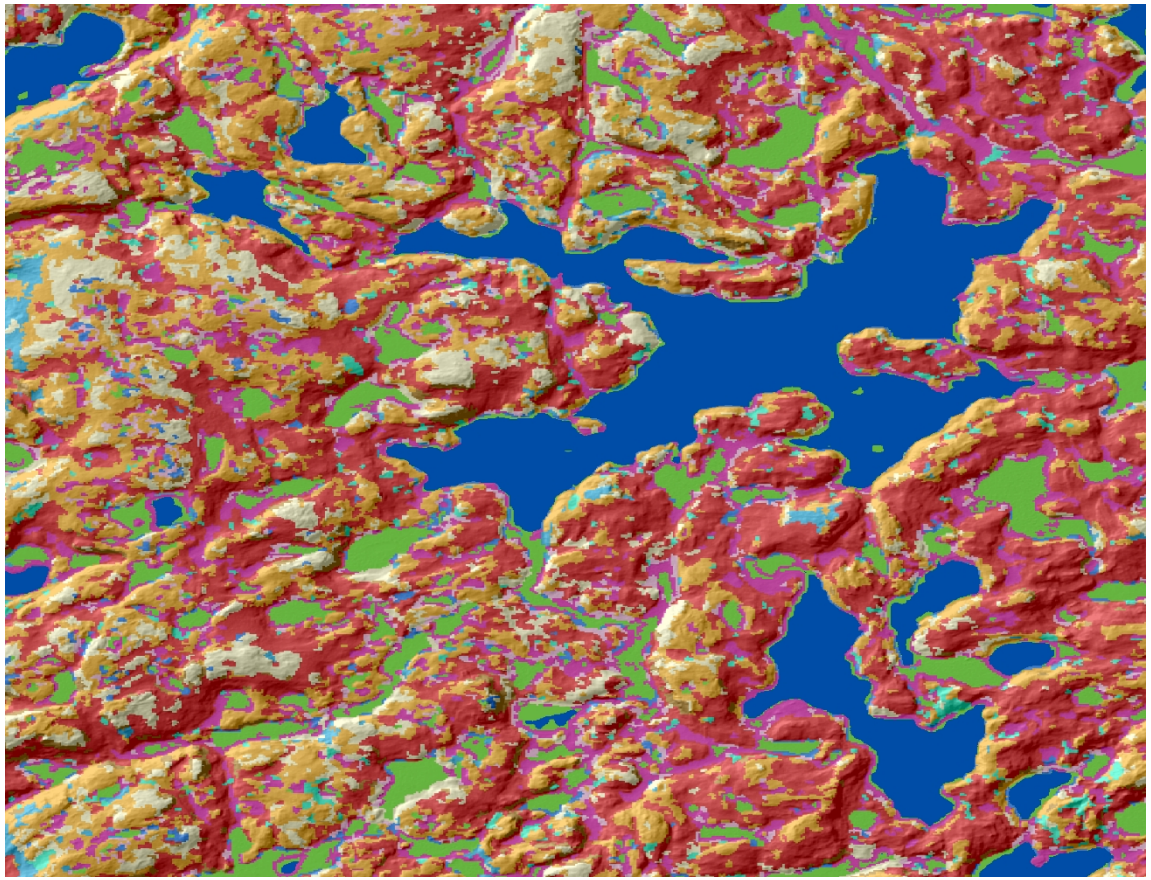
USDA

United States Department of Agriculture



Soil and Plant Science Division

Natural Resources Conservation Service

Mapping Salt-Affected Soils of the United States of America

2021-10-28 | Stephen Roecker, Suzann Kienast-Brown, Chad Ferguson , Jessica Philippe, Todd Skaggs, David Lindbo

Natural Resources Conservation Service

nrcs.usda.gov/

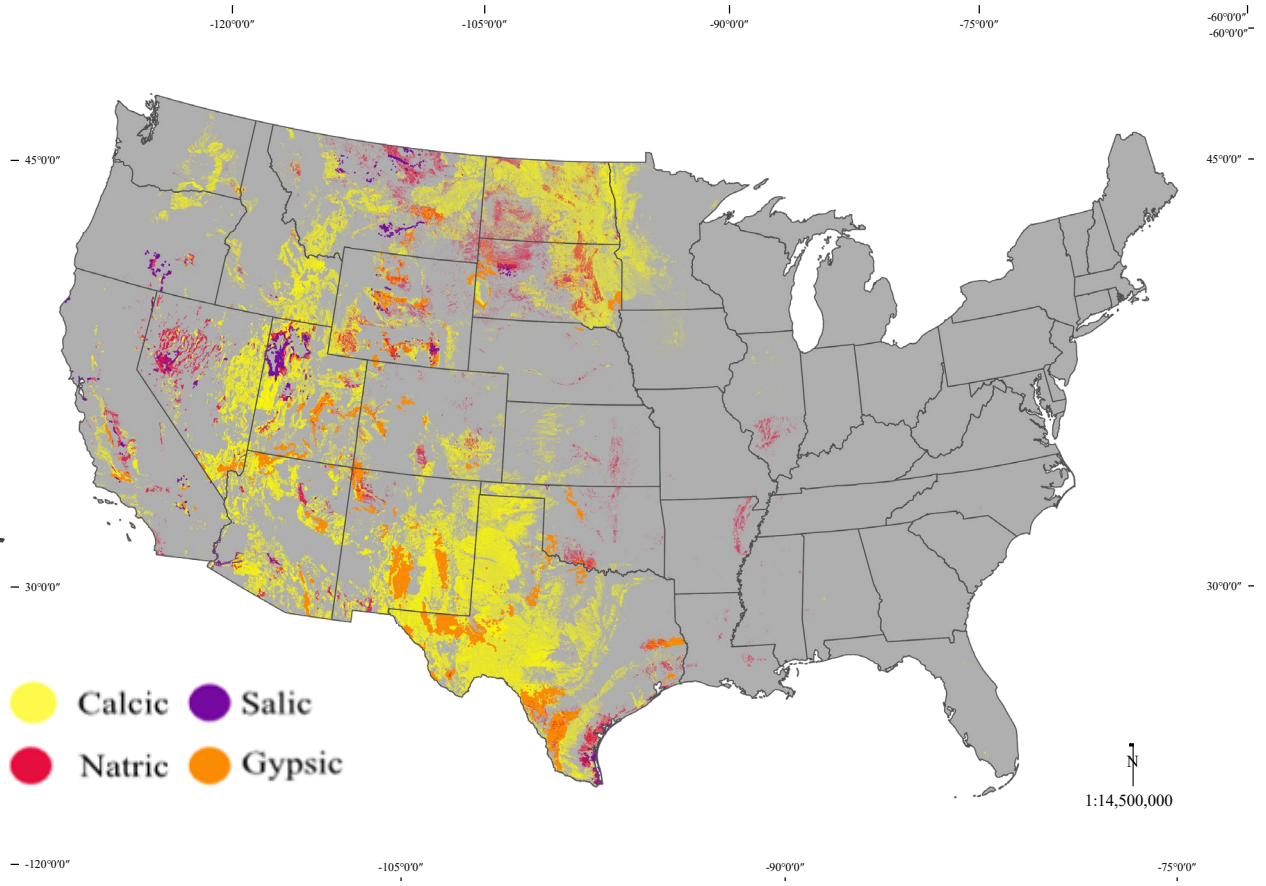
Outline

- **USA Physiography and Causes**
- **USA Salinity Programs**
  - U.S. Salinity Laboratory
  - National Cooperative Soil Survey
- **SAS Mapping**
  - Training data
  - Covariates
  - Maps
  - Key Findings & Future

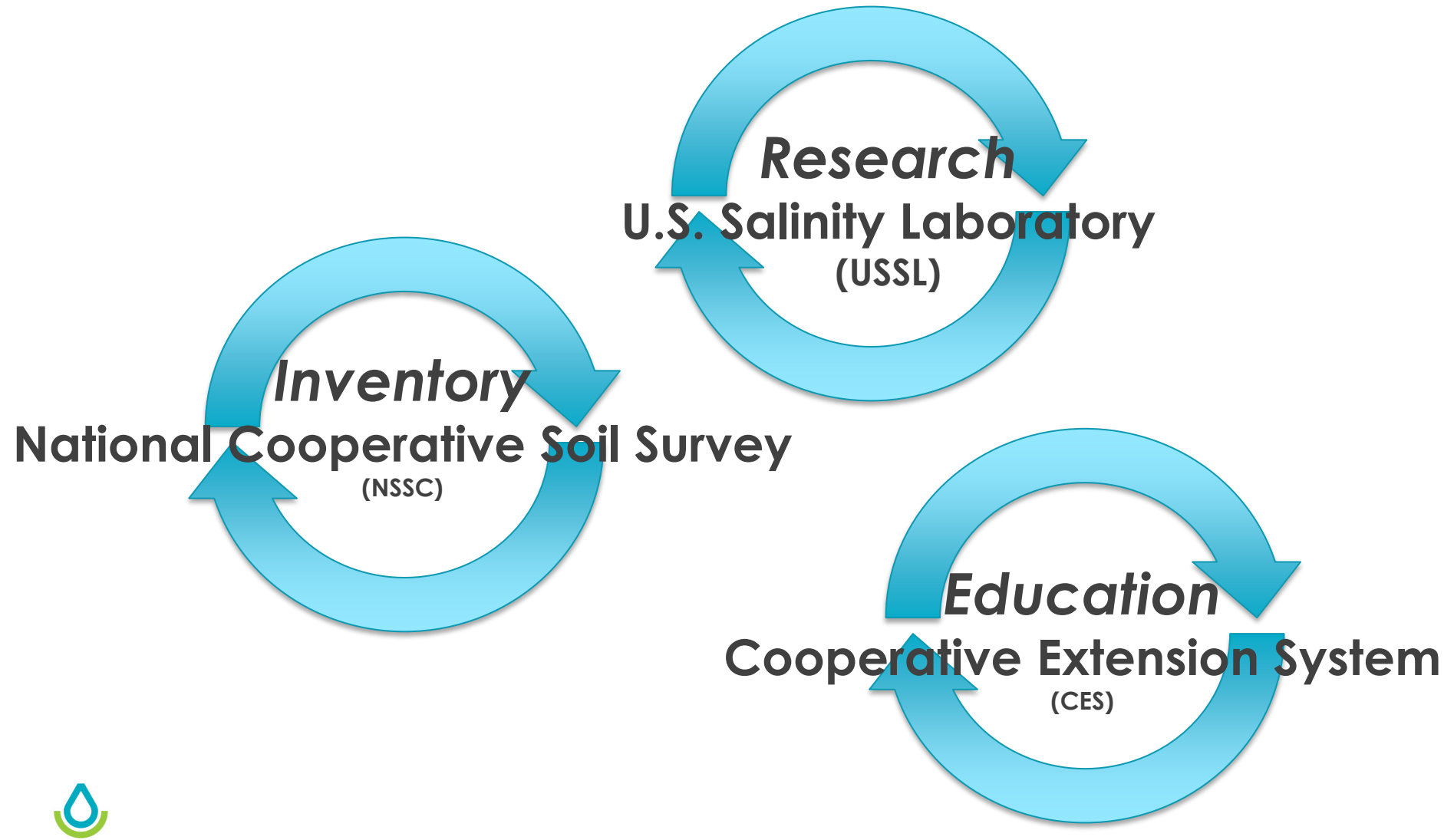
Physiography and Sources

Sources

- Weathering
- Closed basins
- Aridity
- Time
- Ground water
- Irrigation
- Dust



USA Agriculture Salinity Programs



U.S. Salinity Laboratory (USSL)

USDA – Agricultural Research Service (ARS); Riverside, California

USSL is the National Laboratory for basic research on the chemistry, physics, and biology of salt-affected soil-plant-water systems

- Climate change, increased competition for resources, and new water regulations all pose risks to irrigated agriculture
- Improved crop varieties and genetics, and advanced water, soil, and salinity management, are keys to sustaining productivity

Research Programs

Plant Genetics & Production

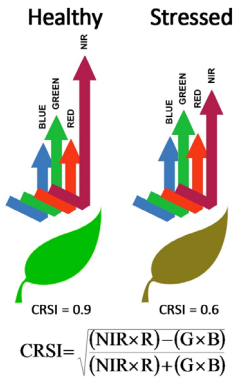
Water & Salinity Management

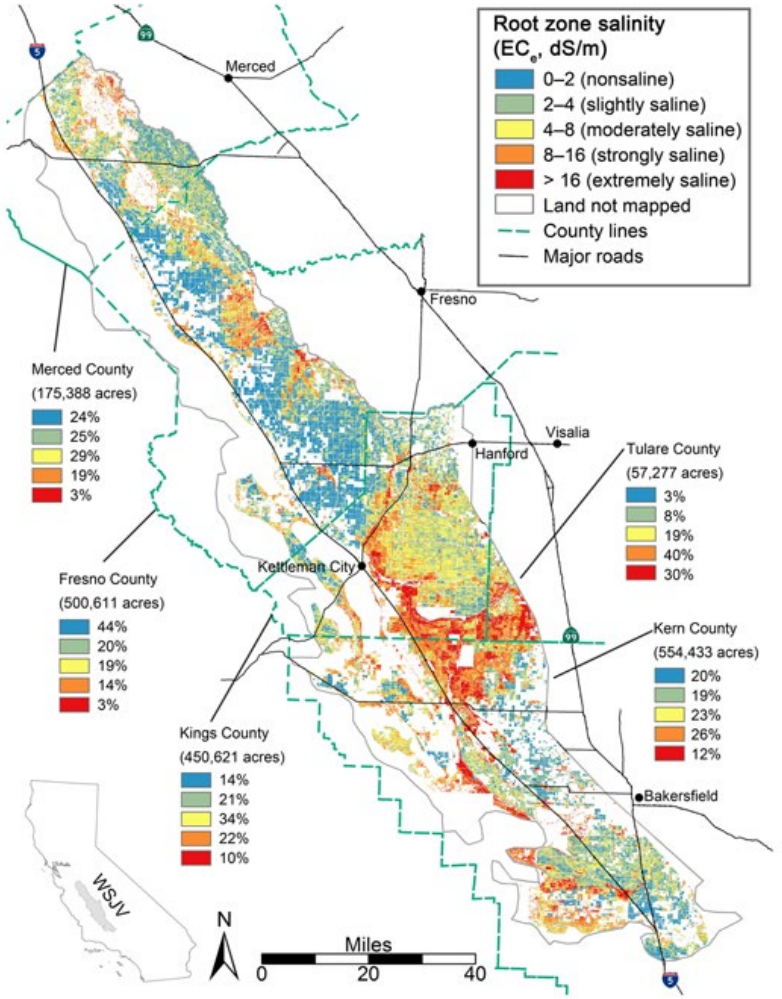
Soil & Air Quality

USSL – Western San Joaquin Valley

Remote sensing is a viable tool for assessing soil salinity in agricultural lands

- USSL improved remote sensing methods and mapped soil salinity across western San Joaquin Valley (WSJV), California



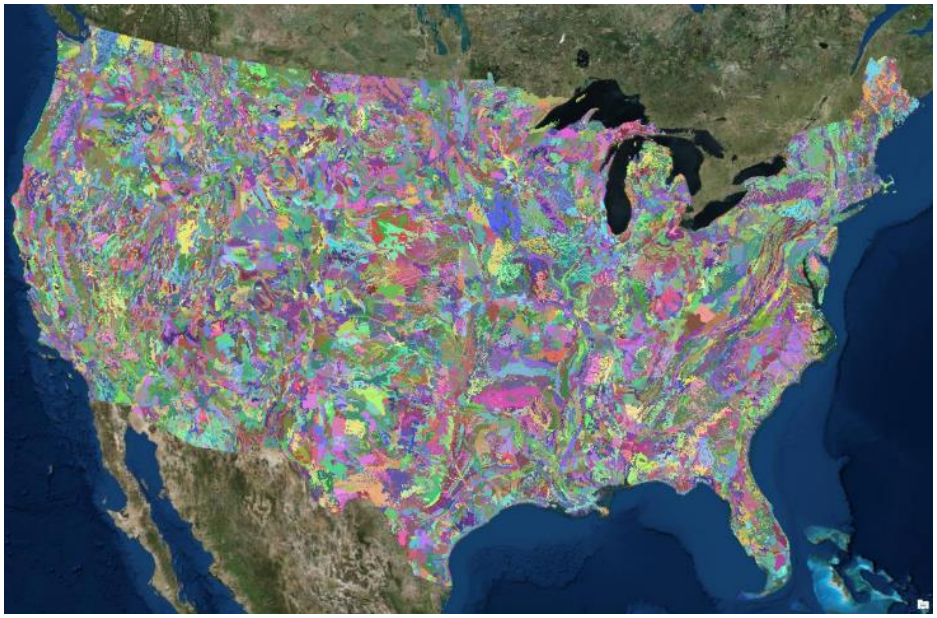


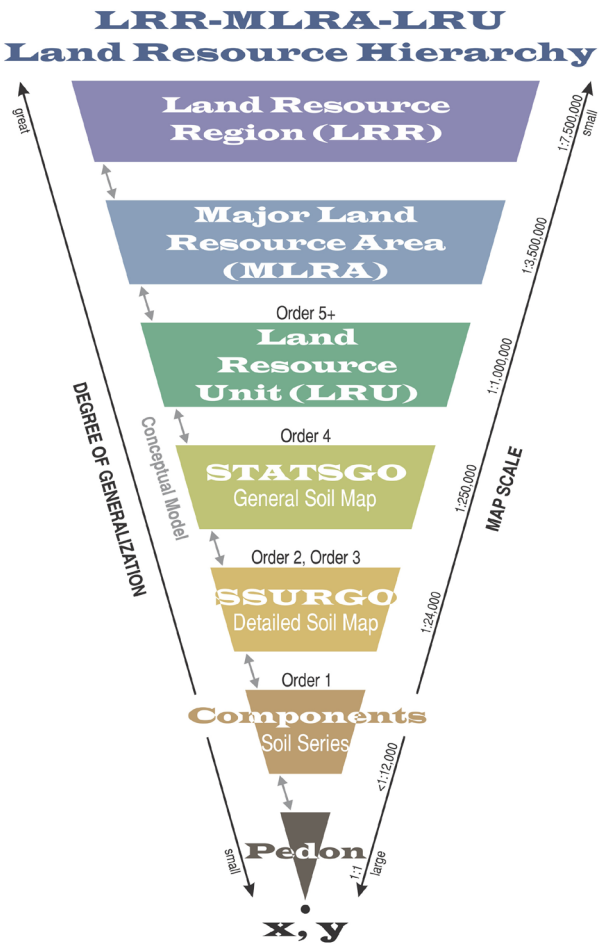
FINDINGS AND IMPACT

- 45% (780,000 acres) was salt-affected
- 30% was highly saline
- Carnegie Mellon University researchers estimated that salinity in WSJV resulted in revenue losses of $277–$2292 million in 2014

National Cooperative Soil Survey (NCSS)

A partnership of federal, state, local, and academic institutions, lead by the USDA-NRCS, to map and classify soils, develop soil interpretations, and publish soil information relevant to agriculture and land use management.





NCSS – Soils 2026

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Soils2026 and digital soil mapping – A foundation for the future of soils information in the United States

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ABSTRACT

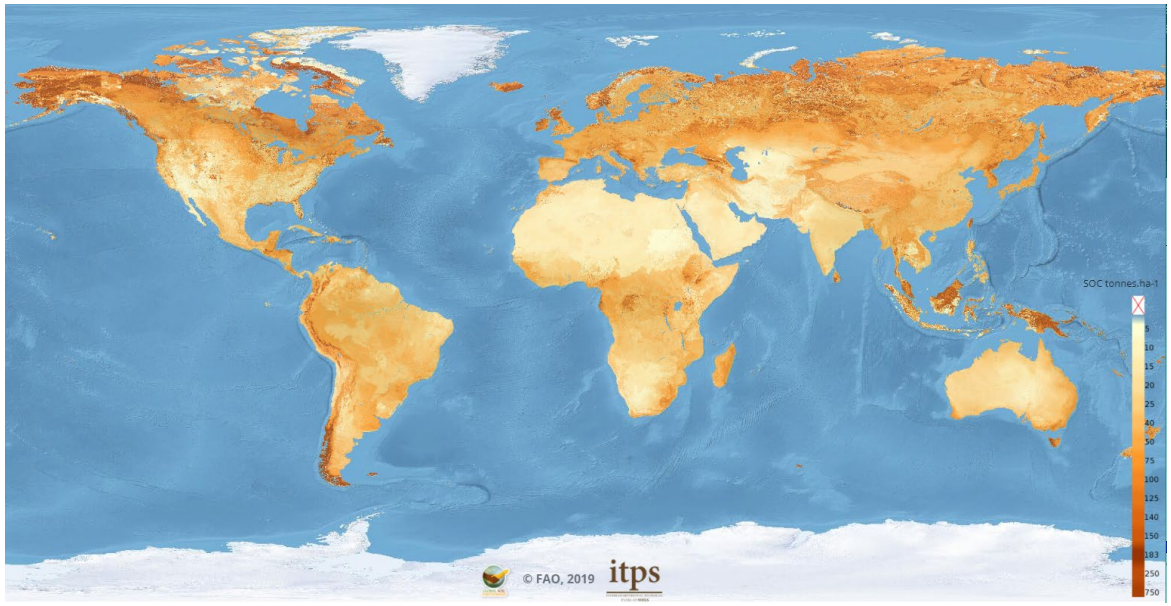
Soils are our most critical natural resource. However, urgent social, economic, and environmental issues such as carbon sequestration, drought mitigation, and nutrient management are forcing us to seek answers to questions using incomplete soil data and/or inappropriate soil information. The United States (US) Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), Soil and Plant Science Division has launched Soils2026, an ambitious initiative to provide a new inventory of soils and provisional ecological sites for all areas of the United States by 2026. Soils2026 aims to provide basic soil and ecological site information that will be useful to land managers, ecologists, modelers, and other natural resource professionals. This effort will rely heavily on digital soil mapping (DSM) to produce the next generation of raster-based soil information products for the interpretation of soil physical, chemical, and biological properties across the United States.

The USDA-NRCS Digital Soil Mapping Focus Team was formed to support Soils2026 and includes collaborating members from the National Cooperative Soil Survey representing the NRCS, US Geological Survey, USDA Forest Service, West Virginia University, and New Mexico State University. The DSM Focus Team is applying the latest DSM methods to produce continuous soil property predictions and estimates of uncertainty for all areas of the United States. Initially, the 30-m resolution products will include predictions for 12 key soil properties at six depth intervals, conforming to GlobalSoilMap specifications, with the option to expand properties or add class predictions as user needs demonstrate. Interpretations for use and management will be derived from the continuous properties products and provided to users. Fundamental pedology and communication of soil knowledge will be the primary focus of this effort, yielding a framework for delivery of seamless raster-based soils data for all areas of the United States on yearly cycles. This framework will foster an environment of continuous improvement and support a complete, consistent, correct, comprehensive, and current inventory of the soil resources of the United States.

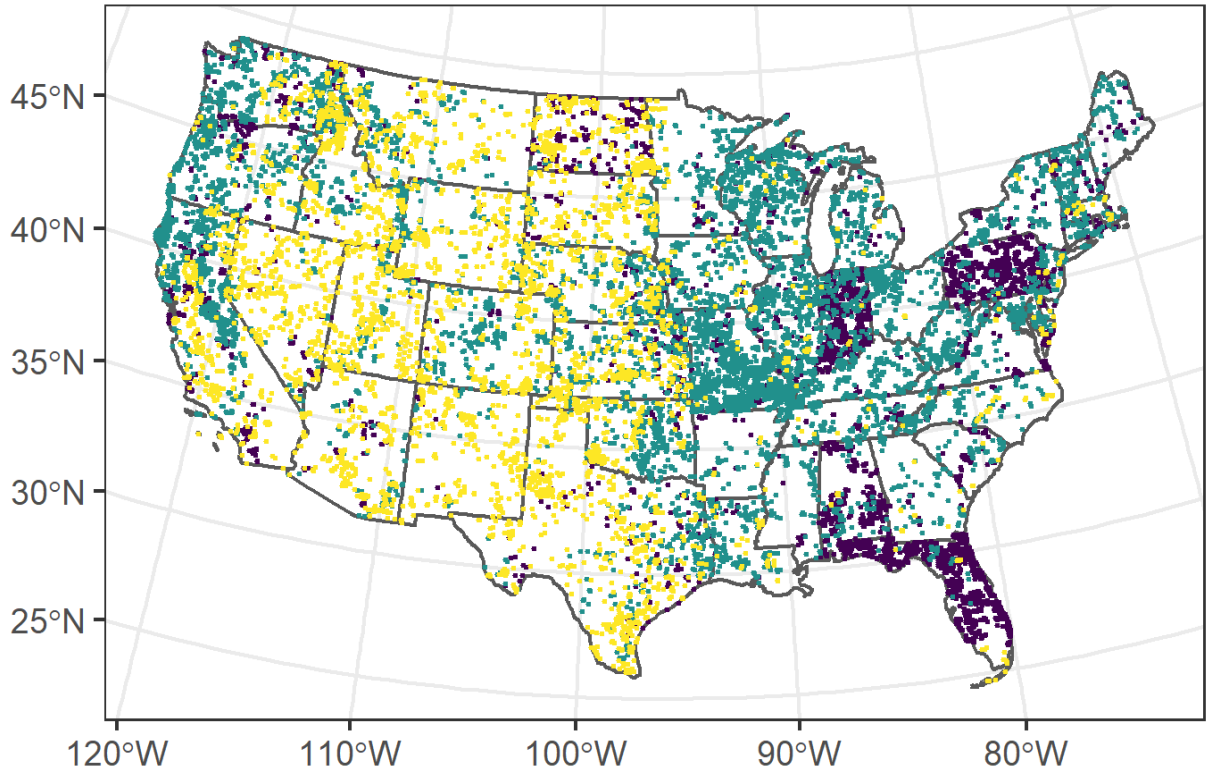
Global Soil Partnership

Pillar 4: Information and Data

- 2018 Soil Organic Carbon
- **2020 Salt Affected Soils**
- 2021 Black Soils
- 2021 Soil Organic Carbon Sequestration



NCSS Training Data - KSSL Soil Properties

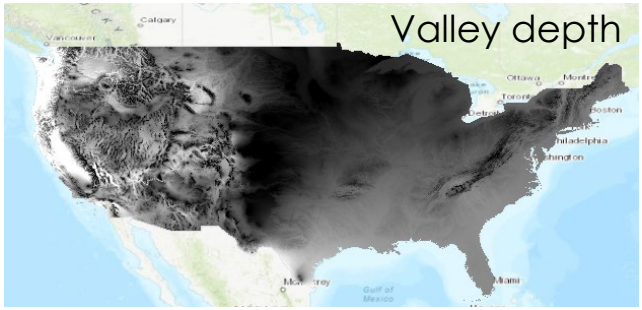


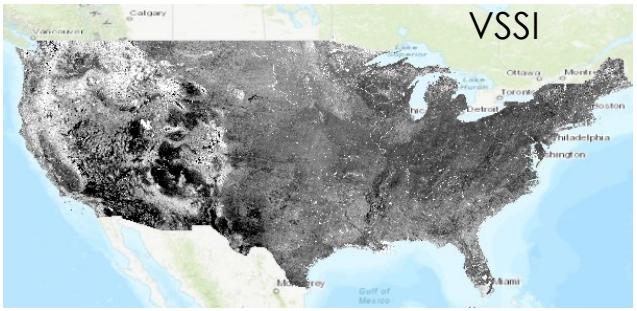
Property	Depth Interval (cm)	Total Pedons
pH	0-30	27,533
	30-100	27,305
ESP	0-30	21,502
	30-100	21,388
EC	0-30	7,023
	30-100	7,021

Covariates

(soil, climate, organisms, relief, parent material)

- GSP/ISRIC (72)
  - Elevation and spectral data (MODIS) derivatives
  - Vegetation
- NRCS (23)
  - Elevation derivatives
  - Landsat – salt indices
  - Landfire existing vegetation
  - National Landcover Dataset (NLCD)
- gNATSGO (2)
  - pH
  - Sodium Absorption Ratio (SAR)
  - 0-30cm, 30-100cm
- STATSGO (2)
  - Major Land Resource Area (MLRA)
  - Parent material





Model building and prediction

- Covariate selection
  - Selected best predictors for each property and depth interval using Boruta algorithm
    - pH, ESP (25)
    - EC (~45)
  - All properties included
    - STATSGO MLRA
    - STATSGO parent material
- Predicted each property and depth interval using quantile random forests with cross-validation

Accuracy Assessment

Prediction Results

- Qualitatively evaluate results against gNATSGO property layers

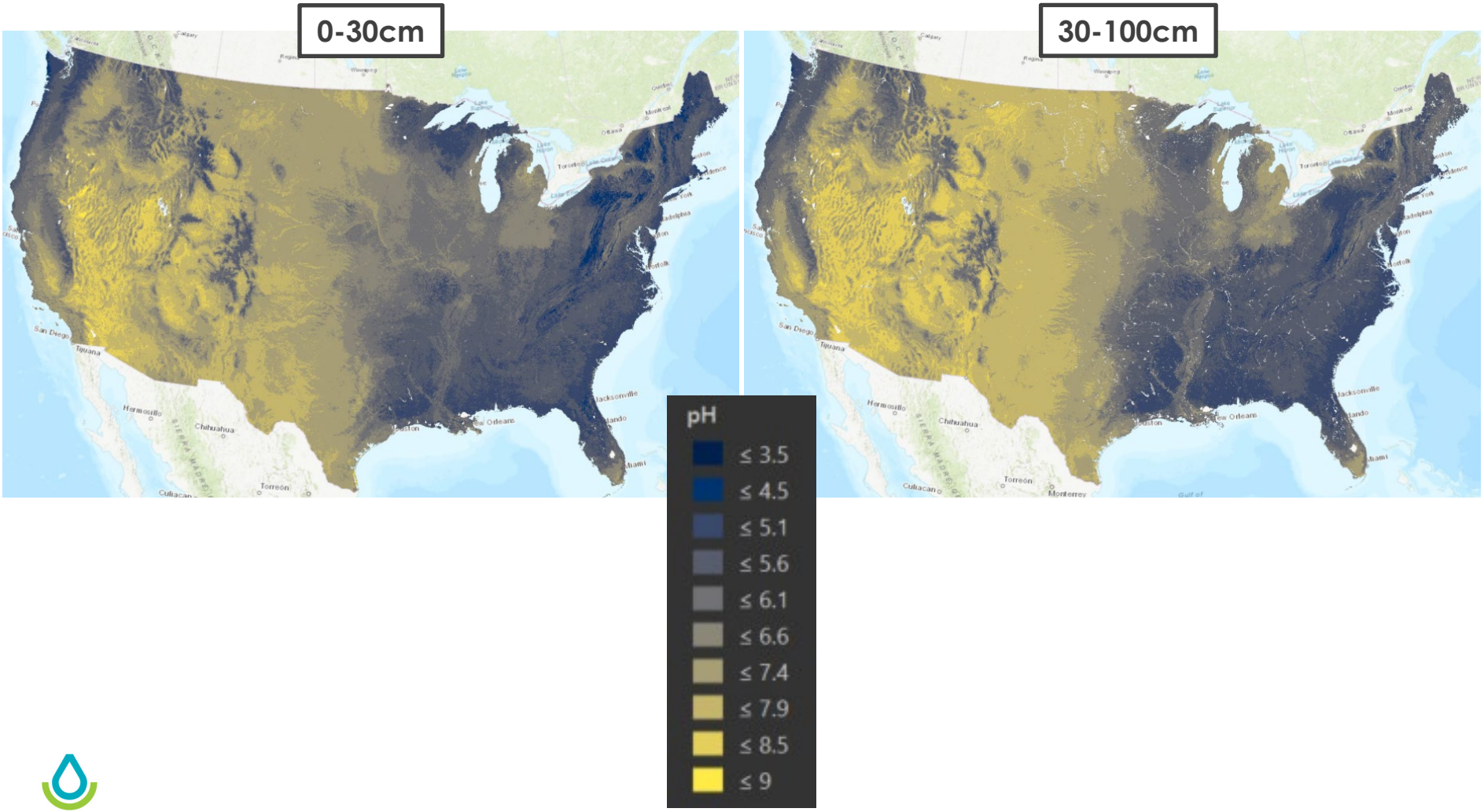
Accuracy

- Statistics generated using test data

Uncertainty

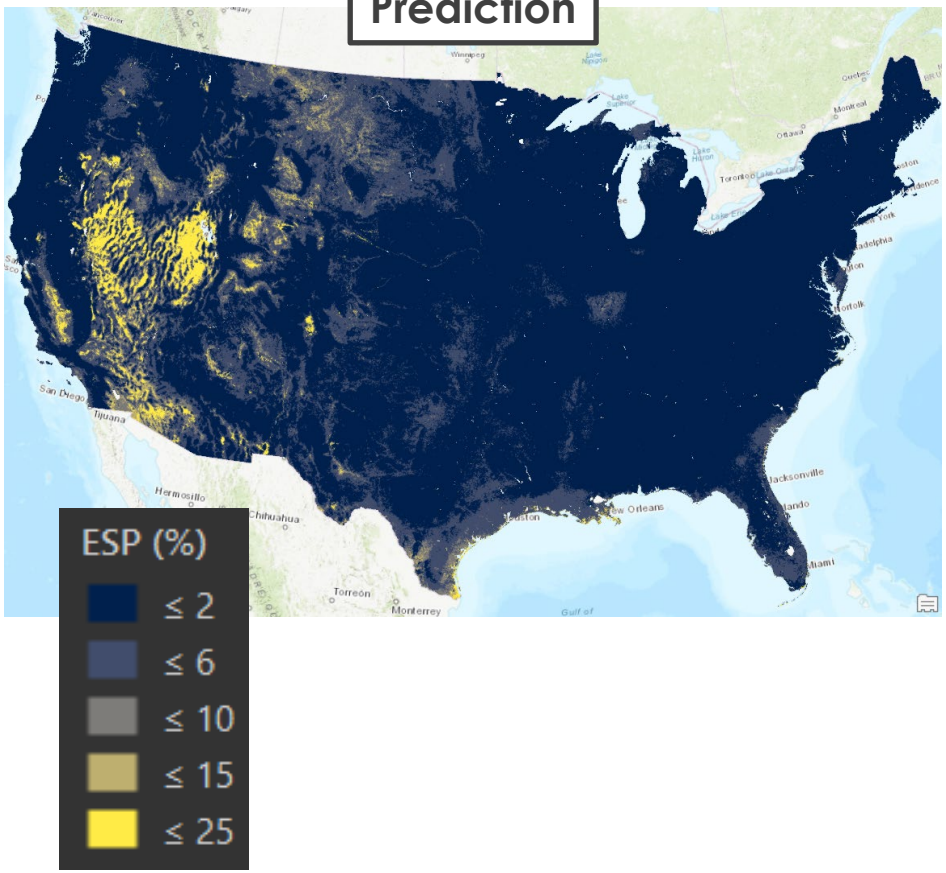
- Spatial layer of prediction interval width generated

USA Salt-Affected Soils Map: pH

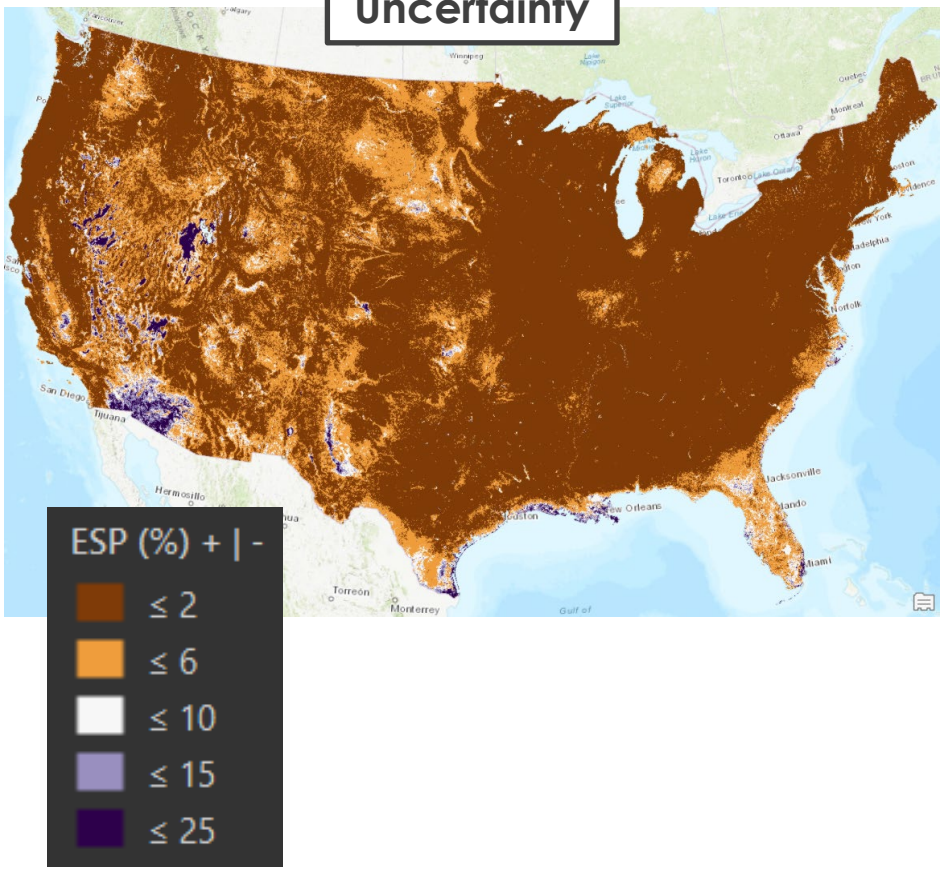


USA Salt-Affected Soils Maps: ESP 30-100cm

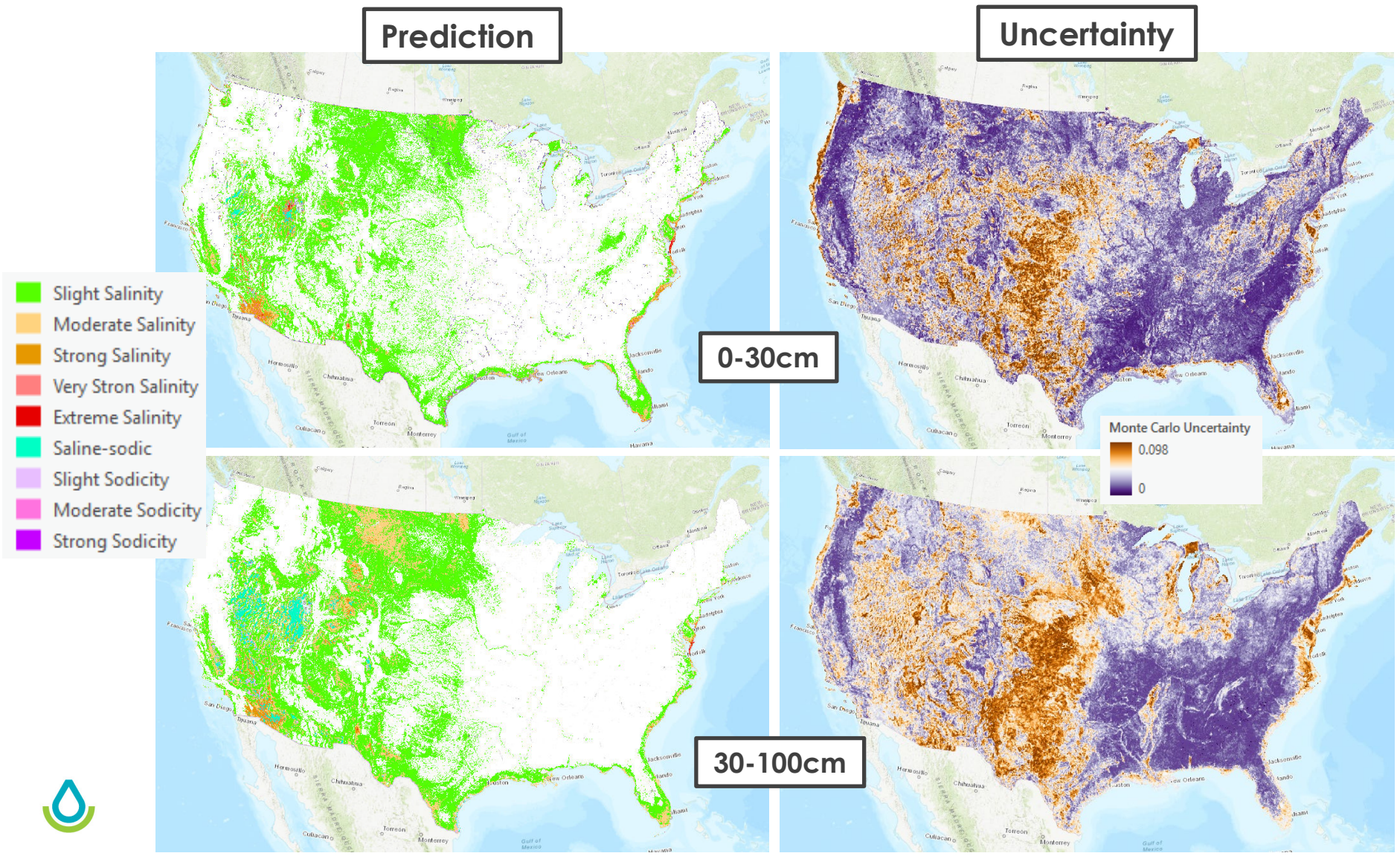
Prediction



Uncertainty



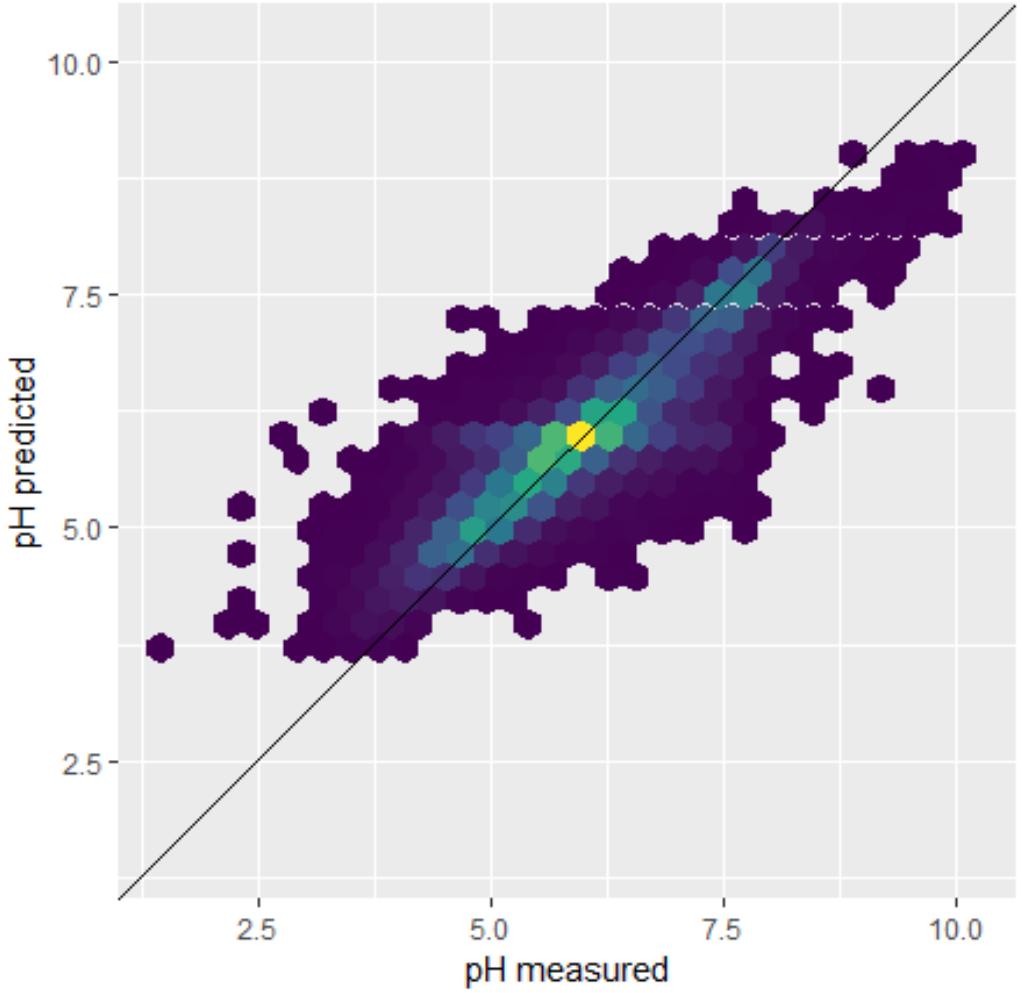
USA Maps: Salt-Affected Soil Classes



Accuracy Metrics

Dataset	Variable	Depth	Bias	RMSE	R-squared	NSE
train	EC	0-30	-1.52	15.74	0.6	0.45
test	EC	0-30	-1.94	18.02	0.84	0.56
train	EC	30-100	-2.04	19.31	0.45	0.22
test	EC	30-100	-1.83	11.5	0.69	0.44
train	ESP	0-30	-1.38	14.71	0.54	0.25
test	ESP	0-30	-0.84	14.92	0.19	0.1
train	ESP	30-100	-1.95	10.22	0.59	0.42
test	ESP	30-100	-1.08	5.93	0.6	0.49
train	pH	0-30	0	0.42	0.85	0.84
test	pH	0-30	-0.01	0.63	0.62	0.61
train	pH	30-100	0	0.44	0.87	0.87
test	pH	30-100	-0.01	0.65	0.66	0.66

DSM Predictions vs KSSL Data: pH 0-30cm



Summary

Findings

- 38% of CONUS has SAS within 100-cm (9% according to USDA system)
- 64 million hectares (158 million acres) of cropland have SAS (8 million hectares (20 million acres)
- Many areas lack pedon data (especially OCONUS)
- SSURGO+STASTGO are useful DSM covariates

Future

- Develop a national strategy to close data gaps
  - Sample to capture temporal trends in DSPs (e.g. salinity, carbon, moisture)
  - Increase adoption of proximal sensing
- Investigate SSURGO where it diverges significantly from DSM