Thrive Biochar Trial Design

Grower: *There are a few things I hope to accomplish by using biochar. The first is to increase water retention in the soil, especially during the dry and hot part of the year. The second is to create a more conducive environment in the beds for microbial growth and diversity. I'm really hoping to achieve less water consumption while simultaneously giving a more ideal environment for the soil biome. I believe that if it works well, our produce will cost us less to produce and be of a higher quality. I am also cautiously optimistic that nutrient density of our produce will see some sort of increase as a result of using these practices.*

Figure Left*, shows three 100ft x 2.5ft beds that were broken into four subsections. Each has a different combination of Poultry Litter Biochar (5 or 10 ton/acre), Compost (10 ton/acre), and growers preplant amendments applied. There was little research done on Poultry Litter Biochar, so we wanted to consider multiple combinations.*

The combination of being a mollisol (inherently good structure and fertility) and having been previously amended indicated that biochar addition may not make a stark improvement. Soil testing showed little deficiencies. There is research noting improved water holding capacity which aligns with grower’s goals. We teamed up with Jensen to monitor soil moisture levels with tensiometers.

Soil Map

Map Scale: 1:1,190 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 4N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Island of Oahu, Hawaii
Survey Area Data: Version 16, Sep 15, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 29, 2017—Oct 11, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
WkA	Waialua silty clay, 0 to 3 percent slopes	2.0	100.0%
Totals for Area of Interest		**2.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Island of Oahu, Hawaii

WkA—Waialua silty clay, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: hqjc
Elevation: 10 to 100 feet
Mean annual precipitation: 25 to 50 inches
Mean annual air temperature: 72 to 75 degrees F
Frost-free period: 365 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Waialua and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Waialua

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Alluvium

Typical profile

H1 - 0 to 12 inches: silty clay
H2 - 12 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.4 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 3c
Hydrologic Soil Group: C
Ecological site: R158XY401HI - Isohyperthermic Ustic Naturalized Grassland
Hydric soil rating: No

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Soil Health

Soil health interpretations are designed to be used as tools for evaluating and managing a soil's capacity to function as a vital living ecosystem that sustains plants, animals, and humans. Example interpretations include compaction, surface sealing, carbon sequestration, resistance and resilience, management systems and practices, and cover crops.

Organic Matter Depletion

Soil Organic Matter Depletion

Soil health is primarily influenced by human management, which is not captured in soil survey data at this time. These interpretations provide information on inherent soil properties that influence our ability to build healthy soils through management.

A fertile and healthy soil is the basis for healthy plants, animals, and humans. Soil organic matter is the very foundation for healthy and productive soils. Understanding the role of organic matter in maintaining a healthy soil is essential for developing ecologically sound agricultural practices. Perhaps just as important is identifying areas at greater risk of organic matter depletion. For organic matter to accumulate in soil, the processes that synthesize organic matter generally need to be greater than the processes that destroy organic matter. These processes occur at continental and local scales. Continental-scale factors include the mean annual temperature, which ultimately governs the rates of biological processes, including both the synthesizing and destroying of organic matter. Another continental-scale factor is the amount of water generally available for use by plants and soil microbes. The amount of available water is governed by the amount of rainfall or snowmelt that an area receives in relation to evapotranspiration. This interpretation does not take into account the application of irrigation water.

The continental-scale factors are modified by local factors. Oxygen is needed for both the accumulation and destruction of organic matter. It can be excluded from the soil by seasonal saturation, which generally favors the accumulation processes. The antecedent organic matter content is used as an indicator of the level of a soil's vulnerability to loss of organic matter. In general, well aerated soils tend to have higher oxidation rates but may still accumulate organic matter, depending on other factors, such as ground cover, length of time that living roots are present in the soil, and management practices. Clay-sized particles in the soil help protect organic compounds and so tend to favor organic matter accumulation. The shape of the land surface also influences the organic matter content. Water and sediment tend to accumulate in concave areas while material tends to disperse in convex areas. The degree of limitation caused by each of these properties is rated for a soil and the sum of the ratings is the overall rating.

The ratings are both verbal and numerical. Numerical ratings indicate the propensity of the individual soil properties to influence organic matter degradation. The ratings are shown in decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest ability to enable organic carbon depletion (1.00) and the point at which the soil feature becomes least likely to allow organic matter depletion (0.00).

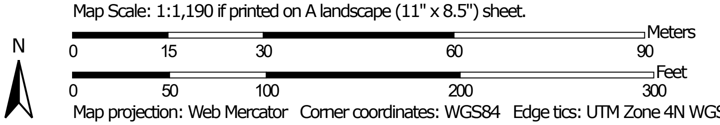
Rating class terms indicate the extent to which the soils enable the depletion of organic matter. "Organic matter depletion high" indicates that the soil and site have features that are very conducive to the depletion of organic matter. Very careful management will be needed to prevent serious organic matter loss when these soils are farmed. "Organic matter depletion moderately high", "Organic matter depletion moderate", and "Organic matter depletion moderately low" are a gradient of the level of management needed to avoid organic matter depletion. "Organic matter depletion low" indicates soils that have features that are favorable for organic matter accumulation. These soils allow more management options while still maintaining favorable organic matter levels.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Map—Organic Matter Depletion

Map Scale: 1:1,190 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 4N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- OM depletion high
- OM depletion moderately high
- OM depletion moderate
- OM depletion moderately low
- OM depletion low
- Not rated or not available

Soil Rating Lines

- OM depletion high
- OM depletion moderately high
- OM depletion moderate
- OM depletion moderately low
- OM depletion low
- Not rated or not available

Soil Rating Points

- OM depletion high
- OM depletion moderately high
- OM depletion moderate
- OM depletion moderately low
- OM depletion low
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

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Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: Island of Oahu, Hawaii
Survey Area Data: Version 16, Sep 15, 2021

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Date(s) aerial images were photographed: Jan 29, 2017—Oct 11, 2020

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Tables—Organic Matter Depletion

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
WkA	Waialua silty clay, 0 to 3 percent slopes	OM depletion moderately high	Waialua (100%)	High oxidation rate (1.00)	2.0	100.0%
				Well aerated (1.00)		
				Moderate moisture deficit (0.77)		
				Moderate antecedent organic matter content (0.46)		
				Not water gathering surface (0.33)		
Totals for Area of Interest					**2.0**	**100.0%**

Rating	Acres in AOI	Percent of AOI
OM depletion moderately high	2.0	100.0%
Totals for Area of Interest	**2.0**	**100.0%**

Rating Options—Organic Matter Depletion

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Limitations for Aerobic Soil Organisms

Inherent Limitation for Aerobic Soil Organisms

Soil health is primarily influenced by human management, which is not captured in soil survey data at this time. These interpretations provide information on inherent soil properties that influence our ability to build healthy soils through management.

Soil is the habitat for a wide variety of organisms, ranging from microscopic viruses, bacteria, archaea, fungi, and protozoa to micro- and meso-fauna including nematodes, mites, and springtails to macrofauna such as earthworms, centipedes and beetles to name just a few. A healthy soil is a living system that supports an abundant and diverse biological community that aids crop production by providing key services and functions. These include: 1) the decomposition of organic materials and conversion into soil organic matter; 2) enhanced nutrient cycling; 3) improved soil structure and stability that positively influences water flow, storage and availability; 4) plant protection against disease, pests, and environmental stress; and, 5) detoxification of pollutants. Soil microbes are generally most abundant in the surface layer around plant roots (termed the rhizosphere). Soils vary in their inherent ability to foster plant growth and thus also in their ability to support microbial populations. Although bacteria and archaea possess alternative metabolic strategies to survive under low or no oxygen content (i.e., anaerobic conditions), all other soil organisms require oxygen and the majority of soil bacteria in agricultural soils function more efficiently in aerobic conditions. therefore, only aerobic organisms are considered.

Several site and soil properties contribute to major attributes in the suitability for aerobic organisms. Those chosen for this table include:

• Soil temperature, since most biological processes increase, often double, with a 10C increase in temperature;

• water, inferred through the average total yearly precipitation since plant productivity is linked to precipitation and soil microbes thrive in the rhizosphere;

• soil organic matter content as organic carbon is required by many soil organisms as an energy and carbon source;

• soil pore space influences water and gas movement as well as physical space for organisms to occupy and the tortuosity of paths through which they may move;

• soil water content is important as when too much water is present anaerobic processes begin and shifts the population to anaerobic bacteria and when too little is present organisms may die or go dormant; and,

• osmotic conditions are also important, as are the presence of toxic materials or the absence of required elements. . The degree of favorability of each of these properties is rated for a soil and the degree of limitation of the least favorable attribute determines the overall rating.

The ratings are both verbal and numerical. Numerical ratings indicate the suitability of the individual soil properties. The ratings are shown in decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest favorability for organisms (1.00) and the point at which the soil feature becomes not favorable (0.00).

Rating class terms indicate the extent to which the soils are favorable considering all the soil features that are examined for this land use. "Very favorable" indicates that the soil has features that are very favorable for aerobic soil organisms. Healthy and thriving populations can be expected on properly managed agricultural systems on these soils. "Somewhat favorable" indicates that the soil has features that are moderately favorable for aerobic soil organisms. The soil can be made more favorable by careful management. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for aerobic soil organisms.

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

This interpretation is being provided for review and comment by the user community. Please forward any feedback to the Soils Hotline soilshotline@lin.usda.gov.

References

Blanco-Canqui, H., M.M. Mikha, D.R. Presley, and M.M. Claassen. 2011. Addition of cover crops enhances no-till potential for improving soil physical properties. Soil Sci. Soc. Am. J. 75:1471–1482. doi:10.2136/ sssaj2010.0430.

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Custom Soil Resource Report
Map—Limitations for Aerobic Soil Organisms

Map Scale: 1:1,190 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 4N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Lines

Very limited

Somewhat limited

Not limited

Not rated or not available

Soil Rating Points

Very limited

Somewhat limited

Not limited

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Tables—Limitations for Aerobic Soil Organisms

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
WkA	Waialua silty clay, 0 to 3 percent slopes	Somewhat limited	Waialua (100%)	pH somewhat limiting (0.05)	2.0	100.0%
Totals for Area of Interest					**2.0**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Somewhat limited	2.0	100.0%
Totals for Area of Interest	**2.0**	**100.0%**

Rating Options—Limitations for Aerobic Soil Organisms

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Susceptibility to Compaction

Soils are rated based on their susceptibility to compaction from the operation of ground-based equipment for planting, harvesting, and site preparation activities when soils are moist. Soil compaction is the process in which soil particles are pressed together more closely that in the original state. Typically, the soil must be moist to be compacted because the mineral grains must slide together. Compaction reduces the abundance mostly of large pores in the soil by damaging the structure of the soil. This produces several effects that are unwanted in agricultural soils since large pores are most effective at transmitting water and air through the soil. Compaction also increases the soil strength which can limit root penetration and growth. The ability of soil to hold water is adversely affected by compaction since the large pores hold water. The degree of compaction of a soil is measured by its bulk density, which is the mass per unit volume, generally expressed in grams per cubic centimeter.

Compacted soils are less favorable for good plant growth because of high soil bulk density and hardness, reduced pore space, and poor aeration and drainage. Root penetration and growth is decreased in compacted soils because the hardness or strength of these soils prevents the expansion of roots. Supplies of air, water, and nutrients that roots need are also less favorable when compaction decreases soil porosity and drainage.

Interpretation ratings are based on soil properties in the upper 12 inches of the profile. Factors considered are soil texture, soil organic matter content, soil structure, rock fragment content, and the existing bulk density. Each of these is thought to contribute to resisting the susceptibility of a soil to compaction when present. Organic matter in the soil provides resistance to compaction and the resilience to ameliorate the effects with time. Soil structure adds strength as discrete aggregates and it is the aggregates that are deformed or destroyed by compactive forces, thus strong soil structure lowers the susceptibility to compaction. Similarly, rock fragments in the soil can bridge and provide a framework to resist compaction. Finally, if a soil is already fairly dense causing further compaction is more difficult.

Definitions of the ratings:

Low - The potential for compaction is insignificant. This soil is able to support standard equipment with minimal compaction. The soil is moisture insensitive, exhibiting only small changes in density with changing moisture content.

Medium - The potential for compaction is significant. The growth rate of seedlings may be reduced following compaction. After the initial compaction (i.e., the first equipment pass), this soil is able to support standard equipment with only minimal increases in soil density. The soil is intermediate between moisture insensitive and moisture sensitive.

High - The potential for compaction is significant. The growth rate of seedlings will be reduced following compaction. After initial compaction, this soil is still able to support standard equipment, but will continue to compact with each subsequent pass. The soil is moisture sensitive, exhibiting large changes in density with changing moisture content.

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References:

Adams, P.W. 1998. Soil Compaction on Woodland Properties. Oregon State University Extension Publication EC 1109.

Adams, P.W. 1981. Compaction of Forest Soils. Oregon State University Extension Publication PNW 217.

Map—Soil Susceptibility to Compaction

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N

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 4N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- High
- Medium
- Low
- Not rated or not available

Soil Rating Lines
- High
- Medium
- Low
- Not rated or not available

Soil Rating Points
- High
- Medium
- Low
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

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This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Island of Oahu, Hawaii
Survey Area Data: Version 16, Sep 15, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jan 29, 2017—Oct 11, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Soil Susceptibility to Compaction

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
WkA	Waialua silty clay, 0 to 3 percent slopes	Low	Waialua (100%)	Rock fragments, 0-12 inches (1.00)	2.0	100.0%
				Soil structure grade, 0-12 inches (1.00)		
				Subaerial (1.00)		
				Organic matter content, 0-30 cm (0.56)		
				Soil texture, 0-12 inches (0.50)		
Totals for Area of Interest					**2.0**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Low	2.0	100.0%
Totals for Area of Interest	**2.0**	**100.0%**

Rating Options—Soil Susceptibility to Compaction

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Health

Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. This folder contains the tabular reports that provide the information specific to the education and importance of managing soils so they are sustainable for future generations.

Soil Health - Organic Matter

Organic matter percent is the weight of decomposed plant, animal, and microbial residues exclusive of non-decomposed plant and animal residues. It is expressed as a percentage, by weight, of the soil material that is less than 2 mm in diameter.

Significance

Soil organic matter (SOM) influences the physical, chemical, and biological properties of soils far more than suggested by its relatively small proportion in most soils. The organic fraction influences plant growth through its influence on these soil properties. It encourages soil aggregation, especially macroaggregation, increases porosity, and lowers bulk density. Because the soil structure is improved, water infiltration rates increase. SOM has a high capacity to adsorb and exchange cations and is important to pesticide binding. It furnishes energy to microorganisms in the soil. As SOM is decomposed by soil microbes, it releases nitrogen, phosphorous, sulfur, and many micronutrients, which become available for plant growth. SOM is a heterogeneous, dynamic substance that varies in particle size, carbon content, decomposition rate, and turnover time. In general, the content of SOM is highest at the surface—where plant, animal, and microbial residue inputs are greatest—and decreases with depth.

Total organic carbon (TOC) is the carbon (C) stored in SOM. Total organic carbon is also referred to as soil organic carbon (SOC) in the scientific literature. Organic carbon enters the soil through the decomposition of plant and animal residues, root exudates, and living and dead microorganisms. Inorganic carbon is common in calcareous soils in the form of calcium and magnesium carbonates. In calcareous soils, the content of inorganic carbon can exceed TOC.

Factors Affecting Content of SOM and SOC

Inherent factors - Soil texture, parent material, drainage, climate, and time affect accumulation of SOM. Soils that are rich in clay have greater capacity to protect

SOM from decomposition by stabilizing substances that bind to clay surfaces. The formation of soil aggregates—enabled by the presence of clay, aluminum and iron oxides, fungal hyphae, bacterial exudates (carbohydrates), and fine roots—protects SOM from microbial decomposition. Extractable aluminum and allophanes, which are present in volcanic soils, can react with SOM to form compounds that are stable and resist microbial decomposition. Warm temperatures increase decomposition rates of SOM. High mean annual precipitation increases accumulation rates of SOM by stimulating the production of plant biomass.

Loss of SOM through erosion results in SOM variations along slope gradients. Areas of level topography tend to have much more SOM than areas with other slope classes. Both elevation and topographic gradients affect local climate, vegetation distribution, and soil properties. They also affect associated biogeochemical processes, including SOM dynamics. Analysis of factors affecting C in the conterminous United States indicates that the effects of land use, topography (elevation and slope), and mean annual precipitation on SOM are more obvious than the effects of mean annual temperature. However, when other variables are highly restricted, SOM content clearly declines with increasing temperature.

Dynamic factors - Dynamic gains and losses in SOM are due primarily to management decisions in combination with climate and microbial influences. Accumulation of SOM is controlled by the rate of C mineralization, the amount and stage of decomposition of plant residues, and the addition of organic amendments to soil.

Soil organic carbon comprises approximately 52 to 58% of the SOM and is the main source of energy for soil microorganisms. The C within plant residues, particulate organic matter, and soil microbial biomass is generally considered to be within the active pool of SOM (table 1). The emergent view of SOM focuses on microbial access to SOM and includes an emphasis on the need to manage C flows rather than discrete C pools. During decomposition of SOM, energy and nutrients are released and utilized by plant roots and soil biota. Recognizing that SOM is a continuum of decomposition products is a first step in designing management strategies for renewing SOM sources throughout the year.

Table 1—Soil Organic Matter Pools

Soil organic matter fraction	Particle size	Description
Soil microbial biomass	Variable	The living pool of soil organic matter, particularly bacteria and fungi
Plant residues	>= 2.0 mm	Recognizable plant shoots and roots
Particulate organic matter	0.06 to 2 mm	Partially decomposed plant material, hyphae, seeds, etc.
Biochemically stable organic matter		The ultimate stage of decomposition, dominated by stable compounds

Soil aggregates of various sizes and stabilities can act as sites at which SOM is physically protected from decomposition and C mineralization. Soil disturbance and aggregate destruction increase biodegradation of SOM. Aggregates are readily broken apart by tillage operations.

Crop residues incorporated into or left on the soil surface reduce erosion and the losses of SOM associated with sediment. In acidic soils, applications of lime increase plant productivity, microbial activity, organic matter decomposition, and CO_2 release.

The diversity of the soil microbial population affects SOM. For example, while soil bacteria and some fungi participate in SOM loss by mineralizing C compounds, other fungi, such as mycorrhizae, facilitate stabilization and physical protection by aggregating SOM with clay and minerals. SOM is better protected from degradation within aggregates than in free-form.

Relationship to Soil Function

SOM is one of the most important soil constituents. It affects plant growth by improving aggregate stability, soil structure, water availability, and nutrient cycling. SOM fractions in the active pool, described above, are the main source of energy and nutrients for soil microorganisms, which mediate nutrient cycling in the soil. Biochemically stable SOM participates in aggregate stability and in holding capacity for nutrients and water.

Microaggregates are formed by mineral interactions with iron and aluminum oxides and are generally considered an inherent soil characteristic. They are, however, impacted by current and past management. Fine roots, fungal hyphae, and organic carbon compounds, such as complex sugars (carbohydrates) and proteins (also referred to as glues), bind mineral particles and microaggregates together to form macroaggregates that are still porous enough to allow air, water, and plant roots to move through the soil.

An increase in SOM leads to greater biological diversity and activity in the soil, thus increasing biological control of plant diseases and pests.

Problems Associated with Low Organic Matter Levels

Low levels of SOM result in energy-source shortages and thereby lowered levels of microbial biomass, activity, and nutrient mineralization. In noncalcareous soils, aggregate stability, infiltration, drainage, and airflow are also reduced. Scarcity of SOM results in less diversity in soil biota and a risk of disruption to the food chain equilibrium. This disruption can cause disturbance in the soil environment (e.g., increased plant pests and diseases and accumulation of toxic substances).

Improving SOM Levels

An estimated 4.4×10^9 tons of C have been lost from soils of the United States due to traditional farming practices. Most of this carbon was SOC. Nearly half of the SOM has been lost from many agricultural soils. Other farming practices, such as no-till and cover cropping (especially when used together), can stop losses of SOM and even lead to increases. Continuous application of manure and compost can increase SOM. Burning, harvesting, or otherwise removing plant residues decreases SOM.

Measurement

SOM is measured in the laboratory by determining total carbon (TC) content using either dry or wet-dry combustion. Current analytical methods do not distinguish between decomposed and nondecomposed residues, so soil is first sieved to 2 mm to remove as much of the recognizable plant material as possible. If no carbonates are present, TC is considered to be the same as TOC (or SOC). For calcareous soils, soil inorganic carbon in the form carbonates must also be measured and then subtracted from the TC to determine TOC content. Results are given as the percent TOC in dry soil. To convert percent TOC to percent SOM, multiply the TOC percentage by 1.724. To convert percent SOM to percent TOC, divide the SOM percentage by 1.724. Note that this value continues to be debated by researchers with possible values ranging from 1.4 to 2.5 (Pribyl, 2010). A conversion factor of 2 has been suggested for this database but has not yet been adopted. Detailed procedures for measurement of SOM are outlined in “Soil Survey Investigations Report No. 42, Kellogg Soil Survey Laboratory Methods Manual, Version 5.0,” (Soil Survey Staff, 2014).

Many soil testing laboratories use a “loss on ignition” method to estimate soil organic matter. The estimate produced by this method must be correlated to analytical TOC measurements for each area to improve accuracy. The loss on ignition method can provide a good indication of the trend in SOM content within a field. It is important to note that temperature and timing used for the loss on ignition approach vary across labs and can influence results. Thus, comparisons should be made using only results from within a given lab.

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Currently, no standard method exists to measure TOC in the field. Attempts have been made to develop charts that match color to TOC content, but the correlation is better within soil landscapes and only for limited soils. Near-infrared spectroscopy has been tested for measuring C directly in the field, but it is expensive and sensitive to moisture content.

Estimates

Color and feel are soil characteristics that can be used to estimate SOM content. Color comparisons in areas of similar parent materials and textures can be correlated with laboratory data and thereby enable a soil scientist to make field estimates. In general, darker colors or black indicate the presence of higher amounts of organic matter. The contrast of color between the A horizon and subsurface horizons is also a good indicator. Sandy soils tend to look darker with a lower content of SOM. In general, lower numbers for hue, value, and chroma (in the Munsell soil color system) tend to be associated with darker soil colors that are attributed to higher content of SOM, soil moisture, or both.

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Report—Soil Health - Organic Matter

Soil Health - Organic Matter–Island of Oahu, Hawaii						
Map symbol and soil name	**Pct. of map unit**	**Horizon Name**	**Depth (inches)**	**Organic matter low (Pct)**	**Organic matter RV (Pct)**	**Organic matter high (Pct)**
WkA—Waialua silty clay, 0 to 3 percent slopes						
Waialua	100	H1	0-12	2.0	3.5	5.0
		H2	12-60	0.5	0.8	1.0