Degradation of Rangeland Ecosystems

NREM 612

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Degradation of Rangelands (RLs)

I. Terminology

A. First need to define types of Drylands

1. What are definitions of Drylands based on?

   veg. cover

   soil type & moisture

   Aridity Index (AI) = P / PET ratio, must be < 0.65
# 4 Main Dryland Types

<table>
<thead>
<tr>
<th>Type</th>
<th>Aridity Index</th>
<th>Vegetation</th>
<th>% Global Land Area</th>
<th>% RL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Subhumid</td>
<td>0.5-0.65</td>
<td>dry forests, woodlands, savannas, trees present</td>
<td>8.7</td>
<td>34</td>
</tr>
<tr>
<td>Semiarid:</td>
<td>0.2-0.5</td>
<td>grass, shrub veg. cover; too dry for regular rain-fed ag.</td>
<td>15.2</td>
<td>54</td>
</tr>
<tr>
<td>Arid</td>
<td>0.05-0.2</td>
<td>veg. sparse or absent; no seasons in which crops could be raised w/ natural rainfall</td>
<td>10.6</td>
<td>87</td>
</tr>
<tr>
<td>Hyper-arid:</td>
<td>&lt;0.05</td>
<td>veg. cover most unlikely (i.e. true desert)</td>
<td>6.6</td>
<td>97</td>
</tr>
</tbody>
</table>

*Based on data from dyped countries

(MEA 2005)
B. **Desertification** > 100 def.; degr. of ecosystems in drylands measured in ↓ of productivity or diversity (Barrow 1991)

1. Includes: ↑ in dist. to fuel wood (fuelshed);

2. ↓ of available H$_2$O due to ↓ river flow or GW;

3. encroachment of sand;

4. ↑ sedimentation, air pollution (UNEP 1977)

Process mediating desertification in arid grazing systems (Asner et al. 2004)
C. **Rangelands** (RLs): areas suitable for grazing livestock, in which veg. is predom. grasses, forbs*, shrubs, including areas **TOO**: dry, steep, wet, shallow, infertile, fragile to support forests or ag.

1. Prairies, savannas, shrublands, drylands, alpine communities, coastal marshes, wet meadows could all be RLs.
2. Types of RLs

- Semi-arid Grasslands
- Desert Shrublands
- Alpine Meadows
- Savanna Woodlands
Grazing intensity at which ecosystems become degraded changes with bioclimatic setting, with greater impacts in very dry & very humid settings (Asner et al. 2004)
D. **Pasture**: intensively-managed grazing areas in humid climates or similar irrigated areas in arid/semiarid climates

1. tillage when needed

2.
E. Grazing vs OVERgrazing

1. Grazing
   a. Moderate herbivory often beneficial, ↑ veg cover, diversity (Oba 2000)
   b. plants that evolved w/ herbivory dvped survival strategies

2. Overgrazing causes
   a. compaction, ↓ productivity
   b. ↓ plant & litter cover, ↑ wind erosion
   c. ↓ infiltration, ↑ H₂O erosion
d. Changes in spatial arrangements of nutrients, plants, H₂O

i. Loss of diversity

ii. Shift to comm dominated by toxic, spinescent spp (Milton et al. 1994)

iii. Islands of fertility: ↑ nutrients, H₂O, & ↓ temp. below shrubs (Schlesinger et al. 1990)
II. RLs exhibit non-equilibrium behavior (DeAngelis & Waterhouse 1987)

A. **Unpredictable variability** in productivity due to variability in?

1. In a given year,
2. **Ex:** Sahel

1950-1960: wet years

1969-1997: dry years

1983-1984: severe drought

3. Pastoral cultures suited for variability

   a. Strategy (Barrow 1991)

      i. **follow rain**: avoid droughts, bring stock to productive areas

      ii. **use multispecies herds**: diversified spp, diff. tolerances to drought

   b. Tends to ↓ degr:

      i. herds not in 1 place long enough to cause permanent damage

      ii. diff. herbivores graze on diff. plant species
III. Current Status of RLs

A. Few early records of RL conditions (Milton et al. 1994)

   1. Climatic variability makes it difficult to det. whether RLs:

      a. continue to degrade

      b. remain stable

      c. are improving (Pickup et al. 1998)
B. Extent: Grazing systems cover 25% of global land area (33 M km²) (Asner et al. 2004)

1. Countries w/ most land area in grazing (M km²):
   Australia (4.4); China (4.0); USA (2.4); Brazil (1.7), Argentina (1.4)

2. Countries w/ highest % grazing land:
   Mongolia (80%), Botswana (76%), Uruguay (76%)

3. Countries w/ highest stocking rates (AU km⁻²):
   Malaysia (320), India (272), N. Korea (213), Vietnam (184)

   a. AU = n(cows+buffalo) + 0.2n(sheep+goats) + 1.2 n(horses+ camels)
C. DL Population

1. *How many people currently live in DLs?*

2. 72% of dryland area in dving countries, 28% in dvped
D. Wide range of Degradation/Desertification estimates

1. ~33% of land surface threatened by desertification (Barrow 1991)

2. 70% of dryland’s suffer from desertification (Drenge & Chou 1992) – Overestimation (MEA 2005)

3. 20% of world’s drylands suffer from soil degr. (Middleton & Thomas 1997)

4. Medium certainty that 10-20% of drylands suffer from degradation (MEA 2005)
IV. Economic Value of Eco. Services

A. Grasslands provide $906 billion (US) yr⁻¹ or

1. $232 ha⁻¹ yr⁻¹ (Constanza et al. 1997)

2. services: food prod., waste treatment, erosion control, recreation

3. What about drylands?
V. Causes of RL Degr.

Common theme: Usu. involves damage to veg. cover (Barrow 1991)

A. Natural Factors

1. Physical events: droughts, pest outbreaks, fires, ENSO, etc.
B. Human-Induced Factors

1. Population pressure

   a. Degr. blamed on growth of human & livestock pops

   b. Major cause = overgrazing by cattle, sheep, goats
      i. Accounts for 1/3 of all desertif. (B&W 1999)
      ii. Prevalent in drylands of Sahel, SW US

   c. **Caveat:** areas of low human pop density (i.e. Austr, SW US) experience degr. due to overstocking
2. Economic

   a. Herders have little incentive to sell excess stock:

      i. due to middlemen & taxes

      ii. herd: more concrete form of wealth than $,

   b. Consolidation of ranches
c. Livestock market fails to provide incentives for conservation

i. tax incentives make high-density grazing an attractive prop.

ii. cost of RL beef not linked to carrying cap. or Δs in eco. services
3. Land Tenure

a. Ownership: communal land, individual herd = Tragedy of Commons
4. Social/Cultural

a. Herd size assoc. w/ wealth & social standing

   i. herders keep as many animals as possible despite assoc. degr.
b. Recreation: Popularity of off-road vehicles

i.
5. Political

a. Nomadic pops. often “marginalized” due to dist. from centers of decision making, transient lifestyle

b. Gov’t efforts to “SEDENTARIZE” people & stock

   i. sinking of wells, est. of food dist., health centers, hold pastoralists in single location, when better strategy is to be OPPORTUNISTIC, follow rainfall (Oda et al. 2000)
c. Gov’t imposes **mandatory** stocking rates → overgrazing Austr. (Diamond 2004)

d. Taxes on unproduct. land in S. Africa provide perverse incentive to graze (Milton et al. 1994)
e. Misdirected aid projs. (US AID, World Bank, FAO) invested millions of $ in RL mgmt. in Africa on projects that have generally failed (Oba et al. 2000)

Why?


a. Overgrazing $\rightarrow$ ↓ veg cover, ↑ compaction, only drought-tolerant, hearty inv. spp. can revegetate RLs

b. Inv. spp often more spinescent, toxic (alkaloids) to grazers
VI. Models for RL Mgmt

A. Range Succession Model (Sampson 1917, Stoddard & Smith 1943)

1. Equilibrium model--Clements

2. Climax state

3. Grazing pressure in opposite direction

4. Successional/grazing equilibrium =

5. 1° model for RL mgmt (Westoby et al. 1989)
(Westoby et al. 1989)
6. Stocking Rate

a. **Moderate** stocking rates usu. give greater long-term returns than heavy stocking rates

7. Limitations

a. Veg. $\Delta$s in response to grazing not always: continuous, reversible, consistent (Westoby et al. 1989)
B. State-&-Transition Model

1. Non-equilibrium--Gleason

2. Transitions triggered by nat. events (weather, fire) mgmt. actions (change stocking rate), or both

3. Westoby et al. (1989) allow for:
   a. alternative stable states
   b. discontinuous & irreversible transitions
   c. non-equilibrium communities & stochastic effects
(Westoby et al. 1989)
4. Model proposed as way to organize info for mgmt.

5. Model should influence research, policy, & mgmt. to:
   
   a. drop assumption that conservative grazing is safe

   b. inform managers of transition opportunities or threatening hazards & how to respond

(Westoby et al. 1989)
VII. RL/Pasture Mgmt. Systems

A. **Continuous**: allow livestock access to pasture during grazing season, w/ little to no recovery

   i. w/ low-mod. stocking, suitable for bermudagrass, Kent. bluegrass, ryegrass, & tall fescue
B. **Rotational**: placing fences so livestock graze only part of pasture at a time
Rotational grazing pasture system
C. **Deferred**: delay start of grazing beyond normal period

1. *Why?* permits spp likely to be damaged to become more vigorous & produce seed

2.
VIII. Some RL/Pasture BMPs

A. Seek local-input, & dvp culturally-sensitive mgmt options

B. Consider non-eqlb. models, multiple stable states

C. Adjust stocking rate by season, precip.

D. Leave 50% of forage for reserve & residue

E. Use rot., def., & multi-species grazing