Managing and Restoring Landscape Resilience

Wood River Channel and Wetland Restoration Project, Oregon

Sources:
The Resilience Alliance: http://www.resalliance.org/1.php
ESA Restoring Resilience in Social –Ecological Systems: http://www.ecologyandsociety.org/issues/view.php?sf=22

Resilience: diversity with a purpose

What is ecosystem resilience?

- Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes.
- A resilient ecosystem can withstand shocks and rebuild itself when necessary.
- Resilience in social systems has the added capacity of humans to anticipate and plan for the future.

What is ecosystem resilience?

"Resilience" as applied to ecosystems, or to integrated systems of people and the natural environment, has three defining characteristics:

- The amount of change the system can undergo and still retain the same controls on function and structure
- The degree to which the system is capable of self-organization
- The ability to build and increase the capacity for learning and adaptation

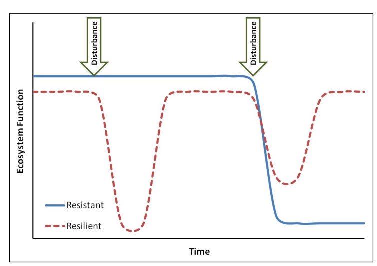
Resilience is…

- the ability to absorb disturbances, to be changed and then to re-organize and still have the same identity (retain the same basic structure and ways of functioning). It includes the ability to learn from the disturbance. A resilient system is forgiving of external shocks.
- As resilience declines, the magnitude of a shock from which it cannot recover gets smaller and smaller.
- Management for resilience shifts attention from purely growth and efficiency to additional characteristics of recovery and flexibility.

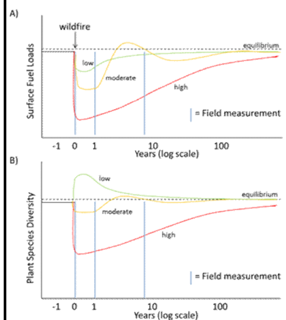
Resistance vs Resilience

- **Resilient** ecosystems have the capacity to *regain* their fundamental structure, processes, and function following disturbance & stressors.
- **Resistant** ecosystems have the ability to *retain* their fundamental structure, processes, and function (or remain largely unchanged) despite disturbance and stressors.

Resistance vs. Resilience



Hypotheses for Burn Severity



- Surface fuel accumulation will be highest and fuel treatment effectiveness lowest following moderate severity burns where most but not all of the overstory trees are killed and fine canopy fuels are not consumed.
- Recovery of plant species diversity to pre-fire levels will be slowest in large, severe fire patches.

Catastrophic Shifts in Ecosystems- when resilience is lost

- When resilience is lost or significantly decreased, a system is at high risk of shifting into a qualitatively different state (which often is undesirable).
- Restoring a system to it's previous state can be complex, expensive, and sometimes impossible. Research suggests that to restore some systems to their previous state requires a return to environmental conditions well before the point of collapse.
- Even in the absence of disturbance, gradually changing conditions, e.g., nutrient loading, climate, habitat fragmentation, etc., can surpass threshold levels, triggering an abrupt system response.

How is resilience lost?

The resilience of social-ecological systems (SES) depends largely on underlying, slowly changing variables such as climate, land use, nutrient stocks, human values and policies.

Resilience can be degraded by a large variety of factors including:

- Loss of biodiversity
- Biological invasive species
- Novel or altered disturbance regimes
- Toxic pollution
- Subsidies that encourage unsustainable use of resources
- A focus on production and increased efficiencies that leads to a loss of diversity and redundancy

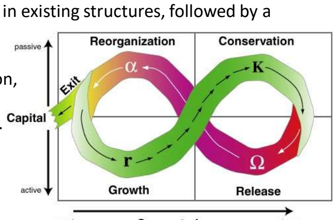
How is resilience enhanced?

- Natural systems are inherently resilient. Their capacity to cope with disturbance can be degraded but also enhanced.
- The key to resilience in social-ecological systems is diversity. Diversity plays a crucial role by providing **functional redundancy**.
- For example, in a grassland ecosystem, several different species will often commonly perform nitrogen fixation, but each species may respond differently to climatic events, thus ensuring that even though some species may decline, the process of nitrogen fixation within the grassland ecosystem will continue.

Adaptive cycles

Social-ecological systems, like all systems, are never static, and they tend to move through four, recurring phases, known as an adaptive cycle

r) rapid growth phase through to a
K) conservation phase in which resources are increasingly unavailable, locked up in existing structures, followed by a
Ω) release phase that quickly moves into a phase of reorganization, and then into
α) another growth phase.



Adaptive Capacity

- Adaptive capacity in ecological systems is related to genetic diversity, biological diversity, and the heterogeneity of landscape mosaics (Carpenter et al. 2001a, Peterson et al. 1998, Bengtsson et al. 2002).
- Systems with high adaptive capacity are able to re-configure themselves without significant declines in functions in relation to primary productivity, hydrological cycles, social relations and economic prosperity.
- A consequence of a loss of resilience and adaptive capacity, is loss of opportunity, constrained options during periods of re-organization and renewal, an inability of the system to do different things.

(Gunderson and Holling 2002, Folke et al. 2002)

Resilience is key to enhancing adaptive capacity

Are there elements that sustain adaptive capacity of social-ecological systems in a world that is constantly changing?

- Addressing how people respond to periods of change, how society reorganizes following change, is the most neglected and the least understood aspect in conventional resource management and science
- Learning to live with change and uncertainty;
- Nurturing diversity for resilience;
- Combining different types of knowledge for learning; and
- Creating opportunity for self-organization towards social-ecological sustainability.

(Gunderson and Holling 2002, Folke et al. 2002)

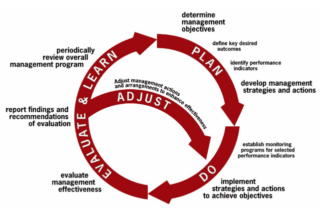
Transformability

In cases where a system is already in an undesirable regime and efforts to get it back into a desirable regime are no longer possible, one option for resolving the predicament is transformation to a different kind of system - new variables, new ways of making a living.

Adaptive Cycles in Management

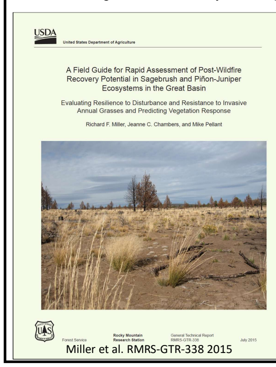
- Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties.
- It uses management as a tool not only to change the system, but as a tool to learn about the system.
- It is concerned with the <u>need to learn and the cost of ignorance</u>, while traditional management is focused on the need to preserve and the cost of knowledge.

The Adaptive Management Cycle



http://www.reefresilience.org/coral-reefs/management-strategies/measuring-effectiveness-and-adaptive-management/adaptive-management/

Evaluating Resilience to Disturbance & Resistance to Invasive Annual Grasses in Sagebrush and Pinyon-Juniper Ecosystems of the Great Basin


USDA United States Department of Agriculture

A Field Guide for Rapid Assessment of Post-Wildfire Recovery Potential in Sagebrush and Piñon-Juniper Ecosystems in the Great Basin

Evaluating Resilience to Disturbance and Resistance to Invasive Annual Grasses and Predicting Vegetation Response

Richard F. Miller, Jeanne C. Chambers, and Mike Pellant

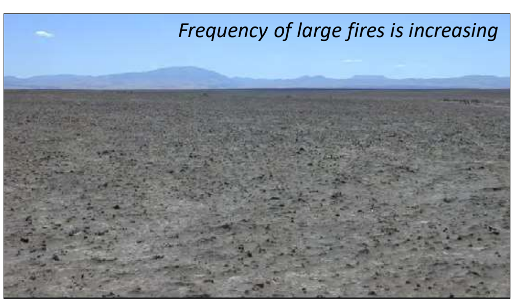
Miller et al. RMRS-GTR-338 2015


Rangeland Ecology & Management

Using Resilience and Resistance Concepts to Manage Persistent Threats to Sagebrush Ecosystems and Greater Sage-grouse

Chambers et al. 2017

How can we maintain <u>resilience to fire</u> and <u>resistance to invasion</u> in Great Basin sagebrush ecosystems?



Field Guide Focus

- How resistant and resilient is the current area?
- What could we do to make it more <u>resistant to invasion and resilient to disturbance</u>?

Not so much a guide for designing post-fire restoration/rehabilitation treatments; more focused on creating resistant and resilient systems

Many questions arise post-fire

Burned Area Emergency Response (BAER) and Emergency Stabilization and Recovery (ES&R) teams

1. What is the resilience (recovery potential) of the ecological sites in the burned area?
2. How resistant is the area to invasive annual grasses?
3. How susceptible is the burned area to erosion?
4. What areas within the burn perimeter need seeding and are/or suitable for treatment?

Post-fire rehabilitation options

- Do nothing
- Drill seeding
- Aerial seeding
- Seed mix options
  - Native
  - Non-native
  - Source of seed

Factors that impact resistance & resilience and treatment options

Is post-fire seeding needed? What kind?

Primary drivers of resistance and resilience

1) characteristics of the ecological site
2) vegetation composition and structure prior to the wildfire

Modifiers

3) fire severity
4) post-wildfire weather
5) post-wildfire management, especially grazing
6) monitoring and adaptive management

Primary components

	Primary Components	Key Questions
1	Ecological Site Characteristics	Temperature regime? Moisture regime? Potential vegetation? Suitable for seeding?
2	Current Vegetation	Reference state & phase (seral state)? Invaded state or phase-at-risk? Invasive species seed source? Need to seed? Old-growth woodland or woodland phase?
3	Wildfire Severity	Intensity & duration? Crown or surface fire? Size and complexity? Time of year? Surface disturbance?
4	Post-Wildfire Weather	Fuel loads and moisture? Seed banks? Post-treatment establishment? Recent drought?
5	Post-Wildfire Grazing	Deferment period? Active management?
6	Monitoring & Adaptive Management	Were the objectives met? If not, what adjustments or follow-up management are required?

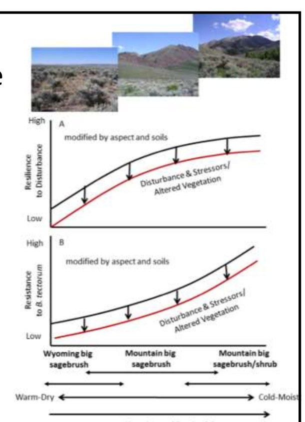
Potential Vegetation on Ecological Sites

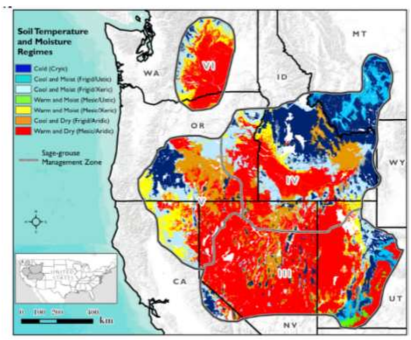
Describe *dominant* shrubs, grasses, and common forbs

- Climate, topography, soils
- Soil temperature/moisture regime
- Soil processes
- Vegetation dynamics

Big sagebrush ecosystems in the Great Basin

- ❑ Resilience to disturbance increases with elevation and precipitation but can be modified by aspect and soil characteristics
- ❑ Resistance to cheatgrass increases with elevation and precipitation but is also modified by aspect and soil characteristics.





Factors that impact resistance & resilience and treatment options

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Post-fire vegetation composition

is a function of

- Pre-fire vegetation composition and structure
  - Cover and density of shrubs, grasses, forbs
  - Annual grass abundance
- Fire severity
  - Areas with > 15% shrub cover often burns with higher severity
- Post-wildfire herbivory
- Weather

Why does pre-fire shrub cover matter?

Fire Severity Indicators

Low severity	Moderate severity	High severity
>75% burned sagebrush skeletons remaining	15 to 75% burned sagebrush skeletons remaining	Sagebrush basal stumps remain or burned below the soil surface
<25% tree foliage dead, <15% foliage consumption	25 to 75% tree foliage dead, 15 to 50% foliage consumed	>75% tree foliage dead, >50% consumed
Tree duff blackened but little consumed	Majority of tree duff consumed, surface blackened	White ash layer beneath tree canopy
>2 inches blackened stubble remains on burned grasses	0.25 to 1 inch blackened stubble remains on burned grasses	Grass crowns consumed to or below the surface
Unburned patches >50%	Unburned patches 15 to 50%	Unburned patches <15%
Interspace litter consumption <50%	Interspace litter consumption 50 to 80%	Interspace litter consumption >80%, white ash deposition
Shrub canopy litter consumption <50%	Shrub canopy litter consumption 50 to 80%	Shrub canopy litter consumption >80%, white ash deposition
Minimal ash, ground fuels blackened and recognizable	Thin layer of black to gray ash, some litter recognizable	Layer of powdery gray or white ash, >90% surface organics consumed
No fire-induced water repellency	Weak to medium water repellency at or just below the surface	Strong water repellency at or below the surface
Surface soil structure Unchanged	Surface structure slightly to not altered	Aggregated stability reduced or destroyed, surface loose and/or powdery
Cheatgrass seeds common with minimal signs of consumption outside of pre-fire shrub canopies	Cheatgrass seeds few to moderately abundant outside of pre-fire shrub canopies, seed consumption variable	Cheatgrass seeds sparse both inside and outside of pre-fire shrub canopies, seed consumption nearly complete

Soil and litter indicators are derived from Parson and others (2010).

Factors that impact resistance & resilience and treatment options

1) characteristics of the ecological site
2) vegetation composition and structure prior to the wildfire
3) fire severity
4) post-wildfire weather
5) post-wildfire management, especially grazing
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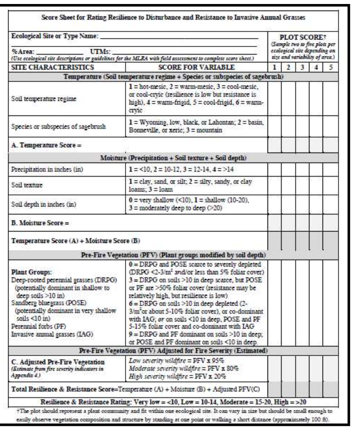
Score sheet

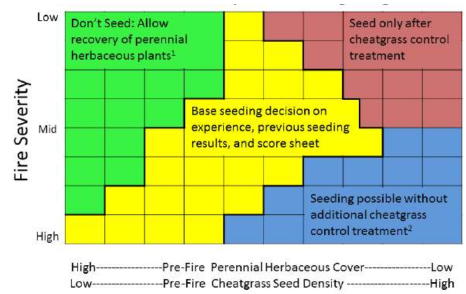


Score Sheet for Rating Resilience to Disturbance and Resistance to Invasive Annual Grasses						
Ecological Site or Type Name: ____ %Area: ____ UTMs: ____ *(Use ecological site descriptions or guidelines for the MLRA with field assessment to complete score sheet.)*		PLOT SCORE† *(Sample two to five plots per ecological site depending on size and variability of area.)*				
SITE CHARACTERISTICS	SCORE FOR VARIABLE	1	2	3	4	5
Temperature (Soil temperature regime + Species or subspecies of sagebrush)						
Soil temperature regime	**1** = hot-mesic, **2** = warm-mesic, **3** = cool-mesic, or cool-cryic (resilience is low but resistance is high), **4** = warm-frigid, **5** = cool-frigid, **6** = warm-cryic					
Species or subspecies of sagebrush	**1** = Wyoming, low, black, or Lahontan; **2** = basin, Bonneville, or xeric; **3** = mountain					
A. Temperature Score =						
Moisture (Precipitation + Soil texture + Soil depth)						
Precipitation in inches (in)	**1** = <10, **2** = 10-12, **3** = 12-14, **4** = >14					
Soil texture	**1** = clay, sand, or silt; **2** = silty, sandy, or clay loams; **3** = loam					
Soil depth in inches (in)	**0** = very shallow (<10), **1** = shallow (10-20), **3** = moderately deep to deep (>20)					
B. Moisture Score =						
Temperature Score (A) + Moisture Score (B)						
Pre-Fire Vegetation (PFV) (Plant groups modified by soil depth)						
Plant Groups: Deep-rooted perennial grasses (DRPG) (potentially dominant in shallow to deep soils >10 in) Sandberg bluegrass (POSE) (potentially dominant in very shallow soils <10 in) Perennial forbs (PF) Invasive annual grasses (IAG)	**0** = DRPG and POSE scarce to severely depleted (DRPG <2-3/m² and/or less than 5% foliar cover) **3** = DRPG on soils >10 in deep scarce, but POSE or PF are >50% foliar cover (resistance may be relatively high, but resilience is low) **6** = DRPG on soils >10 in deep depleted (2-3/m² or about 5-10% foliar cover), or co-dominant with IAG; *or* on soils <10 in deep, POSE and PF 5-15% foliar cover and co-dominant with IAG **9** = DRPG and PF dominant on soils >10 in deep, or POSE and PF dominant on soils <10 in deep.					
Pre-Fire Vegetation (PFV) Adjusted for Fire Severity (Estimated)						
C. Adjusted Pre-Fire Vegetation *(Estimate from fire severity indicators in Appendix 4.)*	*Low severity wildfire* = PFV x 95% *Moderate severity wildfire* = PFV x 80% *High severity wildfire* = PFV x 20%					
Total Resilience & Resistance Score=Temperature (A) + Moisture (B) + Adjusted PFV(C)						
Resilience & Resistance Rating: Very low = <10, Low = 10-14, Moderate = 15-20, High = >20						

†The plot should represent a plant community and fit within one ecological site. It can vary in size but should be small enough to easily observe vegetation composition and structure by standing at one point or walking a short distance (approximately 100 ft).

Miller et al. RMRS-GTR-338 2015

Post-Fire Recovery and Seeding Diagram



[1] Reseeding with shrubs may be appropriate depending on rehabilitation objectives.

[2] It is assumed that high fire severity associated with increased sagebrush canopy cover (>15%) decreases cheatgrass seed density through consumption and mortality.

Ecological site is a cool-mesic/aridic Wyoming big sagebrush/bluebunch (10 – 12" PZ) south of Rome, OR, at 5,000 ft. Native herbaceous vegetation prior to the burn was probably severely depleted to absent, and the presence of a sagebrush canopy was unknown.

The treated area was drill seeded in the fall following the fire to native grasses.

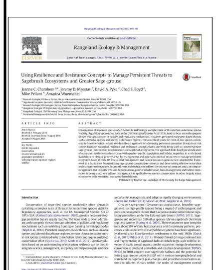
9 years later, the seeded area is 23% cover of native deep-rooted perennial species and 65% cheatgrass.

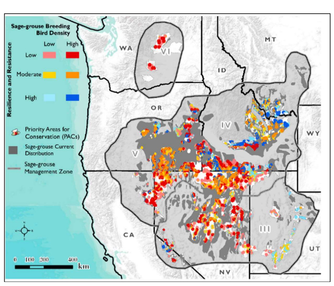
The unseeded area is 7% native deep-rooted perennial and 69% cheatgrass.

Seeding is not always necessary

Mtn big sagebrush, loamy, 12-16 inch PZ
Burned in wildfire in July 2007, picture from June 2009

Using Resistance and Resilience Concepts to Manage Persistent Threats to Sagebrush Ecosystems and Greater Sage-grouse





Chambers et al. 2017

Resistance to invasion by cheatgrass

What variable was the best predictor of cheatgrass cover (invasive annual grass) in Wyoming big sagebrush steppe?

a) Crested wheatgrass cover (Introduced perennial bunchgrass)

b) Sandberg bluegrass cover (Native shallow-rooted perennial bunchgrass)

c) Total cover of all native bunchgrasses

d) Average annual temperature

Bowman-Prideaux 2018

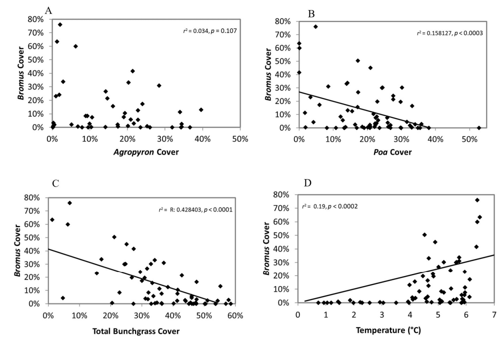


Figure 2 Scatter plots showing linear regression plotted for the effect of the proportion of cover for *A. cristatum* (A), *P. secunda* (B), all bunchgrass species, excluding *P. secunda*, (c), and PRISM average minimum annual temperature (D) on *B. tectorum* cover.

Bowman-Prideaux 2018

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