Rangeland ecology: Key global research issues & questions

Robin Reid[1] and Maria Fernandez-Gimenez[2]
[1]Director, Center for Collaborative Conservation
[1]Senior Research Scientist, Natural Resource Ecology Lab
[2]Associate Professor
Colorado State University, Fort Collins, Colorado, USA

Global Issues and Questions in Rangeland Ecology

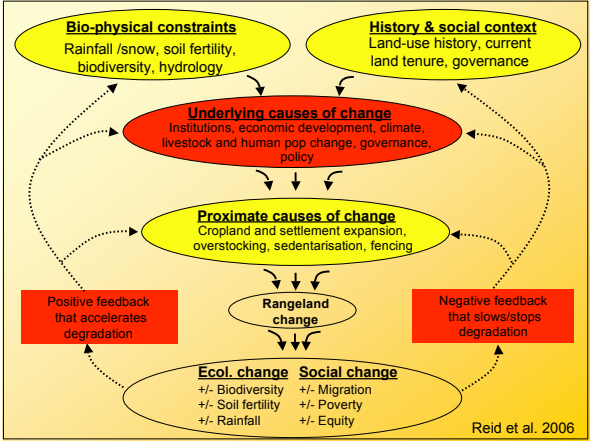
- Despite the focus here on global issues, we need to recognize that Mongolia is the home of many of the advancements in our knowledge about rangelands

What we will cover today

In this short presentation, we cannot cover all of the global questions about rangeland ecology

We will focus on:

- Causes of rangeland change
- General viewpoints (paradigms) of the dynamics of rangelands (equilibrium / non-equilibrium)
- Models of how rangelands change (range succession and state-and-transition models)
- A possible future for Mongolia? Landscape fragmentation in rangelands



Why should we seek to understand the dynamics of pastoral ecosystems?

'Unless pastoral ecosystem dynamics are considered and used as guidelines for development policies, interventions are likely to be random activities which comprise development by trial and error, a practice with unfortunate implications for the ecosystems and people on which these "development experiments" are performed.'

p. 458, Ellis and Swift 1988

Two main viewpoints in the debate about how rangeland systems function

The equilibrium view / paradigm

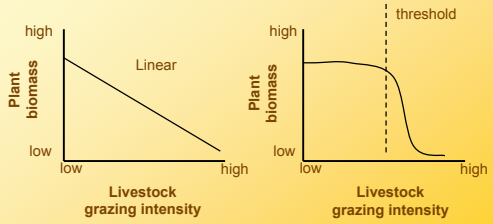
- Every rangeland has a set vegetation 'carrying capacity', determined by rainfall and soils, which determines how many livestock it can support
- Vegetation response to grazing is linear and reversible, and herders can manage vegetation by changing the number of animals they graze
- When grazing is too heavy, it can decrease the ability of the range vegetation to support livestock in the future

Two main viewpoints in the debate about how rangeland systems function

The non-equilibrium view / paradigm

- Dry rangelands have no set 'carrying capacity'; this varies widely according to rainfall
- Vegetation response to grazing can be non-linear and irreversible, and herders *cannot* manage vegetation by changing the number of animals they graze
- Grazing rarely becomes too heavy because frequent droughts or winter storms prevent livestock populations from growing too large
- Because of this, livestock rarely decrease the ability of the range vegetation to support livestock in the future

Linear and non-linear change, and thresholds in rangelands



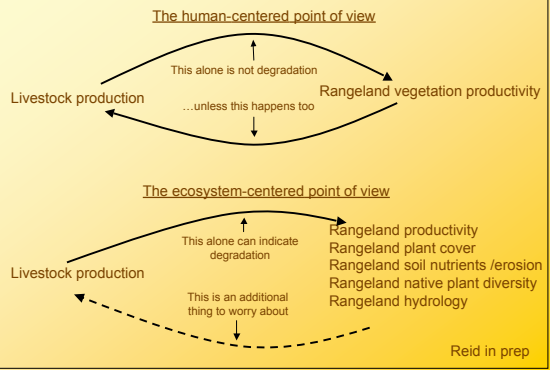
What is the most controversial part of these viewpoints?

If rangelands follow the non-equilibrium viewpoint, then herders and their livestock rarely degrade rangelands

So, do livestock degrade rangelands or do they not?

- In wet, semi-arid rangelands, much research suggests degradation is possible, but, if reversible, these rangelands can recover quickly
- In arid rangelands, research is mixed, sometimes livestock do and sometimes they do not degrade rangelands. Degradation may occur more often in wetlands or riverine corridors. Here, it often depends on how heavy and continuous the grazing is. Some of these rangelands are quite resilient to grazing.
- But, this also depends on how 'degradation' is defined, from whose viewpoint, the scale under consideration, and by what measure

For example, human values affect what observers think is degradation in rangelands



Reid in prep

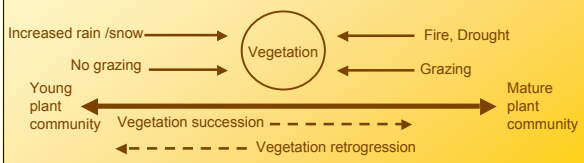
Models that explain how rangelands change

Range succession / condition model

State-and-transition model

Range succession / condition model

- Assumes that vegetation change is linear, continuous and reversible
- Assumes that all disturbances /stresses that modify vegetation have similar effects (like grazing, fire, drought, winter storms)

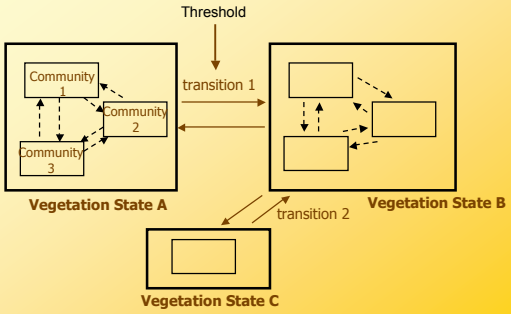


Dyksterhuis 1949

Problems with the range succession / condition model

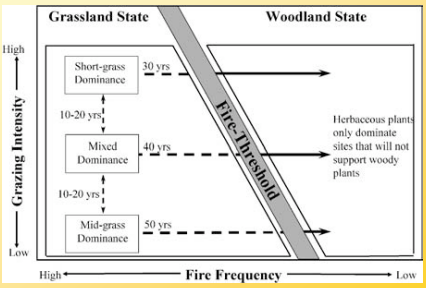
- Sometimes, it fails to predict what happens when a grazing or fire or another disturbance is removed
- It predicts only one vegetation endpoint, rather than the multiple vegetation endpoints that are often possible in a particular place
- Does not tell us about many other aspects of rangelands that are important like water, biodiversity, erosion potential, nutrient cycling
- Change is measured against an historical mature (climax) community that with climate change may not exist
- Grazing was considered to be an external disturbance rather than part of the rangeland

State & Transition Model



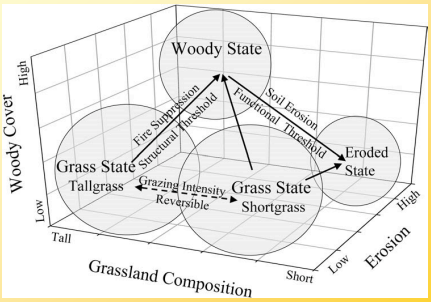
Bestelmeyer et al. 2003

Here, a fire threshold separates a grassland and a woodland state. Transitions among the three grassland communities on left are reversible by changing grazing intensity.



Fuhlendorf and Smeins 1997

Different states of rangelands, as measured by the cover of woody plants, the types of grass and the amount of soil erosion



Briske 2005, Bestelmeyer 2003, Stringham 2001

State & Transition Models:

- Improve on the Range Succession / Condition model because:
  - Non-linear change is possible
  - Irreversible change is possible
  - Multiple vegetation states are possible
  - Different causes of change (like grazing, fire, drought, winter storms) can have different effects
- Do not replace range succession / condition models, but provide another tool that strengthens these models
- Are very useful for bringing together local, traditional and scientific knowledge

There are multiple and interacting causes and consequences of rangeland conversion and fragmentation

Causes → **Processes** → **Consequences**

Causes
- Livestock population growth
- Human population growth (intrinsic, migration)
- Human development
- Land tenure and settlement policies
- Technology
- Conflict and revolution
- Markets
- Disease
- Climate (drought, CC)

Processes

Rangeland / habitat conversion
- Cropland
- Settlement (rural and urban)
- Infrastructure (roads, railways)
- Impermeable fencing
- Land tenure rules
- Protected area establishment

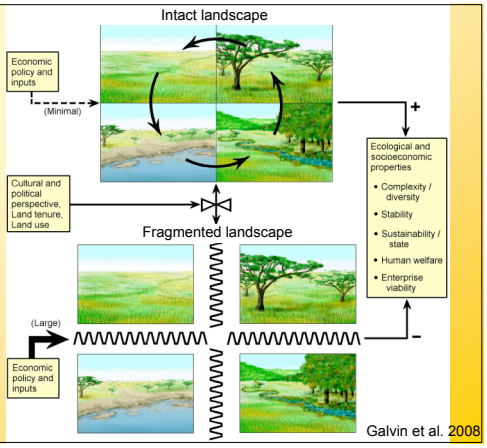
Rangeland / habitat modification
- Wood collection
- Charcoal making
- Hunting
- Grazing
- Permeable fencing
- Fires
- Droughts

Rangeland / habitat fragmentation
- Permanent fragmentation as a result of processes under loss above
- Temporary fragmentation as a result of processes under modification above

Consequences
- Population loss or species extinction
- Change in hydrology
- Change in the movement of individuals and pathogens
- Change in genetic variation in populations
- Change in primary and secondary productivity
- Change in nutrient and water cycling
- Change in greenhouse gas emissions and carbon sequestration

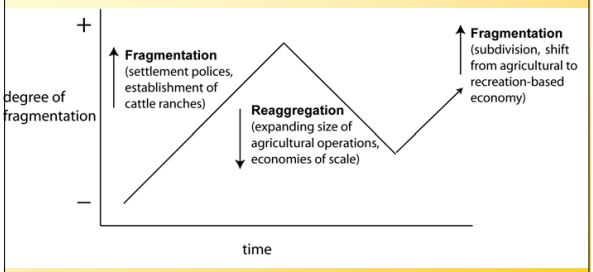
Reid et al 2004

Intact landscapes allow livestock to move to reach diverse vegetation types that they need in different seasons. Intact landscapes support more livestock per hectare.



Galvin et al. 2008

Over time, people can both fragment and un-fragment rangelands



Lackett et al 2008

Global Questions in Rangeland Ecology (1)

- What are the major causes of rangeland change and how do these causes interact?
- What are the management objectives of users of rangelands? Does livestock grazing causes undesirable change in rangelands (like lower plant productivity, fewer native plants, reduced stream flow)?
- Do these feedback on the livestock? In other words, does livestock grazing affect rangeland productivity to the extent that future livestock grazing suffers?
- At what level of grazing do these changes begin to occur?

Global Questions in Rangeland Ecology (2)

- If grazers are removed, does the rangeland recover to the pre-grazed state or are grazers causing irreversible change? Is this change undesirable (= degradation) and from whose point of view?
- How does livestock grazing interact with climate and land use to influence the state of rangelands?
- What mix of local, traditional and scientific indicators of change are most useful to measure the health of the rangeland?
- At broader scales, what are the forces driving fragmentation in rangelands and what policies can slow down this process?

Literature in this presentation (1)

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Literature in this presentation (2)

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Some definitions

- Carrying capacity is the upper limit of forage (grass, shrubs) that livestock can graze and still sustain the productivity of the range for the subsequent seasons.
- Plant community: a homogeneous group of plants that occurs at a particular point in place and time
- Disturbance: a change (often temporary) in grazing, fire, or other factors that causes a major change in an ecosystem (in this case, a range plant community)
- Plant succession: a reasonably predictable and orderly change in the composition (types of species) and structure of plant communities over time, in the absence of major disturbance
- Plant retrogression: a reversal of plant succession

State and Transition Model Definitions

- **State**: An alternative, persistent vegetation / soil community with a unique vegetation structure, biodiversity & management requirements.
- **Transition**: A shift between states that is not reversible just by removing livestock or another disturbance; it requires significant labor or capital to be reversed.

State and Transition Model Definitions

- **Threshold:** An irreversible, non-linear change between states, such that one or more primary ecological processes has been irreversibly changed and must be actively restored before a return to a previous state is possible.