UNIT LESSON PLAN

RX-310, INTRODUCTION TO FIRE EFFECTS

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LESSON: Fire Effects and Resource Management – Soils

UNIT: Unit 3B

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

1. Identify and describe soil properties and processes as they relate to fire effects.
2. Identify how fire regimes affect the biological, chemical, and physical properties of soils.
3. Discuss appropriate management practices for modifying first order fire effects on soils.
4. Identify key soil attributes to evaluate the first order fire effects on soils.

NARRATIVE:

I. INTRODUCTION TO SOILS

- Soil – unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time
- Soil Properties – collectively used to include the characteristics, reactions, and processes that occur in soils
- Soil Horizon – a layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistency, kinds and number of organisms present, degree of acidity or alkalinity
- Soil Profile – a vertical section of the soil through all its horizons
- Soil Layer – a layer in the soil deposited by a geologic force (wind, water, glaciers, oceans, etc.) and not relating to soil forming process

- Soil Horizon Nomenclature
    - O – Organic Horizon
    - A – Mineral horizons that formed at the surface or below an O horizon
    - E – Mineral horizons in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration other resistant materials
    - B – Horizons that formed below an A, E, or O horizon and is in general an accumulation layer undergoing transformations such as chemical alteration of clay structure
    - C – Horizons or layers, excluding hard bedrock, that are little affected by pedogenic processes and lack properties of O, A, E, or B horizons

- R – Hard bedrock including granite, basalt, quartzite and indurated limestone or sandstone that is sufficiently coherent to make hand digging impractical.

II. SOIL PHYSICAL PROPERTIES

- Fire Severity – the ecosystems responses to fire that can be used to describe the effects of fire on the soil and water system, ecosystem flora and fauna, the atmosphere, and society
  - It reflects the amount of energy (heat) that is released by a fire which affects resource responses
  - Fire severity, loosely, is a product of fire intensity and residence time and is generally considered to be light, moderate, or high
- Soil Physical Characteristics Affected by Soil Heating
  - Texture
  - Clay Content
  - Soil Structure
  - Bulk Density
  - Porosity (amount and size)
- Depth of Soil Heating
  - Most significant effects at the soil surface
  - Peak temperature decreases rapidly with depth
  - Soil temperature with depth is dependent on fire intensity and fuel load
- Water Repellency – produced by soil organic matter and can be found in both fire and non-fire environments (GTR-42-4)

  Water repellency can result from the following processes involving organic matter:
  - An irreversible drying of the organic matter (for example, rewetting dried peat)
  - The coating of mineral soil particles with leachates from organic materials (for example, coarse-grained materials treated with plant extracts)
  - The coating of soil particles with hydrophobic microbial byproducts (for example, fungal mycelium)
  - The intermixing of dry mineral soil particles and dry organic matter
  - The vaporization of organic matter and condensation of hydrophobic substances on mineral soil particles during fire (for example, heat-induced water repellency)
- Interception – the hydrologic process by which vegetative canopies and accumulations of litter and other decomposed organic matter on the soil surface interrupt the fall of precipitation from the atmosphere to the soil surface
- Infiltration – is the process of water entering the soil
- Soil Water Storage – a function of the surface area of soil particles (particle-size) and the amount of porosity occurring between these particles (soil structure)
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- Mesification of Xeric Forests

  Thoughts on
  - Nutrients
  - Moisture Regime
  - Perception
  - Policy

III. SOIL CHEMISTRY

Chemical properties of the soil that are affected by fire include individual chemical characteristics, chemical reactions, and chemical processes

- chemical characteristics most commonly affected by fire are organic matter, carbon (C), nitrogen (N), phosphorus (P), sulfur (S), cations, cation exchange capacity, pH, and buffer power
- purely chemical reactions include the exchange of cations adsorbed on the surface of mineral soil particles and humus with their surrounding solutions
- chemical weathering of rocks and their eventual transformation into secondary clay minerals during soil formation
- common chemical processes occurring in soils that are affected by fire are involved in nutrient availability and the losses and additions of nutrients to the soil

- Soil pH
  - Fire raises pH
  - Cations released during combustion are deposited on soil surface
  - Usually pH only altered in upper soil horizons temporarily
- Soil Nutrients
  - Fire converts nutrients from organic matter to mineral form
  - Nitrogen is lost primarily when plant material is reduced to white ash
  - Post fire phosphorous and nitrogen varies from increase, no change, to loss
  - Soluble salts like potassium, magnesium, and calcium increase for as little as a year post fire
- Black Carbon – growing interest in the role of charcoal in soils, but in soils exposed to forest and grassland burning (wildfire or prescribed fire) and in soils receiving soil biochar amendments from bioenergy projects

  Charcoal offers numerous benefits to soil chemical and physical properties. However, uncertainties about prescription conditions for optimal production and the high level of spatial variability following burning underscore the fact that insufficient knowledge exists to assess the practical importance of soil charcoal derived from fuel reduction practices (GTR-241).

IV. SOIL BIOLOGY

- Biological component of soils are made up of both living and dead biomass
- Microbial responsiveness to fire
  - Microorganisms are skilled at recolonizing disturbed forests. Their resiliency is a function of unsurpassed physiological and genetic diversity.
  - Fire effects are greatest in the forest floor and decline rapidly with mineral soil depth. Recovery of microbial populations in the forest floor is not guaranteed, particularly in dry systems with slow reaccumulation of organic material.
  - Severe wildfire and prescribed fire reduce organic matter content and increase the potential for loss of soil by erosion.
  - Prescriptions that avoid drastic changes in the environmental factors controlling microbial life—soil temperature, moisture, and substrate availability—will be the most successful at meeting operational objectives while ensuring a functioning soil biotic community

V. GROUP EXERCISE

- Break into 4 groups of 6 to 7 people for 5 to 10 minutes
- As a group identify 3 of the most significant physical, chemical, or biological soil properties to consider when conducting prescribed burns in Pennsylvania

- Then identify measures to modify the first order fire effects associated with each of the 3 properties
- Taking 3 or 4 minutes each group will present 1 soil property and the identified measure for modifying first order fire effects associated with it

NOTE: Each group must present a different soil property

REFERENCES:

Fire Effects Information System
http://www.feis-crs.org/beta/

Fire Ecology Database
http://talltimbers.org/fire-ecology-database/

USDA Natural Resources Conservation Service – Soils
http://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/

FOFEM (First Order Fire Effects Model) Software
http://www.firelab.org/project/fofem

GTR-42-vol. 4. - Wildland fire in ecosystems: effects of fire on soils and water
http://www.fs.fed.us/rm/pubs/rmrs_gtr042_4.html

GTR-241 - Fuel Reduction Practices and Their Effects on Soil Quality
http://www.fs.fed.us/psw/publications/documents/psw_gtr241/