Towards More Efficient Regulatory Design for Ecosystem Management in the Great Basin: Private Ranchers, Public Rangeland, and the Control of Invasive Weeds

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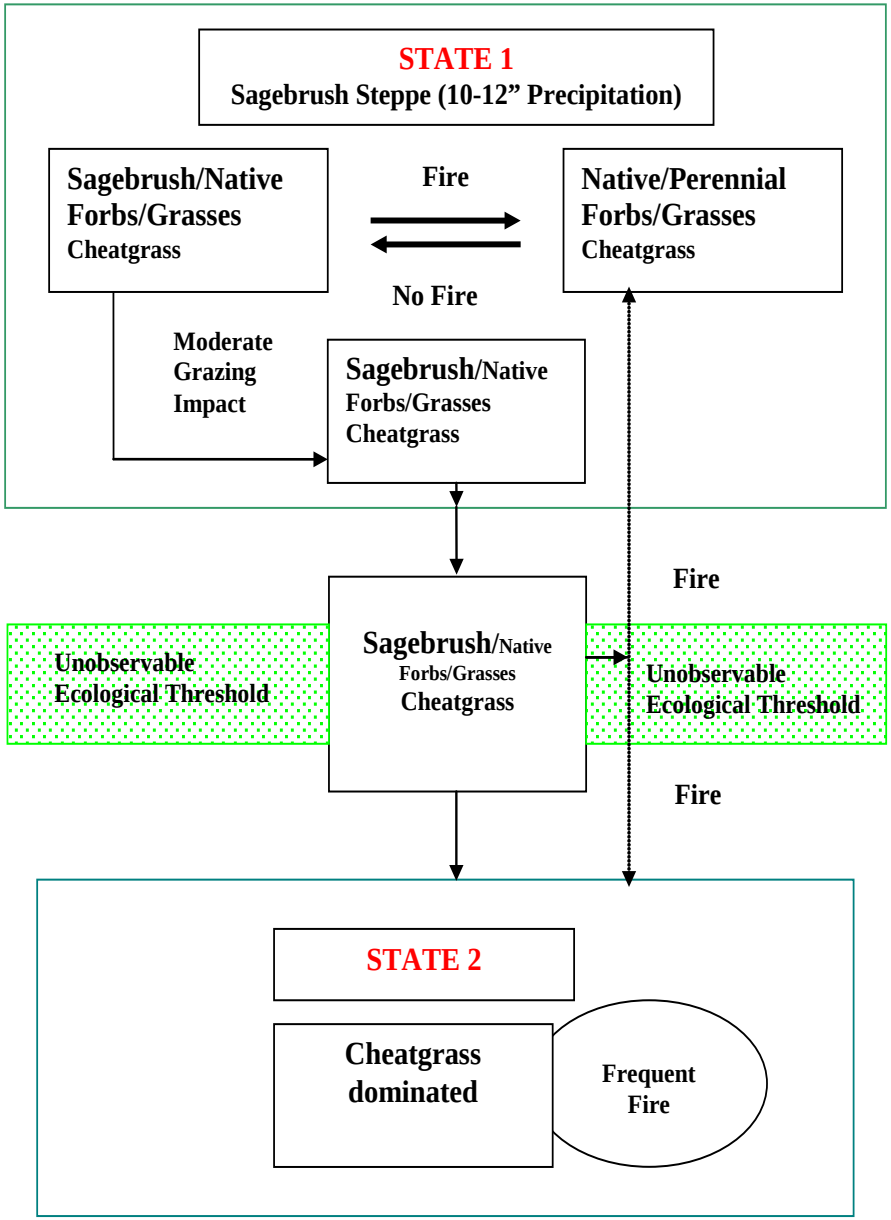
Kimberly Rollins, Mimako Kobayashi, and Mike Taylor
University of Nevada, Reno

Outline

- Description of rangeland invasive annual grass problem
- Briefly description and summary of results of 4 models that together characterize decision problems related to management of public rangelands in the west
  - Dynamic process of invasive plant species spread
  - Stochastic wildfires
  - Private users operating on public lands
- Next steps
  - Extend the models for policy design
  - Investigate use of indicators of rangeland health as signals for use in performance contracts


STATE 1
Sagebrush Steppe (10-12” Precipitation)
Sagebrush/Native Forbs/Grasses Cheatgrass
Fire
No Fire
Native/Perennial Forbs/Grasses Cheatgrass
Moderate Grazing Impact
Sagebrush/Native Forbs/Grasses Cheatgrass
Fire
Unobservable Ecological Threshold
Sagebrush/Native Forbs/Grasses Cheatgrass
Unobservable Ecological Threshold
Fire
STATE 2
Cheatgrass dominated
Frequent Fire

4 rangeland management models

1. SDP(1): solve for optimal livestock herd and management strategy
   - Basis for other models
2. SDP(q): extends SDP(1) to recognize 3 rangeland states
   - Transition across thresholds
3. PA(1): means to achieve the social optimum
   - Based on SDP(q)
   - Numerical solution of incentive payments
4. PA(2): regulator's problem: performance or input based policy/contracts
   - When regulator faces a budget constraint

Stochastic Dynamic Programming Model of Private Rancher: SDP(1)

Dynamic optimization for cow-calf operations and fuel treatment with stochastic fire, cheatgrass, social planner vs rancher

- Model structure:
  - Rancher chooses: herd size & land treatment acreage
  - Constraint: fixed grazing land acreage
  - Dynamics: cattle reproduction & fuel growth
- Predict producer response to cheatgrass-induced changes in rangeland condition (not 'state')
  - Direct loss through reduced forage quality and quantity
  - Indirect loss through increased fire frequency and size
  - Connects vegetation (rangeland ecology) & fuel (fire science)
- 3 rangeland states
  - Model parameters altered to reflect different levels of rangeland state, i.e. productivity and fire regimes

Stochastic Dynamic Programming Model of Private Rancher: SDP(1)

- Policy exercises:
  - Herd management, cow-calf operation: more cheatgrass → all else equal, less profitable
  - Cost of treatment: needs to be sufficiently low for ranchers to adopt treatment
  - Size of grazing area: flexibility from larger size reduces incentives to invest in invasives management & increases rate of return

SDP(1) model limitation

- Heavy grazing, wildfire and accumulation of invasives cause rangeland ecosystems to transition to steady state dominated by invasive annuals
- Lighter grazing and use of treatment can improve rangeland condition - move away from transition

SDP(1) does not include impact of grazing and treatment on transitions between rangeland state

- So treatment is undervalued relative to “true” value
- This assumption may be closer to the rancher’s knowledge about range ecology relative to the land manager’s knowledge.
  - e.g. Huffaker and Cooper

Private vs. social: 3 aspects

1. Whether or not transition between rangeland states are taken into consideration in decision making
2. Marginal impacts on fire regime:
   - Rancher bears the cost of reduced rangeland availability
   - Part of the marginal impact of rancher actions on fire regime is external to the private problem = fire suppression costs
3. Society (public) pays more at the margin for worsened ecosystem
   - The marginal impact of the rancher's decision on all other goods and services produced from rangelands are valued by others' in society.
   - Results from a pilot survey: about $40 per household per year (for a specific change of double fires or half fires) (**Kobayashi, Rollins and Evans 2010**).

SDP(q)

- Variable q represents rangeland states in continuum
- SDP(1) extension to treat transition in rangeland states as endogenous
  - Different regions of q are governed by different dynamics
- Complexity of modeling
  - SDP(q) is numerically solved, as is SDP(1)
  - A trial version is running
- Analytical work also in progress
  - Limited treatment of biophysical relationships
  - Phase diagrams give insights on optimal dynamic paths
  - This work will be presented in upcoming AERE meetings

Principal-Agent, PA(1)

- SDP(q) to solve social planner's problem
- Next step: How can social planner's solution be achieved under biophysical uncertainty and information asymmetry between public land manager and private land users?
- PA(1) is based on SDP(q)
  - Policy instruments that induce good behavior by private users
  - To be solved numerically
- Additional information on signals is needed to complete PA(1)
  - Signals that are correlated with private actions and rangeland state
  - Value of signals
    - Next step is to identify criteria for selecting indicators of rangeland state for use as signals in reward/penalty contracts

PA(2) – Regulation on Public Rangelands
Introduction and Research Questions

- Regulation of Public Rangelands
  - Model analyses regulatory design on public rangelands
  - Compares input mandate (e.g., AUM restrictions), cost-sharing/taxation (e.g., grazing fees), and performance (output) regulation (e.g., changes in grazing restrictions based on monitoring)
  - Externalities: Wildlife habitat, frequency and severity of wildfires, soil erosion and watershed health, recreation
- Questions
  - How have regulator's informational and institutional constraints shaped existing regulation on public rangelands?
  - Under what conditions are AUM restrictions be part of an efficient regulatory regime?

PA(2) – Regulation on Public Rangelands Regulator's Constraints

- Informational Constraints
  - Rancher better informed than the rancher about ranch-level ecological conditions
  - Rancher's actions not perfectly observable by regulator
  - Detailed monitoring of ecological state is infeasible
- Institutional Constraints
  - Budget constraint
  - Level of penalty assessed to the rancher

PA(2) – Regulation on Public Rangelands Summary of Results

- Input Mandate (e.g., AUM restrictions)
  - Preferred if the regulator has a relatively strict budget constraint or if monitoring yields a is relatively uninformative signal of how the rancher's actions influence rangeland health
  - Does not achieve first-best if unobserved inputs also influence ecosystem health or if the rancher has private information
- Cost-Sharing/Taxation (e.g., grazing fees)
  - Non-Binding Budget Constraint: Similar to an Input Mandate
  - Binding Budget Constraint: Expected welfare increasing in the regulator's budget
- Performance Regulation (e.g., changes in grazing restrictions based on monitoring)
  - Gives ranchers the incentive and flexibility to use private information
  - Efficient when monitoring yields a is relatively informative signal of how the rancher's actions influence rangeland health

PA(2) – Regulation on Public Rangelands

Summary of Results: Joint Use of Regulatory Instruments

- Input-Mandate and Performance Regulation
  - Improves welfare when the performance measure provides a poor signal of the influence of the observed input (e.g., AUMs) on ecosystem health
  - Holechek (1988) finds that grazing restrictions are efficient when monitoring provides a poor signal for how livestock grazing influences rangeland health
- Cost-Sharing/Taxation and Performance Regulation
  - Unambiguously improves welfare when used in combination over either instrument used individually

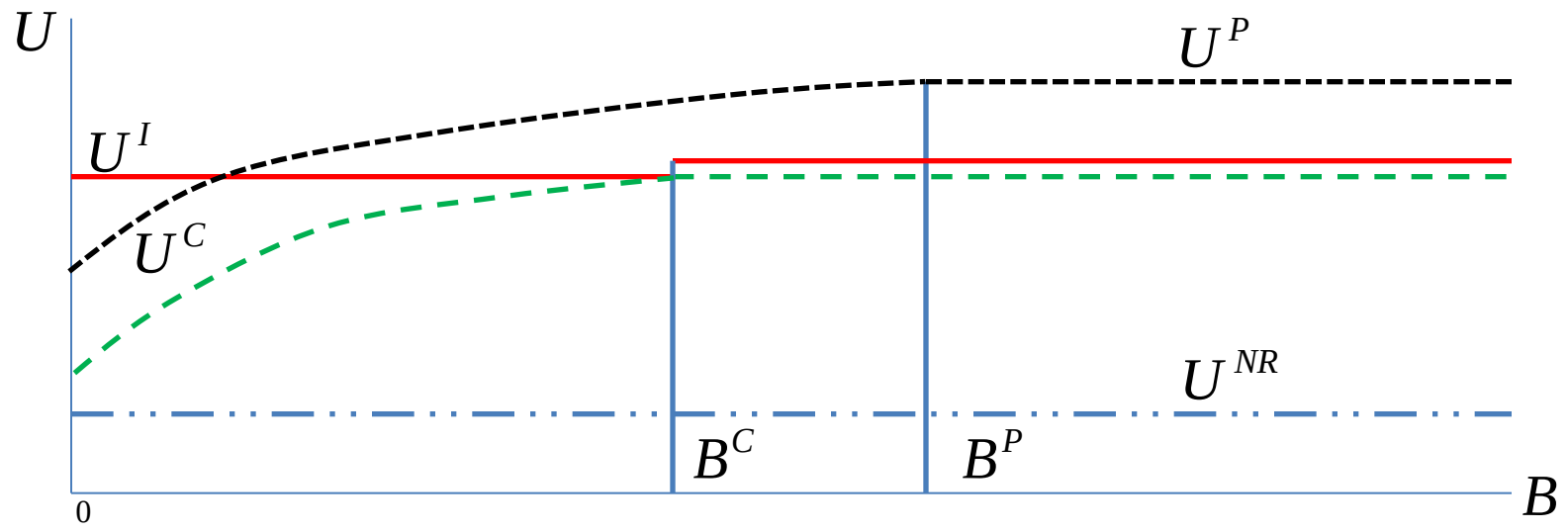
Next Steps

- Complete SDP(q)
- Research on signals in include in contract design – Exploring the use of data being monitored as indicators for rangeland condition
- Complete PA(1)
- Policy analysis

PA(2) – Regulation on Public Rangelands

Relative Efficiency of Three Regulatory Instruments

Case 1: Performance Regulation Dominates for Large Values of Regulator's Budget



PA(2) – Regulation on Public Rangelands

Relative Efficiency of Three Regulatory Instruments

Case 2: Cost-Sharing / Input Mandate Dominates for Large Values of Regulator's Budget