Swanton Pacific Ranch
COMPOST APPLICATION RATES TO RESTORE DEGRADED RANGELANDS

Project Design and Preliminary Data for CDFA Healthy Soils Project.

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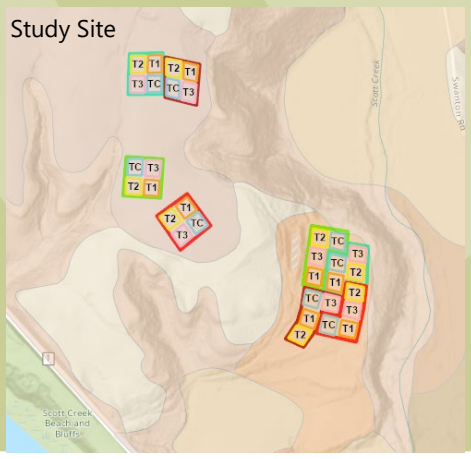
- **COMPOST APPLICATION BENEFITS**
- Increased forage production
- Increase microbial biomass
- Increased carbon storage
- Better infiltration and aggregate stability
- Improved water holding capacity
- Improve plant nutrition (soil nutrients)
- Better overall soil health

- **COMPOST APPLICATION DRAWBACKS**
- Excess nutrients/losses of nutrients to environment
- Cost
- Application difficulty

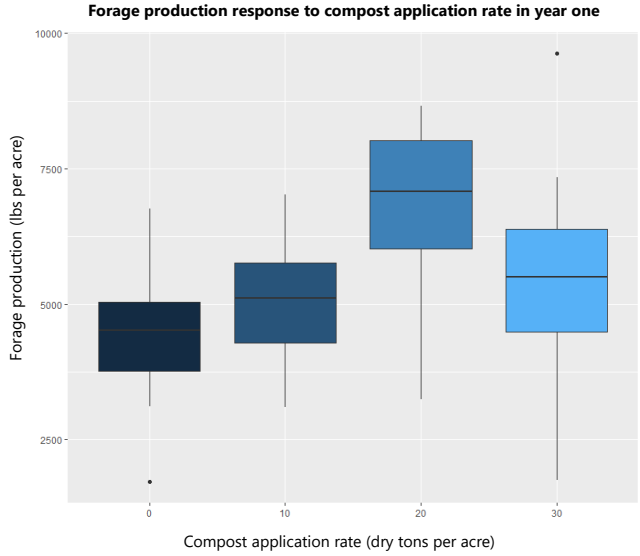


THEY TELL ME COMPOST IS GOOD, BUT HOW MUCH SHOULD I APPLY?

What rates for what outcome?

Existing California Healthy Soils program recommends a potentially low rate of compost application for degraded rangelands (5 tons per acre). Previous research suggests that in degraded soils a larger dose of compost may be required to overcome limitations. More research needed to identify optimum compost application rates. Different rates may be required for different goals. **This demonstration project investigates larger compost application rates.**

- The optimum rate for forage production might not be the optimum rate for carbon sequestration.
- Application rates are 10, 20 and 30 dry tons/acre on two different soil types.



HOW WILL SOIL TYPE INFLUENCE SOIL HEALTH OBJECTIVES AND RESPONSE TO SOIL HEALTH PRACTICES?

Soils are variable, soil health indicators are variable, will soil health interventions work across soil systems?

Here at Swanton Pacific Ranch, we are blessed with a unique natural experiment. A series of marine terraces create a natural laboratory where all the environmental factors are held constant, expect the age of the soil. As soils develop, many changes happen to the soil profile that can affect management. Soil nutrients, soil texture and rangeland productivity can all very. The current compost application study is being applied to two unique soils, different only in age and degree of soil development*. This unique natural experiment allows us to ask these questions:

- How does soil development and soil type influence soil health?
- Will the response from compost application in yield, soil carbon sequestration and soil health be similar for two soil types?

*White et al. 2008

Soil Health Field Assessment Worksheet Appendix[1, 2, 3]

[1]Adapted from NRCS soil Health Assessment, https://efotg.sc.egov.usda.gov/references/public/CA/Soil_Health_Field_Assessment_Worksheet_03-2015.pdf,
[2]Adapted from NRCS Soil Health For educators https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=nrcs142p2_053870
[3]Adapted from Rangeland Soil Quality Information Sheets, https://web.extension.illinois.edu/soil/sq_info/range.htm

Soil Physical Properties

What are they?

- **Compaction:** How easy the soil is to work. Compaction is when soil is pressed too close together from machines or hooves of large animals, and the pore space is reduced.
- **Soil Structure:** Soil structure is the naturally occurring arrangement of soil particles into aggregates.
- **Aggregate Stability:** Aggregate stability refers to the ability of aggregates to resist degradation. Additions of organic matter to the soil enhance the stability of aggregates.
- **Roots and Pores:** Active or decomposing plant roots, and pores are the air- or water-filled voids in soil.
- **Soil Texture:** This is the measure of sand, silt and clay or sizes.

What do they do?

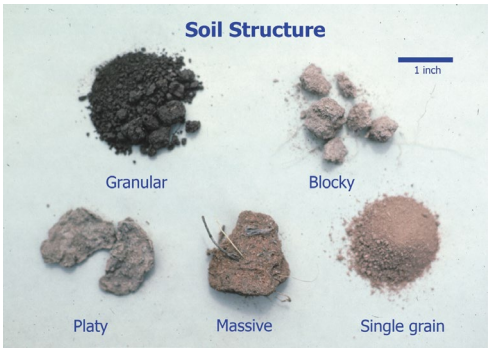
- **Compaction:** High compaction can lead to reduced root growth, low infiltration and accelerated erosion.
- **Soil Structure:** The structure of the surface layer commonly is granular or blocky, but a degraded surface layer can be crusted, platy, or structureless. Pores important for the movement of air, water, and plant nutrients occur within and between aggregates. Pores also provide thoroughfares for soil organisms.
- **Aggregate Stability:** Stable aggregates are critical to erosion resistance, water availability, and root growth. Weak aggregates break down and clog soil pores.
- **Roots and Pores:** Abundant roots can indicate a healthy soil. Roots and rooting patters can also indicate potential soil limitations. Pores allow water to infiltrate and gases to escape. Abundant pores indicate a less compacted soil, and good water and air exchange in the soil system.
- **Soil Texture:** Soil texture has an important role in infiltration, water holding capacity, and nutrient retention/supply.

Compaction

Soil compaction in agricultural systems can result from repeated wheel or hoof traffic. In areas of rangeland, compacted soil layers are generally at the soil surface or less than 6 inches below the surface, although they can be as deep as 2 feet under heavily used tracks and roads. Increases in density can be small to large. Management-induced compaction occurs at depths of 2 – 8 inches. Try to insert a wire flag into the soil and see how easily it bends. Compare the resistance to a known non-compacted area such as in a fence row. Alternatively, excavate a small hole, and press the flag stake into the sides of the hole. Asses what depths feel compacted. **Assess moist to wet soil.**

Soil Structure

Observe structure in the surface 6 inches. **Strong** structure has units that are distinct in undisturbed soil and separate cleanly. **Moderate** structure has units that are well-formed and evident in place or in a hand sample. **Weak** or **structure-less** soil has barely observable or no discreet units. The photo on the left are examples of soil structure, the photo on the right is an example of a sandy clay loam soil with strong structure. Soil texture will affect structure. Structure in coarser-textured soils will typically not be as well- developed as finer-textured soils. **Assess dry to moist soil.**



Aggregate Stability

Take a soil clod, about the size of a golf ball, and submerge it in water. Obtain the sample from the surface just below any residue that may be present. Note whether the clod remains intact or falls apart. The picture on the right demonstrates the test using glass cylinders with suspended samples, but in the field any clear container of adequate depth can be used.

Soil Secrets

Roots and Pores

Healthy soil should have an abundance of living and dead roots and pores. Usually, the most obvious pores are those that are decayed root channels. Below is a guide for evaluating the quantity of roots and pores. Make the observations on a horizontal plane of the soil, 3 – 6 inches below the surface. The assessment area is dependent on the size of the roots and pores (Table 1). Determine the number of roots and pores per assessment area. Then correlate the number to the quantity class for scoring (Table 2).

Table 1.

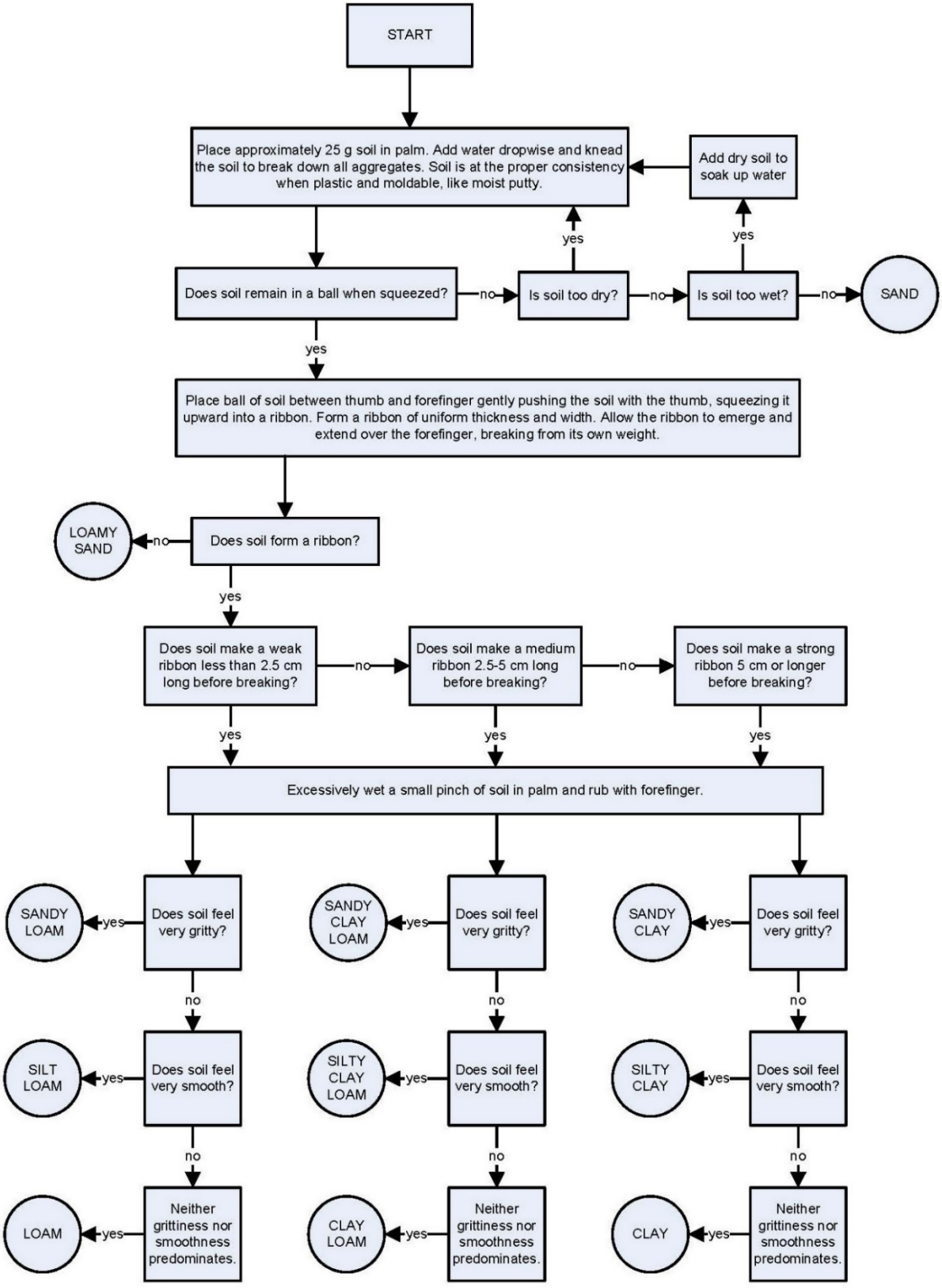
Size Class	Code		Diameter	Soil Area Assessed [1]
	Conv.	NASIS		
Very Fine	vf	VF	< 1 mm	1 cm^2
Fine	f	F	1 to < 2 mm	1 cm^2
Medium	m	M	2 to < 5 mm	1 dm^2
Coarse	co	C	5 to <10 mm	1 dm^2
Very Coarse	vc	VC	≥10 mm	1 m^2

Table 2.

Quantity Class [1]	Code		Average Count [2] (per assessed area)
	Conv.	NASIS	
Few	1	#	<1 per area
Very Few [1]	—	#	<0.2 per area
Moderately Few [1]	—	#	0.2 to <1 per area
Common	2	#	1 to <5 per area
Many	3	#	≥5 per area

Soil Texture

Soil texture is an estimate of the relative amounts of sand, silt and clay particles in a soil. The physical and chemical behavior of a soil is influenced strongly by soil texture. Soil texture affects the movement and availability of air, nutrients and water in a soil and is often used to estimate other soil properties, particularly soil water properties.



Soil Biological Properties

What are they?

- **Soil Earthworm Count:** A bioindicator of soil health.
- **Biological activity:** A bioindicator of soil health. The presence of fungal hyphae, macro-invertebrates, etc.
- **Soil Smell:** Earthy and fresh smell.

What do they do?

- **Earthworms:** Improve soil physical and biological properties. Increase mineralization of nutrients.
- **Biological activity:** Break down soil OM (shredders) and prey on pest insects. Fungal feeders may attack pathogenic fungi.
- **Soil Smell:** Healthy soil will have an earthy, sweet, pleasant intense smell.

Earthworms

If soil is too dry, worms may not present. In addition to worms, look for sign of worms such as holes (left photo) or their casts (right photo) in the forms of little piles of soil, mineral particles, or organic matter on or in the soil. The volume of an average shovel full of moist soil will be about ⅙-cubic foot, so multiply the number counted by 6 to score the indicator. Break the shovel of soil apart and carefully look for earthworms or signs of earthworms. **Assess moist to wet soil for worms. Casts can be seen in dry soil.**

USDA-NRCS

USDA-NRCS

Biological Activity – Fungi, etc.

Fungal hyphae will appear as white to light tan threads (photo on left) or masses (photo on right). Other things to look for are meso- and macro-invertebrates such as mites, springtails, millipedes, roundworms beetles and termites.

Smell

Healthy soil will have an earthy, sweet, pleasant intense smell while unhealthy soil will have a sour, metallic, rotten egg-like, sulfide, or otherwise unpleasant smell. The sweet, earthy smell of a healthy soil is from geosmin which is produced by actinobacteria in the soil. Regularly cultivated cropland without a cover maintained may smell rich and earthy, but not as intense as soil with high biological activity. If you are unsure what healthy soil should smell like, find an undisturbed/natural area where you can dig a little and take a sniff. **Avoid smelling dry soil because of the increased risk of inhaling dust or other soil constituents or contaminants.**

Soil Chemical Properties

[1]adapted from *NRCS soil health for educators (Kurvera 2012)*

What are they?

- **Soil pH:** A measure of soil acidity or alkalinity.
- **Soil Nitrogen: N** is an important plant nutrient.
- **Soil Phosphorus: P** is an important plant nutrient.

What do they do?

- **Soil pH:** High or low pH can reduce nutrient uptake, limit the activity of beneficial microorganisms and reduce soil health. pH 6.5-7.0 is the best.
- **Soil Nitrogen:** Too little N can reduce yields, too much N and it will be lost to the water ways, or as a potent greenhouse gas. N can be released (mineralized) from organic matter such as composts and manure.
- **Soil Phosphorus:** Soil P limits plant growth. Too much P can hurt the environment. Manure and compost are good sources of P. P can be released (mineralized) from organic matter such as composts and manure.

Measuring Soil Nitrate, Phosphate and pH in the Field

Step 1: Soil nitrate N and P levels are highly variable, depending on management history, field location, and time of year. Factors include the rate of erosion, soil texture, organic matter content, and applications of manure or fertilizer. Examples of variables for P include soil texture, organic matter content, and application of compost, manure or other fertilizer. Using a soil probe or shovel, gather at least 10 small samples randomly from an area that represents a particular soil type and management history. The probe should extend to a depth of 8 inches or less for a surface layer sample and to a depth of as much as 3 feet for a subsurface layer sample. Place samples in a plastic container and mix. Surface layer and subsurface layer samples should be placed in

separate containers. Do not include large stones and plant residue. Repeat step 1 for each sampling area.

Step 2: Fill scoop with mixed soil, tamping down during filling by carefully striking scoop on a hard, level surface. Put soil in vial. Add two scoopfuls of water to the vial, resulting in a 1:2 ratio of soil to water, on a volume basis.

Step 3: Tightly cap the vial and shake 25 times. Let settle for 1 minute. Remove cap, and carefully decant 1/16 inch of the soil and water slurry into the cap.

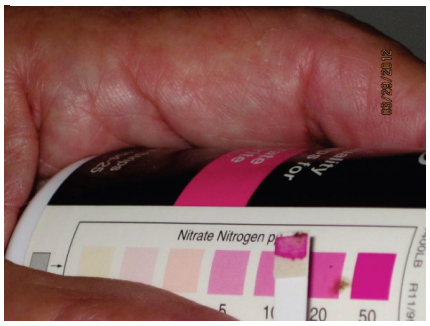
Step 4: Allow to settle for 2 to 3 minutes. Touch end of nitrate test strip to soil and water slurry. Touch end of phosphate test strip to soil and water slurry. Touch pad of pH test strip to soil and water slurry. Leave until liquid is drawn up to least 1/8 to 3/16 inch beyond the area covered by the soil (see figure).

Step 5: After 1 to 2 minutes, compare color of wet test strip to color chart on the test strip container (see figure). The color on the chart that most closely matches the color on the test strip indicates the amount of nitrate and phosphate in the saturated soil. For the pH strip, different pH pads are reactive in different rages of pH. Compare the pH strip that most closely resembles a range of pH on the box.

Nitrate Test

Phosphate Test

pH test



Additional Information

- Rangeland soil quality indicators–
  - General
    - https://web.extension.illinois.edu/soil/sq_info/RSQIS2.pdf
  - Compaction—
    - https://web.extension.illinois.edu/soil/sq_info/RSQIS4.pdf
  - Organic Matter
    - https://web.extension.illinois.edu/soil/sq_info/RSQIS6.pdf
  - Soil Biology
    - https://web.extension.illinois.edu/soil/sq_info/RSQIS8.pdf
  - Water erosion
    - https://web.extension.illinois.edu/soil/sq_info/RSQIS9.pdf
  - Aggregate Stability
    - https://web.extension.illinois.edu/soil/sq_info/RSQIS3.pdf

- General soil quality indicators–
  - Soil Structure – http://www.soilassociation.org/LinkClick.aspx?fileticket=n5L15U4y8jg%3D&tabid=1703
  - Surface Crusts – http://soilquality.org/indicators/soil_crusts.html http://www.fao.org/docrep/t1696e/t1696e06.htm
  - Residue Cover – http://ianrpubs.unl.edu/live/g1931/build/g1931.pdf
  - Roots and Pores –Field book for describing and sampling soils, V 3.0. 2012. Pg. 70 – 75. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052523.pdf
  - Earthworms – http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053863 http://www.ctahr.hawaii.edu/sustainag/news/articles/v5-valenzuela-worm.pdf http://www.sarep.ucdavis.edu/worms/ewupdate
  - Biological Activity – Fungi, etc. http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1015&context=agronomyfacpub
  - Aggregate Stability – https://www.youtube.com/watch?v=cx_hmse9Se8
  - Soil Texture by Feel http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311
  - Soil Quality Test Kit http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/assessment/

	Indicator	Rating	
		Control	Treated
Physical	**Compaction** (3 = No evidence of compaction; 2 = Some penetration resistance; 1 = Clear evidence of a compacted layer)		
	Structure (3 = Strong; 2 = Moderate; 1 = Weak or structure-less)		
	Aggregate stability (3 = Clods remain intact; 2 = Clods exhibit moderate stability; 1 = Clods disintegrate)		
	Roots and Pores (3 = Many roots or pores; 2 = Common roots or pores; 1 = Few to no roots or pores)		
	Soil Texture: Record the soil textural class (loam, clay loam, sandy clay loam etc.) (no score)		
Biological	**Earthworms** (Number of worms or worm sign/cubic foot of soil: 3 = abundant (at least 10); 2 = few (1 to 9); 1 = None)		
	Biological activity (The presence of fungal hyphae, macro- invertebrates, etc.: 3 = Clearly evident; 2 = Few evident upon close examination; 1 = No biological activity visible)		
	Smell (3 = Earthy, sweet, and rich; 2 = Earthy, fresh, not unpleasant; 1 = Sour, putrid, or chemical-like)		
	Total qualitative indicators (add the numbers in the grey boxes). Maximum score is 21. Greater score represents better soil health		
Chemical*	**pH (record value on test strip)**		
	N (record value on test strip)		
	P (record value on test strip)		

* use for relative comparisons between treatments only