The Wildfire Effect: Understanding Soil Changes in a Fire-Prone Climate

a presentation for
2026 NSTA Conference in Anaheim
by

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Workshop Outline

- Workshop Goals
- Introductions
- Fire Impacts on soil
- Visualizing Wildfire Impacts
- Classroom Connections & Resources

Workshop Resources:
https://www.soils4teachers.org/nsta

Workshop Goals

Goal:
Understand how high-intensity wildfires fundamentally alter the physical, chemical, and biological properties of soil, creating long-term shifts in ecosystem stability and recovery.

Objectives:

- Participants will analyze the mechanisms of soil degradation, specifically focusing on the creation of water-repellent (hydrophobic) layers and the changes in nutrient cycling.
- Participants will identify the biological consequences of extreme heat on soil health.
- Participants will identify instructional resources to support the teaching and learning about the impacts of wildfire impacts on soil.

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KNOW SOIL KNOW LIFE

Introductions

Soil Science Society of America
Soil Science Society of America · www.soils.org
www.soilsforteachers.org
USDA United States Department of Agriculture
Natural Resources Conservation Service

Introductions

- Your team!
  - Clay Robinson, CRC Soil and Ecosystem Services, LLC
  - Gordon Rees, Cal Poly San Luis Obispo
  - Qudus Uthman, Formerly at Science Systems and Applications, Inc.
  - Missy Holzer, SSSA K12 Committee Chair

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Who's Joining Us Today?

Elementary School	5 years or less
Middle School	6-19 years
High School	20+ years
Higher Ed	
Informal Ed	

Workshop Resources:
https://www.soils4teachers.org/nsta

Modeling Wildfire Soil Hazards

If you were to develop a model to determine the wildfire impacts on soil, what would you include?

Turn and Talk!

Workshop Resources:
https://www.soils4teachers.org/nsta

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Fire Impacts on Soils

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Fire impacts soil

- Fire affects almost every aspect of soil including:
  - Physical properties
  - Chemistry
  - Carbon and nutrients
  - Life in soils

USDA USFS

Fire is natural

USDA USFS

- Almost every ecosystem naturally burns, some more often than others
- Most soils have developed over thousands of years with natural fire impacts shaping their properties

BUT extreme fires are not normal

The history of humans putting out small fires means there is now more fuel to burn in many areas, so when they do burn the fires are more intense

- Less frequent fire = more intense fire
- Intense fire = severe impacts for soils

USDA USFS

Fire = HEAT!

Fire releases energy -> Heat (as high as 700°C)

- Severe forest fires can release as much energy as burning 3 gallons of gasoline across every square meter of forest

USDA USFS

Fire = HEAT!

Temperature reached depends on

- Rate of burn: Fast fire = less heat
- Amount of fuel: Lots of wood = lots of heat
- Soil moisture: Wet soil heats up slowly
- Soil depth: Surface soil gets very hot, but deeper soil is insulated and less affected

USDA USFS

Fire impacts: Physical properties

- High temperatures destroy soil structure, which can lead to erosion, compaction, and other issues

USDA USFS

Fire impacts: Physical properties

- Heat from fire can create “hydrophobic” soils, which repel water
  - This can lead to more surface runoff, which can increase erosion

Clay Robinson, 2026

USDA USFS

Fire impacts: Chemistry

- White ash contains base oxides (eg CaO) which can raise pH to values as high as 12
- Soil pH above 7 can lead to nutrient issues, reduced plant growth, and reduced microbial activity

USDA USFS

Fire impacts: Carbon

- Fire can burn away carbon in soil
- Carbon may also transform into charcoal

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Fire impacts: Nutrients

- Fire can result in a short-term increase in plant-available nutrients BUT
- Long-term it results in nutrient loss through:

USDA ARS

1. Oxidation/vaporization of nutrients
2. Nutrients lost in blown ash
3. Increased erosion after the fire

Fire impacts: Erosion

- Loss of organic cover exposes mineral soil
- Loss of structure means soil can erode more easily
- Hydrophobicity can increase surface water flow, causing more erosion

USDA ARS

Fire impacts: Life in soil

Gordon Rees

- Fire kills microbes and other life in the soil, especially near the surface
- Changes in soil nutrients and chemistry mean the organisms that come back may be different than before the fire

Fire impacts: Urban soil

- Fires in urban environments have similar impacts on soils PLUS
- Burning homes, vehicles, and man-made material releases chemicals that may pollute soils for years

USDA USFS

Solutions

USDA USFS

- The best way to address negative impacts is by reducing the severity of fires
  - Controlled burns create low intensity fire which has minor impacts and removes fuel
  - Thinning forests by removing smaller trees and brush can also help
  - In urban settings, clearing a defensible space around buildings can slow the spread of fire

Solutions

- After a severe fire, slowing erosion is critical
  - Replanting burned areas so plants and their roots protect the soil
  - Temporary mulches or other erosion control tools can be used at the most susceptible areas

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Visualizing Wildfire Impacts

Soil Science Society of America

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Slake Test…..

Miles Loamy Fine Sand, Donley County, TX

Miles Loamy Fine Sand, Donley County, TX

After 01:30 mm:ss

Irrigated cotton, conventional inversion tillage, No surface residue	**Irrigated sorghum for hay, no till Standing and flat residue**	**Conservation Reserve Program, permanent grass**

Miles Fine Sandy Loam, Donley Co, TX

After 02:20 mm:ss

Irrigated, conventional inversion tillage, No surface residue	Irrigated, no till

Pullman Silty Clay Loam, Bushland, TX

Pullman Silty Clay Loam, Bushland, TX

After 05:10 mm:ss

Dryland wheat-sorghum-fallow rotation, inversion tillage	Dryland, wheat-cotton-fallow rotation, no till

pH test

- 1:2 soil to water ratio
- Shake the mixture
- Allow the soil to settle
- Dip the litmus into the supernatant solution
- Another option - use the Rapitest soil chemistry test kits

Fire impact on soil life demo…

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Classroom Connections and Resources

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Modeling Wildfire Soil Hazards

If you were to develop a model to determine the wildfire impacts on soil, what would you include?

How would you weight the importance of each of items you included?

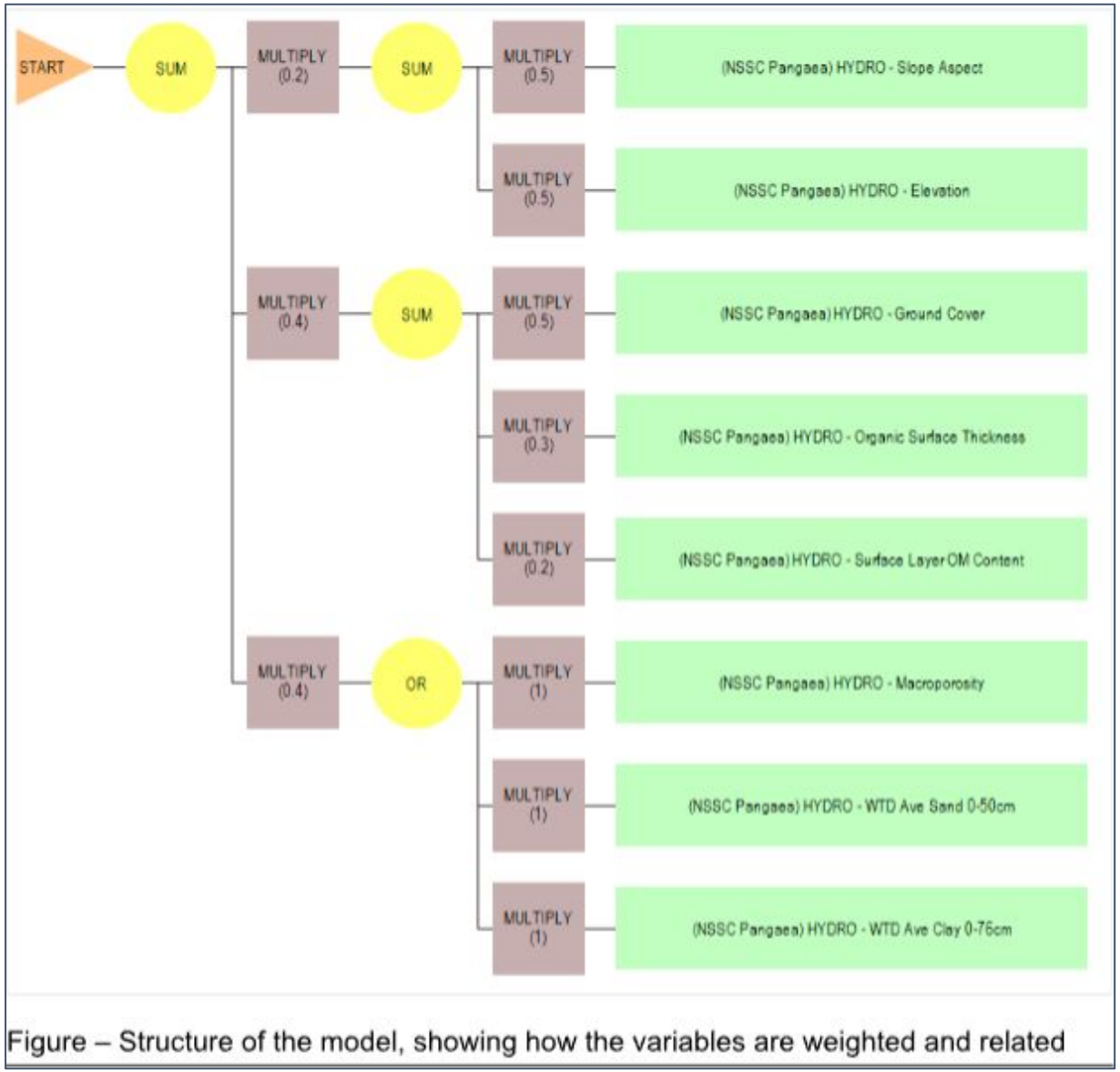
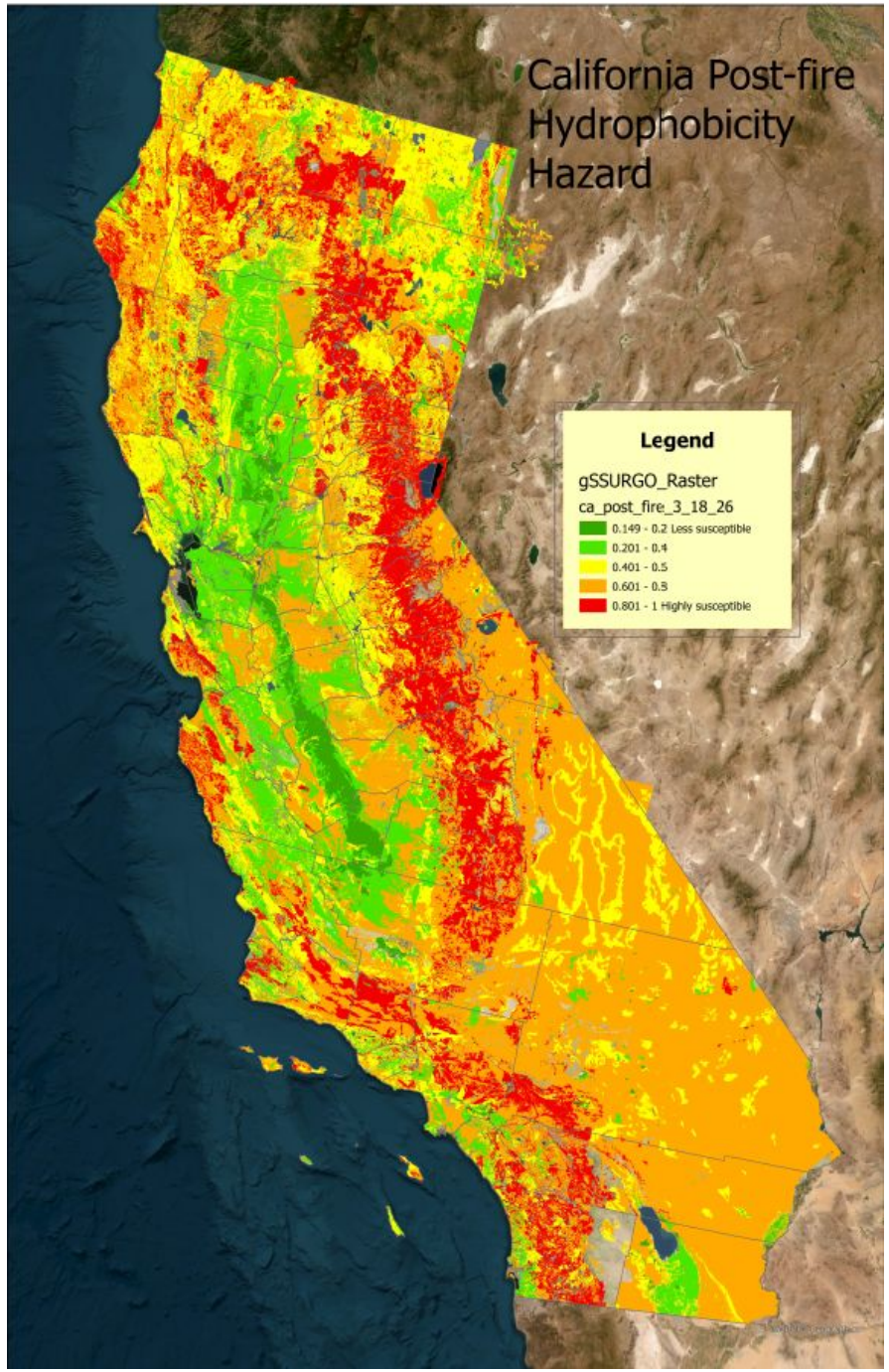


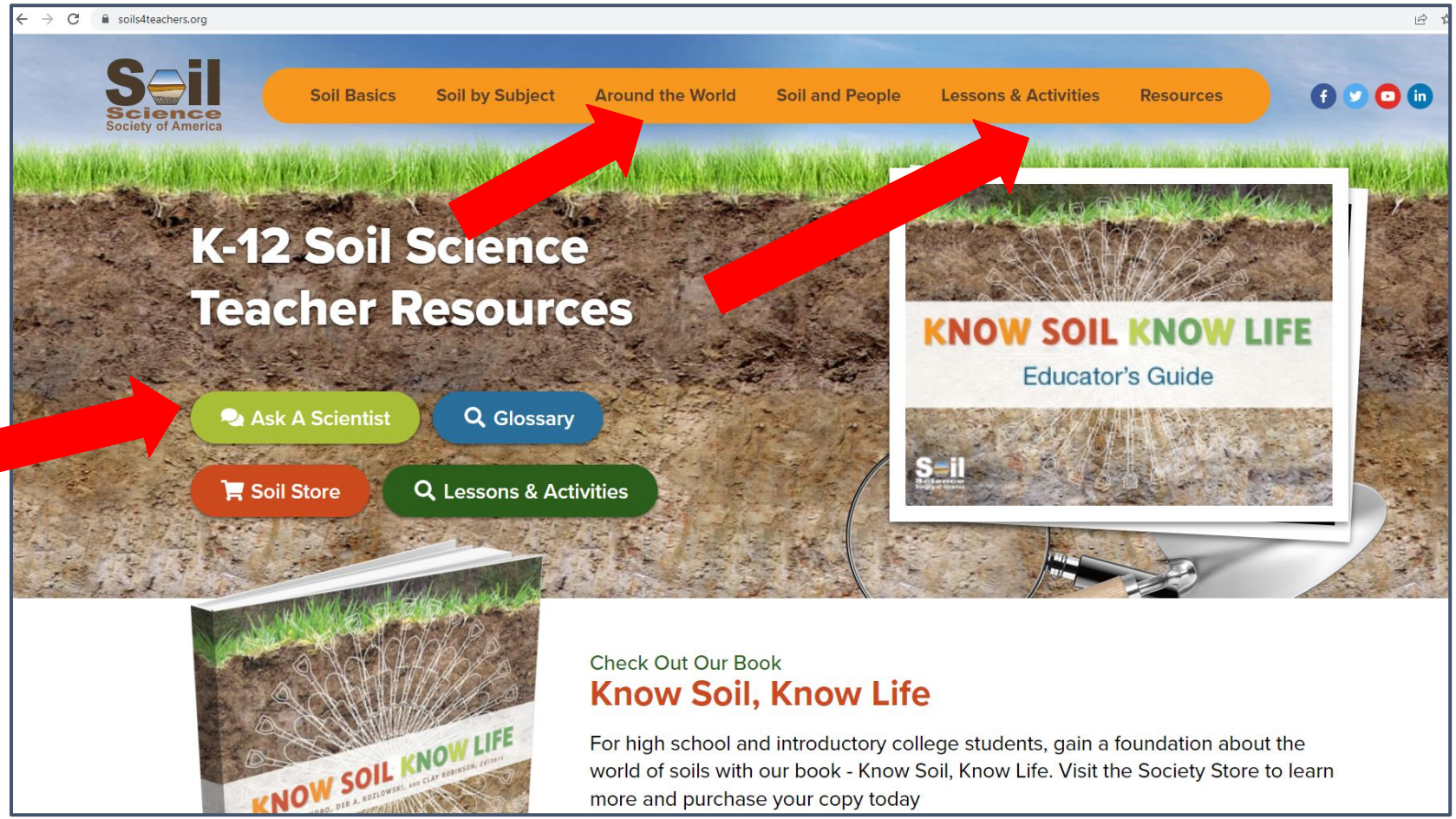
Figure – Structure of the model, showing how the variables are weighted and related



Instructional Resources from SSSA

Flagship Website: Soils 4 Teachers

www.soils4teachers.org



State Soil Booklets

New! State Soil Booklets

Learn the story of your state soil!

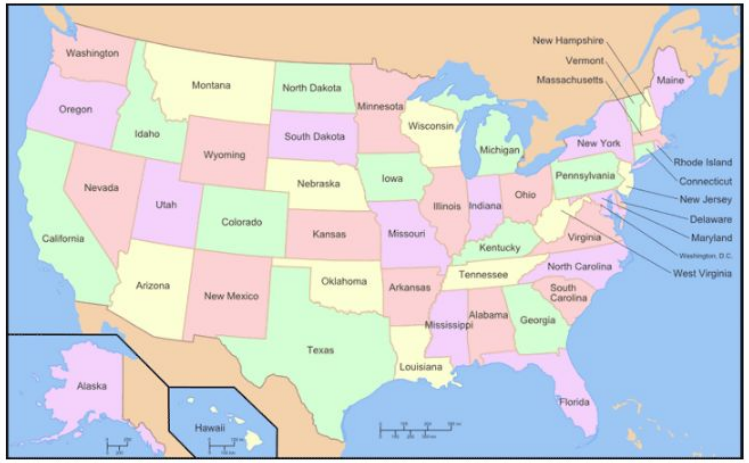
Developed and written by soil scientists to tell the stories of the unique soils found in the US states and territories!

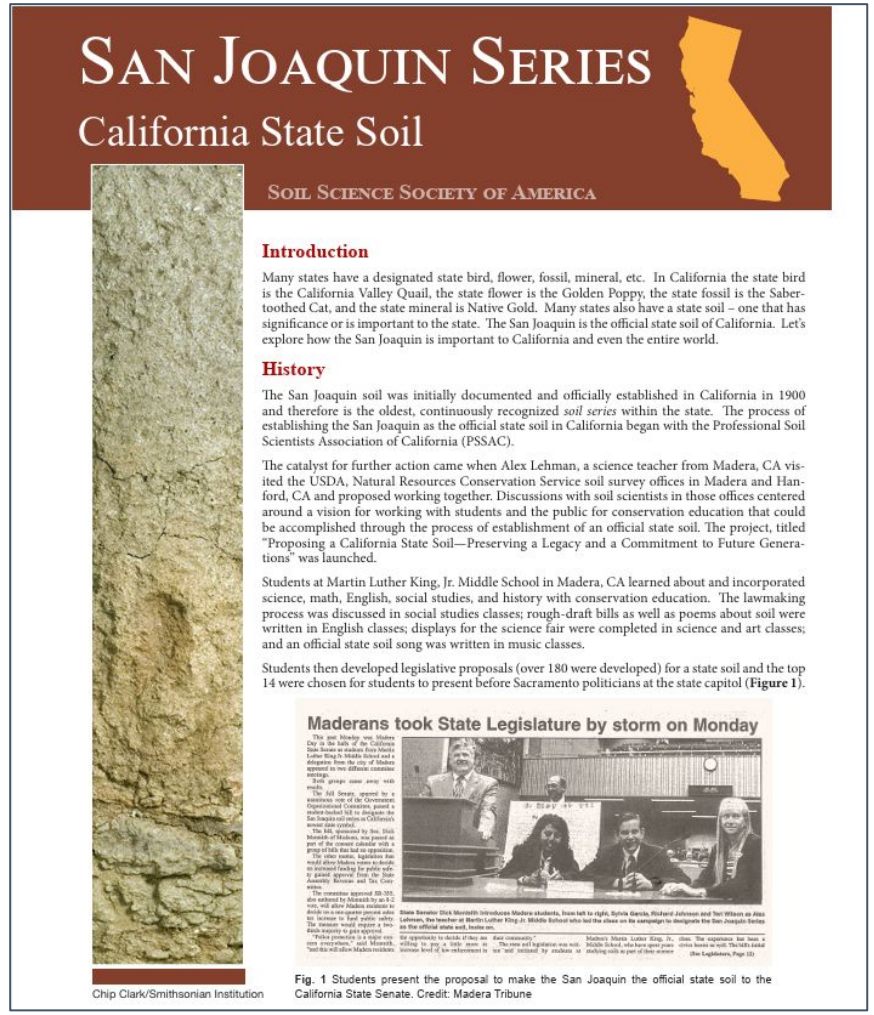
This interactive map features state soils booklets – developed and written by soil scientists to provide in-depth information on each state soil. The booklets include a brief history of how the state soil came to be, where the state soil is found, importance and uses, limitations, management, soil formation, ecoregions and land use, a glossary, and additional resources.

Just hover over any state and select it when highlighted to read more.

Have fun with our state soils word search!

Teachers - use this activity and worksheet in your classroom!





San Joaquin Series

California State Soil

Soil Science Society of America

Introduction

Many states have a designated state bird, flower, fossil, mineral, etc. In California the state bird is the California Valley Quail, the state flower is the Golden Poppy, the state fossil is the Saber-toothed Cat, and the state mineral is Native Gold. Many states also have a state soil – one that has significance or is important to the state. The San Joaquin is the official state soil of California. Let's explore how the San Joaquin is important to California and even the entire world.

History

The San Joaquin soil was initially documented and officially established in California in 1900 and therefore is the oldest, continuously recognized *soil series* within the state. The process of establishing the San Joaquin as the official state soil in California began with the Professional Soil Scientists Association of California (PSSAC).

The catalyst for further action came when Alex Lehman, a science teacher from Madera, CA visited the USDA, Natural Resources Conservation Service soil survey offices in Madera and Hanford, CA and proposed working together. Discussions with soil scientists in those offices centered around a vision for working with students and the public for conservation education that could be accomplished through the process of establishment of an official state soil. The project, titled "Proposing a California State Soil—Preserving a Legacy and a Commitment to Future Generations" was launched.

Students at Martin Luther King, Jr. Middle School in Madera, CA learned about and incorporated science, math, English, social studies, and history with conservation education. The lawmaking process was discussed in social studies classes; rough-draft bills as well as poems about soil were written in English classes; displays for the science fair were completed in science and art classes; and an official state soil song was written in music classes.

Students then developed legislative proposals (over 180 were developed) for a state soil and the top 14 were chosen for students to present before Sacramento politicians at the state capitol (**Figure 1**).

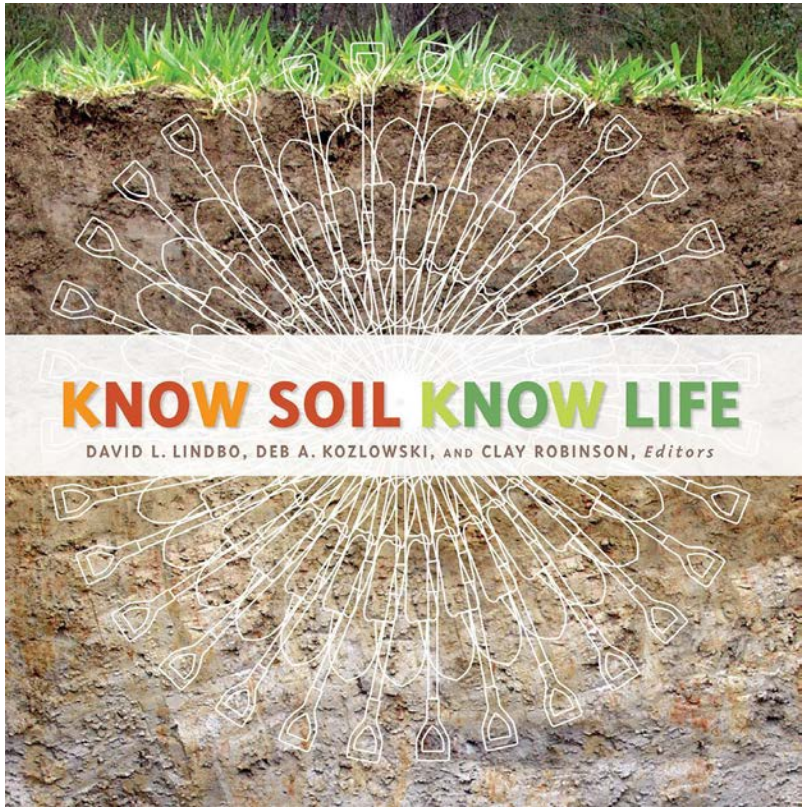
Maderans took State Legislature by storm on Monday

Chip Clark/Smithsonian Institution

Fig. 1 Students present the proposal to make the San Joaquin the official state soil to the California State Senate. Credit: Madera Tribune

Know Soil Know Life

- Educator's Guide
  - Overview
  - Powerpoints
  - Activities
  - Worksheets

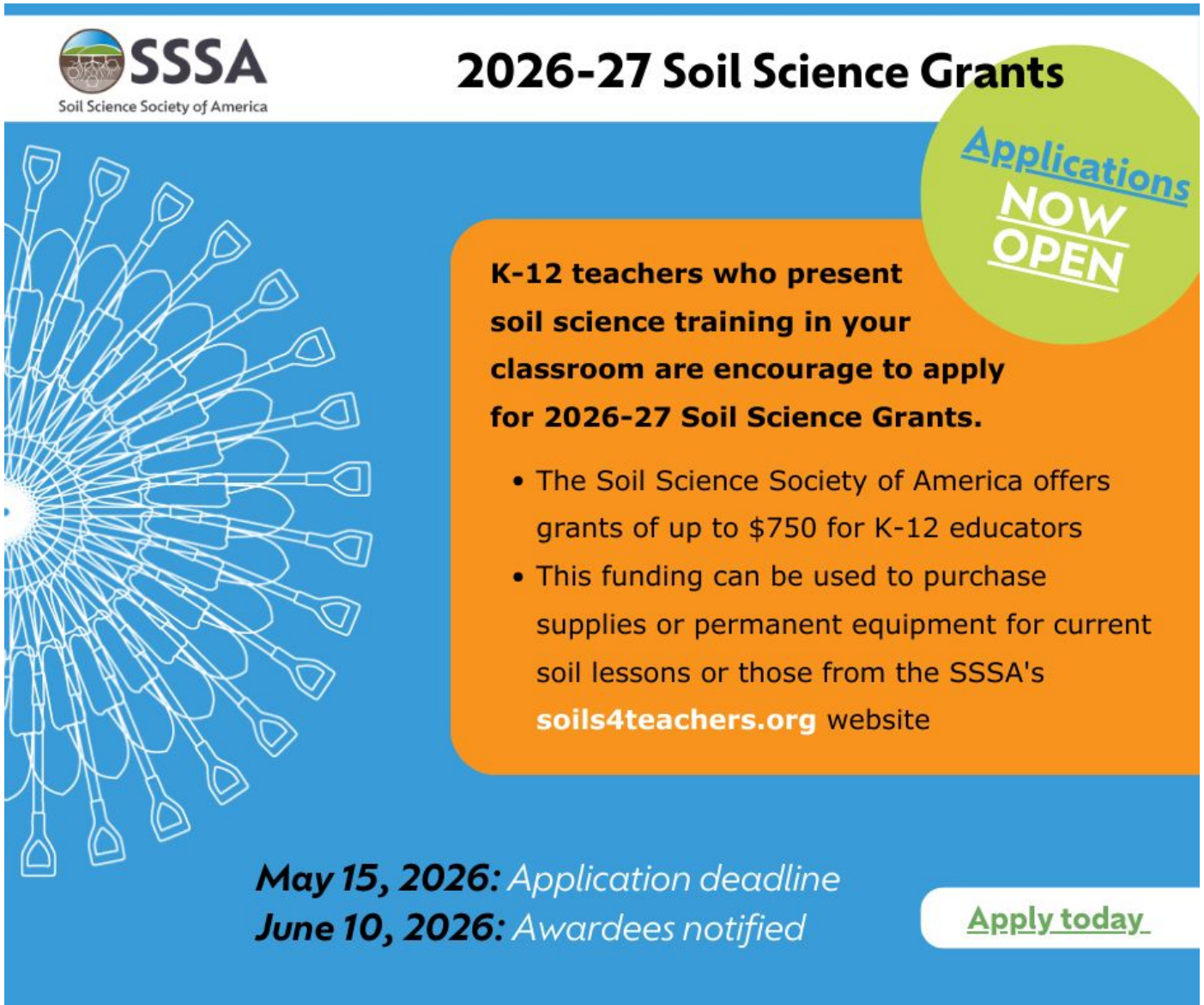


Teachers Inservice and Materials

- Soil Basics/Soil Sampling
- Soil Chemistry
- Soil Biology
- Soils and Climate Change
- Web Resources

- Overview | Powerpoint | Videos | Activities

Grants for Teachers!



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Thank you!

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Missy Holzer: missy.holzer@gmail.com

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