FOTG Section II: Soils Information

Soil Health Management Systems (SHMS) on Cropland **Rev. April 14, 2017**

To: All Offices

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Conservation Planning:
Implementation of Soil Health Management Systems (SHMS) on Cropland

NRCS planners may refer to the following guide on how to respond to physical, biological or chemical soil limitations. A list of short descriptions for the main soil health NRCS practices is given as a quick reference at the end of the guide. **This is not a substitute for the guidance found in the full NRCS practice standard on all elements in a Conservation Plan.**

Steps to Determine and Address Resource Concerns
Using a Soil Health Management System Approach

1. **Determine if any of the following conditions exist or have been observed and/or documented in management records**
   - SOIL EROSION - Sheet and Rill, Wind, Irrigation Induced, Concentrated flow
   - SOIL QUALITY DEGRADATION – Compaction, concentration of salts or other chemicals, organic matter depletion
   - INSUFFICIENT/EXCESS WATER – Ponding, crusting, wilting of plant species, poorly drained soils
   - WATER QUALITY DEGRADATION - Excess nutrients in surface and groundwater, excess pathogens and chemicals from manure, bio-solids or compost applications, excessive sediment in surface waters
   - DEGRADED PLANT CONDITION - Undesirable plant productivity and health, excessive plant pest pressure
   - EFFINICIENT ENERGY USE – Farming/ranching practices and field operations

2. **Determine management options**
   - Understand site history/farm background
   - Understand site limitations and advantages
   - What are the technical abilities and experience of the producer?

3. **Identify representative management areas and make field observations in at least three site specific locations to document soil characteristics and properties**
   - Record soil function as it relates to physical, chemical, and biological assessments
   - Consider how the 5 soil health principles can be applied when making management decisions
   - Identify management that is affecting soil function of the physical, chemical, and biological properties
   - Determine social, economic and ecological constraints and opportunities

4. **Conservation planning & application**
   - Develop a conservation plan that addresses the resource concerns identified or documented by field assessment
   - Address properly identified resource concerns by implementing a combination of conservation practices that address the 5 soil health principles

5. **Implement and evaluate**
   - Make changes based on observations
   - Adopt management changes that produce results related back to production goals

Assessing Soil Health

Soil health assessment is a determination of how well a soil is functioning with a consideration of its inherent soil properties and responses to management of its dynamic soil properties. A heathy soil will have enhanced function that is preserved and improved upon overtime. Soil health is measured best by evaluating how the whole system is performing over time in relation to the management goals. When a soil is functioning at its highest levels plant resilience, water quality and nutrient cycling will improve. Ecological diversity will increase in each trophic level helping to increase the soils ability to provide optimal habitat for both the soil food web and plants to thrive in. Soil health can be observed in the field using the soil health card to look at the soils physical, chemical, and biological properties (Figure 9). Soil health is evaluated over time or by comparing two different management systems that have similar inherent soil properties. By asking and answering key questions that are related to the five soil health principles, we can began to implement a management strategy to address observed resource concerns.

Figure 1: Radishes interseeded in between corn rows can provide forage for fall grazing of livestock and maintain a living root in the SHMS.

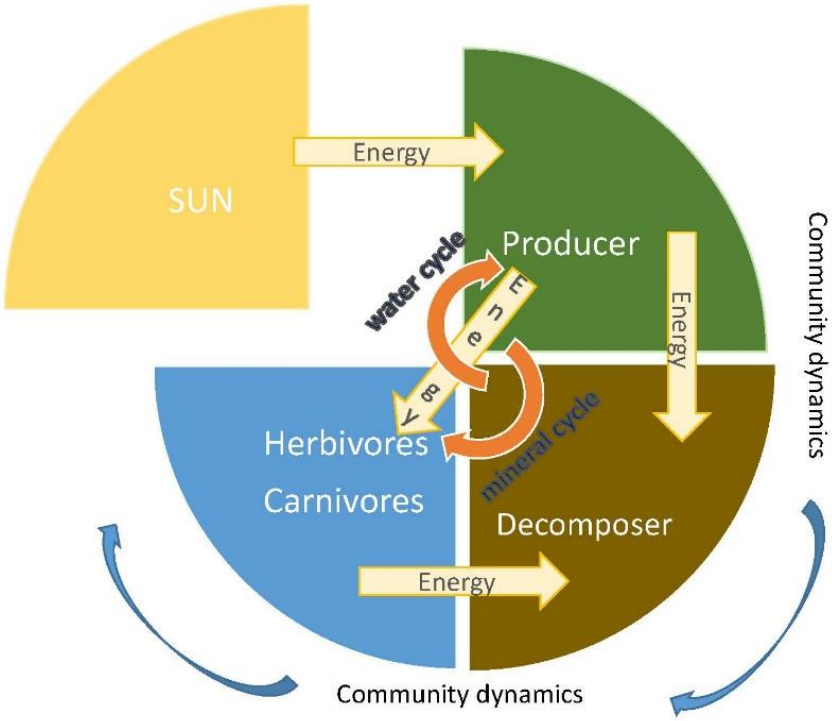

Figure 1: The diagram depicts how energy from the sun moves through the trophic levels of an ecosystem affecting the water and mineral cycles. These cycles can be enhanced when we understanding the effects of management on the community dynamics within the ecosystem.

The following information can be collected by the conservation planner when using the Colorado NRCS Soil Health Cropland Resource Concern Assessment Card:

1) **What percentage of the soil is covered with residue or plants?**

Figure 2: Residue provides food and habitat for the soil food web.

Assessment factors:

- What percent of surface is covered with residue?
- Are there cracks on the soil surface?
- What is the residue depth and is there diversity of the kinds of residue?
- Soil crust thickness if present (biological or physical)?
- What is the percent of plant canopy cover?
    - Broadleaves – Warm or Cool
    - Grasses – Warm or Cool
    - Inter seeded companion Crops
    - Legumes
- Soil temperature
    - What is the temperature under canopy, under residue, top 2" of soil?

2) **Are there living roots?**

Assessment factors:

- Document root size – Very fine, fine, medium, coarse or very coarse.
- Document root colors (desiccated or alive).
- Document root quantity – Few, common, many.
- Is there evidence of nodules on the legume roots?
- Are rhizosheaths present?

Figure 3: Rhizosheaths provide evidence of the synergistic relationship between plants and soils.

3) **Has the soil been disturbed?**

Assessment factors:

- Soil structure - Granular, platy, blocky, massive (structure less), single grain (structure less)
    - Size & Grade
- Is there a plow pan? What depth? What is the thickness of the Ap1 and/or Ap2 horizon?
- What is the soil consistency of the top soil (0-2 ")?
    - Dry and Moist rupture resistance
- Does the soil slake when immersed in water (air dried)?
    - After: 60 seconds, 2 minutes, 5 minutes, 10 minutes, 1 hour
- Does the soil infiltrate water after quickly after snow melt or rain event?
- Is chemical disturbance being minimized?

4) **Is there diversity in the system?**

Figure 4: Multi species cover crop planting.

<u>Assessment factors</u>:

- List all the plants grown in the rotation.
- How many years between rotations?
  - 3 – 5 year outlook
- Are cover crops being used as part of the rotation to biologically prime the soil?
- Are plants emerging quickly?
  - Vigor?
  - Chlorosis?
  - Even stands?
  - Yields?
- Is there evidence of micro and macro biological diversity of insects, spiders or other soil food web life?

5) **Are animals or their byproducts incorporated into the system?**

Figure 5: Livestock can help with improve economics and biological inputs in a soil health management system.

<u>Assessment factors</u>:

- Is grazing being planned?
- Grazing green plants or residue?
  - 2/3 of plant remain after grazing
  - Rest and recovery time allowed
- Does the grazing residue cover armor soil after a grazing event?
- What is the water source for the animals?
- Is there manure in the system or other biological additives?
  - Saliva, urine, mucus
- Are the animals fed out on the land?
- Is there an available source of compost or biosolids?

<u>Key questions for producer:</u>

a) What equipment is available (owned, available for rent or custom hire) to seed cover crops in my area?
b) What windows of opportunity exist as defined by weather and climate, current cropping practices, cover crop genetics—and can current windows be expanded by acceptable adjustments like shorter season crops or alternative cover crops?
c) How will the cover crop be terminated and how will an acceptable stand of the next crop be achieved?
d) Will the time and labor be available to make this work?
e) What's the contingency plan—and risks—if the cover crop doesn't establish or doesn't die on schedule?

Management Options

To make good management decisions, a conservationist needs to gain understanding of the farm history and develop realistic management goals. Every farm and operator has constraints and opportunities. One helpful way to think about how to implement a soil health management system is to discuss the "5-T's" with producers. Each of the following needs to be considered to help ensure that the soil health strategy can be successful:

Figure 6: Sunflower and Sudan sorghum provide high carbon inputs.

Tradition

- Farm history
- Management history
- Community influence
- Cultural norms
- Market niche
- Economic paradigm shift

Technology

- Equipment available
- Precision agriculture
- Implementation
- Soil health testing

Tools

- No-till drill, direct seeding
- Termination equipment (crimpers)
- Cover crop seeds
- Compost or compost extract (tea)
- Rotations, seed calculators
- Economic spreadsheets

Figure 8: Residue can help reduce temperature fluctuations.

Technique

- Drill depth
- Herbicides and their residual effects
- Seed blends and combinations
- Depth of planting

Timing

- Growing degree days being used
- Planting, harvest
- Precipitation, irrigation
- Termination of cover crops (grazing, winter kill, solarization)

Assessme	Suggested Management Practices		Colorado NRCS Practice
	Short Term	Long Term	(code)
Chemical Concerns			
Low pH	• Add lime or wood ash per soil test recs • Add calcium sulfate (gypsum) in addition to lime if aluminum is high • Use less ammonium or urea	• Test soil annually & add "maintenance" lime per soil test recs to keep pH in range • Raise organic matter to improve buffering capacity (BC)	(340) (512) (590)
High pH	• Stop adding lime or wood ash • Add elemental sulfur per soil test recs	• Test soil annually • Raise organic matter to improve EC buffering capacity	(590)
Low Phosphorus	• Add P amendments per soil test recs • Use cover crops to recycle fixed P • Adjust pH to 6.2-6.5 to free up fixed P	• Promote mycorrhizal populations • Maintain a pH of 6.2-6.5 • Use cover crops to recycle fixed P	(340) (590)
High Phosphorus	• Stop adding manure and compost • Choose low or no-P fertilizer blend • Apply only 20 lbs/ac starter P if needed • Apply P at or below crop removal rates	• Use cover crops that accumulate P and export to low P fields or offsite • Consider low P rations for livestock • Consider phytase for non-ruminants	(340) (393) (484) (590) (633)
Low Potassium	• Add wood ash, fertilizer, manure, or compost per soil test recs • Use cover crops to recycle K • Choose a high K fertilizer blend	• Use cover crops to recycle K • Add "maintenance" K per soil recs each year to keep K consistently available	(340) (590)
High Potassium	• Stop adding high K fertilizer or manure • Grow high K removing crops	• Use cover crops to accumulate K and export to low K fields or offsite	(340) (590)
Low Micronutrients	• Add chelated micros per soil test recs • Use cover crops to recycle micronutrients • Do not exceed pH 6.5 for most crops	• Promote mycorrhizal populations • Improve organic matter • Decrease soil P (binds micros)	(340) (590) (633)
High Micronutrients	• Raise pH to 6.2-6.5 (for all high micros except Molybdenum) • Do not use fertilizers with micronutrients	• Maintain a pH of 6.2-6.5 • Monitor irrigation/improve drainage • Improve soil calcium levels	(449) (512) (590) (606)
High Salinity	• Leach soils • Use fertilizers with a low salt index (avoid chlorine and ammonium/urea fertilizers) • Do not use Chilean nitrate	• Test compost for soluble salts • Use EC meter to monitor salts in the soil and irrigation water • Improve drainage	(449) (512) (590) (606)

Assessments	Suggested Management Practices		Colorado NRCS Practice
	Short Term	Long Term	(code)
Physical Concerns			
Aggregate stability	• Incorporate fresh organic materials • Use shallow-rooted cover/rotation crops • Add compost, green manure, mulch	• Reduce tillage • Use a surface mulch • Incorporate perennial crops	(328) (329) (340) (484) (512) (528)
Available Water Capacity	• Add stable organic materials, mulch • Add compost or biochar • Incorporate high biomass cover crop	• Reduce tillage • Rotate with sod crops • Incorporate high biomass cover crop	(328) (329) (317) (340) (484) (512) (528)
High Surface Hardness	• Perform some mechanical soil loosening (strip till, aerators, broadfork, spader) • Use shallow-rooted cover crops • Use a living mulch or interseed cover crop	• Shallow-rooted cover/rotation crops • Avoid traffic on wet soils, monitor • Avoid excessive traffic/tillage/loads • Use controlled traffic patterns/lanes	(328) (345) (340)(484)(528) (512) (548)
High Subsurface Hardness	• Use targeted deep tillage (subsoiler, yeomans plow, chisel plow, spader.) • Plant deep rooted cover crops/radish	• Avoid plows/disks that create pans • Avoid heavy loads • Reduce traffic when subsoil is wet	(324) (329) (345) (340) (548) (606)
Biological Concerns			
Low Organic Matter	• Add stable organic materials, mulch • Add compost and biochar • Incorporate high biomass cover crop	• Reduce tillage/mechanical cultivation • Rotate with sod crop • Incorporate high biomass cover crop	(328) (329) (340) (317) (484) (528) (512)
Low Active Carbon	• Add fresh organic materials • Use shallow-rooted cover/rotation crops • Add manure, green manure, mulch	• Reduce tillage/mechanical cultivation • Rotate with sod crop • Cover crop whenever possible	(328) (329) (340) (345) (484) (528) (511) (512)
Low Mineralizable Nitrogen	• Add N-rich organic matter (low C:N source like manure, high N well-finished compost) • Incorporate legume or young, green cover crop (inoculate legume seed) • Adjust pH to 6.2-6.5 (helps molybdenum)	• Reduce tillage • Rotate with forage legume sod crop • Cover crop and add fresh manure • Keep pH at 6.2-6.5 (helps molybdenum) • Monitor C:N ratio of inputs	(328) (329) (317) (340) (512) (528) (590)
High Root Rot Rating	• Use disease-suppressive cover crops • Biofumigate • Plant on ridges/raised beds • Monitor irrigation	• Use disease-suppressive cover crops • Increase diversity of crop rotation • Sterilize seed and equipment • Improve drainage/monitor irrigation	(328) (346) (340) (449) (595) (606)

Colorado NRCS Soil Health Cropland Resource Concern Assessment v. 1.7

Date:	Data Collector(s):		Tract/Field:	Time	County:	Soil Survey Area:	MU Sym:	GPS
Landowner:		Producer Concerns:				Surface Texture (field est.):		
Crop Rotation:						Soil Moisture (est.):		

Indicator	*Least preferred* 1	Indicator Values 2	Most *preferred* 3	Value for Each Location 1	2	3	Average	Observations	SOIL PROFILE	Soil Function
Soil Erosion	Evidence of rills and sheet erosion, pedestals, basal roots, or ephemeral gullies observed, sediment build up apparent around fence post	Some rills and evidence of sheet erosion, few pedestals or basal roots observed, evidence of sediment build up around fence row	Absence of rill or sheet erosion, no pedestals or basal roots observed and sediment build up absent from fence row							W, N, D, S
Soil Structure	coarse blocky structure, platy structure or Structureless and hard rupture resistance	medium blocky structure, moderately hard rupture resistance	granular or fine blocky structure, friable rupture resistance							W, N,D, S
Aggregate Stability	<25% of clod remains intact at 5 minutes	25-75% of clod remains intact at 5 minutes	>75% of clod remains intact after 5 minutes							W, N, D, S
Soil Crusts	Surface crust throughout the field, > 5 mm thick	Surface crusts in places, < than 5 mm thick	No evidence of surface crusts							W, S
Compaction	Clear evidence of compacted layer within 12" (>300 psi)	Some penetration resistance within 12" depth (>200 psi)	No evidence of compaction							W, N, D, S
Residue and Canopy Cover	0-25% of surface covered residue; note crop stage	25-75% of surface covered residue; note crop stage	> 75% of surface covered residue; note crop stage							W, D
Roots and Pores	<10% of roots covered in rhizosheaths no pore or root diversity	>10% but <50% of roots covered rhizosheaths, little root and pore diversity	>50% of roots covered in rhizosheaths, diversity of roots and pore sizes							W, D, N
Soil Color and Smell	light pale or yellowish brown, no color change with depth; smells like mineral	light brown; slight color change from top to bottom; little to slight earthy smell	black or dark brown; distinct color change from top to bottom; strong earthy smell							W, D, N
Soil Food Web	no earthworms, very few macroinvertebrates observed	Presence of 1-5 earthworms, some macroinvertebrates observed	> 5 earthworms, fungal hyphae observed, macroinvertebrates clearly evident							W, D, N
Soil Temperature	soil surface temperature and soil temperature at 2" differs > 20 °F	soil surface temperature and soil temperature at 2" differs < 20° F but > 10° F	soil surface temperature and soil temperature at 2" differs < 10 °F							D, S

W= Regulates and partitions water and solute flow; **N**= Stores and cycles nutrients and carbon; **D**= Sustains biological diversity, activity, and productivity; **S**= Physical stability and support for plants and structures associated with human habitation

Essential Soil Health Practices: (340) Cover Crop, **(328)** Conservation Crop Rotation, **(329)** Residue and Tillage management, No-Till, **(590)** Nutrient Management, (528) Prescribed Grazing

Facilitating Soil Health Practices: (345) Residue and Tillage Management, Reduced-Till,**(315)** Herbaceous Weed Control **(484)** Mulching, **(595)** Integrated Pest Management, **(633)** Waste Recycling

Figure 7: CO NRCS Soil Health Cropland Card can be used by planners to ID resource concerns in the field.

Colorado Soil Health Practice Glossary

Refer to the Colorado Implementation Requirements Worksheet/Job Sheet for site-specific application requirements to achieve the intended purpose(s). Practices will be planned and applied according to NRCS design, Standards and Specifications, and purpose-specific planning criteria. Practices will be operated and maintained according to operation and maintenance agreement.

317-Composting	**393-Filter Strip**	**595-IPM**
324-Deep Tillage	**449-Irrigation Water Mgmt.**	**603-Hebaceous Wind Barr.**
328-Crop Rotation	**484-Mulching**	**606-Subsurface Drain**
329-No till	**512-Forage and Biomass**	**633-Waste Recycling**
340-Cover Crop	**528-Prescribed Grazing**	
345-Reduced Tillage	**590-Nutrient Mgmt.**	

317 – Composting Facility

A structure or device to contain and facilitate the controlled aerobic decomposition of manure or other organic material by micro-organisms into a biologically stable organic material that is suitable for use as a soil amendment. Reduce the pollution potential and improve the handling characteristics of organic waste solids; and produce a soil amendment that adds organic matter and beneficial organisms, provides slow-release plant-available nutrients, and improves soil condition.

324 – Deep Tillage

Tillage operations performed below the normal tillage depth to bury or mix soil deposits from wind or water erosion or flood, decrease the concentration of soil contaminates that inhibit plant growth, and or fracture restrictive soil layers.

328 – Conservation Crop Rotation

Growing crops in a planned sequence on the same field to decrease erosion, maintain or increase soil health and organic matter content, reduce water quality degradation due to excess nutrients, improve soil moisture efficiency, reduce the concentration of salts and other chemicals from saline seeps, reduce plant pest pressures, provide feed and forage for domestic livestock, and or provide food and cover for wildlife including pollinator forage and nesting. This practice applies to all cropland where at least one annually-planted crop is included in the crop rotation..

329 – Residue and Tillage Management – No Till

Limiting soil disturbance to manage the amount, orientation and distribution of crop and other plant residues on the soil surface year round to decrease soil erosion, reduce tillage-induced particulate emissions, maintain or increase soil quality and organic matter content, decrease energy use, increase plant available moisture, and or provide food and escape cover for wildlife.

340 – Cover Crop A seasonal cover of grasses, forbs and or legumes established to decrease soil erosion, maintain or increase soil health and organic matter content, reduce water quality degradation by utilizing excessive soil nutrients, suppress excessive weed pressures and break pest cycles, improve soil moisture use efficiency, and or minimize soil compaction. This practice is applicable to all lands requiring seasonal vegetative cover.
345 – Residue and Tillage Management – Reduced till Managing the amount, orientation and distribution of crop and other plant residue on the soil surface year round while limiting the soil-disturbing activities used to grow and harvest crops in systems where the field surface is tilled prior to planting. This practice is applied as a part of a conservation system to decrease soil erosion, reduce tillage-induced particulate emissions, maintain or increase soil quality and organic matter content, increase plant available moisture, and or decrease energy use.
393 – Filter Strip A strip or area of herbaceous vegetation that removes contaminates from overland flow to decrease suspended solids and associated contaminates in runoff, decrease dissolved contaminate loadings in runoff, and/or decrease suspended solids and associated contaminates in irrigation water.
449 – Irrigation Water Management The process of determining and controlling the volume, frequency, and application rate of irrigation water to improve irrigation water use efficiency, Minimize irrigation induced soil erosion, decrease degradation of surface and groundwater resources, manage salts in the crop root zone, manage air, soil, or plant micro-climate, and or reduce energy use.
484 – Mulching Application of plant residues or other suitable mulch materials to the land surface to conserve soil water, decrease energy use associated with irrigation, provide erosion control, facilitate the establishment of vegetative cover, improve soil health and reduce airborne particulates.
512 – Forage and Biomass Planting Establish adapted species, varieties or cultivars of herbaceous species suitable for pasture, hay or biomass production, to improve or maintain livestock health and nutrition, provide or increase forage supply during periods of low forage production, decrease soil erosion, improve soil and water quality, and or produce biofuel or energy production feedstock.

528 – Prescribed Grazing Managing the harvest of vegetation with grazing and/or browsing animals to improve or maintain desired species composition and vigor of plant communities, improve or maintain quantity and quality of forage for grazing and browsing animals' health and productivity, improve or maintain surface and/or subsurface water quality and quantity, improve or maintain riparian and watershed function, reduce accelerated soil erosion, maintain or improve soil condition, improve or maintain the quantity and quality of food and/or cover available for wildlife, and or manage fine fuel loads to achieve desired conditions.
590 – Nutrient Management Managing the amount (rate), source, placement (method of application) and timing of plant nutrients and soil amendments. Apply this practice to budget, supply and conserve nutrients for plant production, minimize agricultural non-point source pollution of surface and ground water resources, properly utilize manure or organic by-products as a plant nutrient source, protect air quality by reducing nitrogen emissions and the formation of atmospheric particulates, and or improve the physical, chemical and biological condition of the soil.
595 – Integrated Pest Management A site-specific combination of prevention, avoidance, monitoring, and suppression strategies to prevent or mitigate off-site pesticide risks to water quality; prevent or mitigate off-site pesticide risks to soil, water, air, plant, animal and humans from drift and volatilization; prevent or mitigate on-site pesticide risks to pollinators and other beneficial species; and or prevent or mitigate cultural, physical and biological pest suppression risks to soil, water, air, plants, animals and humans.
606 – Subsurface Drain A conduit installed beneath the ground surface to collect and/or convey excess water. This practice may be applied as part of a resource management system to remove or distribute excessive soil water or remove salts and other contaminants from the soil profile.
633- Waste Recycling The use of the by-products of agricultural production or the agricultural use of non-agricultural by-products to protect or improve the quality of natural resources and the environment, and or provide or reduce energy use.

References

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