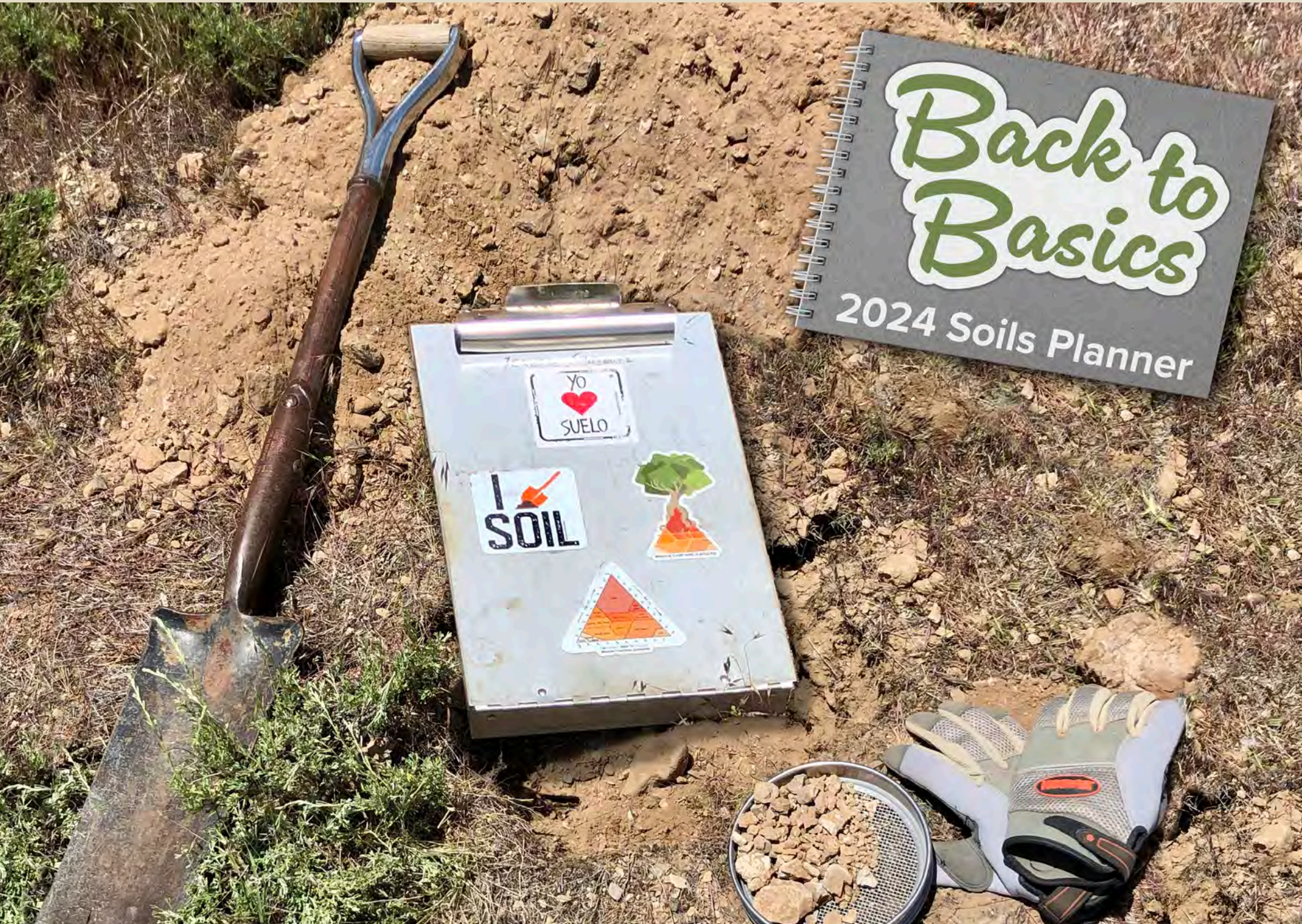
USDA Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE



Message From the Deputy Chief

The National Cooperative Soil Survey (NCSS) has supported the collection of soil survey information since 1899 when texture was first recognized as a primary soil characteristic. From 1920 to 1950, the NCSS recognized more soil properties significant to farming, ranching, and forestry. In the 1950s, cooperative research with State highway departments established the importance of characterizing soils for engineering roads and other nonfarm uses. In 1965, Soil Taxonomy, the official system for classifying soils in the United States, was adopted and increased the need for systematic field soil surveys and laboratory soil analysis. Since then, soil scientists have continued to develop standards for collecting and analyzing soil data.

Our knowledge of the nature, distribution, and extent of soils in the United States has greatly expanded because of the application of standards for collecting and analyzing soil properties and characteristics. The standards are the foundation for what information soil scientists gather and provide to the public. The usefulness of the data reaffirms the importance of scientific soundness, accuracy, and knowledge of basic soil information.

The soil survey information collected and analyzed by soil scientists helps people understand the best use and management of their land. Whether growing crops, building infrastructure, or planning recreational areas, it is important to know the suitabilities, limitations, and potentials of the soil. Understanding basic soil information enables soil scientists to work with conservationists, engineers, local planners, land managers, farmers, and landowners to help ensure a healthy and sustainable world.

The NRCS Soil and Plant Science Division created this planner to spotlight the importance of basic soil survey information. The planner examines 12 soil properties and characteristics that soil scientists regularly observe and analyze and reveals why they are important to us.

Luis Tupas
Deputy Chief for Soil Science and Resource Assessment
USDA, Natural Resources Conservation Service

In Memoriam – Dr. Luis “Louie” Tupas

It is with a heavy heart that we share the passing of Dr. Luis “Louie” Tupas in August 2023. Louie joined NRCS in 2020, providing leadership in strengthening the scientific basis for conservation and sustainable agriculture for the Agency and our mission area. He was a skilled and valued leader, mentor, and friend. He’s remembered for his positivity and ever-present smile, infectious passion for our work, and genuine care for his staff and colleagues.

Louie reminded us all of the importance of having values in public service—something he exemplified daily. He said, “Great values are at the heart of every good organization. Our values shape our culture and drive our behavior. Values are more than words. Values are actions. They are evident in everything that we do, as individuals and as an organization.”

As we carry Louie’s words, example, and legacy forward, he will be dearly missed by the Soil and Plant Science Division staff and the entire NRCS family.

Back to Basics

Soil properties and characteristics are basic to our understanding of how soils behave and their potential land uses. The NRCS Soil and Plant Science Division (SPSD) is responsible for soil survey activities as part of the National Cooperative Soil Survey (NCSS). The Division conducts soil surveys and develops ecological site descriptions using national standards. The SPSD manages these national standards to ensure consistency and repeatability in the collection of soil survey information.

The standards created by the NCSS that govern the collection of soil survey information are applied nationally by the soil science discipline. These standards are critical to developing and delivering accurate and consistent soil information to the public. NCSS standards are dynamic; they are continuously evaluated to integrate changes and additions that support a scientifically credible soil survey for the Nation.

Soil properties and characteristics are measured or inferred from direct observations in the field and laboratory. This soil survey information is important because it is used in soil interpretations, as predictors of soil behavior, and for classifying and mapping soils. This information is available to the public and is widely used for planning and land management.

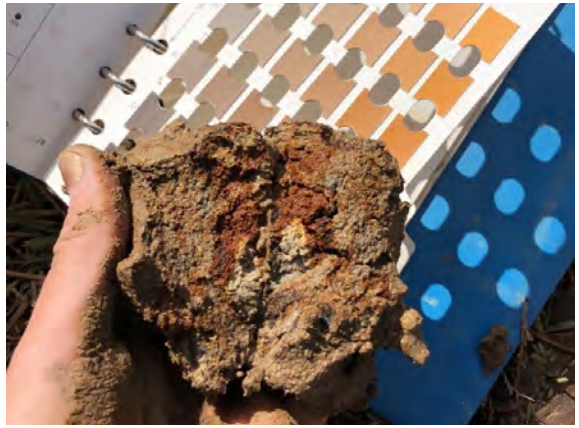
In the pages of this planner, we explore the following basic soil properties and characteristics:

- Parent Material
- Redoximorphic Features
- Rock Fragments
- Color
- Pores
- Texture
- Slope
- Soil Organic Matter
- Artifacts
- Surface Fragments
- Saturated Hydraulic Conductivity
- Electrical Conductivity

Photo Credits:
Cover Photo—Joxelle Velazquez, NRCS
Cover Art—Tammy Umholtz, NRCS

Top Photo—Joxelle Velazquez, NRCS

Middle Photo—Autumn Boxum, NRCS



Bottom Photo—Autumn Boxum, NRCS

January

Photo by Andy Steinert, NRCS

Parent material is the unconsolidated material, mineral or organic, from which soil develops. It may be weathered directly from underlying bedrock or from material subject to transport and deposition by wind, water, gravity, or human activities. Parent material is one of five soil-forming factors.

In Adams County, Colorado, materials of the Fox Hills Sandstone Formation weather easily below the iron-cemented beds and concretions that form the rust-colored ledges at the surface. The photograph above shows three parent materials: eolian sand deposited on the tops of the hills, sandstone bedrock below the eolian sand, and local alluvium in the drainageway at the base of the mounds. The depth to the sandstone bedrock affects the rooting depth of the native plants and influences the suitabilities and limitations of the soil.

February

Photo by Joxelle Velazquez, NRCS

Redoximorphic features are color patterns caused by loss (depletion) or gain (concentration) of pigment compared to the matrix color. These features are formed by oxidation and reduction reactions involving iron and manganese. The presence of these features generally indicates a seasonal high water table is present in the soil at some time during the year. The seasonal high water table causes a cycle between anaerobic (reduced) and aerobic (oxidized) conditions.

At the Talladega National Forest in Alabama, red-colored redoximorphic features are observed in a soil pit sampled for the National Ecological Observatory Network (NEON). This soil, formed in clayey marine sediments, has a seasonal high water table perched at a depth of 60 to 100 centimeters from the soil surface.

March

Photo by Nicholas Kozlowski, NRCS

Rock fragments are unattached pieces of geologic or pedogenic material 2 millimeters in diameter or larger that have a strongly cemented or more rupture resistance class. Rock fragments impact the behavior of the whole soil and can greatly influence the use and management of the soil.

At the Salmon-Challis National Forest in Idaho, scientists from the USDA, Natural Resources Conservation Service and the USDA, Forest Service estimate coarse gravels and cobbles from a soil sample at a Snow Telemetry (SNOTEL) site. The rock fragments less than 20 millimeters in size, including fine and medium gravels, are bagged, tagged, and shipped to the Kellogg Soil Survey Laboratory in Lincoln, Nebraska, for analysis.

April

Photo by Nicholas Kozlowski, NRCS

Color is a noticeable property of soil and is a way to assess soils visually using a scientific approach. To describe soil color, the National Cooperative Soil Survey has adopted the Munsell color system, which uses the elements of hue, value, and chroma. Most soil minerals are naturally white or light gray but change color when organic matter and iron compounds are present.

In the Lemhi Mountains in Idaho, a soil scientist identifies soil color using a color chart. Soil survey information for this site in the Salmon-Challis National Forest is important for land managers. Soil survey data and interpretations are useful for managing healthy soils and wildlife habitats and for recreational planning in this highly popular destination for hunting, camping, and hiking.

May

Photo by Autumn Boxum, NRCS

Pores are small openings or voids between soil particles and aggregates in the soil material. Pores provide vital paths for water infiltration and storage, the entry and movement of air, and chemical transport and exchange. A network of pores often accounts for about half of a soil's total volume.

While conducting soil survey mapping in Sweetwater County, Wyoming, a soil scientist observes macropores formed by cicadas tunneling through the soil. Cicadas spend most of their lives in underground burrows at a depth of 30 to 46 centimeters and emerge every 13 to 17 years, depending on the species. Cicadas emerge from the ground when the soil temperature reaches 18 degrees Celsius (64 degrees Fahrenheit).

June

Photo by Mary Ellen Cannon, NRCS

Soil texture refers to the relative proportions of sand, silt, and clay particles that make up the mineral fraction of the soil. Texture is determined in the field by moistening the soil and rubbing a small amount between the thumb and fingers to estimate the relative proportions of sand, silt, and clay.

In Weld County, Colorado, a soil scientist conducts a technical onsite soil investigation to locate a suitable site for a catastrophic mortality, large animal disposal area to bury poultry infected with, or exposed to, highly pathogenic avian influenza. The soil scientist determines the soil has a sandy texture, which indicates it has a high leaching potential. This site is unsuitable for the proposed purpose because of the environmental and health concerns its use could present.

July

Photo by Erin Kreutz, NRCS

Slope refers to the ground surface configuration. It has aspect, gradient, complexity, and length. Slope gradient is the inclination of the land surface with respect to the horizontal plane and is commonly referred to as “slope percent” or simply “slope.” In percentage terms, slope represents the elevation that occurs between two different points. Slope classes are assigned to soil map units to convey the dominant range of slope gradients occurring within it.

In Washington State, the steepness and length of the slopes on the Olympic National Park’s High Divide Loop (7 Lakes Basin) Trail influence how fast water runs off the soil and the amount of soil erosion that may occur. The steep slopes of the trail make it a challenging route and affect other recreational uses.

August

Photo by Joxelle Velazquez, NRCS

Soil organic matter is a dynamic soil property that drives nutrient availability in the soil, encourages granulation and good tilth, increases porosity, lowers bulk density, promotes water infiltration, reduces plasticity and cohesion, and increases available water capacity. Soil organic matter consists of plant and animal tissue at different stages of decomposition and is primarily made up of carbon, which enters the soil through the decomposition process.

In a forested area in Semmes, Alabama, soil organic matter accumulates on the surface of alluvial soils. Soil organisms, including fungi, microbes, and earthworms, help decompose the soil organic matter and transform it into humus. Humus is a stable form of soil organic matter that contributes to climate change mitigation through its carbon sequestration potential.

September

Photo by Joxelle Velazquez, NRCS

Artifacts are water-stable objects or materials created, modified, or transported from their source by humans, usually for a practical purpose in habitation, manufacturing, excavation, agriculture, or construction activities. Examples are processed wood products, bricks, concrete, plastic, glass, rubber, human-shaped stonework, and landfill waste.

A soil scientist in Staten Island, New York, examines artifacts in soil formed from coal combustion byproducts. These soils are of unique importance because soils in urban areas are a vital resource that serves the needs of urban farmers and diverse communities nationwide. Urban soil survey information can be used to make decisions that strongly impact human health and quality of life.

October

Photo by Nicholas Kozlowski, NRCS

Surface fragments are unattached, cemented pieces of bedrock, bedrock-like material, durinodes, concretions, nodules, pedogenic horizons 2 millimeters or larger in diameter, and woody material 20 millimeters or larger in diameter that are exposed at the surface of the soil. Surface fragments greatly affect soil use and management.

In the Sawtooth Wilderness area, a federally protected wilderness area in Idaho, recent wildfires that are part of the natural disturbance regime give soil scientists an unobstructed view of landforms and surface fragments. Excavation of a tree throw reveals recent colluvium with surface fragments of various sizes over till parent materials. Federal disaster relief funding has been used to restore the degraded ecosystem since the Badger Fire in 2021.

November

Photo by Matt Bromley, NRCS

Saturated hydraulic conductivity (Ksat) is a quantitative measure of the ability of a saturated soil to transmit water when subjected to a hydraulic gradient. In Pulaski County, Indiana, soil scientists measure Ksat with an infiltrometer to understand the link between soil properties, climate, and management type. This site is within the Kankakee River Basin, where the Grand Kankakee Marsh once stretched.

Once the largest wetland area in North America, the Grand Kankakee Marsh's unique ecological landscape was home to high concentrations and diverse populations of plants, birds, fish, and animals. Today, less than 5 percent of the marsh remains. Since 2022, the Pokagon Band of the Potawatomi Indians has worked with NRCS to help restore their ancestral wetlands.

December

Photo by Rich Ferguson, NRCS

Soil electrical conductivity (EC) measures the ability of a soil to carry an electrical current. EC is related to the amount of salts in the soil. A key indication of soil salts is the EC of a soil-water mixture: if salts are present, the salts will dissolve in the water and increase the EC of the solution.

At the Kellogg Soil Survey Laboratory in Lincoln, Nebraska, a scientist develops a saturated paste extract for soil samples from West Virginia. The scientist prepares a soil-water slurry to dissolve the salts into the water and extracts the solution phase from the slurry. The solution phase is then analyzed with an ion chromatograph to determine the amount and kinds of salts. The EC data help landowners make informed decisions about the best uses for their land and how to manage it.

Parent Material

December 2023

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

The Fox Hills Sandstone Formation was deposited during the retreat of the Western Interior Seaway during the late Cretaceous Period. This seaway stretched from the Gulf of Mexico to the Arctic Ocean.

February 2024

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29		

January 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	**Did you know?** The nature of the parent material strongly influences soil properties such as texture, pH, fertility, mineralogy, bulk density, structure, and the kinds and amounts of fragments.		


Redoximorphic Features

In the Talladega National Forest, soil scientists collect soil samples from a National Ecological Observatory Network (NEON) site to help understand and forecast the impacts of climate change, land use change, and invasive species on continental-scale ecology.

February 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Did you know? Bright reddish-orange, yellowish-orange, and grayish “splotches” that are distinguishable from the dominant soil color are typical redoximorphic features, indicating a seasonal high water table occurring at that depth in the soil.				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19 Presidents’ Day	20	21	22	23	24
25	26	27	28	29		

Rock Fragments

February 2024

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29		

At the Salmon-Challis National Forest Snow Telemetry (SNOTEL) site, scientists estimate rock fragments that can influence available water capacity, cation-exchange capacity, saturated hydraulic conductivity, structure, and porosity.

March 2024

April 2024

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Did you know? NRCS installs, operates, and maintains the SNOTEL system. The SNOTEL data are part of the U.S. Climate Resilience Toolkit, which scientists use to monitor temperature, precipitation, and the amount of water stored as snowpack for water supply forecasts at remote mountain sites across the West.					1	2
3	4	5	6	7	8	9
10 **Daylight Saving Time Begins**	11	12	13	14	15	16
17	18	19	20 **Vernal Equinox**	21	22	23
24	25	26	27	28	29	30
31						


Color

March 2024

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

In the Lemhi Mountains in Idaho, a soil scientist identifies soil colors, which can be indicators of important processes happening in the soil as a function of where the soil is on the landscape.

May 2024

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

April 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22 Earth Day	23	24	25	26	27
28	29	30				

Did you know? Soil color can change quickly, both within a soil profile and across the landscape. Color differences may be due to changes in mineralogy, climate, organic matter content, and soil drainage.


Pores

April 2024

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

In Sweetwater County, Wyoming, evidence like these macropores formed by cicadas suggests that cicadas may be emerging earlier than usual due to a warming climate.

June 2024

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

May 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Did you know? The amount and size of pore spaces can be reduced by compaction, which lowers soil productivity and environmental quality.			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27 Memorial Day	28	29	30	31	

Texture

May 2024

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

In Weld County, Colorado, a soil scientist evaluates the soil texture as it relates to the leaching or transmission of fluids through the soil, which may become an environmental, health, and performance concern.

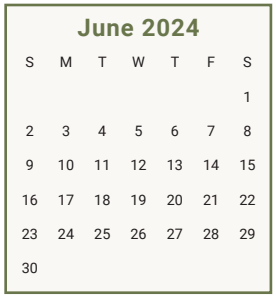
June 2024

July 2024

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Did you know? A soil sample is assigned to one of the 12 soil texture classes according to the values for the proportions of sand, silt, and clay by using the soil textural triangle. The texture classes are sand, loamy sand, sandy loam, sandy clay loam, loam, silt loam, silt, silty clay loam, clay, clay loam, sandy clay, and silty clay.						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19 Juneteenth	20 Summer Solstice	21	22
23	24	25	26	27	28	29
30						


Slope



This very steep slope, along a trail in the High Divide Loop (7 Lakes Basin), is in Olympic National Park in Washington. When the trail is snow-covered, self-arrest skills and ice axes are recommended for hiking the snowy slopes.

July 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4 Independence Day	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31	**Did you know?** The Soil Survey Manual classifies complex slopes into six categories based on slope gradient ranges: nearly level, undulating, rolling, hilly, steep, and very steep.		


Soil Organic Matter

July 2024

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

On a flood plain in Semmes, Alabama, a soil scientist examines an alluvial soil with a large amount of soil organic matter. Soil organic matter helps retain plant nutrients and moisture and develop good soil structure to support forested wetland ecosystems.

August 2024

September 2024

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Did you know? Stable soil organic matter, like humus, has a high carbon sequestration potential. Carbon sequestration is the process of capturing and storing carbon. Since the carbon is stored, carbon dioxide is not released into the atmosphere.				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Artifacts

August 2024

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

In Staten Island, New York, a soil scientist examines coal and slag artifacts in a soil profile. Urban soil surveys expand the availability and enhance the quality of soil information for urban populations, including historically underserved and climate-vulnerable communities.

October 2024

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

September 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2 Labor Day	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22 Autumnal Equinox	23	24	25	26	27	28
29	30	**Did you know?** The Soil and Plant Science Division established a cooperative agreement with Brooklyn College, Rutgers University, and the University of California, Riverside, to investigate new methods to link mappable soil characteristics to functional attributes of soils in urban areas.				

Surface Fragments

In the Sawtooth National Forest in Idaho, a soil scientist has an unobstructed view of surface fragments that would normally be concealed by forest canopy were it not for the recent Badger Fire. Disaster relief funding for the Badger Fire supports restoration of the degraded ecosystem.

October 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Did you know? Disaster relief funding helps communities deliver nature-based solutions for food insecurity, climate change mitigation, and biodiversity loss.		1	2	3	4	5
6	7	8	9	10	11	12
13	14 Columbus Day	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Saturated Hydraulic Conductivity

October 2024

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

In Pulaski County, Indiana, a soil scientist collects saturated hydraulic conductivity data for a dynamic soil property project to compare soils across three different land management states. The goal is to better understand the link between soil properties, climate, and management type.

December 2024

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

November 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Did you know? NRCS is working with the Pokagon Band of the Potawatomi Indians, a federally recognized Tribe, to help restore their ancestral wetlands, only a fraction of which exist today. Thanks to the partnership, over 464 hectares (1,147 acres) of wetlands have been restored.					1	2
3 Daylight Saving Time Ends	4	5	6	7	8	9
10	11 Veterans Day	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28 Thanksgiving Day	29	30

Electrical Conductivity

November 2024

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

At the Kellogg Soil Survey Laboratory in Lincoln, Nebraska, a scientist prepares soil samples from West Virginia to measure the electrical conductivity (EC) of the soils to determine the amount of salts in the soils.

January 2025

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

December 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5 World Soil Day	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21 Winter Solstice
22	23	24	25 Christmas Day	26	27	28
29	30	31 New Year's Eve	**Did you know?** High EC is an indicator of salinity, which can affect plant growth. Soils with high salinity can also have other limitations for land use and management.			





Back to Basics


Program Aid 2278, August 2023

Photos by USDA Natural Resources Conservation Service.

September 2023