Ecological Site Descriptions: A Primer

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Ecological Site:

A distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation, and in its ability to respond to management actions and natural disturbances.

Ecological Site Description:

Reports with associated data that document the characteristics of an ecological site (including its climate, soils, and state-and-transition model) and the interpretation of its properties related to use and management.
History of ecological sites

The forest site (yes, the idea came initially from an employee of the USFS)

C. F. Korstian (1919) “an area considered as to its physical factors with reference to forest producing power, or the combined effect of the climatic and edaphic conditions of the forest habitat”

Focus on potential and climax plant community as the basis for managing forest

Used in estimating forest timber production and guidance for species mixes for reseeding sites
History of ecological sites

Range Condition/Range Sites

“Different kinds of rangeland are referred to as range sites...Site is not to be confused with type, because many types of vegetation may successfully occupy the same range site in response to different grazing treatments. Current range condition can be measured only in relation to some known potential condition and the only certain indicator of potential is the site”. (Dyksterhuis 1953)

• Set long term carrying capacity
• Plant succession as a basis for assessment
• Dynamics with regard to factors affecting livestock forage
History of ecological sites

Succession-retrogression model

% desirable species composition

Succession

Sufficient rainfall
Moderate grazing
Prescribed burning

Retrogression

Drought
Heavy grazing
Lack of fire

Condition class

Poor
Fair
Good
Excellent
Multiple plant communities can occupy a site

They may have similar or differing ability to protect a site from accelerated erosion

Plant communities may have a variety of values in addition to offering site protection

Refer to ideas of ‘threshold’ of rangeland health, multiple stable states, at risk conditions, and early warning indicators as organizing principles
The functions of modern ecological sites

1. Stratify the landscape according to varying ecological potential in order to identify management and restoration targets

2. Assess the risk of persistent degradation and take proactive measures to avoid it

3. Specify constraints to, and opportunities for, desired ecosystem change based on a knowledge of ecological processes

4. Identify specific intervention strategies that can promote desired conditions

5. Design and interpret monitoring based on interventions and expected responses.
What do ecological site descriptions need to contain or link to?

1. Accurate linkages of soil classification and mapping to potential vegetation and ecosystem services

2. State-and-transition models linked to early-warning indicators

3. State-and-transition models that describe ecological thresholds

4. Linkage to specific within-state management and restoration technologies

5. Maps or spatial information on states within sites for monitoring
Basics of ecological site development: scales

LRR-MLRA-LRU
Land Resource Hierarchy

- Land Resource Region (LRR)
- Major Land Resource Area (MLRA)
- Land Resource Unit (LRU)
- General Soil Map
- Detailed Soil Map
- Soil Series
- Pedon

Geographic areas of related ecological sites
Groups ecological sites with common climate
Ecological sites that share landscapes
Intermingled ecological sites or single site
One ecological site or one representative of the site
An observation of plant-soil relationships
MLRAs distinguish broad differences in potential and types of ecological dynamics.

Non-native grass invasion, increased fire frequency, loss of native woody plants

Drought-triggered forest dieback

Non-native grass invasion, altered surface hydrology, reduced productivity

Perennial grass loss, soil erosion, native woody plant dominance

Native woody plant thickening, reduced fire frequency

Non-native woody plant invasion

Major Land Resource Areas of the continental USA
The MLRA-level “model” is filtered by soils/topography and local climate (LRU)

**Gravelly soil (shallow, relict piedmont)**
Surface soil water limited, high risk for grass loss and erosion: **vulnerable/restorable**

**Limestone**
Grass protected by rocks, higher rainfall, good water capture: **low risk**

**Sandy soil (relict basin floor)**
Erodible surface soils once grasses removed: **vulnerable/hard to restore**

**Clayey soil (basin floor)**
Receives water and sediment: **low risk**

**Loamy soil (active piedmont)**
Susceptible to water erosion and grass loss: **vulnerable/restorable**
Subtle soil variations are important: the effects of differences in clay content

Santa Rita Experimental Range, AZ
Ecological sites concepts developed based on relationship of soil profiles to soil processes and vegetation pattern.
Ecological sites classify soil map unit components (soil series phases) of the US National Cooperative Soil Survey

A soil map unit can contain more than one ecological site

An ecological site groups several similar soil map unit components

Map unit/components

ST: Stellar association
- 40% Stellar clay loam, 0-3% slopes = Clayey
- 40% Stellar clay loam, 0-3% slopes, flooded = Bottomland
- 20% other inclusions

BK: Berino-Dona Ana association
- 50% Berino fine sandy loam, 1-5 % slopes = Sandy
- 30% Dona Ana fine sandy loam, 1-5% slopes = Sandy
- 20% other inclusions

OP: Onite-Pajarito association
- 40% Onite loamy sand, 1-4% slopes = Sandy
- 30% Pajarito fine sandy loam, 0-5% slopes = Sandy
- 15% Pintura fine sand, 0-5% slopes = Deep sandy
- 15% other inclusions

A soil map unit can contain more than one ecological site

An ecological site groups several similar soil map unit components
Soil information and geographic databases allow for digital maps of dominant ecological sites across most of United States.
Ecological site keys allow for local identification within map units

MONTANA RANGELAND ECOLOGICAL SITE KEY (part)

7b. Soils Moderately Deep, Deep, or Very Deep (>= 20” deep)
17a. Soil Skeletal
   18a. Soil Sandy-Skeletal
      19a. Sandy-skeletal within 0-10” of soil surface - Gravelly (Gr)
      19b. Sandy-skeletal within 10-20” of soil surface & consists of gravels and/or cobbles
         20a. Strongly or violently effervescent within top 4” – Shallow to Gravel, Limy (SwGrLy)
         20b. Not Strongly or violently effervescent within top 4” – Shallow to Gravel (SwGr)
     18b. Soil Loamy-Skeletal
        21a. Strongly or violently effervescent within top 4” – Limy Droughty (LyDr)
        21b. Not Strongly or violently effervescent within top 4”
           22a. Slope <15%
              23a. Soil surface texture is very fine sandy loam, loam, silt loam, silty clay loam or clay loam – Loamy Droughty (LoDr)
              23b. Soil surface texture is coarse sandy loam to fine sandy loam – Sandy Droughty (SyDr)
           22b. Slope >=15%
              24a. Soil surface texture is very fine sandy loam, loam, silt loam, silty clay loam or clay loam – Loamy Droughty Steep (LoDrStp)
              24b. Soil surface texture is coarse sandy loam to fine sandy loam – Sandy Droughty Steep (SyDrStp)
The state-and-transition model

Diagrams, text descriptions, and associated data that describe possible changes in vegetation and soils within particular ecological sites

1) Each representative of an ecological site can exist as one or more states or community phases

2) State and transition models are repositories of synthesized science information and local knowledge

3) Guide development of management hypotheses and interpretation of assessment and monitoring data

4) Their focus should be on ecological processes underpinning responses to management and natural drivers

5) Monitoring is used to update models
State-and-transition models now feature standardized approaches for the production of narratives (not yet fully adopted)

1. Savanna state
   - 1.1 Reference community
   - 1.2 Another community
   - 1.3 At-risk community

2. Shrub-dominated state
   - 2.1 Community
   - 2.2 Community

3. Shrubland state
   - 3.1 Community

**Community phase**
- Bush muhly-creosotebush community

**State**
- Savanna state

**Community pathway**
- Winter-spring rainfall exceeds 100 mm

**Transition**
- Loss of perennial grasses and soil erosion that favors woody plant dominance and alters productivity

**Restoration pathway**
- Control of woody plants with clopyralid + triclopyr mixture followed by two growing season rest results in increased grass establishment
Narratives for states and communities contain indicator values and management strategies to promote resilience

Specific components of state descriptions

**Reference state**
Black grama-creosotebush savanna (historical + extant)

**Indicators/Diagnosis**
*Bouteloua eriopoda* >15% foliar cover, *Larrea tridentata* <12% foliar cover, little erosion

**Ecological Feedbacks**
Perennial grass continuity promotes soil and water retention and fire

**Management**
Summer grazing rest in drought, fire every 20 years

**Reference community phase**
*Bouteloua eriopoda* (15-60% foliar cover), *Larrea tridentata* (1-5% foliar cover)

**At-risk community phase**
*Bouteloua eriopoda* (3-5% foliar cover), large bare patches

**Alternative states**
Shrub-dominated, shrubland states
Narratives for transitions highlight the sequences of management conditions and events that lead to ecological thresholds.

Specific components of transition descriptions

Transition (T)
- **Slow variables and triggers**: Chronic heavy defoliation coupled to multi-year drought events
- **Threshold**: Black grama grass cover loss to < 3% and inability to recover continuity via vegetative growth

1. **Savanna state**
   - 1.1 Reference community
   - 1.2 Another Community
   - 1.3 At-risk community

2. **Shrub-dominated state**
   - 2.1 Community
   - 2.2 Community

3. **Shrubland state**
   - 3.1 Community
Ecological sites and state-and-transition models are developed through collaboration and include local knowledge

Photo courtesy of Emily Kachergis
Monitoring, management experiments, and historical reconstructions are used to develop transition and restoration narratives.

Altered grazing management

Shrub-specific herbicide
Ecological sites and state-and-transition models also rely heavily on inventory

Medium-intensity inventory within an area of gravelly soils and varying *Larrea* dominance.
Ecological sites and state-and-transition models also rely heavily on inventory

Different management histories (different states of the same ecological site)

Shrub cover never > 12% on high clay soils (a different ecological site)
Standardized measurement and indicator protocols associated with development and testing of models

*E.g.*, change in the basal cover of plants

**Line point intercept for plant cover**

**Basal gap intercept for large spaces between plants**
State-and-transition models can be used to create management hypotheses

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Specific management protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass cover is &gt; 15%, only small bare patches</td>
<td>Keep on doing what you’re doing, fire management if possible</td>
</tr>
<tr>
<td>Shrub savanna state</td>
<td></td>
</tr>
<tr>
<td>Shrub cover &gt;12%, few grass patches, interconnected bare areas</td>
<td>Summer grazing rest, shrub control to increase grasses</td>
</tr>
<tr>
<td>Shrub-dominated state</td>
<td></td>
</tr>
<tr>
<td>Shrub cover &gt;12%, absence of perennial grasses, eroded soil</td>
<td>Long-term rest to take, advantage of very rainy years, shrub control avoided</td>
</tr>
<tr>
<td>Shrubland state</td>
<td></td>
</tr>
</tbody>
</table>
The ecological site description report has four parts

**Physical Characteristics** -- Distinguishing physiographic, climate, soil, and hydrological features of the ecological site class, including variability within the class

**Vegetation Dynamics** – State-and-transition model narratives and data

**Interpretations** – Ecosystem services provided by the site and its states, currently focused on grazing uses and sometimes wildlife, but could be expanded

**Supporting Data** – Provides information on sources of information and data utilized in developing the site description
Maps of ecological sites and states specify where different interventions are needed in a landscape to attain particular services/values.
Landscape-level model-based restoration projects

1. Collaboration

What are the risks and known problems?

Where are they located?

At what scales must solutions be sought?

2. Ecological sites/state-and-transition models, indicators, and management practices

3. Maps of ecological sites and states

4. Apply intervention or do nothing

5. Monitoring to test models (did we cross a threshold or restore the desired species?)

6. Database results and modify models, collaborative learning

- 1. Grassland state
- 2. Savanna state
- 3. Shrubland state
- 1.1 Reference community
- 1.2 Another community
- 1.3 At-risk community
- 2.1 Community
- 2.2 Community
- 3.1 Community

- Ecological site: state map unit
- Mean mesquite canopy cover (%)
National-level updating and storage of information

**National databases**
- Soil Survey Geographic Database (SSURGO)
- National Soil Information System (NASIS)
- Ecological Site Information System (ESIS)

**Data**
- Soil map unit Components
- Ecological site classification
- State-and-transition models

**Planning**
- Soil map units translated to ecological sites
- Ecological states mapped or identified

**Testing at landscape level**
- Selection and test of restoration action
- Ecological site classification and state-and-transition model revision

**State or regional coordinators**