Dynamic Soil Properties and Processes Illustrated in Conceptual Models for Soil Survey

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Objective

• Illustrate how conceptual process models can be used to organize information about management effects on soil/ecosystem processes and dynamic soil properties.

Why?
• To explain/predict/interpret human impacts on soil.
Soil processes

- Process which form soil materials
  - Biogeochemical
- Process of soil horizon and profile development
  - Pedogenic
- Dynamic processes in the rooting zone of plants
  - Ecological

Geomorphic controls

Management and climate change impacts

Modified from Ross, 1989
*Soil Processes*
What is a conceptual model?

A purposeful representation of reality that provides a mental picture of how something works to communicate that explanation to others.

– (Starfield et al., 1993)

A model that represents key processes, interactions, and feedbacks.

– (Gross, 2003)

(Ross, 1989)
Nested/hierarchical approach to showing complexity of ecosystem processes in conceptual models. The global model (A) shows the larger scale controls (drivers) that affect the system while using submodels to convey more detailed processes with (B) state and transition models and associated transition-causes (stressors) in (C) mechanistic models (from O’Dell et al. 2005).
Mechanisms of soil degradation after disturbance

- Decreased porosity
- Erosion
- Nutrient depletion
- Organic matter loss
- Reduced biological activity
- Structural degradation
- Crusting, sealing
- Change in soil-water relations
- Change in soil temperature
- Salinization
- Fire-induced water repellency

Dynamic Soil Properties
- Organic matter
- Aggregate stability
- Salinity
- Infiltration
- Ksat
- Topsoil depth
- Biological crusts
  etc.
Forest State and Transition model

1. Reference State

1.1 (HCPC)
- Ponderosa pine/Idaho fescue
- Overstory structure: Mature-old-growth
- Tree canopy: 25-40%
- Tree age: 125+ years (with mosaic of secondary even-aged small-area stands ranging up to 125+ years old)

1.1a
- CC/STH/TMCF, TSS

1.1b
- SF

1.2
- Ponderosa pine/Idaho fescue
- Overstory structure: Mature (may be two-story)
- Tree canopy: 40-75% (and 25-40%)
- Tree age: 60-125 years (and 30-60 yrs)

1.2a
- TH

1.2b
- GR

1.3
- Ponderosa pine/Idaho fescue
- Overstory structure: Two-story (dense stocking; stagnate growth; high risk for TMCF)
- Tree canopy: 60-90%
- Tree age: 30-60 years and 60-125 years

1.3a
- SF,PG

1.3b
- CC/STH/TMCF, TSS

1.4
- Ponderosa pine/Idaho fescue
- Overstory structure: Mature (may be two-story)
- Tree canopy: 40-75% (and 25-40%)
- Tree age: 60-125 years (and 30-60 yrs)

1.4a
- SF/TH

1.4b
- FE

1.4c
- CC/TMCF, TSS

1.4d
- UG,ISSS

Legend: CC=clearcut harvest; FE=fire exclusion; GR=growth; HCPC=Historic Climax Plant Community; ISSS=invasive species seed source; NUR=native understory restoration; PG=prescribed grazing; SF=surface fire (recurring); SP=site preparation; spa=stems per acre; STH=seed-tree harvest; TH=thinning (prescribed); TMCF=total mortality crown fire; TSS=tree seed source present; UG=uncontrolled grazing. Symbols: “/” = and/or; “,” = and; “-” = or.

(Pinus ponderosa/Idaho fescue; Rev. 1May2007) from L Townsend, NRCS
Models of management-soil-plant dynamics

1.2 Ponderosa Pine-Idaho Fescue Grass dominated and seedlings

DSP values

1.4 Ponderosa Pine-Idaho Fescue Mature overstory

DSP values

2.1 Ponderosa pine/cheatgrass

DSP values

Uncontrolled grazing, Invasive species seed source? Soil degradation?

Surface fire (recurring)
Native understory restoration
Cropland model

Tillage

Light

Moderate

High

Residue

Low

Moderate

High

LT
LR

MT
MR

HT
HR

LT
LR

MT
MR

HT
HR

LT
LR

MT
MR

HT
HR
Soil survey applications: models as a tool to document human impacts

1. Stratify a soil map unit component (phase) based on land use and management systems to guide sampling of dynamic soil properties.

2. Extend data and relationships to other similar soils (e.g. similar Ecological Site or crop management zone).

3. Develop hypotheses of mechanisms of management effects for testing (research) and development of interpretations.
4. Provide a framework to design integrated databases (soil + management + vegetation).

5. Communicate dynamic processes and management effects on soil to technical and non-technical audiences.
Gross, John E. 2003. Developing Conceptual Models for Monitoring Programs, NPS Inventory and Monitoring Program,
http://science.nature.nps.gov/im/monitor/docs/Conceptual_Modelling.pdf

National Park Service Vital Signs Monitoring.
http://science.nature.nps.gov/im/monitor/index.cfm


http://soil.scijournals.org/content/vol69/issue3/#PEDOLOGY