Soil Science Fundamentals Exam

Performance Objectives

Soil Science Society of America's

Council of Soil Science Examiners

Effective December 2018

SOIL SCIENCE FUNDAMENTAL PERFORMANCE OBJECTIVES

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FOREWORD

This booklet represents the Performance Objectives (POs) for the Soil Science Fundamentals Examination. The POs presented are the minimal professional competencies needed by the Certified Professional Soil Scientist (CPSS), Associate Professional Soil Scientist (APSS), and the Certified Soil Technician (CST). These competencies are provided as a list of POs.

The development of the POs began in 1994 when the Soil Science Society of America (SSSA) asked practicing soil consultants, state licensing boards, government officials and academicians to collectively develop a nationally applicable set of standards fundamental to the rigorous solution of environmental and agronomic problems. Subsequently, this group evolved into the Council of Soil Science Examiners (CSSE), which refined that original list of standards and continues to refine the list on a systematic basis. The POs were developed to assist in studying for the Soil Science Fundamentals Exam. The CSSE is also charged with the development of the examinations required for certification and licensure. The examinations are the product of the balanced application of the POs and can best be studied for by developing a technical understanding of each PO.

The goal of the POs, the examination, and the CSSE is to protect the health, safety and welfare of the public and the environment by insuring only competent soil scientists are certified and /or licensed. In doing so, the CSSE repeatedly scrutinizes the POs to insure we are testing the most pertinent soils knowledge. In this right, a subcommittee of the CSSE is formed along with an end user group to review and revise the POs on a routine basis culminating in this document.

Note on Soil Science Licensure: Candidates seeking a Soil Science License with a licensing state will take the Soil Science Fundamentals Examination first, followed by the Soil Science Professional Practice Exam after meeting the requirements for licensure in their respective state(s). This primarily is an experience requirement, but each state has its own statute and rule that prospective examinees should review. There is an additional set of POs for the Professional Practice Exam.

Soil Science is a dynamic field where new discoveries and approaches continue to occur at a rapid pace. The CSSE encourages comments and suggestions concerning possible modifications to the 2018 edition of the POs. Comments should be sent to: SSSA-CSSE, 5585 Guilford Road, Madison, WI 53711.

The SSSA and CSSE would like to thank the many volunteers who contributed to the continuing refinement of this document. It would not be possible without their dedication to the profession of soil science.

A note on conversions:

Examinees should be able to convert between metric and English units and vice versa, as well as understand SI units. Conversion factors will be provided for questions within the exam and/or will be available on a conversion sheet within the exam booklet.

SOIL CHEMISTRY AND MINERALOGY

Competency Area 1. Basic Concepts of Soil Chemistry

1. Define cation exchange capacity (CEC).

2. Define anion exchange capacity.

3. Define pH dependent and independent charge.

4. Calculate approximate pH when given hydrogen ion activity and vice versa.

5. Describe field and laboratory methods for determining soil pH.

6. Describe how pH test method influences pH readings.

7. Convert to and from the following units:
   a. moles.
   b. grams.
   c. molecular weight.
   d. moles of charge.

8. Describe conditions that influence clay flocculation and dispersion.

9. Define the following terms in relation to the soil solution:
   a. electrical conductivity.
   b. ion activity.

10. Define and calculate base saturation given appropriate data.

Competency Area 2. Solid Phase

1. Identify the following clay mineral structures.
   a. 1:1.
   b. 2:1
   c. 2:1:1 or 2:2.

2. Describe differences in, and characteristics of, the following:
   a. kaolinite.
   b. mica (illite).
   c. smectite (montmorillonite).
   d. vermiculite.
   e. chlorite.
   f. oxides of iron, aluminum and manganese.
   g. amorphous materials.

3. Describe and estimate cation exchange capacity based on soil organic matter content, clay content and clay mineralogy.

Competency Area 3. Mineral Weathering

1. Identify the chemical and physical processes that contribute to mineral weathering.

2. Define primary and secondary minerals.

3. Identify nutrients released from the following primary and secondary minerals:
   a. feldspar.
   b. gypsum.
   c. calcite.
   d. hematite.
   e. dolomite.
   f. pyrite.

4. Describe why CO_2 has an acidifying effect on the soil solution.

Competency Area 4. Solid/Solution Equilibria

1. Define mass flow and diffusion, and list the major soil chemical and physical properties affecting mass flow and diffusion.

2. Define the following processes that occur at the mineral/solution and/or solution/atmosphere interface that control the fate and transport of chemicals in soils:
   a. adsorption.
   b. precipitation.
   c. ion exchange.
   d. oxidation/reduction.
   e. complexation.
   f. volatilization.

Competency Area 5. Ion Exchange

1. Convert between meq per 100 g, centimoles of charge per kilogram ($cmol_c kg^{-1}$), pounds per acre, parts per 2 million, or kilograms per ha when given a depth and a bulk density specification.

2. Calculate CEC, percent base saturation, and percent ion saturation, given cation concentrations, mass of soil, and volume of extracting solution.

3. Explain how change in soil pH influences the cation and anion exchange capacities of soils.

4. Describe how the addition of cations to the soil changes the composition of cations on the exchange sites.

5. Explain how pH influences CEC of 1:1 and 2:1 clay minerals and amorphous materials.

6. Explain the difference in magnitude between cation concentration in soil solution and on the soil exchange sites.

7. Distinguish between relative bonding strength of aluminum, ammonium, calcium, magnesium, potassium and sodium on colloids.

Competency Area 6. Sorption and Precipitation Reactions

1. Describe the relationship between soil pH and the chemical solubilities of the following ions:
   a. aluminum, iron, copper, zinc and manganese.
   b. calcium and magnesium.
   c. phosphate and molybdate.

2. List factors affecting mobility in soil of the following:
   a. phosphates.
   b. sulfates.
   c. nitrates.
   d. chlorides
   e. heavy metals.
   f. organic compounds.
   g. pesticides.

3. Distinguish the sorption differences between ionic and non-ionic compounds.

Competency Area 7. Acidity

1. Differentiate between active, exchangeable, non-exchangeable, and reserve acidity.

2. Explain how soil colloids buffer soil pH changes caused by acid rain, liming amendments and nitrogen fertilizers.

3. Identify the major factors that contribute to soil acidity.

4. Describe how soil salts influence soil pH measurements.

5. Describe buffering in soils as it relates to acid-base reactions.

6. Name the form of acidity that is measured by the pH electrode.

Competency Area 8. Oxidation-Reduction Reactions

1. Define oxidation - reduction potential.

2. Identify conditions which lead to a soil becoming reduced.

3. Identify elements likely to be part of redox reactions in the soil.

4. Describe how the redox state of the soil influences ion solubilities.

5. Describe the role of organic matter in oxidation-reduction reactions.

6. Identify the oxidized and reduced forms of the following elements:
   a. manganese.
   b. iron.
   c. sulfur.
   d. nitrogen.
   e. carbon.

Competency 9. Alkaline and Salt Affected Soils

1. Define saline, sodic and saline/sodic soils.

2. Compare and contrast how irrigation under arid and humid climates can influence soil salinity and sodicity.

3. Describe the unique physical and chemical characteristics of sodic, saline and saline/sodic soils.

4. Describe special management concerns of sodic, saline and saline/sodic soils.

5. Describe remediation techniques for sodic, saline and saline/sodic soils.

6. Define:
   a. sodium adsorption ratio (SAR).
   b. electrical conductivity (EC).
   c. exchangeable sodium percentage (ESP).

7. Calculate sodium adsorption ratio and exchangeable sodium percentage given appropriate data.

8. Know common soil cations and anions in saline and/or sodic soils.

9. Know anthropogenic sources of salinity and sodicity.

10. Estimate the soluble salts based on electrical conductivity (EC).

SOIL FERTILITY AND NUTRIENT MANAGEMENT

Competency Area 1. Roles of Nutrients in Plants and their Availability in Soils

1. Identify the useable ionic forms of the following essential plant nutrients and differentiate macro- and micronutrients.
   a. nitrogen.
   b. phosphorus.
   c. potassium.
   d. sulfur.
   e. calcium.
   f. iron.
   g. magnesium.
   h. manganese.
   i. molybdenum
   j. copper.
   k. zinc.
   l. boron.
   m. chloride.

2. Recognize visual plant deficiency symptoms of the following nutrients:
   a. nitrogen.
   b. potassium.
   c. phosphorus.
   d. iron.
   e. sulfur.
   f. magnesium.
   g. boron.

3. Recognize visual plant toxicity symptoms of the following elements:
   a. manganese.
   b. boron.
   c. aluminum.

4. Describe the principal roles of the following essential nutrients in plant growth:
   a. nitrogen.
   b. potassium.
   c. phosphorus.
   d. magnesium.
   e. sulfur.
   f. calcium.
   g. iron.
   h. zinc.

5. Describe temperature effects on plant availability of:
    a. nitrogen.
    b. phosphorus.

6. Describe aeration effects on plant availability of:
    a. nitrogen.
    b. phosphorus.
    c. iron.

7. Describe the mechanisms of phosphorus fixation in alkaline soils and in acid soils.

8. Know how the following conditions affect the relative concentration of NH_4^+ and NO_3^-:
    a. soil moisture content.
    b. temperature.
    c. pH.
    d. soil organic matter content.
    e. microbiology.
    f. redox.

9. Describe the concepts of root interception, mass flow and diffusion in the uptake of N, P, K and S.

10. Describe the effect of carbonates and pH on N volatilization for urea and ammonium fertilizers.

Competency Area 2. pH

1. Describe the effects of the following on soil pH over time:
    a. anhydrous ammonia.
    b. ammonium nitrate.
    c. ammonium sulfate.
    d. monoammonium phosphate (MAP).
    e. diammonium phosphate (DAP).
    f. urea.
    g. potassium chloride.

2. Explain how soil pH affects the availability of the following elements to plants:
    a. nitrogen.
    b. phosphorus.
    c. potassium.
    d. sulfur.
    e. calcium.
    f. iron.
    g. magnesium.

h. manganese.
i. copper.
j. zinc.
k. molybdenum.
l. boron.
m. chloride.
n. aluminum.

Competency Area 3. Acidifying and Liming of Soils

1. Know how soil pH, CEC, organic matter and texture affect requirements for liming materials.

2. Identify soil amendments that increase or decrease soil pH.

3. Explain the process by which liming or acidifying amendments raise or lower soil pH.

4. Describe how particle size and purity affect the application rate of liming and acidifying materials.

5. Calculate the amount of liming material required to neutralize soil acidity.

6. Calculate the amount of acidifying material required to neutralize soil alkalinity.

Competency Area 4. Nutrient Sources

1. Compare and contrast the availability of organic and inorganic sources of nitrogen and phosphorus.

2. List examples of readily available and slow-release fertilizers.

3. Identify conditions under which readily available and slow-release fertilizers are recommended.

4. Describe the N, P, K and S cycles with respect to soil fertility.

5. Describe how cover crops can affect the nutrient cycles of N, P, K, and S.

Competency Area 5. Soil Fertility Sampling

1. Describe the importance of the following on soil testing results:
   a. time of year.
   b. landscape position.
   c. land management practices including cropping scheme and irrigation use.
   d. depth.
   e. sampling scheme/method.
   f. laboratory methodology.

2. Know the importance of composite samples and sample locations.

Competency Area 6. Soil and Plant Analyses and Interpretations

1. Know the importance of plant tissue analysis for identifying plant nutrient toxicity or deficiency symptoms.

2. Describe how the following influence soil test recommendations:
   a. build up and maintenance.
   b. cation ratios/balance.
   c. nutrient sufficiency.
   d. crop removal.

3. Calculate fertilizer application rates based on nutrient source and recommendation.

4. Understand nutrient credits from legumes, cover crops, manure.

5. Know the purpose of soil and plant tissue testing for crop production.

Competency Area 7. Nutrient Management

1. Describe the water quality implications of improper application of nitrogen and phosphorus to soil.

2. Describe environmental concerns associated with manure application on soils.

3. Be able to explain the 4R Nutrient Management concept.

4. Describe how timing of application affects the effectiveness of:
   a. nitrogen.
   b. phosphorus.
   c. liming material.
   d. acidification material.
   e. organic sources of nutrients.
   f. gypsum.

5. Describe advantages and disadvantages of applying fertilizers to soils via:
    a. broadcast with incorporation.
    b. broadcast without incorporation.
    c. banding.
    d. foliar.
    e. fertigation.
    f. injection.

6. Calculate nutrient uptake and removal given biomass quantity and nutrient concentrations.

7. Identify the information needed to assess nutrient availability from organic residues.

8. Contrast nutrient availability from the following:
    a. fertilizers.
    b. compost.
    c. manures.
    d. plant residues.
    e. cover crops.
    f. biosolids.

SOIL PHYSICS

Competency Area 1. Physical Properties

1. List the USDA soil particle size classes.

2. Be familiar with the names/acronyms of additional classification systems used by other disciplines and know where to find information about those systems.

3. Determine the textural class of a soil using the equilateral soil textural triangles given the percent sand, silt, and clay.

4. Determine appropriate modifiers of textural classes given relevant data.

5. Identify the range of sand, silt or clay content for any given soil texture using the soil textural triangle.

6. Define and calculate soil bulk density.

6. Define and calculate soil porosity.

7. Define and calculate soil particle density.

8. Know quantitative methods for determining particle size distribution.

9. Define soil structure.

10. Describe the following types of soil structures:
    a. angular blocky.
    b. subangular blocky.
    c. granular.
    d. prismatic.
    e. platy.
    f. columnar.
    g. single-grained.
    h. massive.
    i. wedge.

11. Explain how land management practices affect soil bulk density and pore space.

12. Describe how soil texture and structure influence water movement and water holding capacity.

13. Given two of the following, calculate the third: total soil volume, soil bulk density, and dry mass of the soil.

14. Describe soil conditions conducive to surface crusting.

15. Describe how soil color indicates soil physical, chemical, and biological properties.

16. Define hydrophobicity and identify factors that affect hydrophobicity in soil.

Competency Area 2. Soil-Water Relationships

1. Describe the gravimetric method of determining soil water content.

2. Calculate gravimetric and volumetric water contents.

3. Given bulk density, convert gravimetric water content to volumetric water content.

4. Define saturation.

5. Define field capacity.

6. Define permanent wilting point.

7. Define plant available water.

8. Define capillary water.

9. Define hygroscopic water.

10. Use the soil water retention curve to estimate plant available water.

11. Identify the following components of the hydrologic cycle:
    a. precipitation.
    b. evaporation
    c. transpiration.
    d. runoff.
    e. infiltration.
    f. redistribution.
    g. deep seepage.
    h. storage.

12. Define:
    a. perched water table.
    b. groundwater table.
    c. vadose zone.
    d. capillary fringe.
    e. aquifer.
    f. aquitard.
    g. aquiclude.

13. List soil properties that affect water movement through the soil.

Competency Area 3. Water Movement and Transport Processes

1. Define the following soil water potentials:
   a. pressure potential.
   b. matric potential.
   c. gravitational potential.
   d. osmotic potential.
   e. total potential.

2. Determine the direction of water movement, given soil water potentials.

3. Define Darcy's Law and its components and be able to use it in calculations.

4. Describe preferential flow in soils.

5. Describe how preferential flow can affect groundwater quality.

6. Describe how leaching potential differs between nitrate-nitrogen and ammonium-nitrogen in soils of different textures.

7. Explain how plant residues on the soil surface affect surface runoff, evaporation and infiltration.

8. Describe the relationship between saturated hydraulic conductivity and soil pore size distribution.

9. Describe how water infiltration and percolation are affected by:
   a. bulk density.
   b. particle density.
   c. porosity.
   d. structure.
   e. tortuosity.
   f. texture.

10. Relate soil morphological properties with relative rates of water movement through soils.

Competency Area 4. Soil Temperature

1. Describe how soil texture, structure, bulk density and water content affect thermal conductivity and heat capacity.

2. Describe how the following affect soil temperature:
    a. soil color.
    b. soil water content.
    c. surface residue.
    d. landscape position.
    e. aspect.
    f. land use.

3. Describe soil temperature change at different depths both seasonally and diurnally.

4. Describe factors controlling temperature at different soil depths.

5. Explain how soil temperature affects microbial and chemical processes.

Competency Area 5. Soil Gases

1. Explain how the following affect soil aeration:
    a. bulk density.
    b. particle density.
    c. porosity.
    d. structure.
    e. organic matter.
    f. water content.

2. Explain how irrigation or precipitation affects soil oxygen content.

5. Identify major potential soil gases.

6. Characterize soil gases across different landscape types, i.e., wetlands, alpine areas.

Competency Area 6. Engineering Properties

1. Compare the shrink-swell potentials of various soils.

2. Identify soil properties that influence shrink swell potential.

3. Relate soil texture, structure and mineralogy to soil compaction.

4. Describe how soil compaction affects infiltration, permeability, bulk density and thermal conductivity and root growth.

5. Describe soil strength and shear stress.

6. Define liquid limit, plastic limit, and plasticity index.

SOIL GENESIS, MORPHOLOGY, AND CLASSIFICATION

Competency Area 1. Soil Forming Factors

1. Define
   a. soil.
   b. rock.
   c. mineral material.
   d. amorphous material.
   e. organic materials.

2. Describe the five soil forming factors.

3. Describe processes and landscape characteristics that result in the formation of soils.

4. Define the following parent materials:
   a. alluvium.
   b. colluvium.
   c. till.
   d. eolian sands.
   e. marine sediments.
   f. residuum.
   g. coastal sediments.
   h. glacial outwash.
   i. lacustrine sediments.
   j. loess.
   k. volcanic ash.
   l. human transported materials.

5. Arrange a set of soil descriptions as they would occur in a toposequence or chronosequence.

6. Given soil descriptions, identify the dominant soil forming factor that influenced the development of horizons.

Competency Area 2. Horizon Forming Processes

1. Describe the following terms or processes:
   a. eluviation.
   b. illuviation.
   c. reduction and oxidation.
   d. chemical weathering.
   e. physical weathering.
   f. additions.
   g. losses.

2. Identify the soil horizon-forming process when given a master horizon or sub-horizon symbol or name.

Competency Area 3. Soil Descriptions

1. Define hue, value, chroma and Munsell notation.

2. Use a soil description to determine the morphological characteristics and horizon nomenclature.

3. Name the diagnostic horizons and the soil order of a soil when given morphological and lab data.

4. Identify the seasonal high water table of a soil when given its description and morphological data.

5. Name the key morphological and chemical features of hydric soils.

6. Define and describe redoximorphic features and variegated colors.

7. Explain how the following soil characteristics vary with depth:
   a. structure.
   b. texture.
   c. color.
   d. bulk density.
   e. porosity.

Competency Area 4. Soil Interpretations and Land Use Management

1. Identify suitabilities and limitations for a map unit from the tables in a National Cooperative Soil Survey Report for the following uses:
   a. crop yields.
   b. recreation.
   c. urban development.
   d. forestry.
   e. septic systems.
   f. wildlife suitability.
   g. engineering properties.
   h. hydrologic properties.

2. Utilize topographic information to evaluate how a landscape partitions water.

Competency Area 5. Soil Classification Concepts

1. Compare and contrast differences among soils using their taxonomic classification.

2. Identify the criteria that differentiate the orders of Soil Taxonomy.

3. Given the taxonomic classification, identify all levels of classification.

Competency Area 6. Soil Mapping

1. Define the following terms:
    a. complex.
    b. association.
    c. inclusion.
    d. mapping unit.
    e. pedon.
    f. polypedon.
    g. soil series.
    h. profile.
    i. phase.
    j. consociation.

2. Recognize information in a modern National Cooperative Soil Survey Report.

3. Explain the limitations of soil surveys and importance of site specific evaluation.

Competency Area 7. Geomorphology

1. Identify the following landforms:
    a. flood plain.
    b. coastal plain.
    c. playa.
    d. meander scar.
    e. till plain.
    f. lake plain.
    g. alluvial terrace.
    h. outwash plain.
    i. esker.
    j. moraine.
    k. alluvial fan.
    l. piedmont.
    m. bajada.

n. dune.
o. bog, fen, moor.
p. terrace.

2. Differentiate the properties of soils formed in the following hillslope positions:
   a. summit.
   b. shoulder.
   c. backslope.
   d. footslope.
   e. toeslope.

Competency Area 8. Soil Forming Environments

1. Identify how morphological, chemical, biological, and physical soil properties vary in the following landscapes:
   a. forest.
   b. desert.
   c. prairie.
   d. arctic and alpine.
   e. wetlands.
   f. agriculture.
   g. urban.

SOIL BIOLOGY AND SOIL ECOLOGY

Competency Area 1. Living Soil Constituents

1. Name the major groups of soil microorganisms involved with organic residue decomposition.

2. Rank the relative populations or biomass of the following microorganisms per gram of dry soil:
   a. bacteria.
   b. actinomycetes.
   c. fungi.

3. Describe the importance of soil microorganisms and macroorganisms to soil processes and soil health.

4. Describe the role of the following fauna in soil.
   a. nematodes.
   b. protozoa.
   c. earthworms.
   d. arthropods.

5. Define rhizosphere and understand its relationship to soil organisms.

Competency Area 2. Soil Ecology

1. Identify the optimal levels of soil temperature, moisture potential, oxygen and pH for activity of major categories of aerobic microorganisms.

2. Identify how changes in temperature, organic matter level, moisture potential and pH affect soil microbial activity.

3. Explain how soil organic matter, soil nutrient levels, oxygen content, and pH influence the overall abundance of soil organisms and their relative proportions.

4. Describe beneficial interactions between plant roots and soil fungi.

5. Describe deleterious interactions between plant roots and soil fungi.

6. Explain why earthworms and insects are important to the decomposition of organic residues in soil.

7. Describe the benefits to both the fungi and plant in a mycorrhizal symbiosis.

8. Describe the benefits to both the rhizobia and the legume in the N_2-fixing symbiosis.

9. Explain how microbial biomass and its activity are affected by intensive tillage.

10. Explain how intensive tillage changes the relative proportions of the major groups of microorganisms.

11. Describe the conditions that affect the establishment of mycorrhizal associations.

12. Describe how the following factors affect nodulation of leguminous and actinorhizal plants.
    a. pH.
    b. inorganic N.
    c. aluminum.
    d. temperature.
    e. moisture.
    f. macronutrients.
    g. micronutrients.

Competency Area 3. Biological and Biochemical Activities

1. Know the following cycles:
    a. carbon.
    b. nitrogen.
    c. phosphorus.
    d. sulfur.

2. Define how microbial activities affect reduction and oxidation of the following:
    a. iron.
    b. manganese.
    c. nitrogen.
    d. sulfur.

3. Describe general decomposition processes of organic materials added to soil.

4. Describe how the rate of decomposition of organic material varies based on:
    a. C:N ratio.
    b. lignin content.
    c. oxidation state of carbon.

5. Define C:N ratio and calculate the carbon to nitrogen ratio given the appropriate data.

6. Describe the fate of carbon in organic matter decomposition.

7. Identify how the following soil factors affect the rate of decomposition of organic materials:
    a. pH.
    b. moisture.
    c. temperature.
    d. aeration.
    e. oxidation-reduction potential.
    f. inorganic nutrients.
    g. soil texture.

8. Calculate the amount of nutrients released from organic amendments based on application rates and given mineralization for:
    a. nitrogen.
    b. phosphorus.

9. Define the following processes for the nitrogen cycle:
    a. nitrification.
    b. denitrification.
    c. biological nitrogen fixation.
    d. immobilization.
    e. mineralization.
    f. ammonification.
    g. volatilization.

10. Identify environmental conditions that determine the rate of the following nitrogen cycle processes:
    a. nitrification.
    b. denitrification.
    c. biological nitrogen fixation.
    d. immobilization.
    e. mineralization.
    f. ammonification.
    g. volatilization.

Competency Area 4. Soil Organic Matter

1. Describe the chemical and physical characteristics of soil organic matter.

2. Explain how organic matter affects soil aggregate formation and stability.

3. Identify how organic matter interacts with the following ions, elements, or substances in the soil:
    a. nitrate.
    b. phosphate.
    c. calcium.
    d. aluminum.
    e. iron.
    f. pesticides.
    g. xenobiotics.

4. Explain the importance of the active and passive soil organic matter fractions.

5. Explain why microorganisms are important for organic matter production.

6. Describe the biological, physical and chemical properties imparted to soil by organic matter.

7. Describe how the following affect the amount of organic matter present in soil:
    a. tillage and/or management.
    b. texture.
    c. precipitation.
    d. temperature.
    e. topography (including slope position)
    f. vegetation.
    g. aspect.

Competency Area 5. Environmental and Agricultural Applications

1. Define and describe bioremediation.

2. Define and describe phytoremediation.

3. Describe the role of soil microbes in bioremediation.

4. Describe how soil microbes facilitate waste management in the following:
    a. composting.
    b. septic systems.
    c. wastewater lagoons.
    d. land application of biosolids.
    e. land application of animal manures.
    f. hydrocarbon contamination.

5. Explain why bacteria are important to anaerobic decomposition of xenobiotics.

6. Describe the role of bacteria in the production of acidity from reduced sulfur and iron minerals.

7. Describe how microbial activities impact the production and consumption of the following greenhouse gases:
    a. carbon dioxide.
    b. nitrous oxide.
    c. methane.
    d. water vapor.

8. Explain why thermophilic bacteria are important in composting.

9. Explain why fungi are important to the decomposition of forest floor litter.

10. Explain the role of bacteria in wetlands.

11. Explain the importance of soil biota to nitrogen availability from plant residues, manures, and other organic residues.

12. Explain the importance of soil biota to phosphorus availability from plant residues, manures, and other organic residues.

13. Describe factors important to the successful use of rhizobial inoculants with legume crop establishment.

14. Explain how reduced-tillage promotes fungal activity in soil.

SOIL AND LAND USE MANAGEMENT

Competency Area 1. Erosion and Sediment Control

1. Define each factor of the Revised Universal Soil Loss Equation (RUSLE2) and Water Erosion Prediction Project (WEPP).

2. Explain how conservation practices affect soil loss estimates using the RUSLE2.

3. Apply the RUSLE2 or WEPP, given appropriate data.

4. Describe factors affecting sediment load in water.

5. Identify soil conditions and management practices that contribute to soil erosion by water.

6. Identify soil conditions, structures and management practices that help control soil erosion by water and sediment deposition.

7. Identify the following erosion types:
   a. sheet.
   b. rill.
   c. gully.
   d. mass wasting.

8. Describe factors important in wind erosion and in the use of WEPS (Wind Erosion Prediction System).

9. Identify the concepts of WEPS and how it is used to predict the effects of conservation/management practices of soil erosion by wind.

10. Characterize processes associated with wind erosion.

11. Identify soil conditions and management practices that contribute to wind erosion.

12. Identify soil conditions, structures and management practices that help control wind erosion and deposition.

13. Explain the effects of erosion on soil properties.

14. Explain the effects of residue management on soil erosion.

15. Describe the erosion potential for:
   a. construction sites.
   b. urban areas (e.g. paved, park, turf areas).
   c. agricultural land.

d. forested land.
e. prairie.
f. rangeland
g. desert.
h. streams and riparian areas.

16. Define highly erodible land (HEL).

17. Understand basic concepts of the following:
    a. National Pollutant Discharge Elimination System (NPDES)
    b. Stormwater Pollution Prevention Plans (SWPPPs)

Competency Area 2. Wetlands and Hydric Soils

1. Describe the functions and values of wetlands.

2. Describe how constructed wetlands can be used to treat contaminated water.

3. Describe unique characteristics of hydric soil properties.

4. Identify morphologic properties of hydric soil indicators.

5. Understand and be able to use the Munsell soil color system.

6. Describe unique hydrology associated with wetlands.

7. Understand topographic position as related to wetland development and for siting constructed wetlands.

Competency Area 3. Soil Quality and Soil Health

1. Define soil quality and soil health.

2. Describe how land use, physical, chemical and biological properties influence soil quality and soil health.

3. Describe carbon sequestration.

4. Describe management practices that influence carbon dynamics.

5. Describe methods to improve plant growth on
    a. highly acidic soils.
    b. highly alkaline soils.
    c. saline and/or sodic soils.

6. Describe methods to improve plant growth on wet soils.

7. Describe how to improve the structure of compacted soils.

8. Describe how compaction affects availability and uptake of nutrients and water for plants.

9. Discuss the concept of best management practices (BMPs).

10. Identify BMPs to control:
    a. surface and subsurface nutrient movement.
    b. surface and subsurface pesticide movement.
    c. soil erosion.

Competency Area 4. Waste Management

1. Identify the common soil properties and management practices used to prevent waste products from contaminating groundwater.

2. Identify the common soil properties and management practices used to prevent waste products from contaminating surface water.

3. Describe the soil properties and management practices used to reduce mobility of heavy metals in land-applied municipal biosolids, effluents and industrial wastes.

4. List the hazards associated with land application of municipal biosolids and industrial wastes as a soil amendment.

5. Describe how pH affects the mobility of heavy metals.

6. Describe water quality impacts related to irrigation with wastewater.

7. Describe how the following soil factors affect placement of a septic system:
    a. soil texture.
    b. hydraulic conductivity of soil horizons.
    c. depth to a seasonally high water table.
    d. depth to bedrock.
    e. topographic position.

8. Describe soil characteristics that limit the use of the following septic systems:
    a. conventional.
    b. low pressure pipe.
    c. drip irrigation.

Competency Area 5. Cropland and Field Management

1. Explain the concept and application of precision agriculture.

2. Identify soil conditions that inhibit plant growth.

3. Describe how tillage and residue management affects soil physical, chemical, and biological properties.

4. Explain how root growth affects soil physical properties.

Competency Area 6. Water Quality and Management

1. Define the following terms:
   a. eutrophication.
   b. hypoxia.
   c. Total Maximum Daily Loads (TMDLs).
   d. turbidity.

2. Distinguish between point and non-point sources of pollution.

3. Be able to identify sources of potential soil contamination.

4. List techniques for remediation of soils contaminated by chemical leaks and spills.

5. Describe soil properties affected by irrigation with poor quality water.

6. Describe the impacts of nitrogen and phosphorus management practices on water quality.

7. Explain the purpose of vegetative buffers and filter strips.

8. Describe how riparian areas, filter strips and vegetated buffers influence nitrogen, phosphorus and sediment movement.

9. Describe water conservation practices used to reduce frequency of irrigation.

10. Describe water conservation practices used to reduce runoff and leaching.

11. Define grey water.

Competency Area 7. Regulatory and Resource Agencies

1. Identify the federal agency responsible for compiling soil survey data.

2. Identify the federal agency/agencies responsible for environmental issues related to:
    a. wetlands.
    b. water quality criteria.
    c. oil and gas.
    d. surface mining.
    e. agriculture and forestry.
    f. soil erosion.
    g. organic agriculture.
    h. food safety.

Competency Area 8. Urban Soils

1. Describe typical characteristics of urban soils:
    a. compaction and soil structure.
    b. soil organic matter and soil biology.
    c. accumulation of metals and salts.
    d. common soil horizon features.

2. Describe “engineered” or “manufactured” soils.

3. Explain why “manufactured” or blended soils are less stable than native soils.

4. Explain how soil texture, particle size distribution, and bulk density interrelate when preparing soil specifications for fill or amendments.

5. Describe factors that influence water movement in urban soils.

6. For urban soils, explain how the use of compost
    a. improves soil physical structure.
    b. balances soil chemical properties.
    c. affects soil nutrient levels and availability.

7. Define brownfields.

Competency Area 9. Forest Soils

1. Understand soil formation under different forest vegetation types.

2. Explain how soil biological, chemical and physical properties may differ between agricultural, forest, range and wildland soils.

3. Define the forest floor and characterize how it affects soil chemical, biological and physical properties.

4. Define the effect of harvest and management on water and temperature dynamics.

Competency Area 10. Geospatial Interpretation

1. Define Geographic Information System (GIS), Global Positioning System (GPS), and remote sensing.

2. Given a set of maps and aerial photos at different scales, identify benchmark features for a given site.

3. Describe uses of GIS and GPS in land use management.