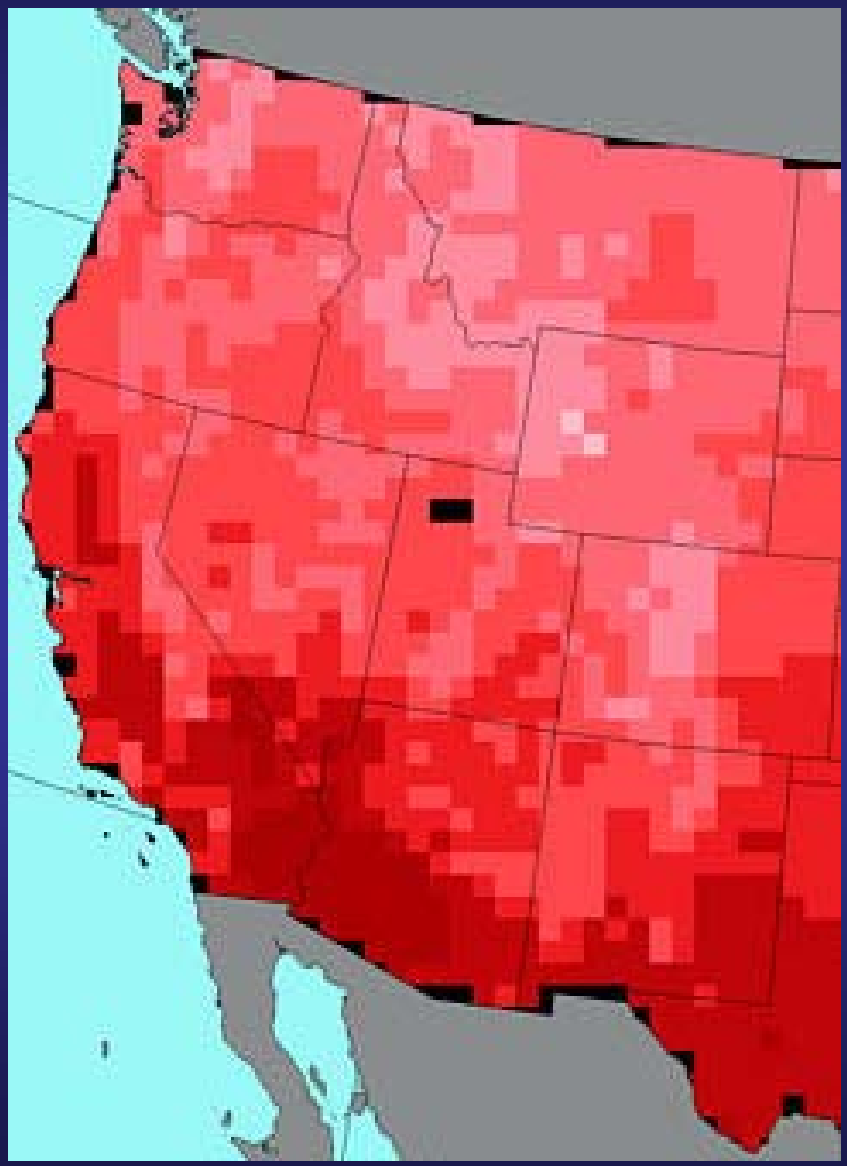
15

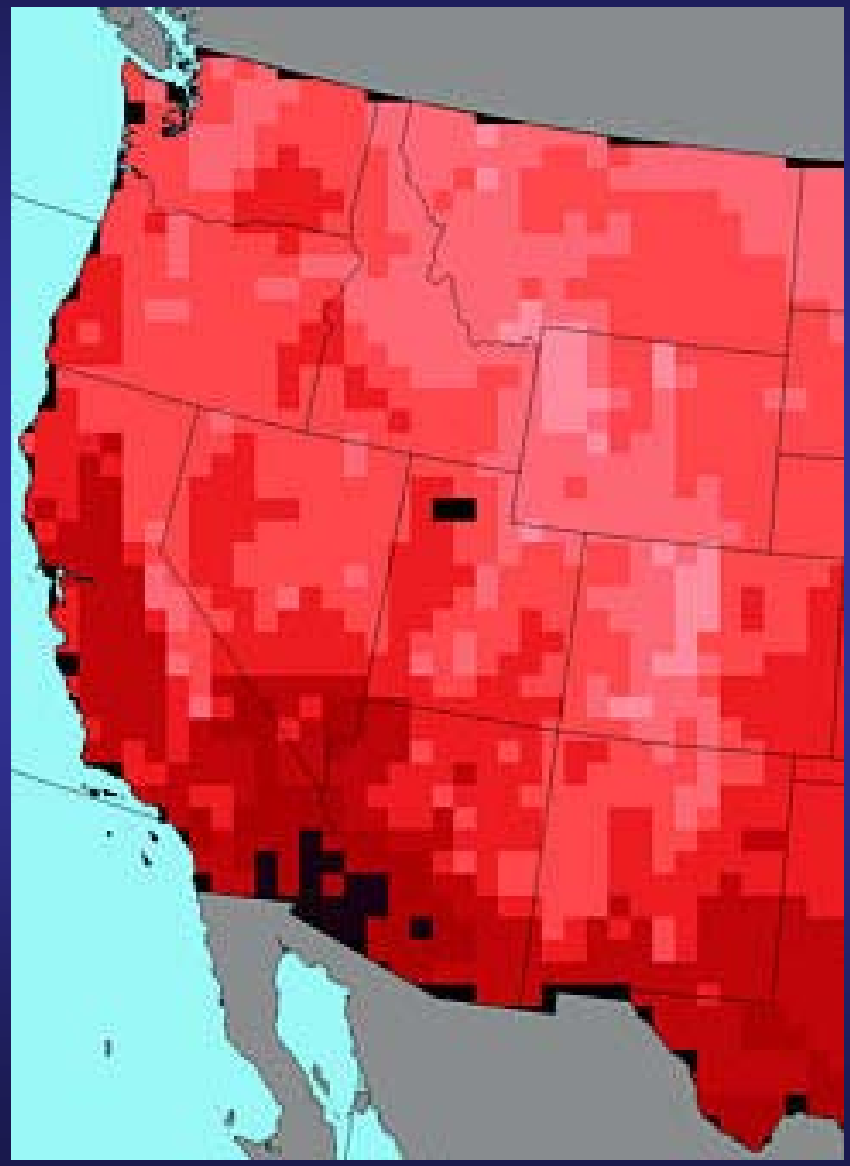
19

23

27

31

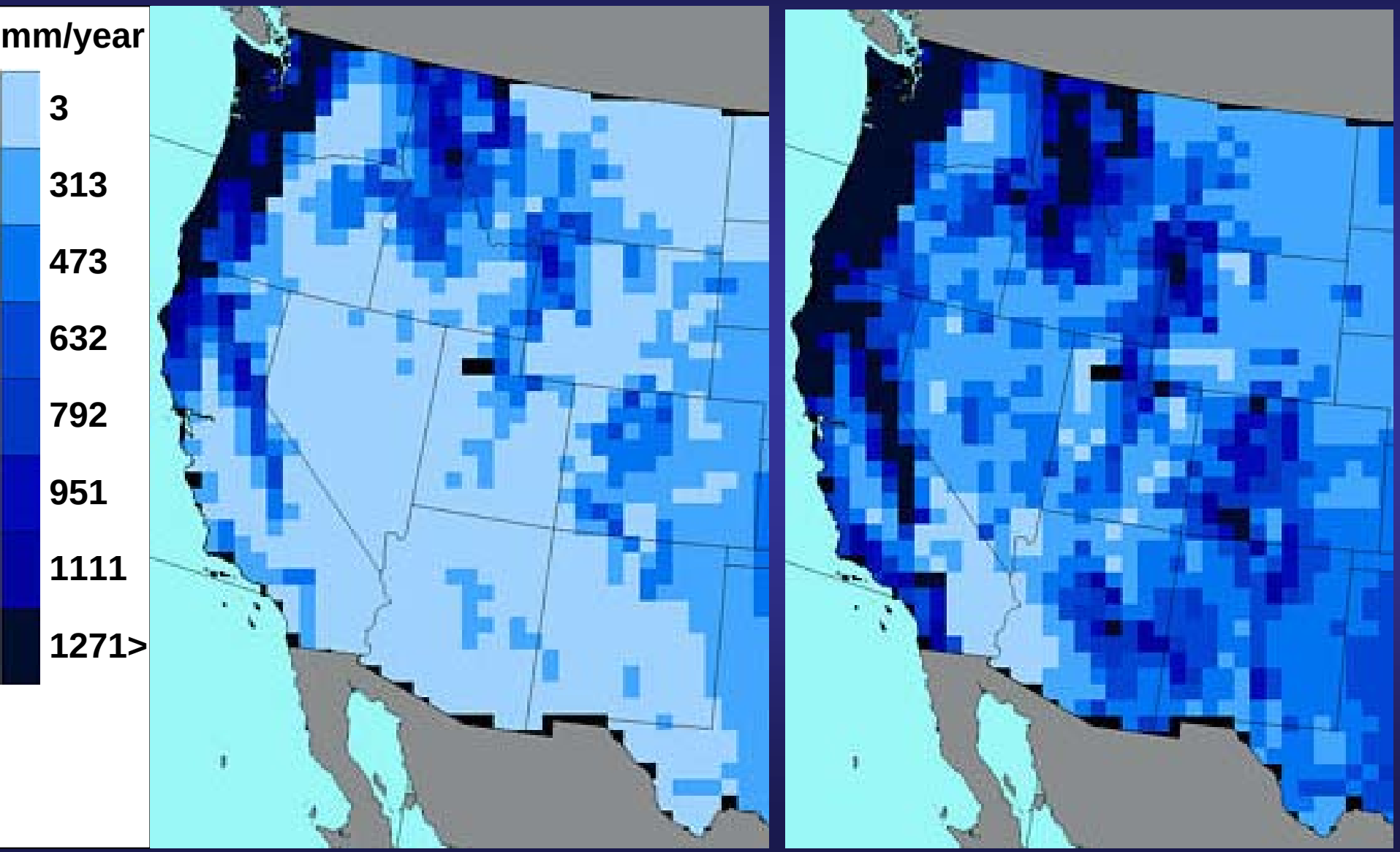




Hadley Center for Climate Prediction and Research

Mean Annual Precipitation

2000 2099



Hadley Center for Climate Prediction and Research

Project Goal:

Obtain a regional understanding of the impacts of climate change on soil properties, soil forming processes and ecosystem services regulated by soil.

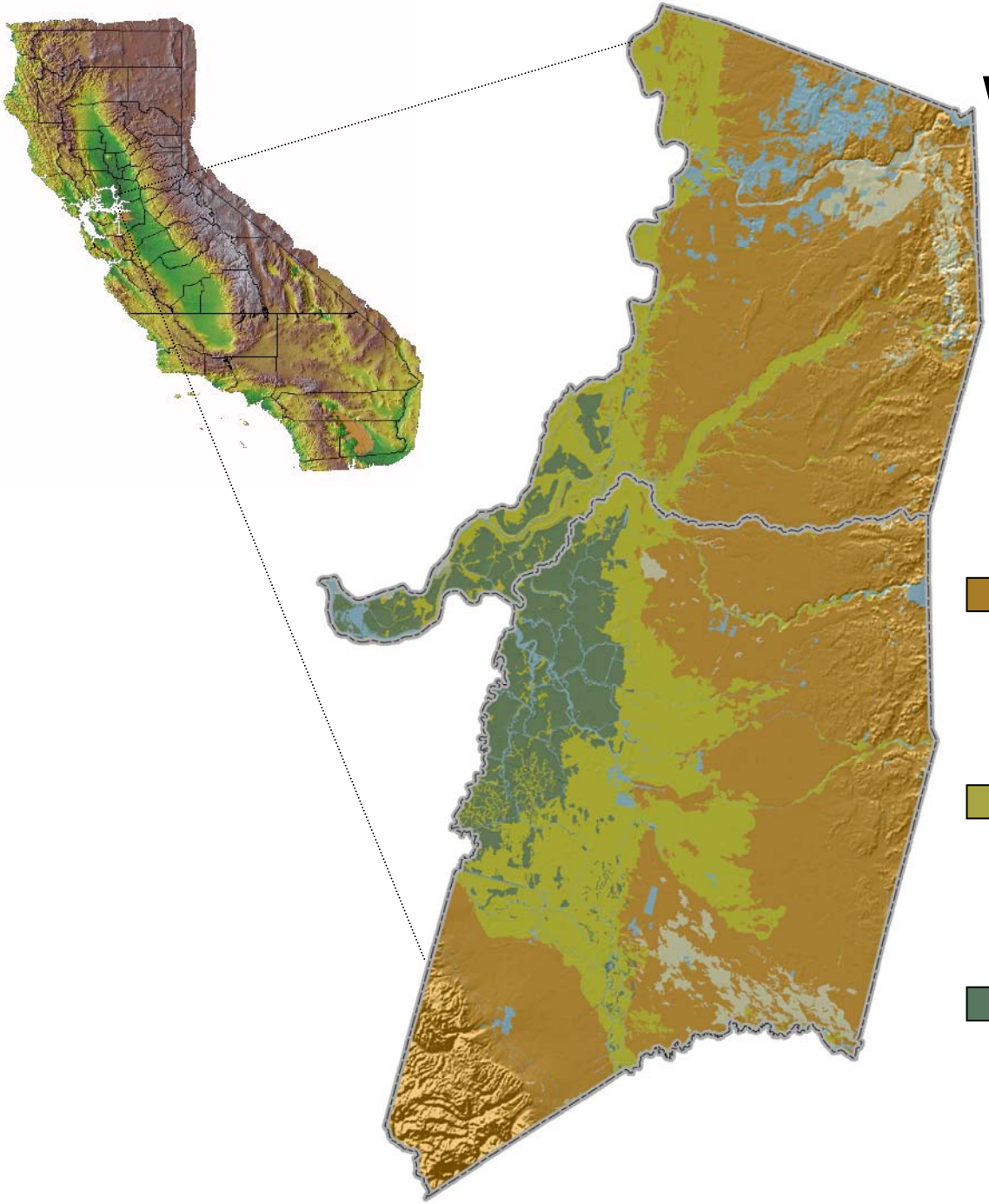
Objective 1

- **Establish benchmark soilscapes to serve as study sites that fit into one of two regional bioclimatic sequences.**

1) Transported materials or residuum

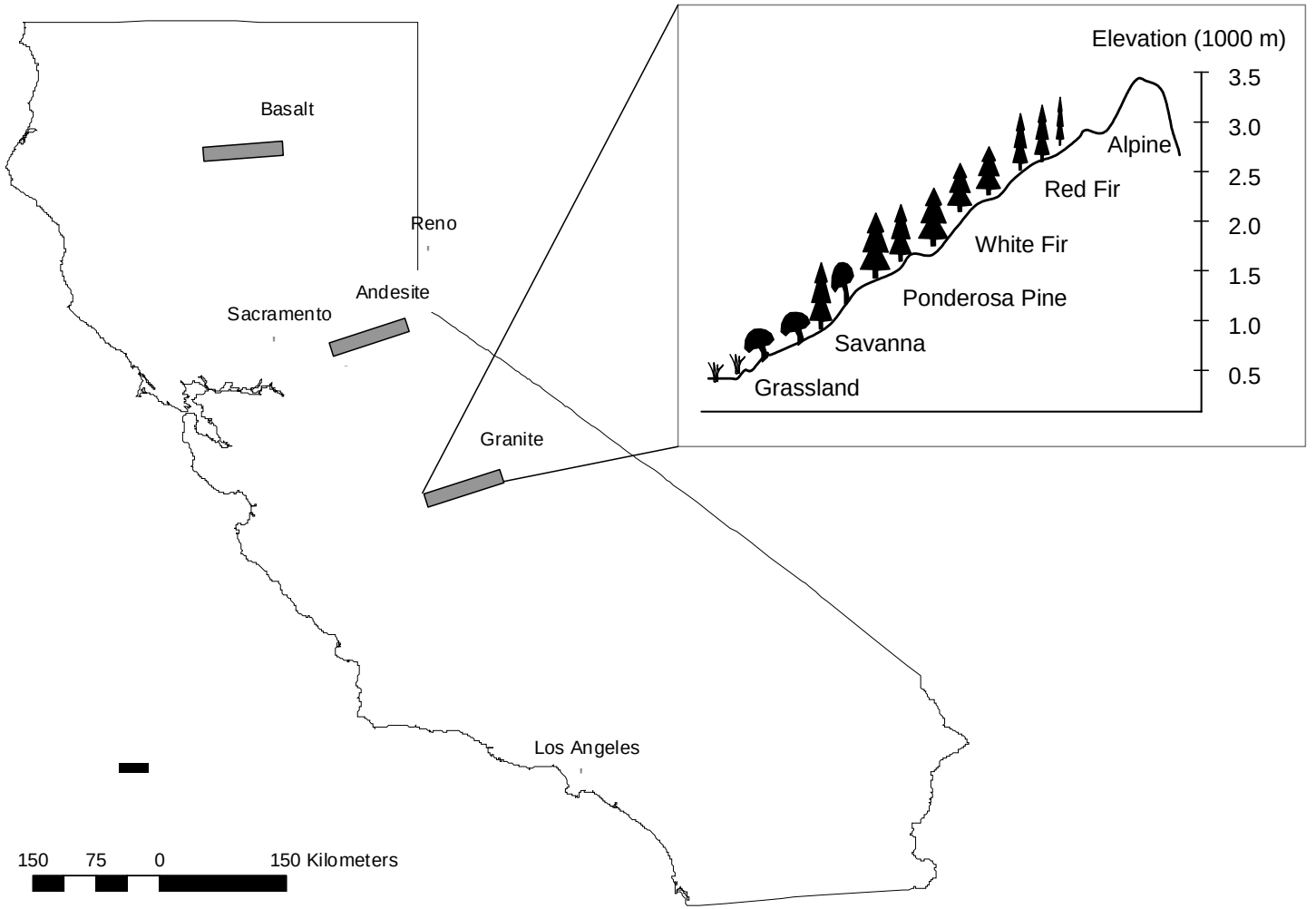
2) Granitic vs volcanic

What is a benchmark soilscape?



- Old dissected terraces and alluvial fans *(Redding, San Joaquin, Corning)*
- Recent alluvium and basin rim deposits *(Tokay, Columbia, Kingdon)*
- Smectitic Basin Alluvium Stockton, Capay

Example of a developmental sequence within the regional project

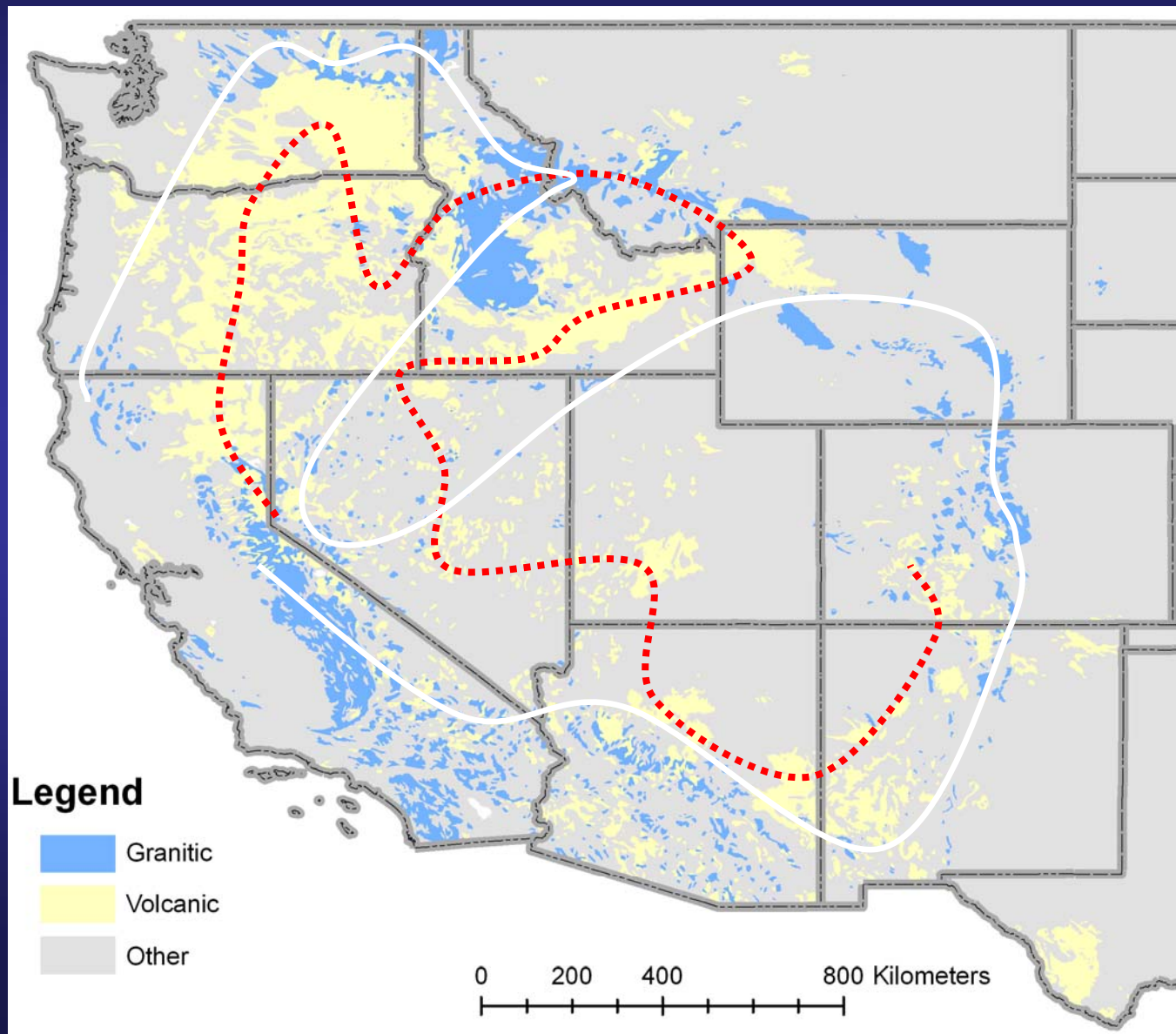


Slide courtesy of Craig Rasmussen

Hypothetical bioclimatic sequences of benchmark soilscapes in the west

Volcanic

Granite



Preliminary sites identified by investigators

Range in MAT- 3-25°C
Range in MAP- 100-3000 mm

Parent Materials	Moisture Regime	Temperature Regime
Granitic residuum & alluvium	Aridic (100-200 mm)	Thermic (18°C)
Ancestral Rio Grande alluvium	Aridic (250 mm)	Thermic (16°C)
Rhyolitic alluvium	Ustic (350-400 mm)	Mesic (14°C)
Ash/loess/colluvium/residuum	Udic (630-1270 mm)	Frigid (3-7°C)
Residual granite/granodiorite	Ustic-Aridic (250-800 mm)	Thermic-Mesic (20-8°C)
Slope of shield volcano	Aridic-Udic (250 -3000 mm)	Thermic/Isothermic (25 - 15°C)
Sierra NV metavolcanic terrain	Xeric (660-890 mm)	Thermic (15°C)
Lassen National Park	Udic	Frigid/Cryic
Gypsiferous alluvial soils	Aridic	Thermic

Objective 2

- Characterize biogeochemical, mineralogical, physical and morphological properties of soils

- Field support from regional offices

- Soil Survey Laboratory support for lab analysis

Objective 3

- **Monitor soil temperature and soil moisture (primary climatic drivers of pedogenesis).**

  - Link monitoring to soil properties and measurable soil forming processes

Objective 4

- **Conduct experiments that quantify the impacts of soil forming processes on ecosystem services:**

Soil Forming Processes

Weathering & secondary mineral formation
Organic matter accumulation
Leaching
Bioturbation and effects of soil fauna

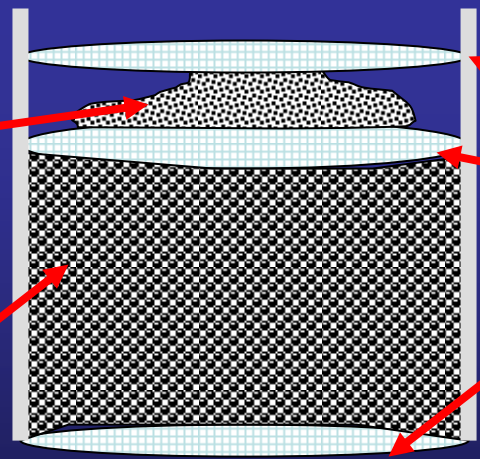
Ecosystem Services

Nutrient cycling
Carbon storage
Biodiversity
Regulation of quantity and quality of water supply

Weathering Intensity: Lithium Feldspar Decomposition

Nutrient cycling

Ion exchange resin soil solution lysimeter



Lithium Feldspar
Avalon Ventures LTD.

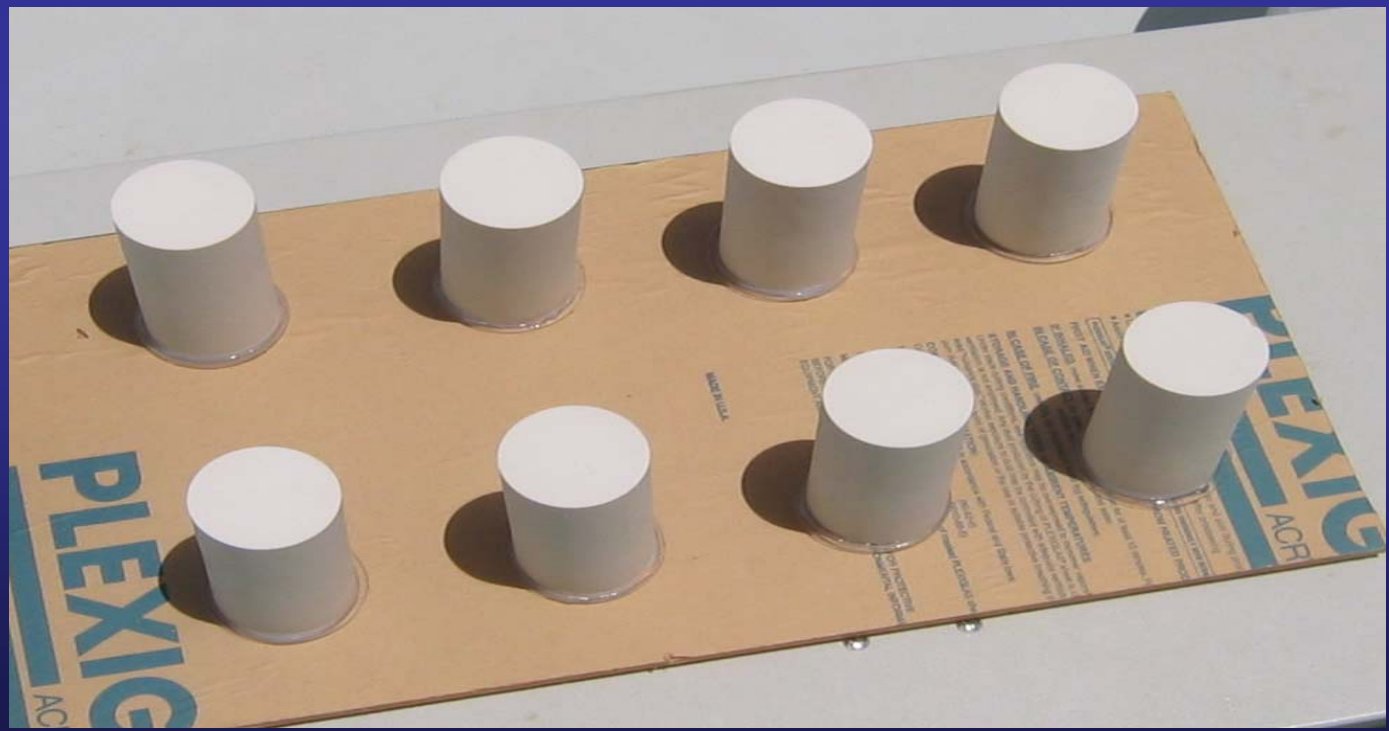
Nitex sheets

Cation and anion exchange resins

Degree of Leaching

regulation of quality and quantity of water supply

Dissolution of gypsum cylinders



Organic Matter Decomposition

Nutrient cycling and fate of carbon

1) Stake condition before insertion, 2) 6 months, 3) 1 year, 4) 1.5 years, 5) 2.0 years. USDA Forest Service Rocky Mountain Research Station.

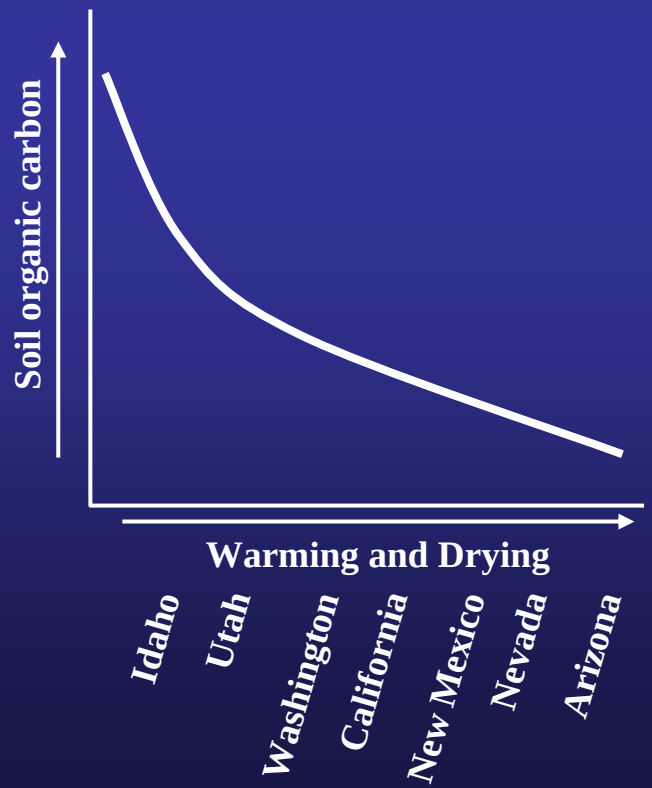
Biodiversity

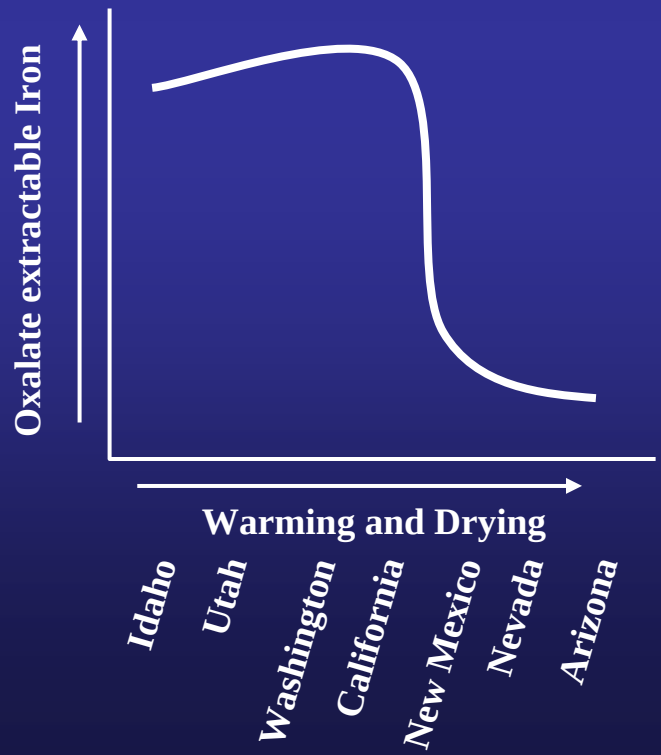
Process: Bioturbation, organic matter accumulation

Objective 5

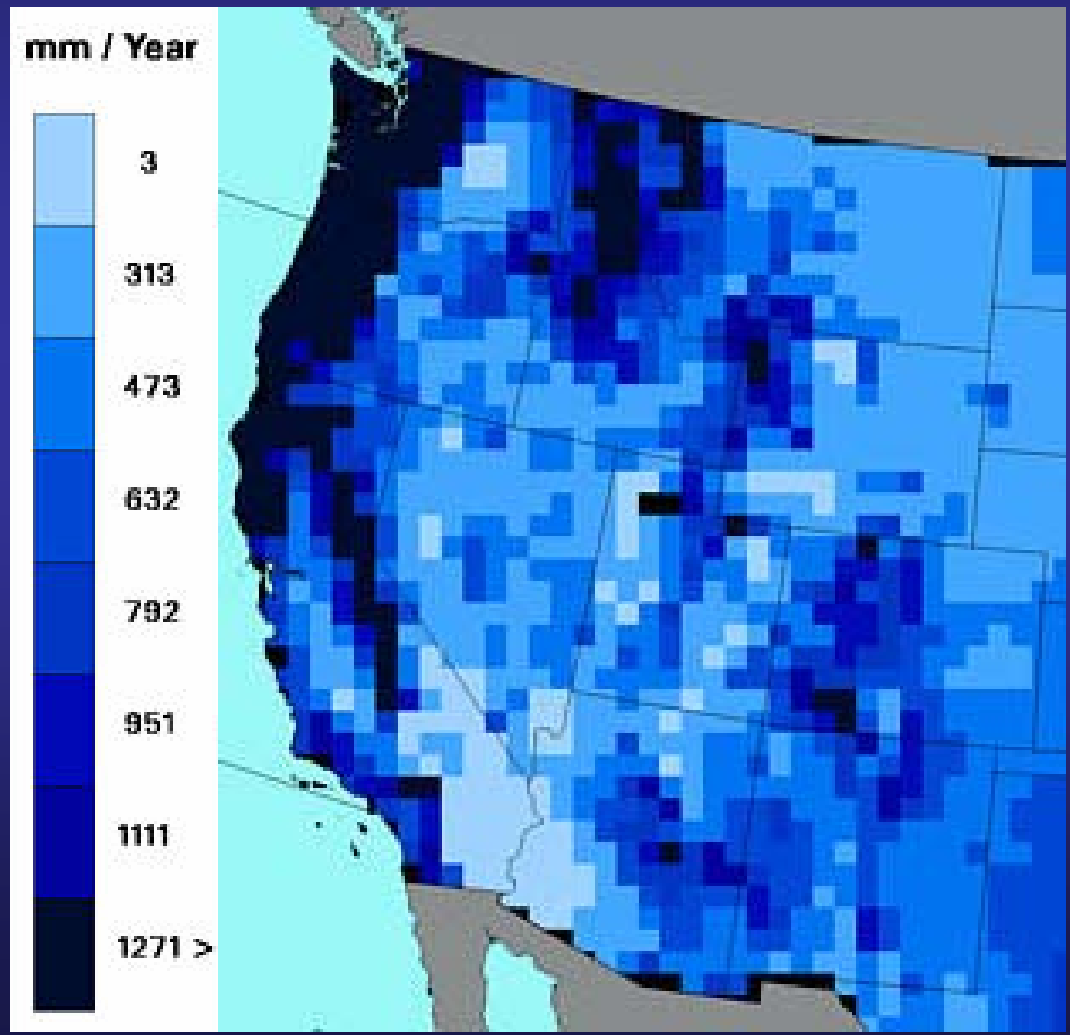
- **Model impacts of climate on soil processes and ecosystem services regulated by soil.**

  - Emphasize pedogenic thresholds that influence the timing and direction of soil and environmental change.





Link climate model predictions with our findings to better understand the consequences of regional environmental change.



Current Participants

Arizona- Craig Rasmussen
California- Bob Graham, Randy Dahlgren, Toby O'Geen, Mike Singer, Randy Southard
Colorado- Keith Paustian
Hawaii- Goro Uehara
Idaho- Paul McDaniel
Oregon- Jay Noller
Nevada- Brenda Buck
New Mexico- Curtis Monger
Utah- Janis Boettinger
Washington- Bruce Frazier

Possible Funding Sources

Link with the UC Kearney Foundation for Soil Science to get a graduate student to shepherd the project

NSF Critical Zone

USDA-CREES