Defining and Evaluating Ecosystem Recovery

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Components of Ecosystem Recovery

- Eliminate invasive or reduce abundance to acceptable levels
- Restore or maintain sustainable ecosystems (native, native and introduced, agronomic)
Goal – Sustainable Ecosystems

- Retain characteristic processes
  - Geomorphic function
  - Hydrologic balance
  - Biogeochemical cycling (nutrient retention)
  - Biological activity and productivity
    (from Chapin et al. 1996; Christensen et al. 1996)

- Exhibit resistance and resilience
- Supply ecosystem services
Defining Recovery

- Type of ecosystem (abiotic & biotic characteristics)
- Stage of invasion
- Ecological condition (or site potential)
- Control/restoration approaches
Control/Restoration Approaches

- Preventative - maintain/increase ecosystem resistance and resilience
  - Remove stressor
  - Reinstate natural disturbance regime

- Control
  - Biological, chemical, etc.

- Control and Restoration
  - Control, site modification, revegetation
Defining Recovery – Stage of Invasion

- Management approaches and recovery measures vary depending on phase

- Phases of invasion
  - Lag or delay
  - Exponential increase
  - Slowed growth as species reaches bounds of new range
Carrying Capacity

Invader abundance

Q₀  C₀  C₁  C₂

Preventative and Control

Invasion

Control and/or Restoration

Time

(Hobbs and Humphries 1995)
Defining Recovery – Ecological Condition

- Species invasions are often triggered by disturbance or site degradation
- Alternative states and transition concepts can be used to -
  - Identify ecological condition
  - Evaluate current site potential
  - Determine appropriate control and restoration procedures
Alternative States and Transitions

- For given ecosystem type, multiple alternative states can exist
  
  - Change between states is often a result of natural and anthropogenic disturbance
  - Thresholds exist between the different states
  - When thresholds are exceeded changes in processes and/or structure result in new states adjusted to the altered factors or processes
Transition threshold controlled by biotic interactions

Recovery requires control & vegetation manipulation

Recovery requires removal of stressor/reinstatement of natural disturbance

Primary processes are mostly functional

Primary processes are nonfunctional or altered

Degradation

Modified from Whisenant 1999
A Demonstration Area on Ecosystem Response to Watershed Scale Burns in Pinyon-Juniper Woodlands

Joint Fire Sciences Program
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ARS
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Cumulative Increase in Trees Over Time

Underdown Canyon, Nevada (n = 15)

- Linear increase in tree density for all plots combined
- 2.0 trees/ac/year
- High tree density areas will increase from 3% to 45% in next 50 years
Live Fuel Loads Contributed by Pinyon Trees

### Underdown Canyon, Nevada (n = 15)

<table>
<thead>
<tr>
<th>Stand Density</th>
<th>Low</th>
<th>Mid</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tons/Acre</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foliage Biomass</td>
<td>2.2</td>
<td>5.3</td>
<td>10.1</td>
</tr>
<tr>
<td>1-Hour Fuels</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>10-Hour Fuels</td>
<td>¾</td>
<td>¾</td>
<td>¾</td>
</tr>
<tr>
<td>100-Hour Fuels</td>
<td>7.2</td>
<td>&gt; 35</td>
<td></td>
</tr>
</tbody>
</table>

- **Fine Fuels**: 2.2 > 10 tons/ac
- **Total Fuels**: 7.2 > 35 tons/ac
Effects of Trees on Understory Cover

Underdown Canyon, Nevada (n = 4)

- Trees 18 > 75%
- Shrubs 35 > 2%
- Forb + Grass 15 > 5%

Tree Density

Total Aerial Cover (%)
Low-Mid P-J Oversory/Sage - Grass Understory

- Fire
- Tree Seed Source
- No Fire Sage Seed

Sage - Grass

- Fire Proper grazing

Mid - Late P-J Overstory And/or Depleted Understory

- Increase in tree density and/or depletion of understory

Native annuals/Residual Grass - forb

- Fire
- Fire/Invasive Grass - forb

Invasive Annual Grasses/Perennial Forbs

- Fire/Invasive Seed Source

Preventative

Revegetation

Control Revegetation
Defining Recovery –

- Ecosystem type
- Stage of invasion
- Site/recovery potential >> Alternative State
Evaluating Recovery - Reference Area or Standard of Comparison

- Ecosystems that exhibit the desired processes or
- Technical publications of the soils and vegetations of the ecological site

- Problem is that restored area is often in an early successional stage & species composition often differs
  - Same environmental characteristics and site potential
  - Similar soil physical and chemical properties (and biota)
  - Comparable vegetation life forms
  - Information about resident & migratory animal species
  - Multiple years of data on variability and trend
Measures of Recovery

- Ideal is to examine ecosystem processes/function – in reality structure is measured

- Measures of recovery should provide information on -
  - The invasive species
  - The restored ecosystem
    - Abiotic characteristics
    - Biotic characteristics
  - The annual variability and long-term trend
Information on the Invasive

- High abundance at any life stage is a good predictor of the ability to invade

  - Seed Bank
  - Number of individuals of seedlings, juveniles, and adults
  - Abundance (density, biomass, cover) of invasive relative to species in the recovering ecosystem
  - Spatial distribution
Information on the Restored Ecosystem

- Abiotic
  - Surface infiltration; erosion
  - Soil physical properties (texture, bulk density)
  - Soil chemical properties (nutrient availability, site specific factors such as soluble salts)
  - Soil microbiotic communities
Information on the Restored Ecosystem

- Biotic – Vegetation
  - Seedling emergence & survival; transplant survival
  - Population turnover (natality and mortality)
  - Biomass/productivity measures
  - Cover
  - Species composition
  - Diversity
Information on the Restored Ecosystem

- Biotic – Animals
  - Single species or species groups
    - Population densities and turnover rates
  - Entire faunal community
    - Total number of resident and nonresident vertebrate species
    - Estimates of population and turnover rates within certain groups of species
Information on the Restored Ecosystem

- **Environmental**
  - Precipitation records
  - Disturbance events

- **Management actions**
  - Land use activities
  - Repeated treatments
Evaluating Recovery

- Measures of recovery -
  - The invasive species
  - The restored ecosystem
    - Abiotic characteristics
    - Biotic characteristics
  - The annual variability and long-term trend

- Reference areas or other standards of comparison can be used to help define goal and assess recovery