Managing succession in rangelands

Optional Reading: Westoby et al., 1989, Opportunistic Management for Rangelands not at Equilibrium,
J Range Management 42:266-274

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Degradation of rangelands has prompted research into restoration

- Loss of species diversity, especially of palatable plants
- Loss of ecological productivity
  - Fewer species are less resilient
  - Reduced potential to support herbivores
  - More bare ground
- Soil erosion
- Non-native species invasion
- Loss of economic potential

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Ecological Restoration

- Restoration of degraded rangelands can be more successful if the causes of succession and their driving mechanisms are identified
  - Non-native species invasion?
  - Disturbance/soil erosion?
  - Overstocking?
- Integrating evaluation of ecosystem structure and function also increases the probability of successful restoration
- Changing views of succession in rangelands is improving management approaches

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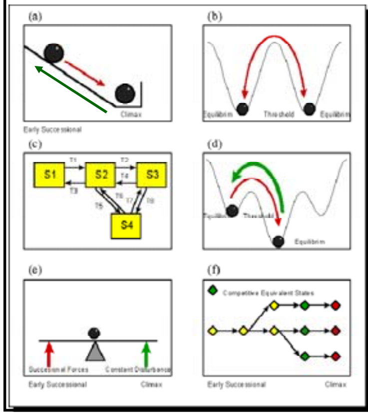
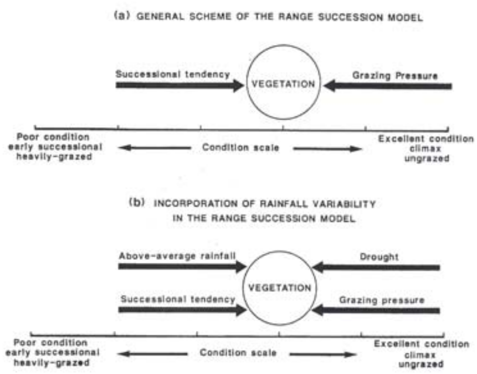
Successional Models: disturbance and equilibrium



a) Classic Clementsian succession
b) Alternative stable states
c) State and transition model
d) Threshold concept w/ hysteresis
e) Constant disturbance
f) Stochastic model

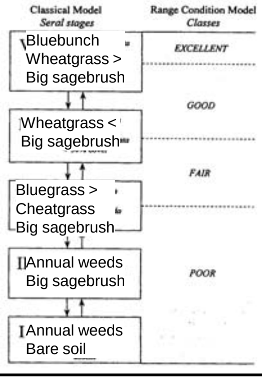
D. Lockwood, unpubl.

Classic succession applied to rangelands



Westoby et al. 1989

An example of Clementsian model from southern Oregon sagebrush steppe



Assumption: Changes in seral stages and range condition are linear, predictable and reversible by altering stocking rates

Classical model can be used to define broad, descriptive categories

Not very useful for site-specific management or restoration

Allen-Diaz & Bartolome, 1998

Limitations of the Clementsian model

- Demographic inertia
  - Episodic recruitment prevents establishment of species at predicted time
- Grazing catastrophe
  - Selection on certain species may eliminate them
- Competition from invasive species
- Fire feedbacks
  - Grasses increase fire frequency and are promoted by fires
- Soil feedbacks
  - Erosion, loss of seedbank, protective crust, compaction, etc.

Alternative to Clementsian Succession: State-transition model

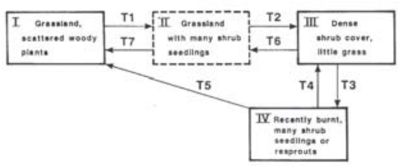


Fig. 4. State-and-transition diagram for Example 2: Semi-arid grassland/woodland in eastern Australia with potential for increase of shrubs. Catalogues in Box 2.

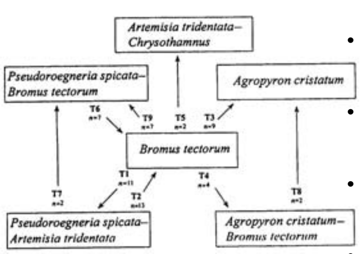
Transitions are recognized as drivers of succession

Result in change of state

T1, good rainfall; T2, decades of shrub growth; T3, fire; T4, resprouting of shrubs; T5, no resprouting shrubs; T6, fire with good shrub recruitment; T7, increased fire frequency or grazing removes most shrubs

Westoby et al. 1989

State-transition model for sagebrush steppe in Oregon



- This model was based on extensive, long-term dataset
- Transitions (such as T1) not always dependent on management
- “Proper” management did not always produce desired result (T2)
- Some transitions reversible, others not

Allen-Diaz & Bartolome, 1998

Different stable states may occur when transitions cross thresholds

- Climate thresholds
  - Warming experiment favored sagebrush over forbs, reduced rangeland productivity
  - Heat wave increased pinyon pine susceptibility to drought, increased mortality
- Increasing atmospheric CO_2
  - Favors C3 over C4 grasses
  - Increased seed production and recruitment of invasive annual grasses

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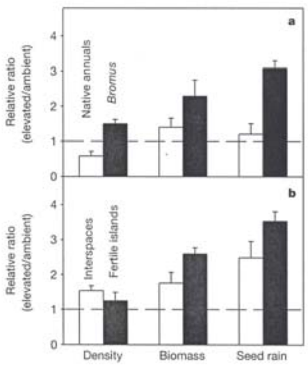
Elevated CO_2 and thresholds



- Elevated CO_2 promoted invasive red brome in southern Great Basin
- Recruitment occurred after a wet El Nino winter
- Invasive species grew better and produced more seeds than natives

Smith et al., Nature, 2000 11

Hydrological threshold:
Removal of shrubs by fire reduced snow retention and favored cheatgrass

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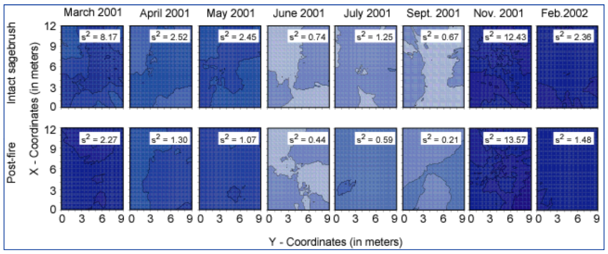
Cheatgrass decreased soil moisture patchiness; fewer "safe sites" for sagebrush recruitment



Cheatgrass *(B. tectorum)* interacted with fire to cause threshold change in sagebrush steppe, leading to new stable state

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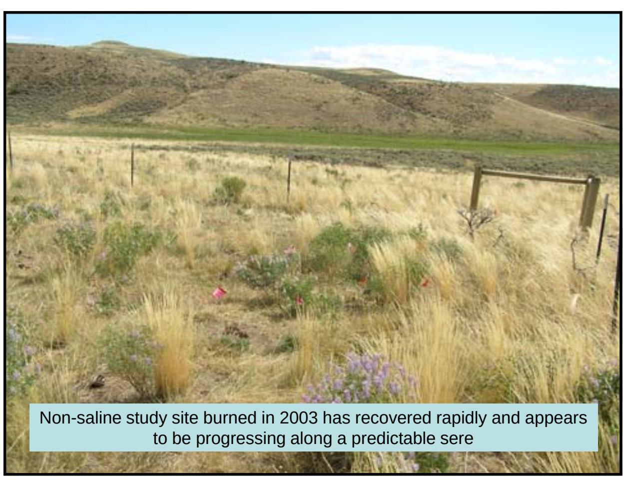
Obrist et al. Plant & Soil 2004



Understanding the causes of succession helps guide management

- Site availability
  - Disturbance alters the biotic (competitors, facilitators) and abiotic (resource availability) characteristics of sites
- Species availability
  - Dispersal; propagule pool
- Species performance
  - Life history traits
  - Ecophysiology
  - Facilitation, inhibition, stress tolerance

The role of disturbance: Site availability

- Disturbance tends to be viewed as a major cause of invasion by non-native plants
- Westoby et al. (1989) suggest that disturbance is an opportunity to shift plant community composition to a more desirable state
- Example: shallow tillage may help discourage leafy spurge and dalmation toadflax

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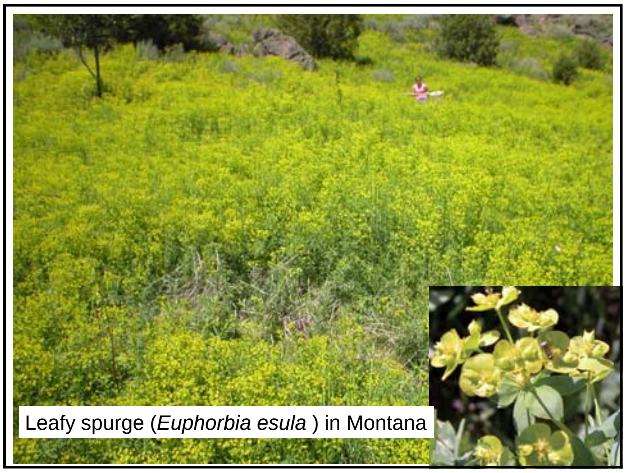
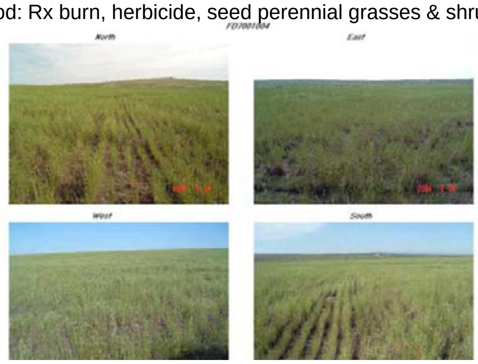


Leafy spurge (*Euphorbia esula*) in Montana

The role of dispersal: Species availability

- It may be very difficult (impossible!) to prevent dispersal of weed seeds
- By contrast, dispersal of desirable species can be managed
  - Seed bed preparation by creating large depressions trapped most seeds and favored survival of sagebrush seedlings
- "Assisted succession" = revegetation by broadcast seeding, drilling, etc.

Cheatgrass dominated sagebrush steppe restoration:
Goal: reduce cheatgrass, improve sage grouse habitat
Method: Rx burn, herbicide, seed perennial grasses & shrubs



http://www.blm.gov/nhp/spotlight/sage_grouse/success/fuel_reduction.htm

The role of species performance: life history, stress tolerance, competition

- Life history of cheatgrass: rapidly growing annual producing LOTS of seeds
  - Removing adults prior to seed set is a key to reducing spread
- Biotic and abiotic stressors may promote native species succession and filter out r-strategists like cheatgrass
  - Carbon-rich soil amendments tie up nutrients and reduce weed establishment
- Assisted succession uses competitive introduced grasses (crested wheatgrass) to improve establishment of native grasses

Ecosystem structure and function change during succession

- Structural attributes:
  - Species composition, functional groups, cover and height of vegetation, patchiness, etc.
- Functional attributes:
  - Productivity, nutrient availability, presence of mutualists, hydrologic functionality, etc.
- Managers are realizing that restoration is more successful when an integrated approach is taken