

Decision-support Tools to Increase the Resilience and Resistance of Sagebrush Ecosystems

Jeanne Chambers, Research Ecologist

US Forest Service, Rocky Mountain Research Station

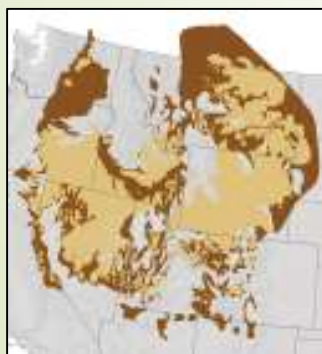
jchambers@fs.fed.us

Resilience and Resistance Tools

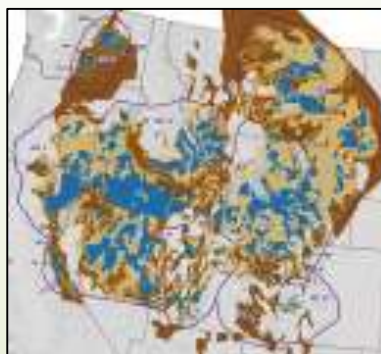
Provide the science basis and management applications for a strategic, multi-scale approach that enables us to:

- Assess and prioritize areas for management
- Determine effective management strategies

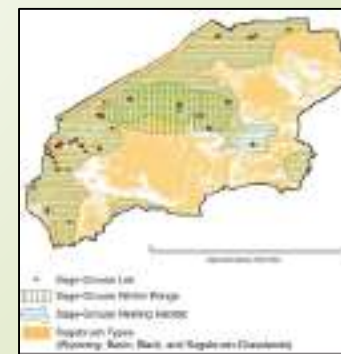
Sagebrush biome

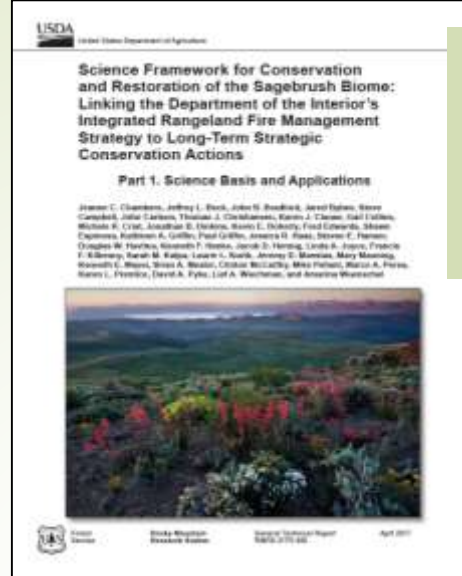


Sage-Grouse MZs and ecoregions

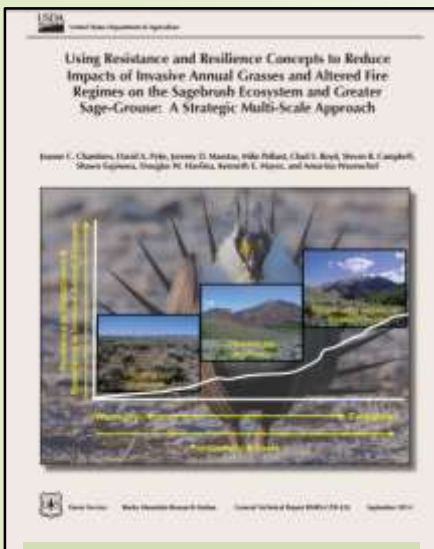


Local and site planning areas

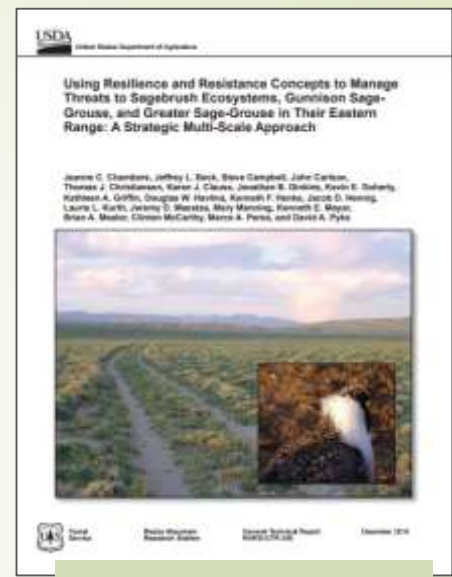




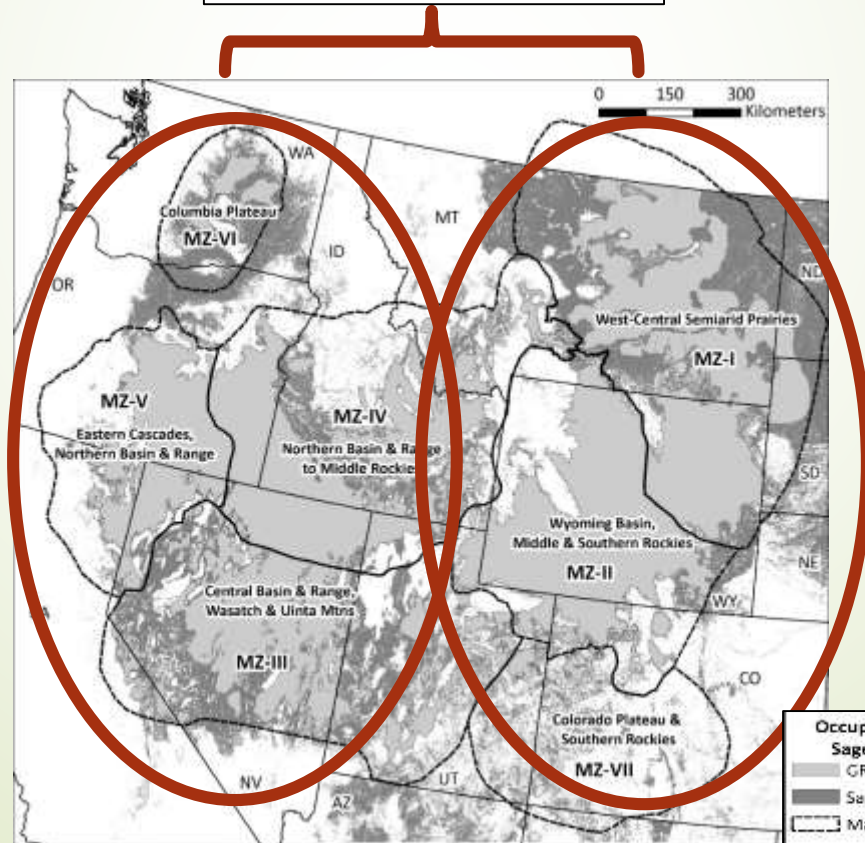
2017
“The Science Framework”
GTR-360



2014
Western Range
GTR-326



2016
Eastern Range
GTR-356



Occupied Range and Sagebrush Biome
 GRSG Occupied Range
 Sagebrush Biome
 Management Zones (MZs)

Science Framework for Conservation and Restoration of the Sagebrush Biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to Long-Term Strategic Conservation Actions

Part 2. Management Applications

Editors

**Karen Prentice, Michele Crist,
Jeanne Chambers, Lief Wiechman, Sue Phillips**



Rocky Mountain
Research Station

General Technical Report
RMRS-

In process

Management Applications for Science Framework

- Adaptive Management and Monitoring
- Climate Adaptation
- Wildfire and Vegetation Management
- Nonnative Invasive Plant Management
- National Seed Strategy Concepts
- Livestock Grazing Management
- Wild Horse and Burro Considerations
- Integration & Trade-offs

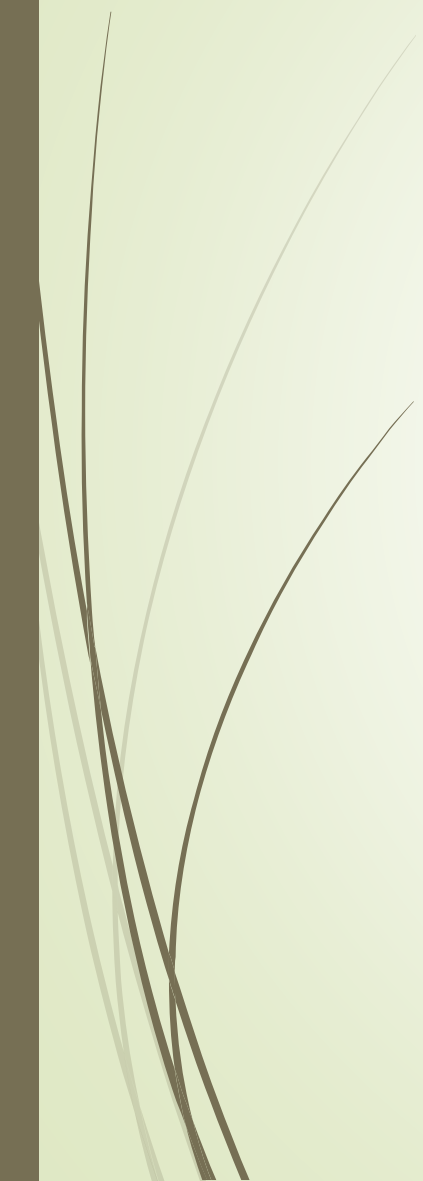
WAFWA-led Sagebrush Conservation Strategy



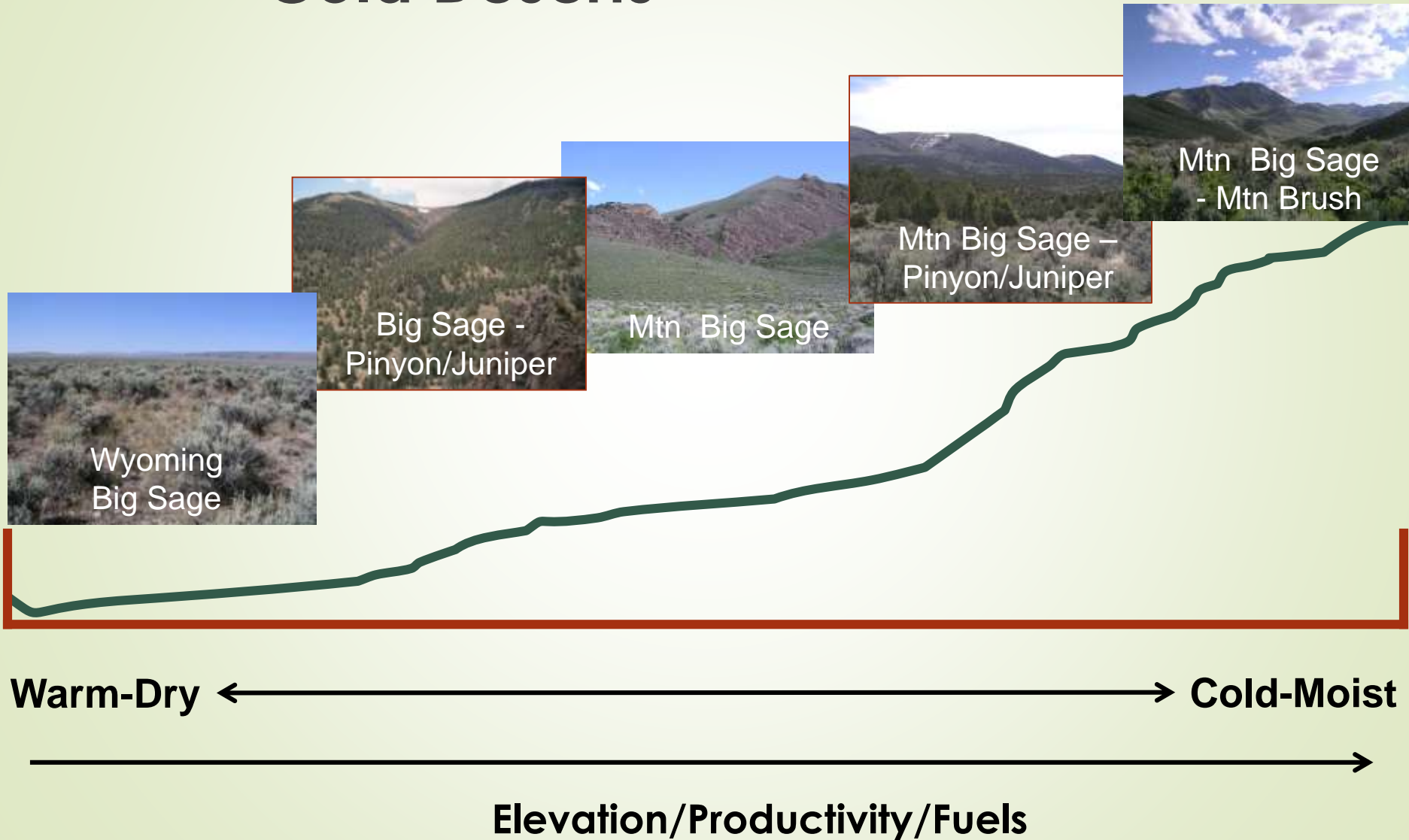
- Joins the Sagebrush Science Initiative & Science Framework
- Focuses on managing sagebrush ecosystems as a whole
 - 350 species of some conservation concern
 - Can't deal with them one at a time
- Maintains momentum of sage-grouse work
- Builds on WAFWA science products and Science Framework



A Strategic, Multi-Scale Approach

- 1) Develop an understanding of ecosystem resilience and resistance for the planning area
 - 2) Identify key habitat indicators
 - 3) Assess dominant threats to the planning area
 - 4) Use the sagebrush R&R habitat matrix to inform management decisions
 - 5) Delineate focal habitats/areas for management
 - 6) Determine the most appropriate management strategies
- 

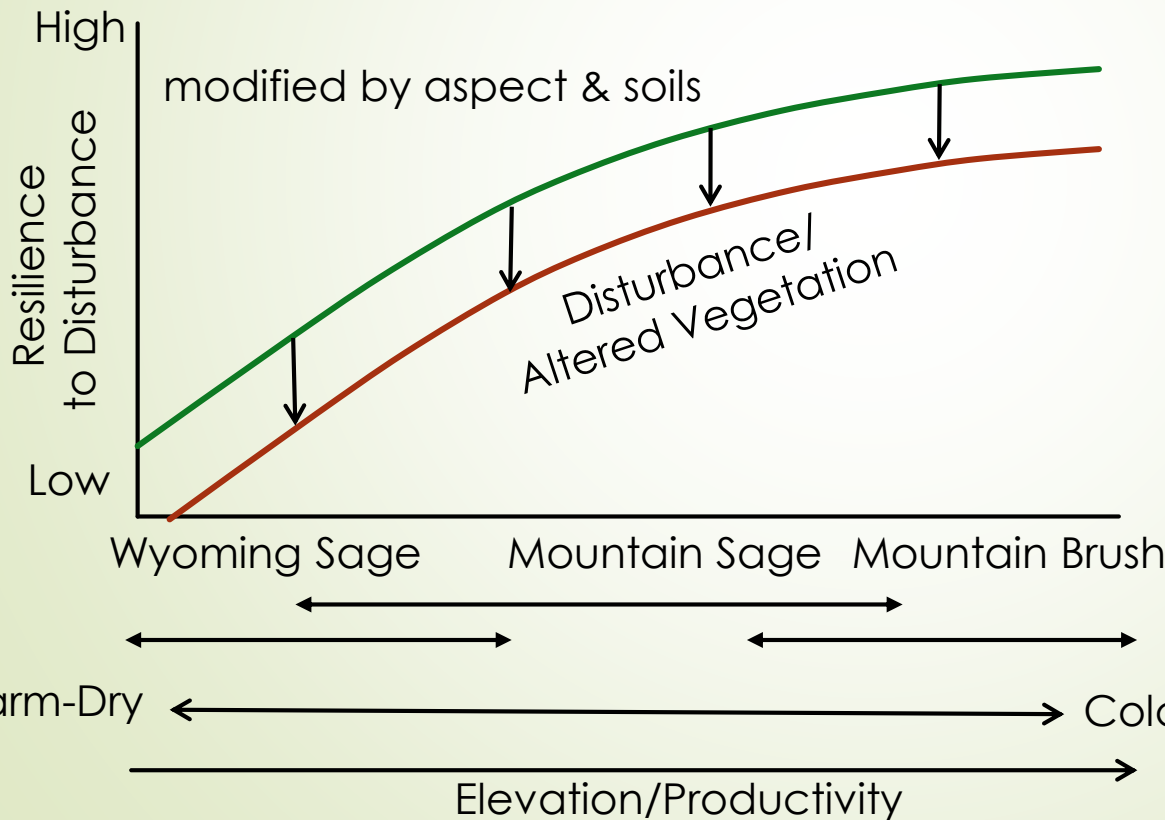
Environmental Gradients Cold Deserts



Resilience to Disturbance Cold Deserts

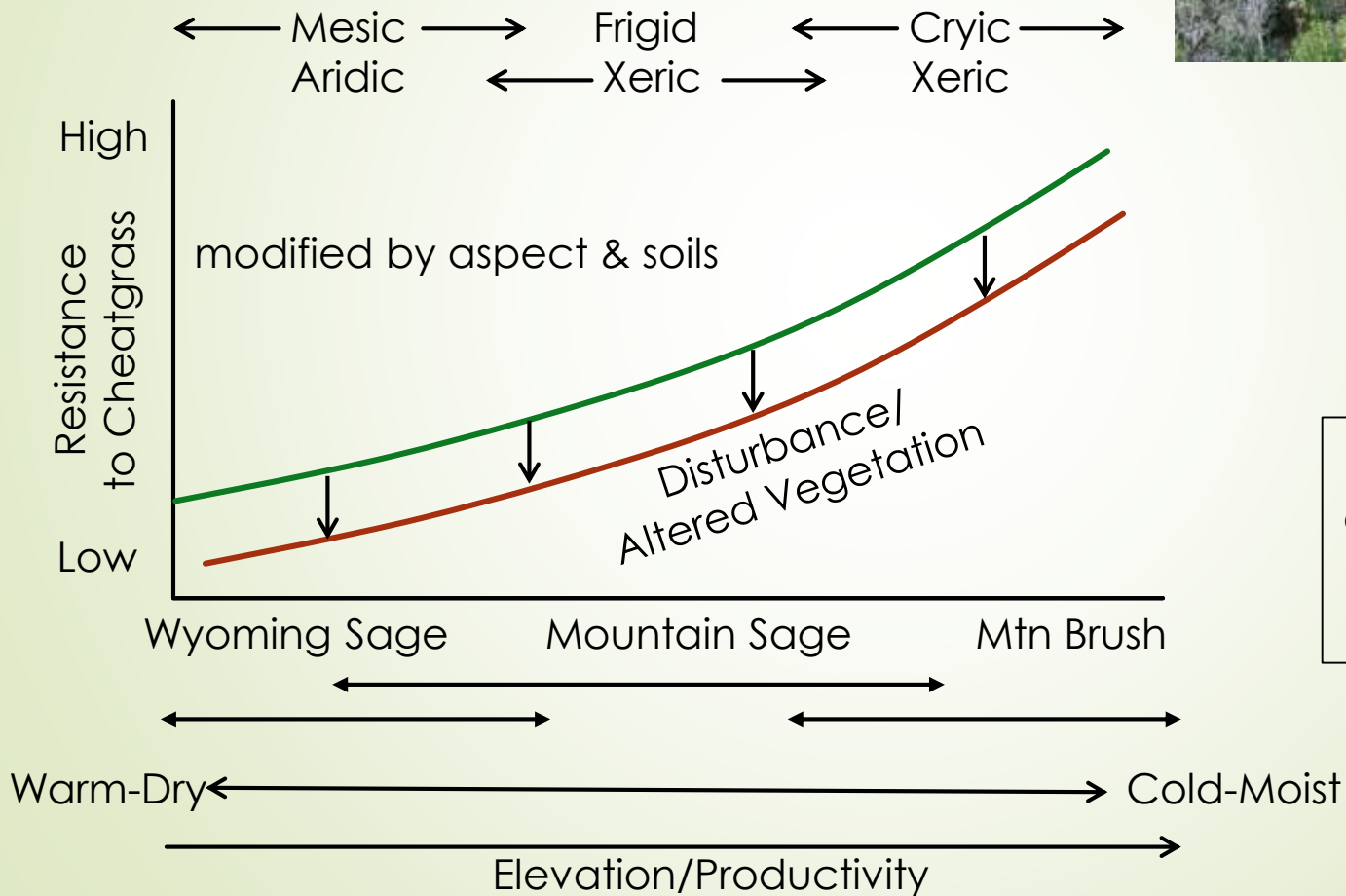


← Mesic → Frigid ← Cryic →
Aridic ← Xeric → Xeric



Chambers 2005,
Wisdom & Chambers 2009;
Brooks & Chambers 2011;
Condon et al. 2011;
Chambers et al. 2014a,b
Miller et al. 2015 a, b
Pyke et al. 2015 a, b
Chambers et al. 2017
Urza et al. 2017

Resistance to Cheatgrass Cold Deserts



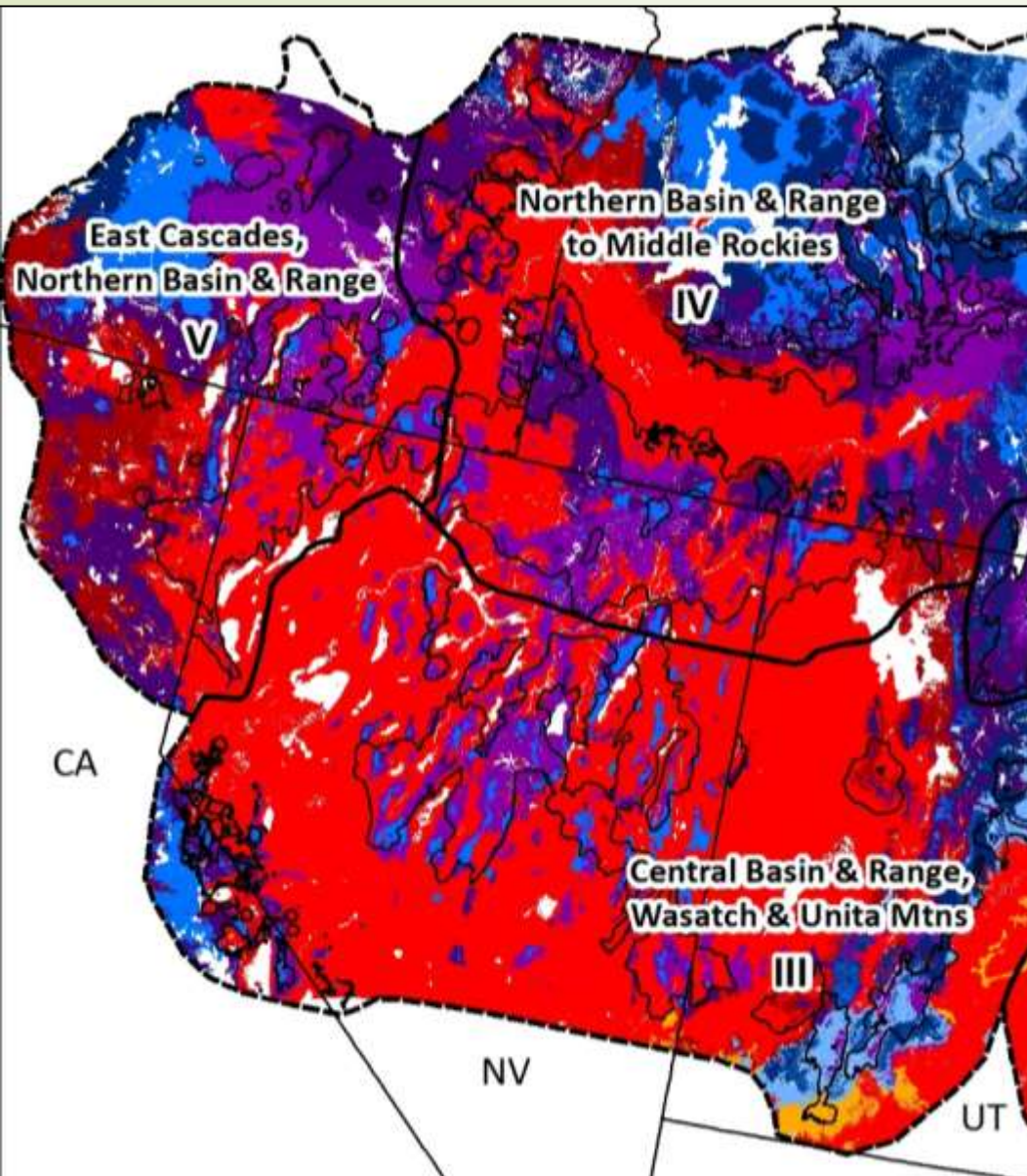
Chambers et al. 2007;
 Condon et al. 2011;
 Chambers et al. 2014a,b
 Miller et al. 2015 a, b
 Pyke et al. 2015 a, b
 Chambers et al. 2017b

Resilience & Resistance of Ecological Types

Relative Resilience & Resistance ↑ High
↓ Low

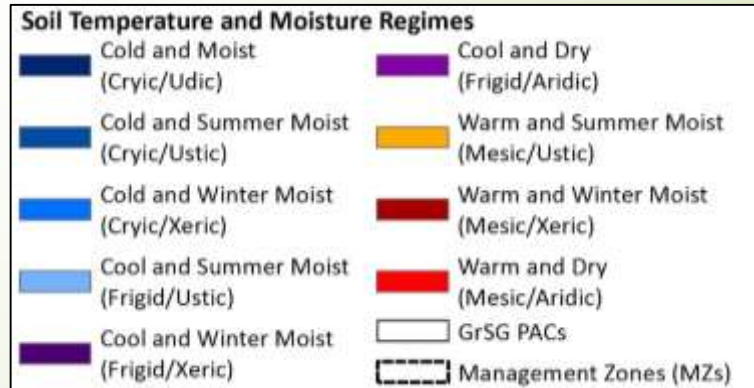
Ecological Type	Characteristics	Resilience and resistance
Cold & Moist <i>Cryic (all)</i>	Typical shrubs: Mountain big sagebrush, Snowfield sagebrush, snowberry, serviceberry, silver sagebrush, and/or low sagebrushes	Resilience – Moderately high Resistance – High
Cool & Moist <i>Frigid/Xeric</i>	Ppt: 12-22" Typical shrubs: Mountain big sagebrush, antelope bitterbrush, snowberry, and/or low sagebrushes Piñon pine and juniper potential in some areas	Resilience – Moderately high Resistance – Moderate
Warm & Moist <i>Mesic/Xeric</i>	Ppt: 12-16" Typical shrubs: Wyoming big sagebrush, mountain big sagebrush, Bonneville big sagebrush, and/or low sagebrushes Piñon pine and juniper potential in some areas	Resilience – Moderate Resistance – Moderately low
Cool & Dry <i>Frigid/Aridic</i>	Ppt: 6-12" Typical shrubs: Wyoming big sagebrush, black sagebrush, and/or low sagebrushes	Resilience – Low Resistance – Moderate
Warm & Dry <i>Mesic/Aridic bordering on Xeric</i>	Ppt: 8-12" Typical shrubs: Wyoming big sagebrush, and or black sagebrush and/or low sagebrushes (large portion of the Great Basin)	Resilience – Low Resistance – Low

Soil Temperature & Moisture Regimes



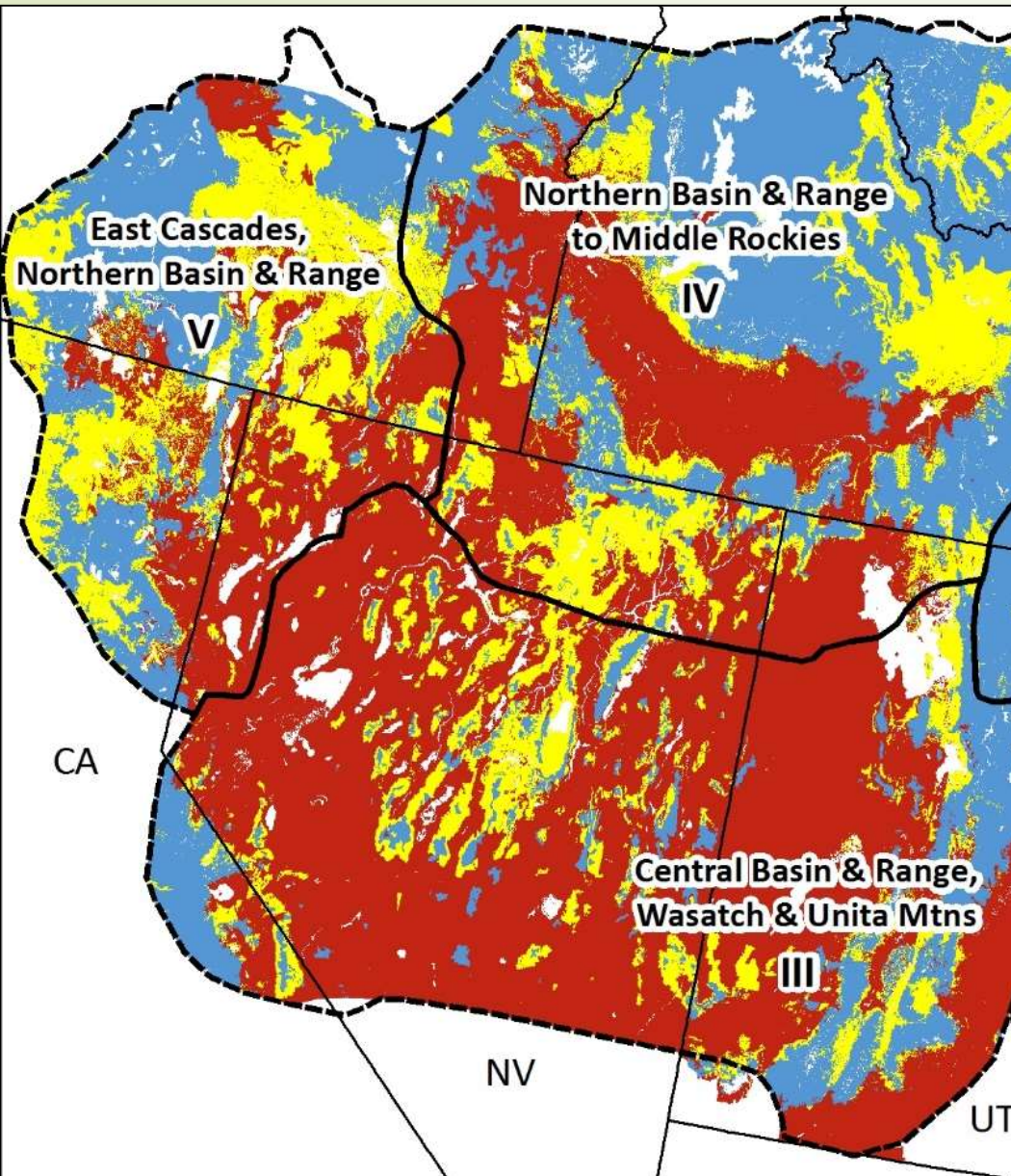
Soil Temperature & Moisture Regimes =

Landscape indicator of resilience & resistance



SURGO – 1:24,000 with gaps filled with STATSGO -1:250,000 (Maestas et al. 2016)

Resilience & Resistance Classes



Soil Temperature & Moisture Regimes =

Landscape indicator of resilience & resistance

Resistance and Resilience

High

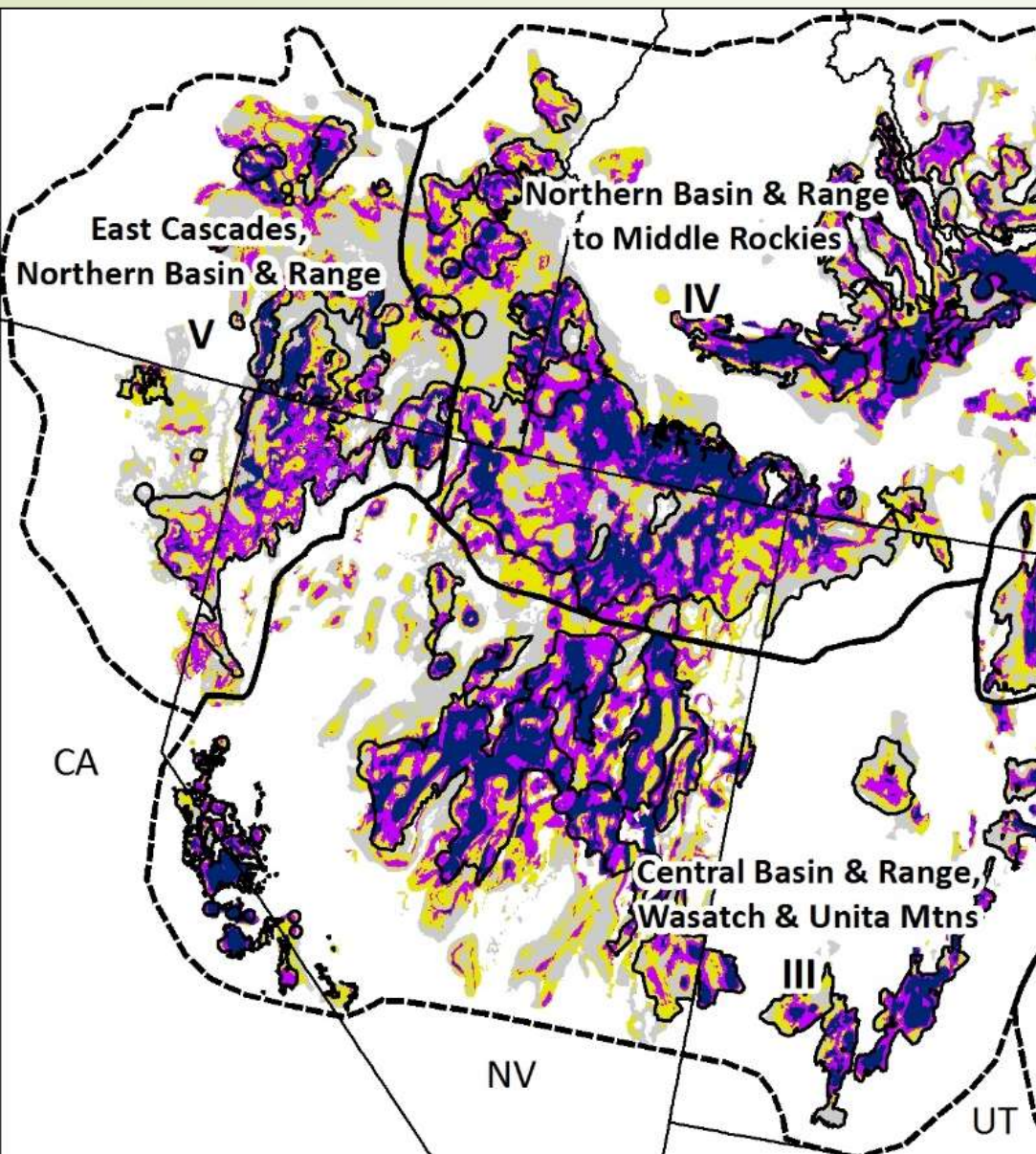
Moderate

Low

Management Zones (MZs)

SURGO – 1:24,000 with gaps filled with STATSGO -1:250,000 (Campbell & Maestas 2016, Maestas et al. 2016)

Sage-Grouse Breeding Habitat Probabilities

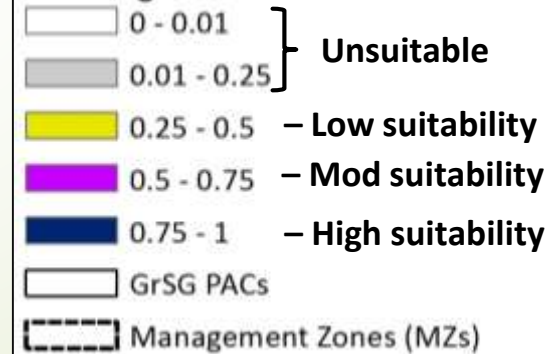


Bases Breeding Habitat on multivariate models –

➤ **2010 – 2014 BBD data**

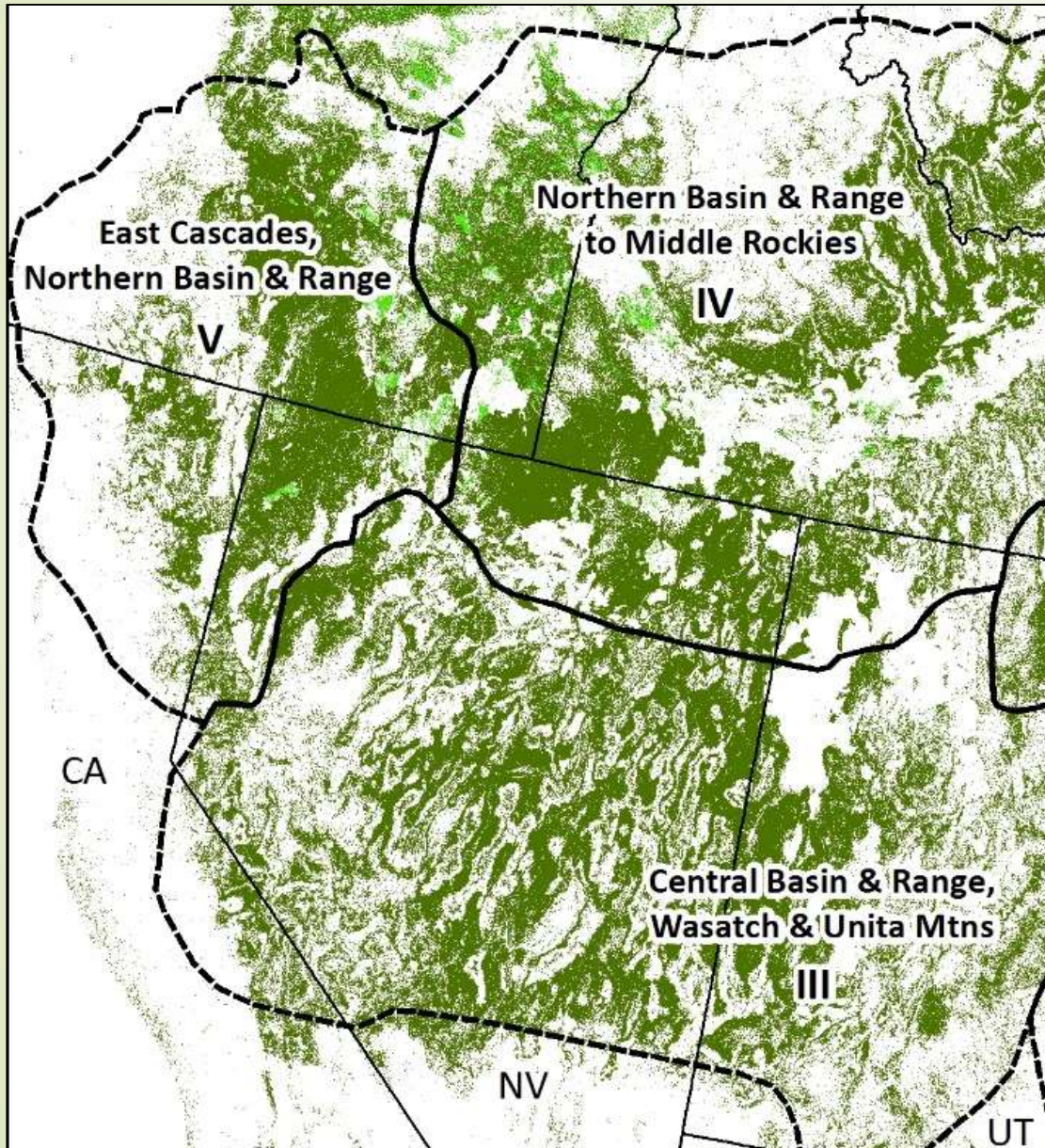
- **General Habitat**
- **Climate**
- **Landform**
- **Disturbance**

Breeding GrSG Habitat Probabilities



Doherty et al. 2016,
Chambers et al. 2017

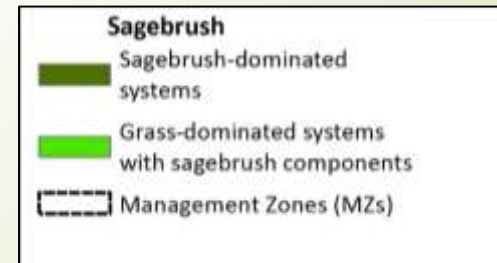
Land Cover of Sagebrush



➤ ***Provides information for –***

- Other sagebrush obligates
- Management activities like prepositioning fire fighting resources




- 1-25% Land Cover
- 26-65%
- 66-100%



LANDFIRE USGS 2014

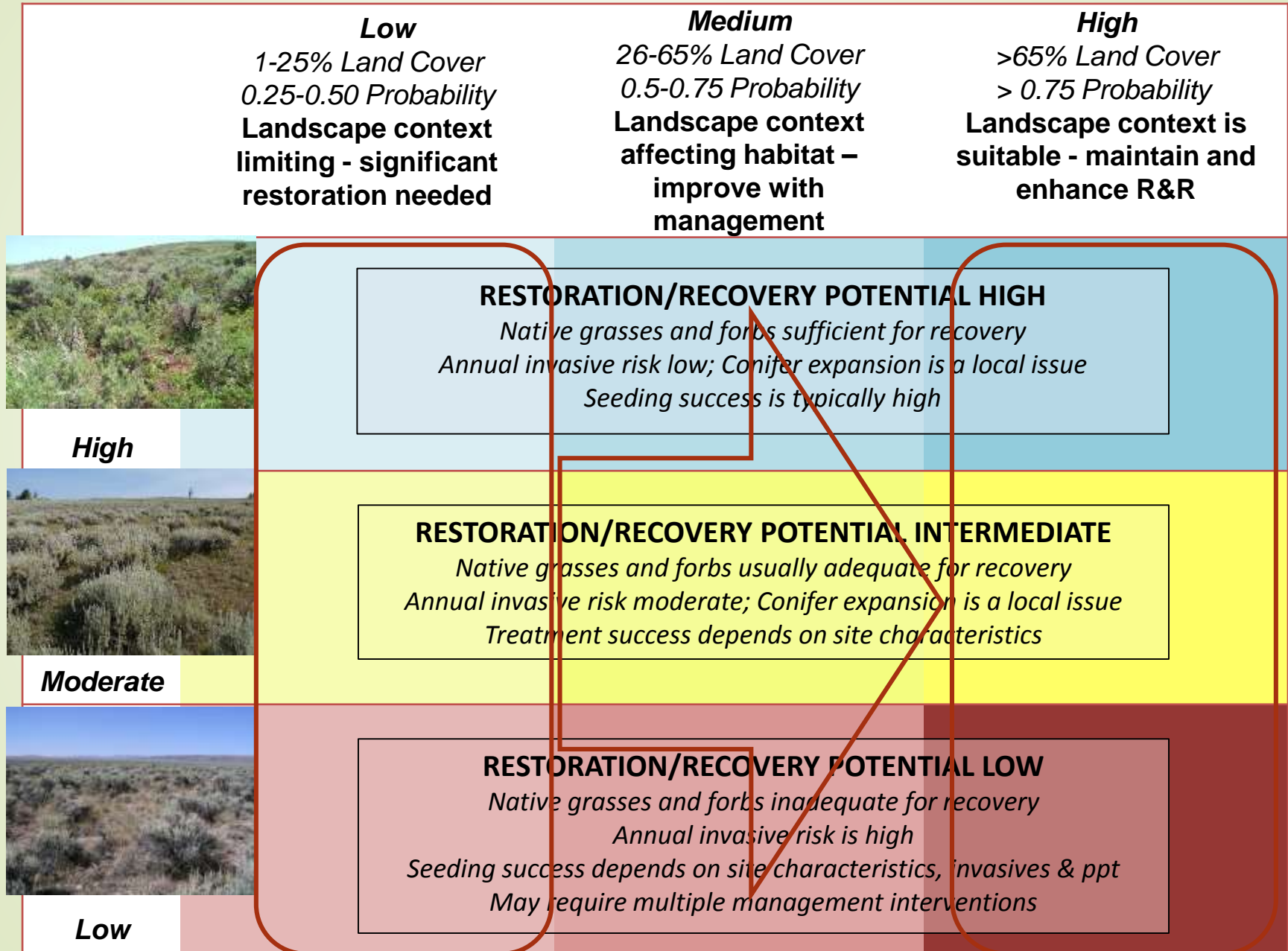
Proportion of Landscape Dominated by Sagebrush or Probability of Sage-Grouse Breeding Habitat

Sagebrush Ecosystem Resilience & Resistance

	Low 1-25% Land Cover 0.25-0.50 Probability Landscape context limiting - significant restoration needed	Medium 26-65% Land Cover 0.5-0.75 Probability Landscape context affecting habitat – improve with management	High >65% Land Cover > 0.75 Probability Landscape context is suitable - maintain and enhance R&R
 High	<p>RESTORATION/RECOVERY POTENTIAL HIGH <i>Native grasses and forbs sufficient for recovery Annual invasive risk low; Conifer expansion is a local issue Seeding success is typically high</i></p>		
 Moderate	<p>RESTORATION/RECOVERY POTENTIAL INTERMEDIATE <i>Native grasses and forbs usually adequate for recovery Annual invasive risk moderate; Conifer expansion is a local issue Treatment success depends on site characteristics</i></p>		
 Low	<p>RESTORATION/RECOVERY POTENTIAL LOW <i>Native grasses and forbs inadequate for recovery Annual invasive risk is high Seeding success depends on site characteristics, invasives & ppt May require multiple management interventions</i></p>		

Proportion of Landscape Dominated by Sagebrush or Probability of Sage-Grouse Breeding Habitat

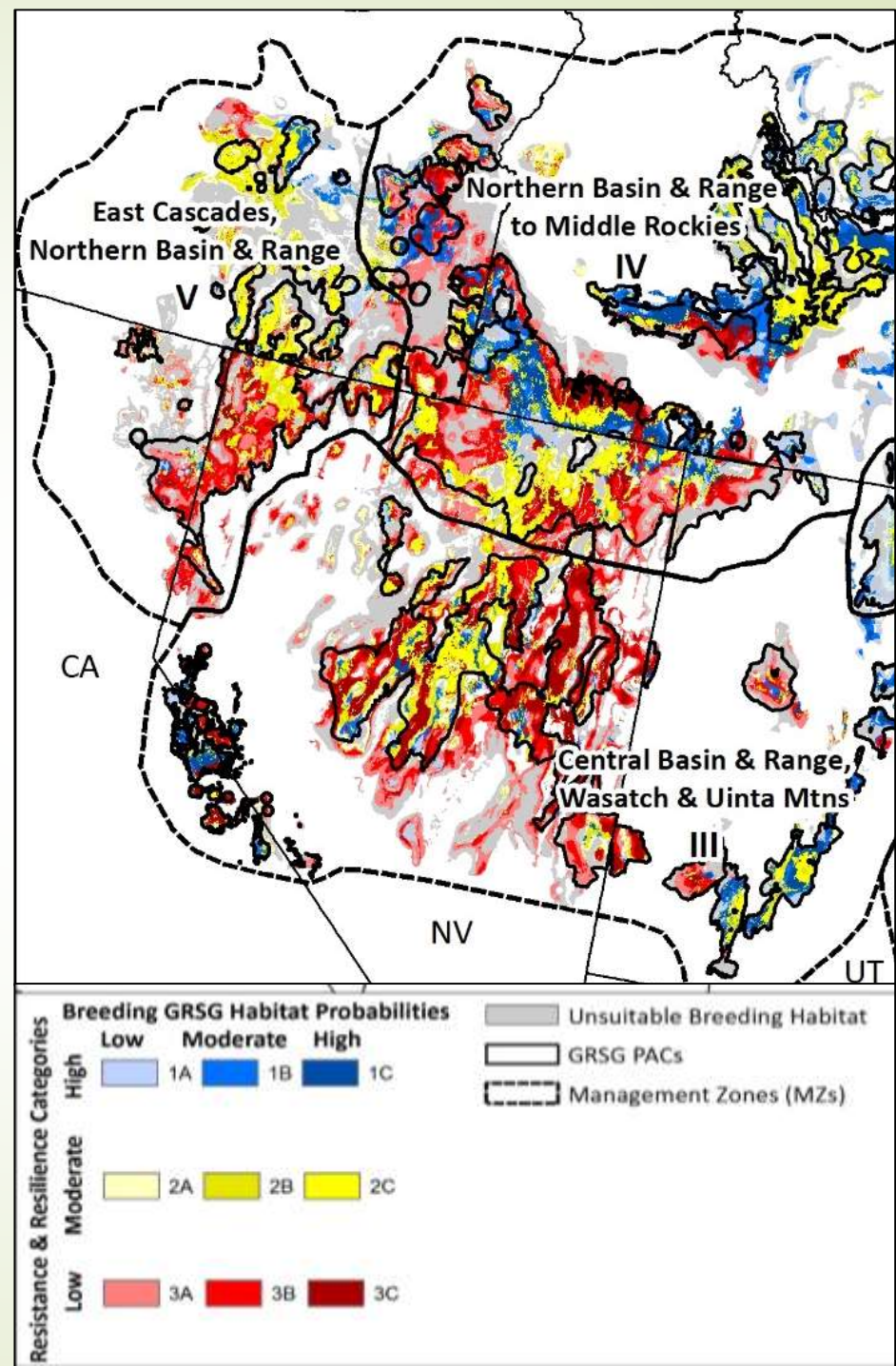
Sagebrush Ecosystem Resilience & Resistance



Map of GRSG Habitat Matrix

Areas for targeted management –

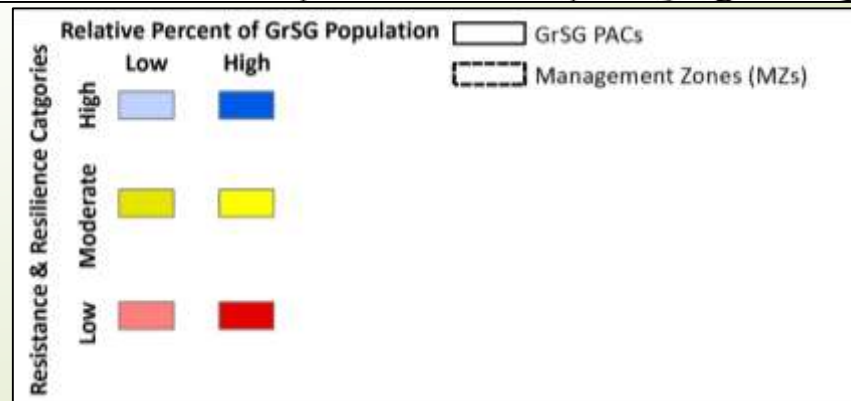
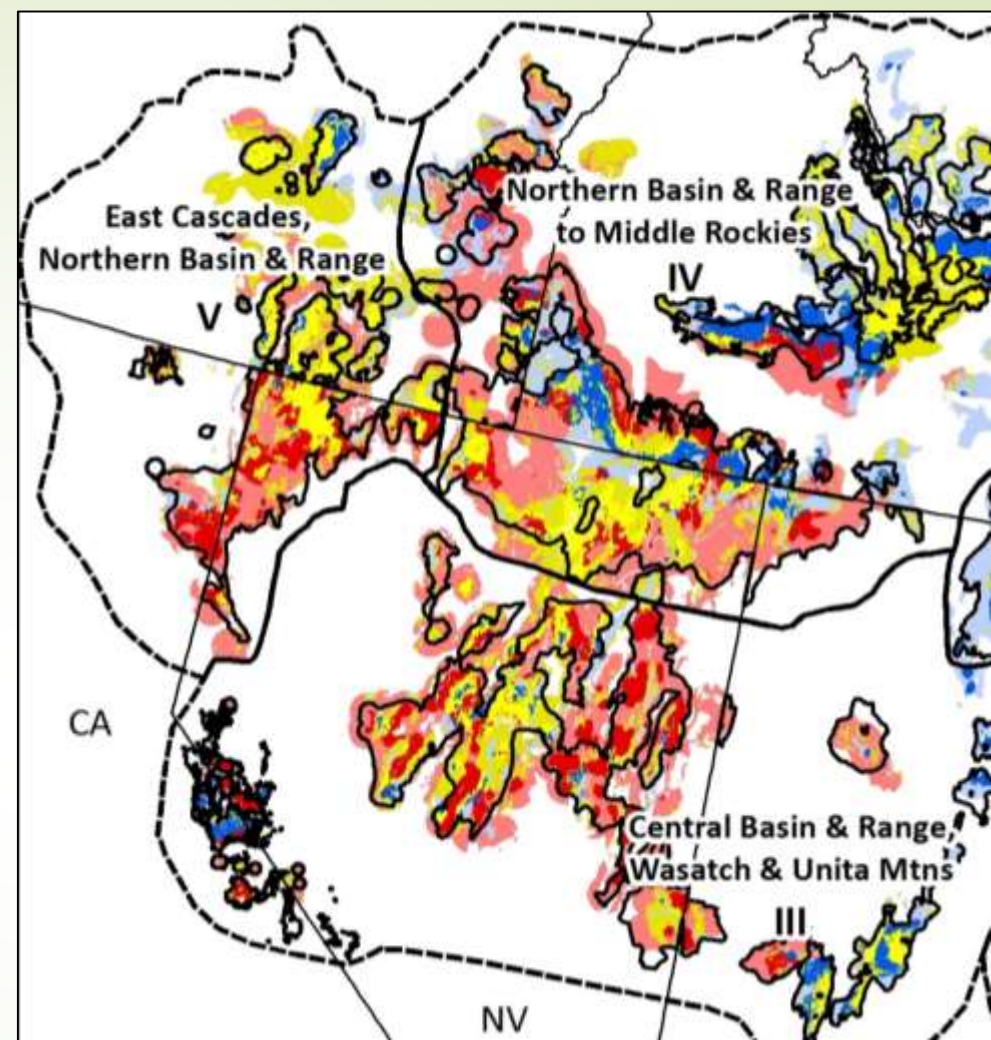
- First filters – GRSG PACS developed by States
- Resilience & Resistance
- Sage-grouse breeding habitat probabilities (Doherty et al. 2015)
- Management strategies can be matched directly to the Matrix



R&R PLUS Breeding Populations

Areas for targeted management –

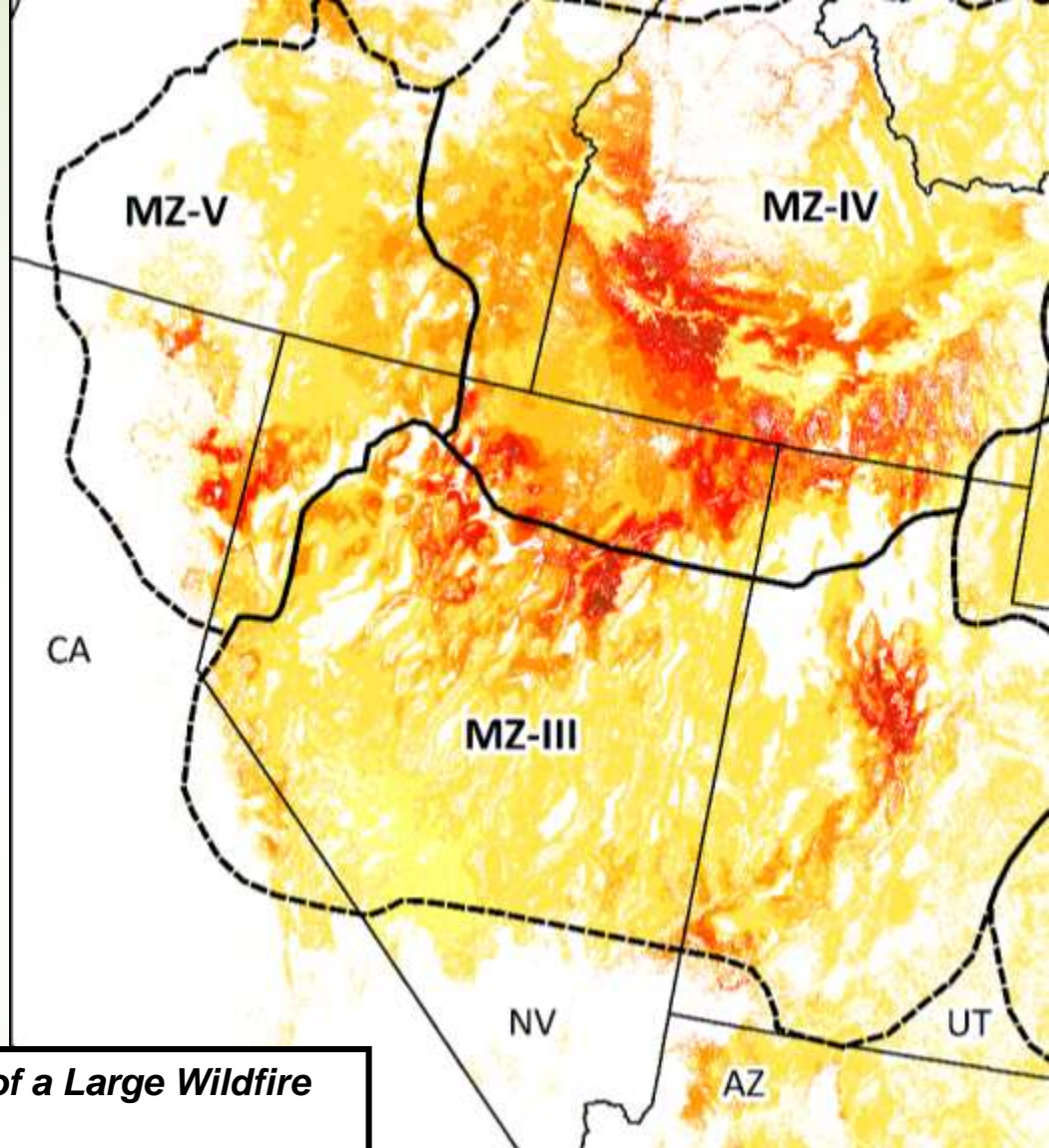
- First filters – GRSG PACS
- Resilience & Resistance
- Breeding bird densities (High density = areas with 80% BBD (Doherty et al. 2015))
- Ensures management areas -
 1. Support large populations
 2. Provide connectivity
 3. Are close enough to breeding centers for recolonization



Threats to Sagebrush Ecosystems

Persistent Ecosystem Threats

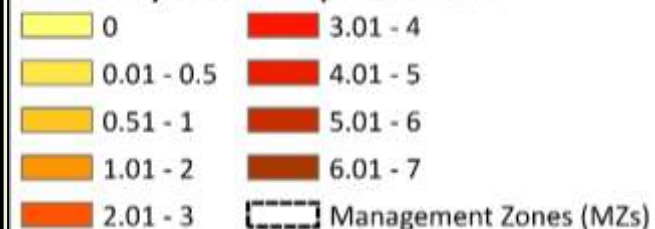
- Invasive Annual Grasses
- Altered Fire Regimes
- Conifer Expansion
- ❖ Identified in Conservation Objectives Team Report (2013)



Probability of a Large Wildfire (> 300ac) =

- Simulated fire ignition and growth using the Fire Simulation (FSim) system
- Short et al. 2016

Probability of Wildfire per 100 Years



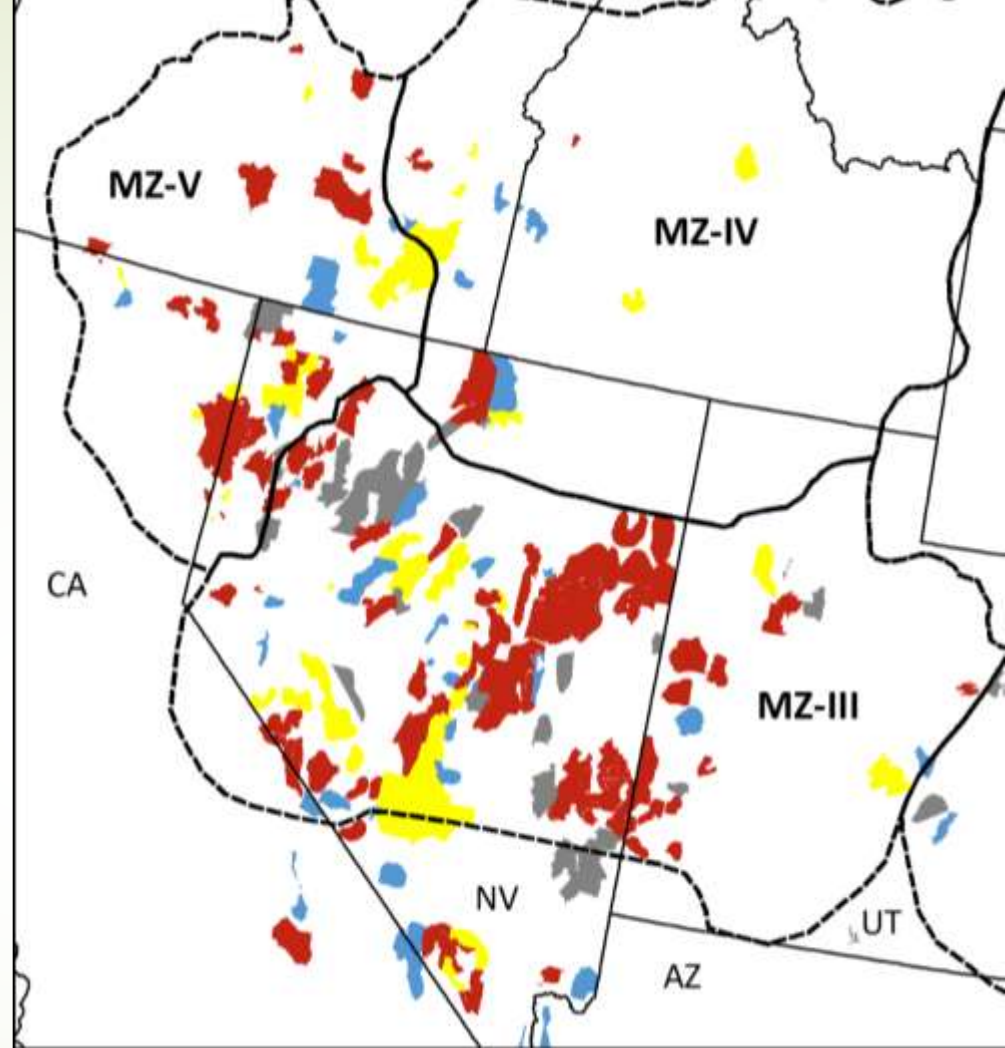
Threats to Sagebrush Ecosystems

Anthropogenic Threats

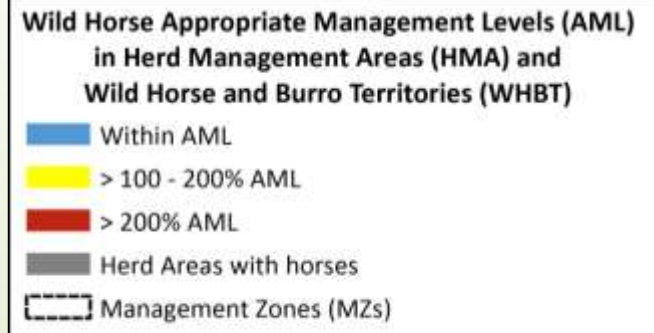
- Cropland Conversion
- Oil and Gas Development
- Exurban Development
- Improper Livestock Grazing
- Wild horse and burro use
- Recreation

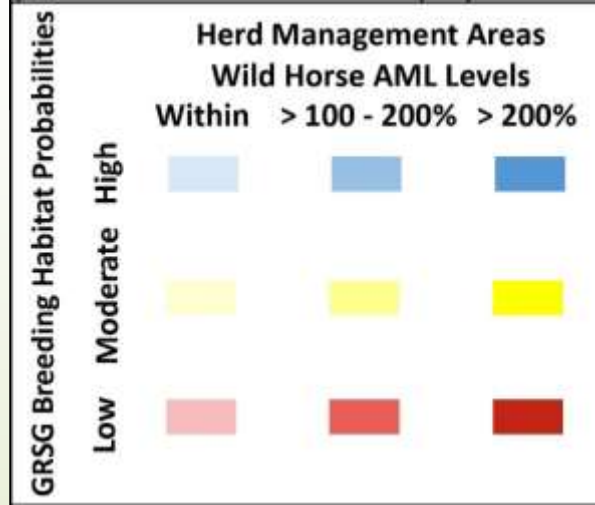
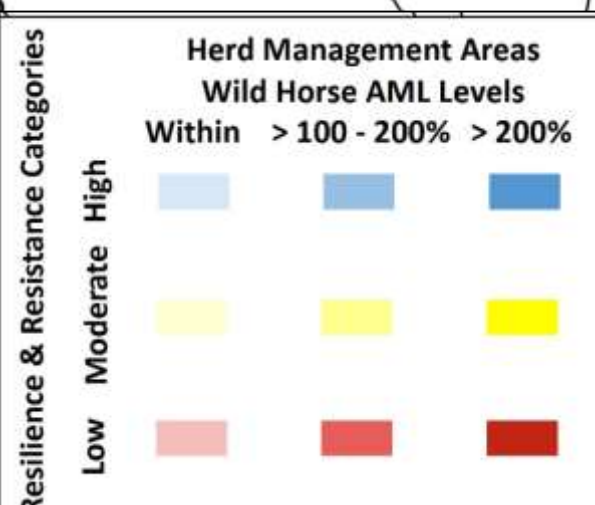
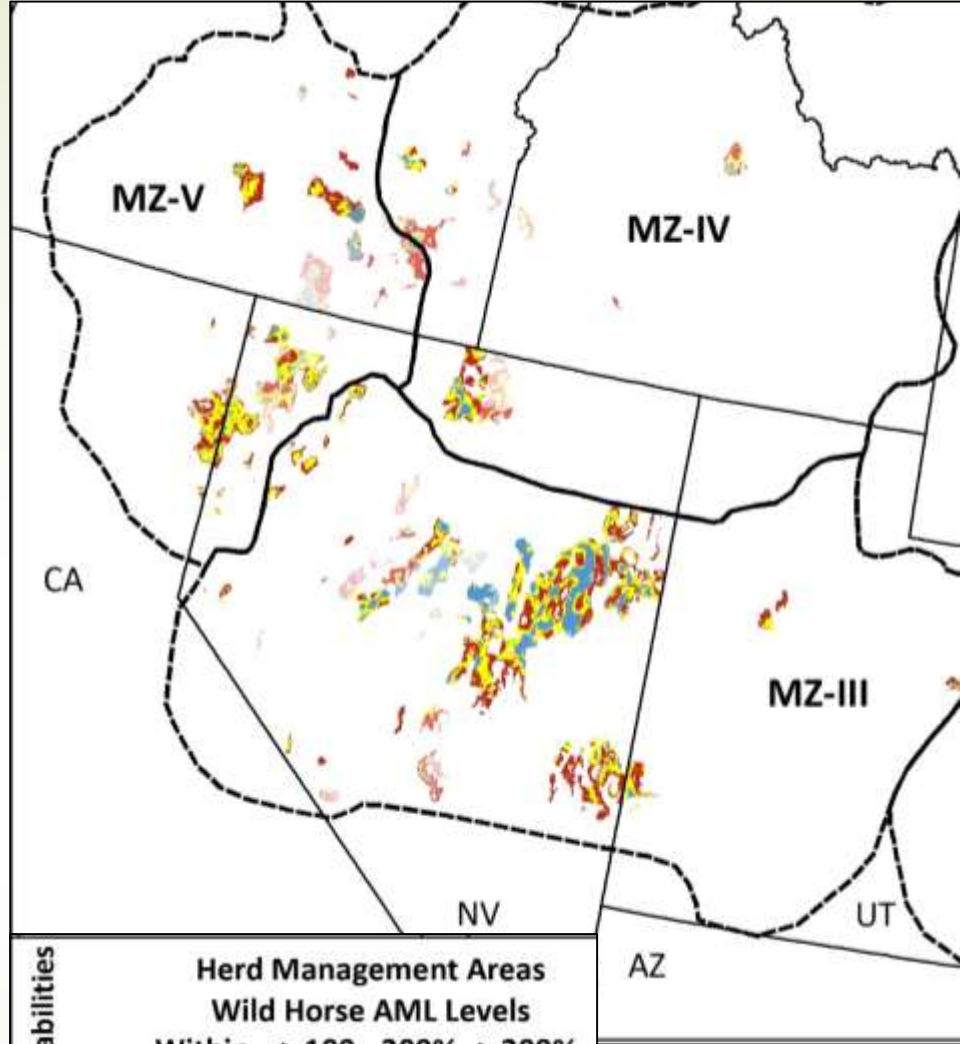
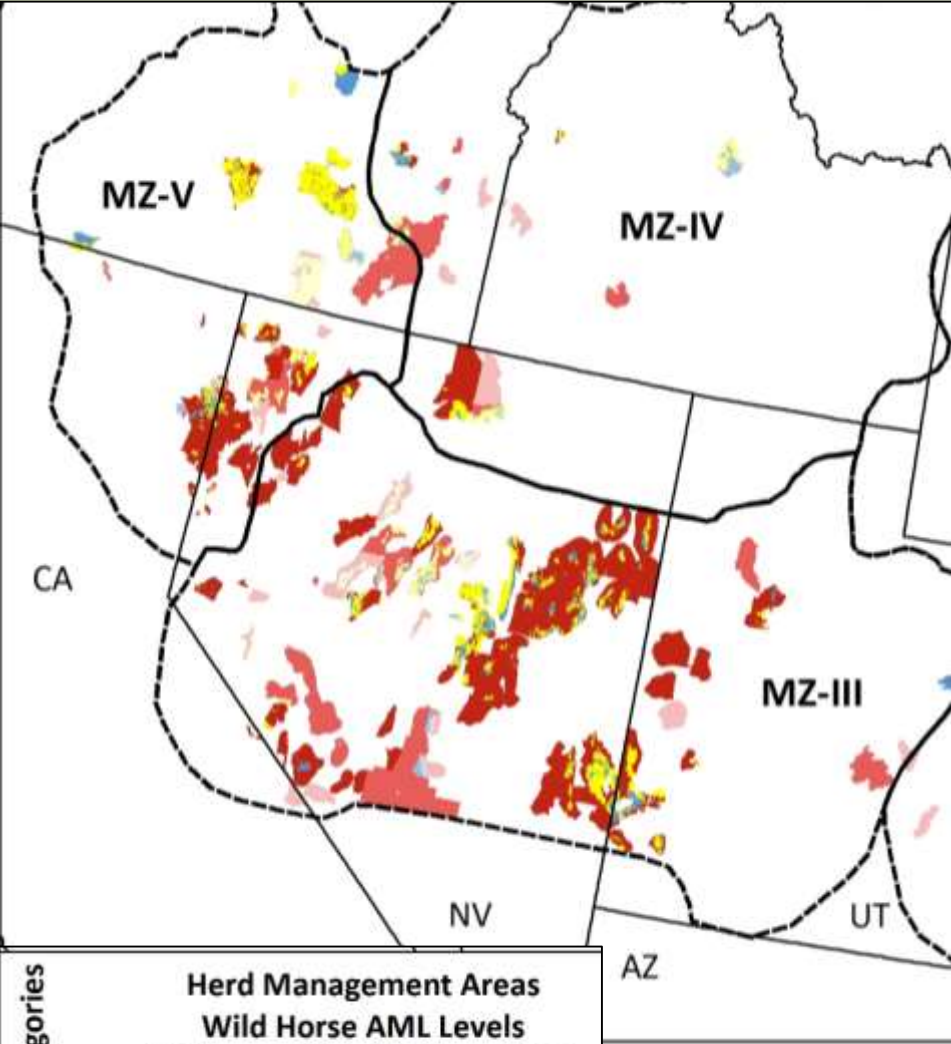
Climate Change

- Effects on Ecosystems and Species



Griffith et al.
in process





Stepping Down to the Land Planning Unit

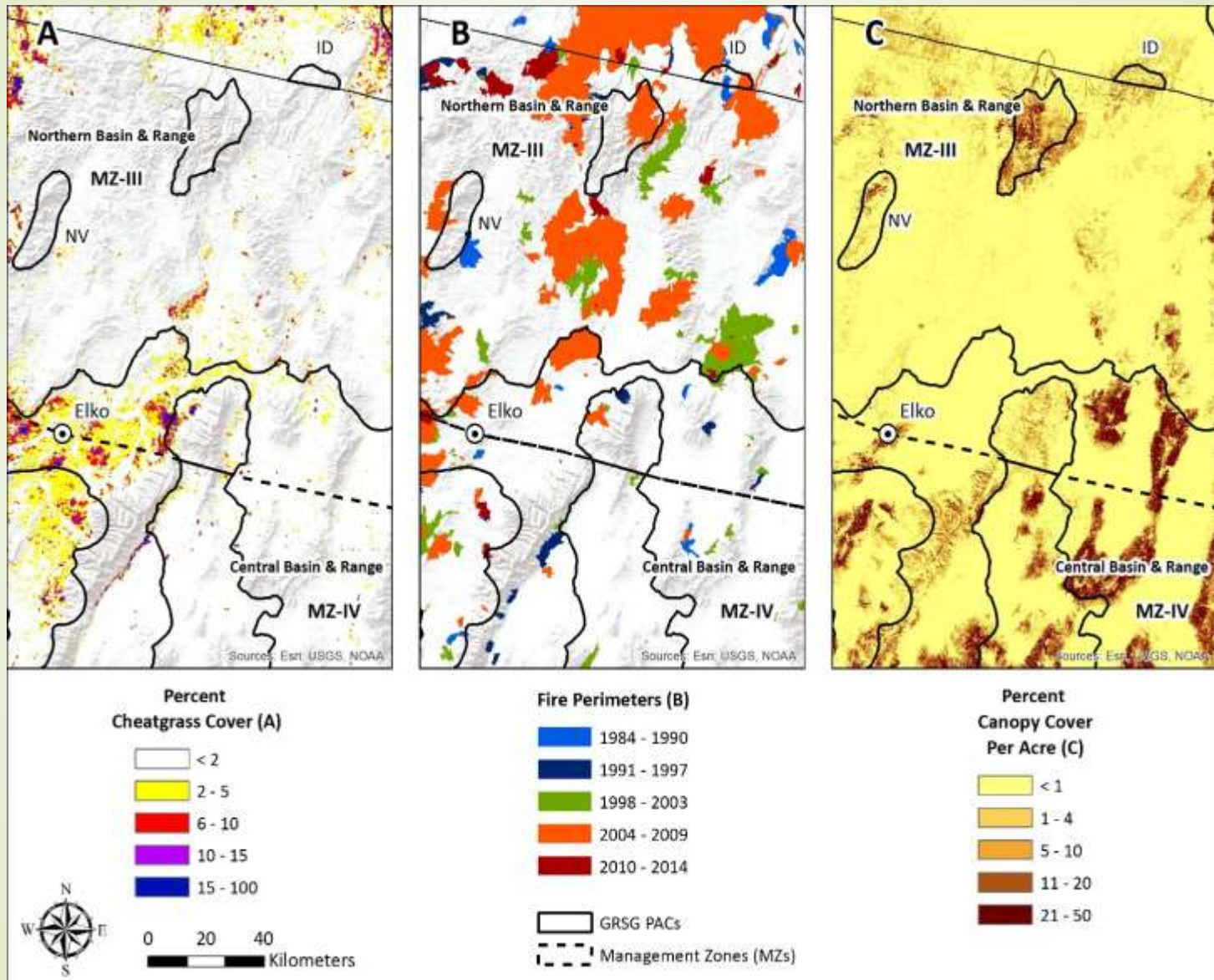
Management activities based on -

- Resilience & resistance
- Sage-grouse breeding habitat probabilities and populations
- Other resource values

- + Dominant threats
- + Finer scale data
- Regional/local expertise



Northeast Nevada – Invasives, Fire, Conifers

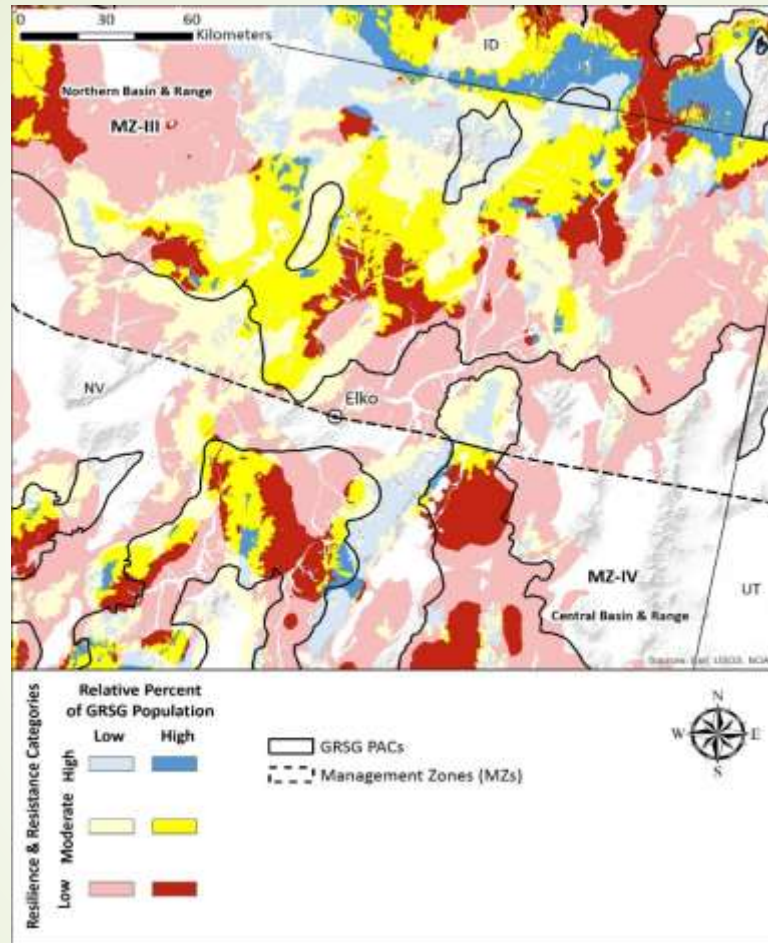


Boyte et al. 2015

MTBS 2014

Falkowski et al. 2017

Northeast Nevada – Invasives, Fire, Conifers



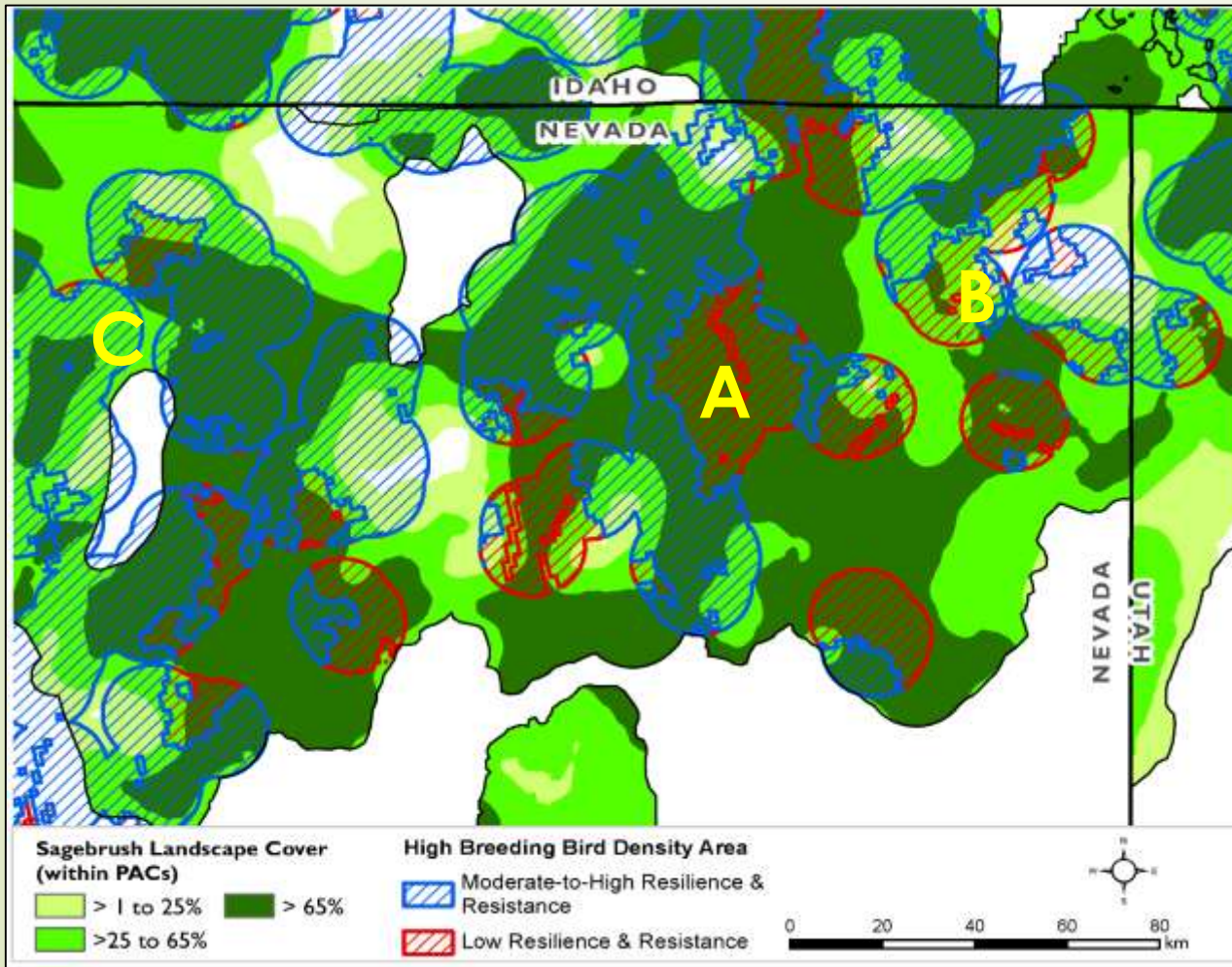
Resilience and Resistance and GRSG Breeding Bird Density

- Large areas within the PACs have high breeding bird densities & they occur over a broad range of R&R

Northeast Nevada – Invasives, Fire, Conifers

Management strategies -

- A. Prepositioning of fuels and active fire management
 - B. Post-fire rehab of sagebrush to increase connectivity
 - C. Reduction in fuels due to conifer expansion
- Manage to increase perennial native grasses





Landscape Approach Data Portal

Data, Maps, and Models from BLM's Landscape Approach Initiatives

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All Geospatial Information Is Available to the Public

<http://www.landscape.blm.gov/geoportal/>

Resources



Integrated Rangeland Fire Management Strategy

- [Downloadable Data](#)
- [Live Map Services](#)
- [Documents](#)
- [Static Maps](#)
- [Web Tools](#)

Conservation & Restoration Strategy

- [Downloadable Data](#)
- [Live Map Services](#)
- [Documents](#)
- [Static Maps](#)

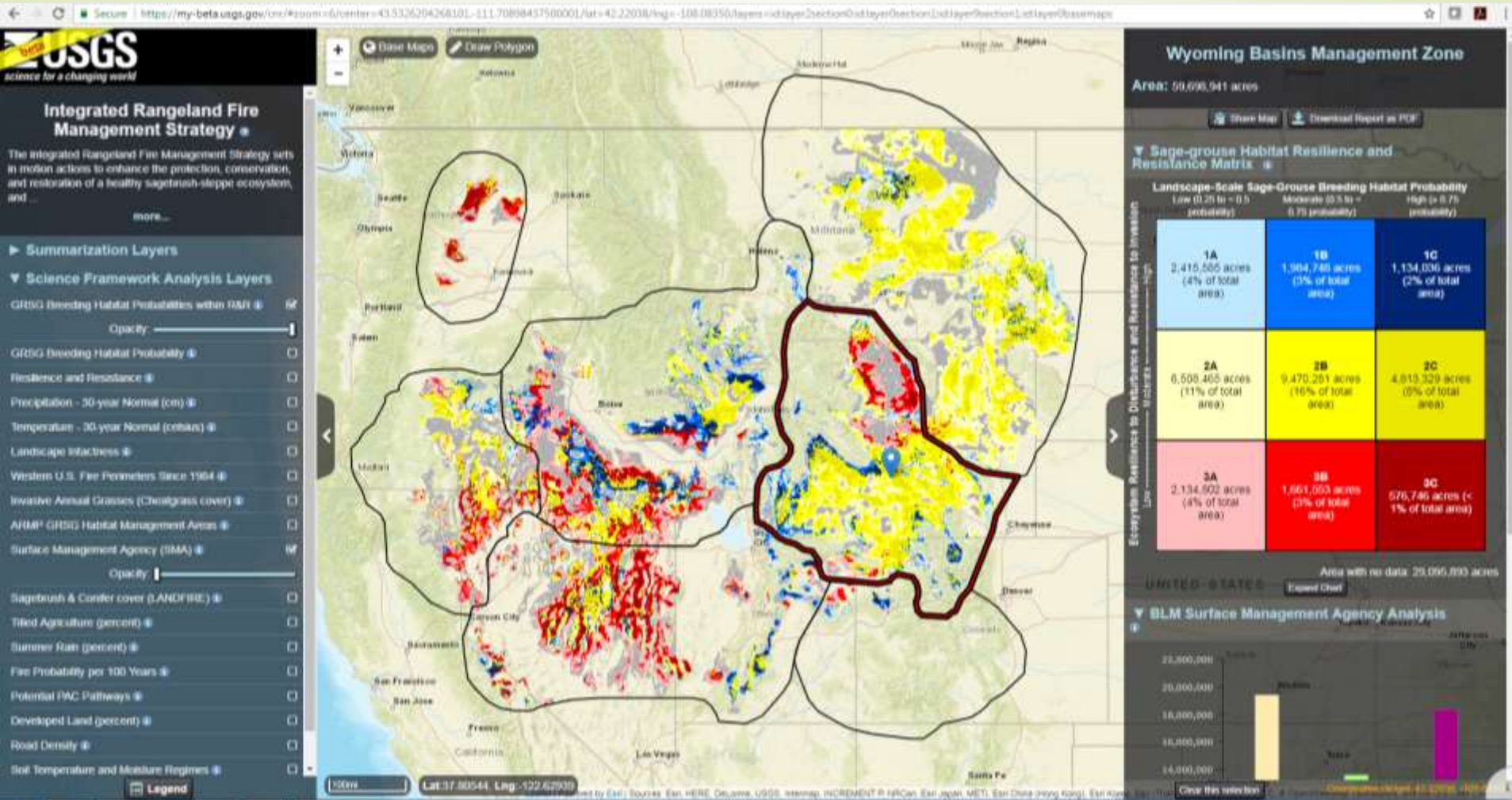
Find IRFMS data using a keyword search

[Search](#)

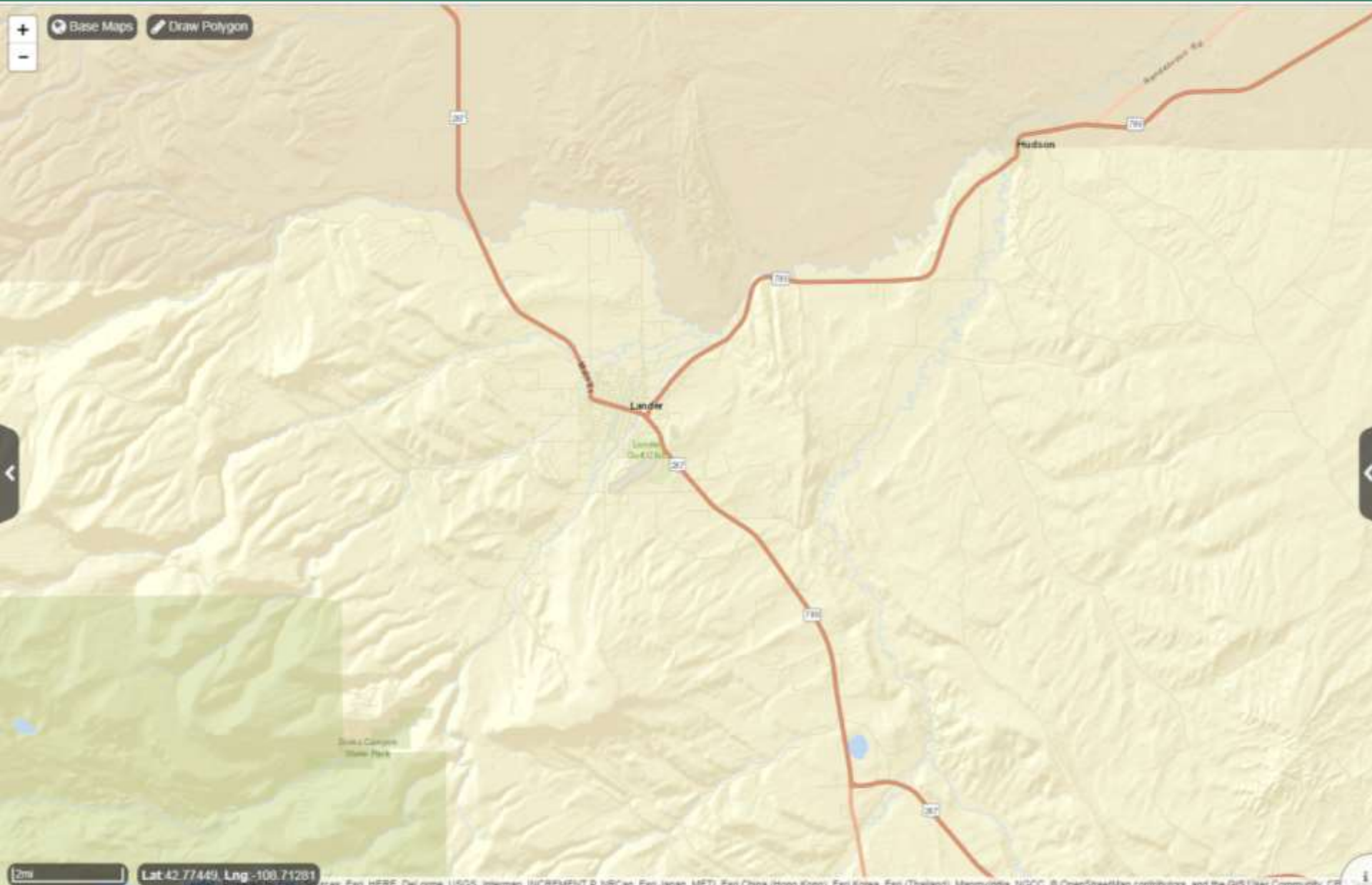
or [Browse](#) by Category

Science Framework Assessment Tool

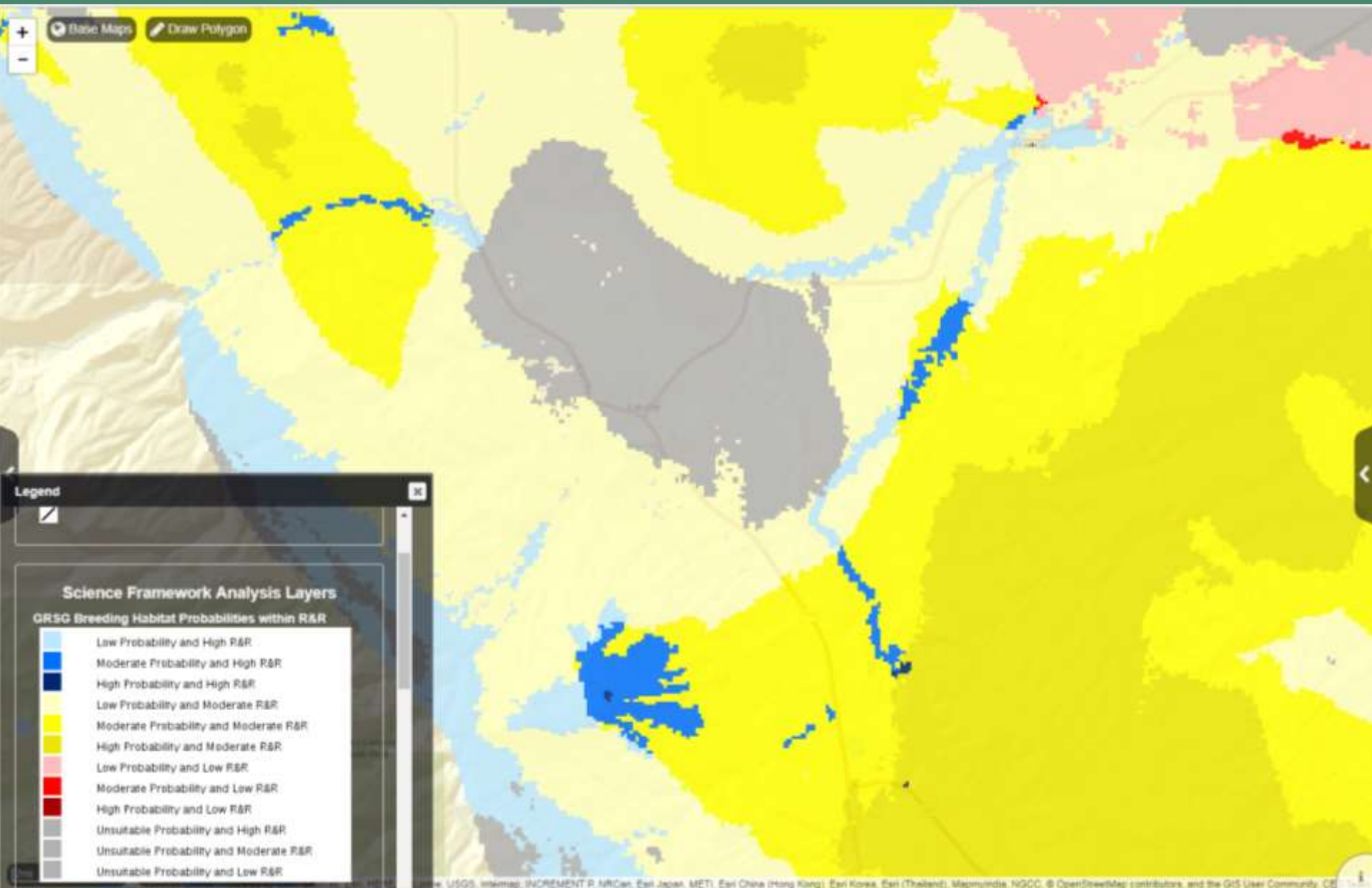
- Data exploration



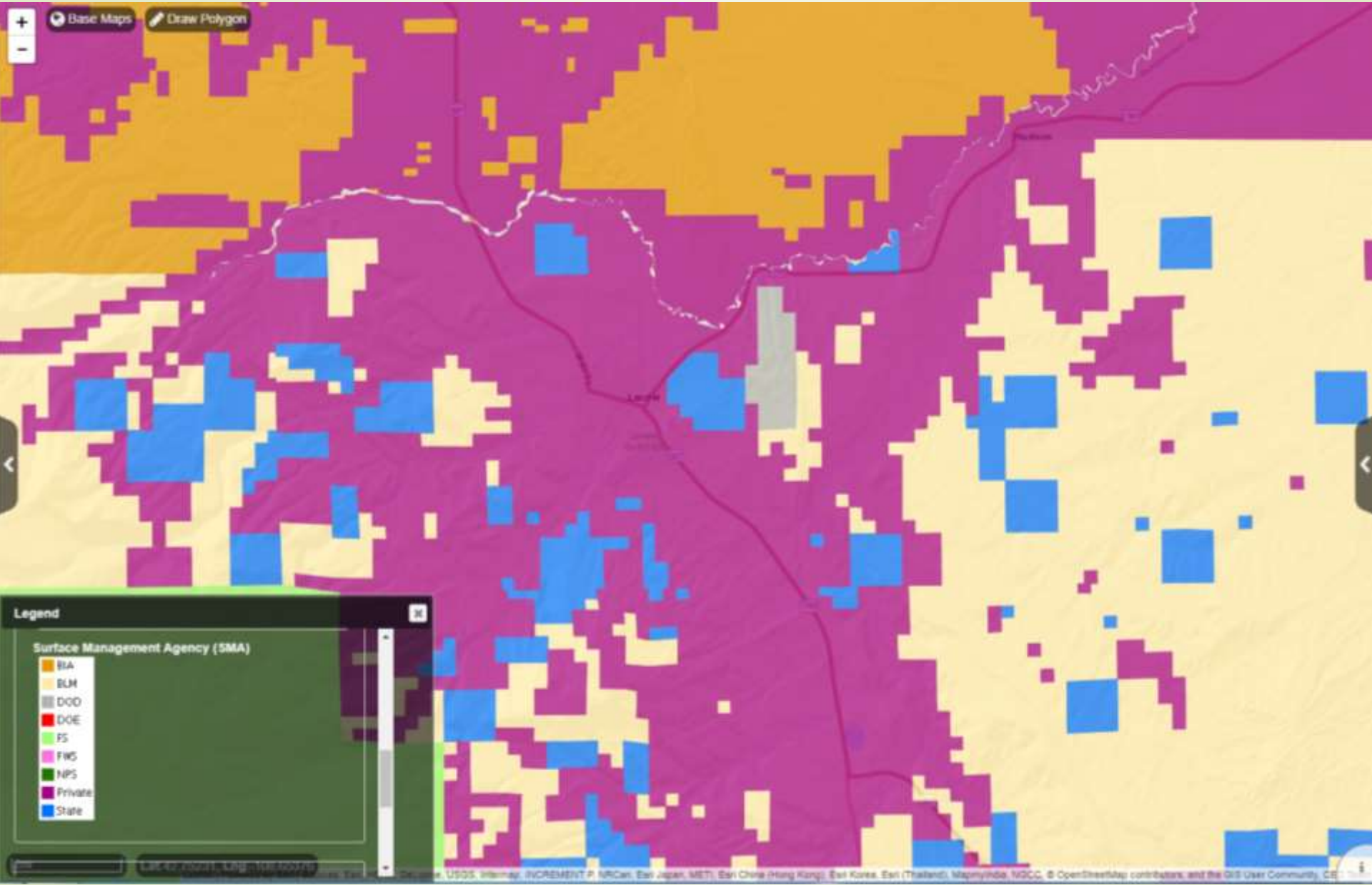
Site Assessment – Near Lander, WY



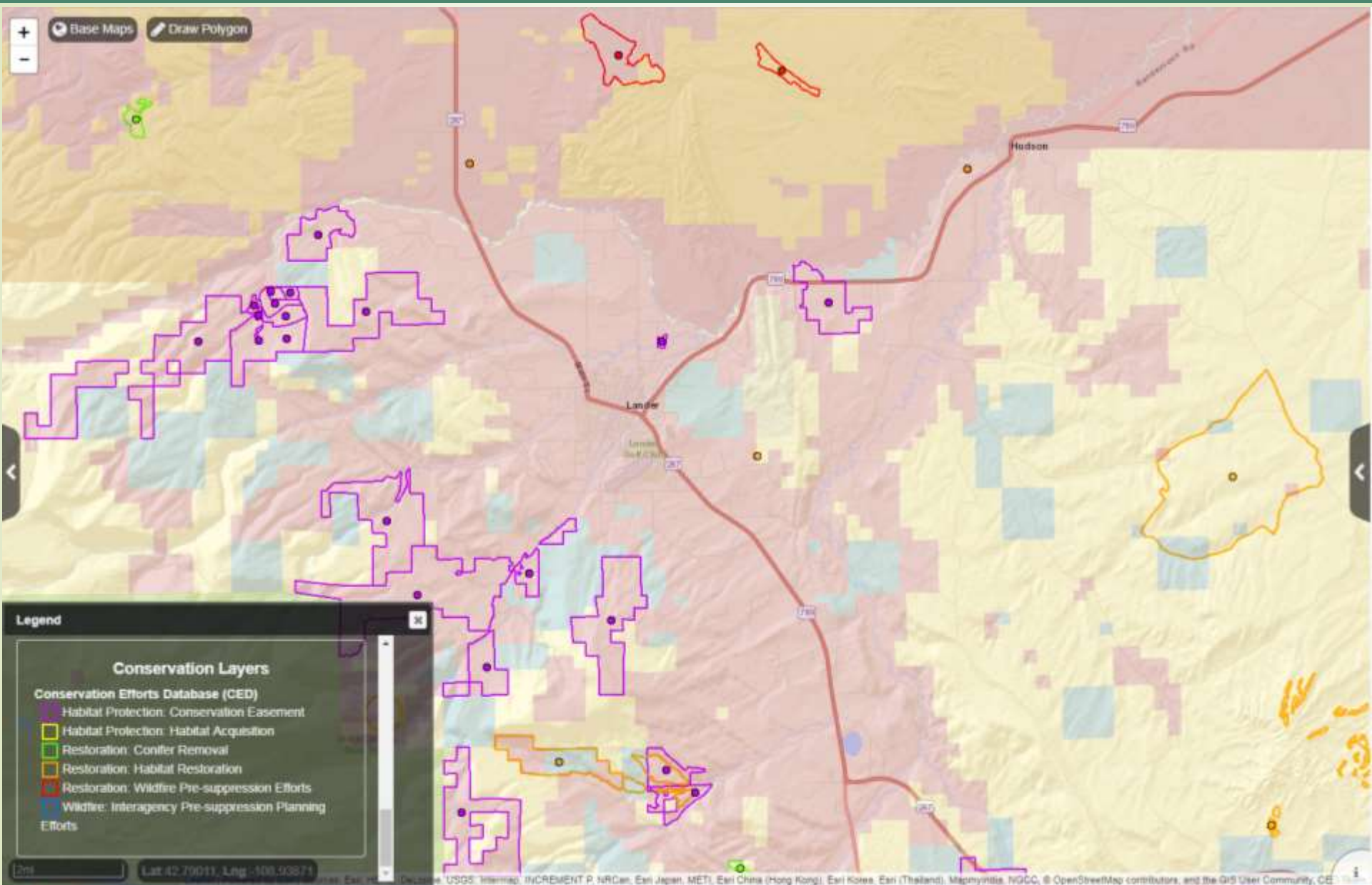
GRSG Breeding Habitat and R&R



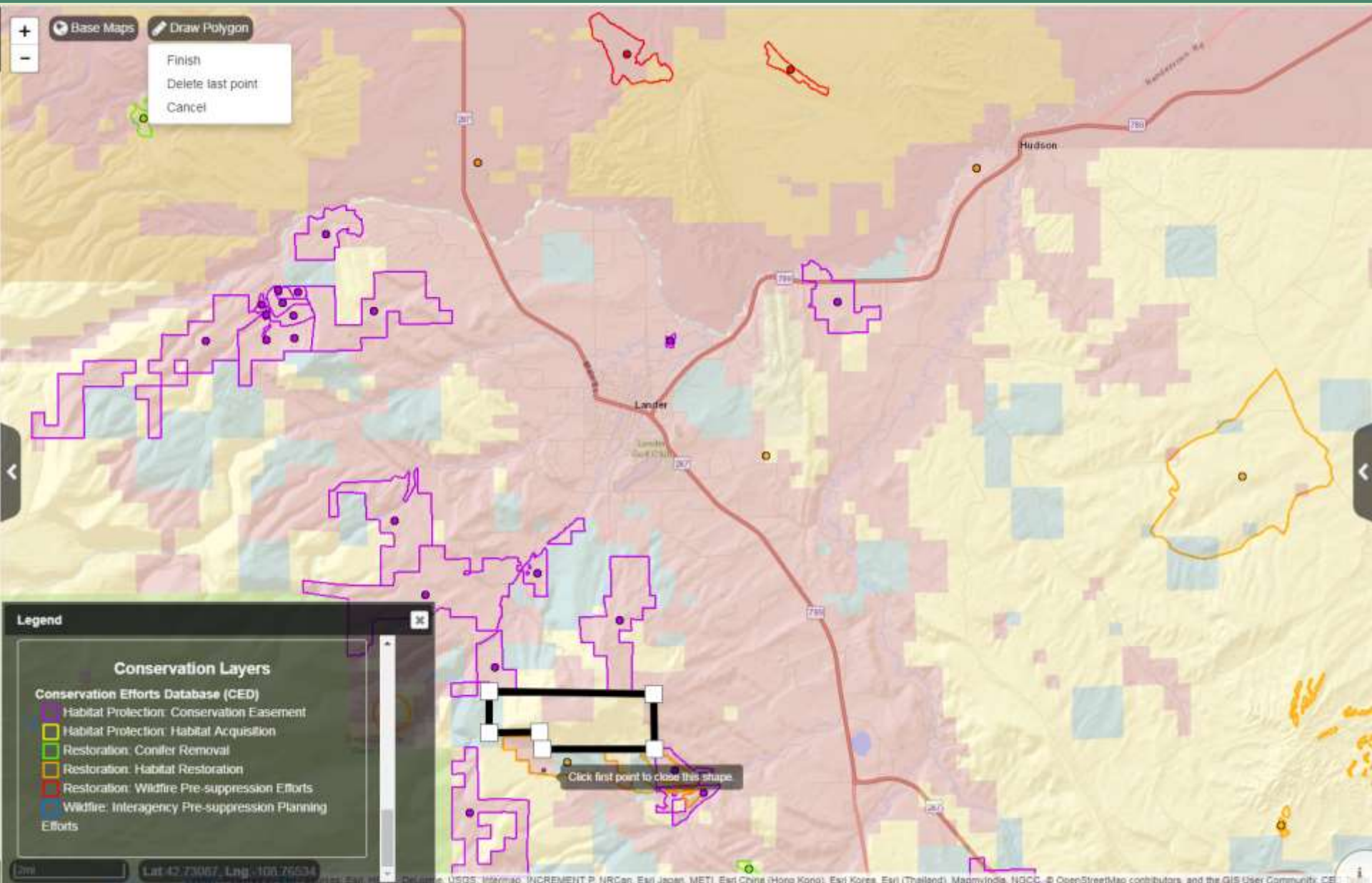
Surface Management Agency - Ownership



Existing Conservation Projects



Define and Analyze Potential Project Area





Integrated Rangeland Fire Management Strategy Summary Report: User Defined Polygon



Generated 2018-01-30. This pdf was generated from the data available at http://msa.bios.usgs.gov/arc/#?appid=10&server=42_74820974006124_108_730498806191820&layers=0,1,layer:QuestionOfUserRangeland,1,layer:Section1,2,layer:Section1,3,layer:Section1,4,layer:Downstream,5,layer:Section2

Available Late Spring



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Topics

- Fuels & Fuel Treatments (219)
- Fire Ecology & Effects (158)
- Restoration (152)
- Invasive Species (121)
- Climate & Fire & Adaptation (109)
- Post-Fire Environment & Management (76)
- Sagebrush (58)
- Sagebrush (55)
- Decision Support (52)
- Sage Grouse (46)
- Fire Communication & Education (42)

See more ▼

Types of Resources

- Article/Book (199)
- Synthesis/Tech Report (87)
- Fact Sheet/Brief (85)
- Field Guide (23)
- Abstracts (20)
- Newsletter/Digest (15)
- Database (13)
- Map (12)
- Tool (11)
- Model/Tool/Technology (10)
- Training (10)

HIGHLIGHTS



2018 Webinar Series:
Managing Cheatgrass
by Putting What We
Know into Practice



Provide Your Input on
the Actionable Science
Plan for Integrated
Rangeland Fire
Management



Science Resources:
Targeted Grazing For
Fuels Management

UPCOMING EVENTS



Fire Leadership for
Women - Prescribed
Fire Training Center



Prescribed fire for
ecologically-based
management



Restoration of
Sagebrush Ecosystems
Class

<http://greatbasinfirescience.org/>



Contact an Expert
Have a question related to



Share Your Research Needs
What research topics would



Suggest an Event
We have funding available

- Identify management technical needs
- Develop and synthesize the information and technical tools
- Provide the information and tools in preferred venues

Prepared in cooperation with U.S. Joint Fire Science Program and National Interagency Fire Center, Bureau of Land Management, Great Northern Landscape Conservation, and Western Association of Fish and Wildlife Agencies

Restoration Handbook for Sagebrush Steppe Ecosystems with Emphasis on Greater Sage-Grouse Habitat— Part 1. Concepts for Understanding and Applying Restoration

Prepared in cooperation with U.S. Joint Fire Science Program and National Interagency Fire Center, Bureau of Land Management, Great Northern Landscape Conservation, and Western Association of Fish and Wildlife Agencies

Restoration Handbook for Sagebrush Steppe Ecosystems with Emphasis on Greater Sage-Grouse Habitat— Part 2. Landscape Level Restoration Decisions

Prepared in cooperation with U.S. Joint Fire Science Program and National Interagency Fire Center, Bureau of Land Management, Great Northern Landscape Conservation, and Western Association of Fish and Wildlife Agencies

Restoration Handbook for Sagebrush Steppe Ecosystems with Emphasis on Greater Sage-Grouse Habitat— Part 3. Site Level Restoration Decisions



Information & Tools for Managers

Tapping Soil Survey Information for Rapid Assessment of Sagebrush Ecosystem Resilience and Resistance

By Jeremy D. Maestas, Steven B. Campbell, Joanne C. Chambers, Mike Pellant, and Richard F. Miller

On the Ground

Emerging applications of ecosystem resilience and resistance concepts in sagebrush ecosystems

Resilience and resistance concepts help managers better understand the limits of ecosystem change, identify relative risks of crossing thresholds to degraded states, and



Great Basin Factsheet Series 2016

Information and tools to conserve and restore Great Basin ecosystems

Springer Series on Environmental Management

Matthew J. Germino
Jeanne C. Chambers
Cynthia S. Brown *Editors*

Exotic Brome-Grasses in Arid and Semiarid Ecosystems of the Western US

Causes, Consequences, and Management Implications

C. Chambers

Assessing R&R at the Site Scale



United States
Department of
Agriculture
Forest Service
Rocky Mountain
Research Station
General Technical
Report RMRS-GTR-338
November 2014

A Field Guide for Selecting the Most Appropriate Treatment 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

Warm and dry
Wyoming big
sagebrush—
Invaded State



Cool and dry
mountain big
sagebrush—
Reference State



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

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Forest Service

Rocky Mountain
Research Station

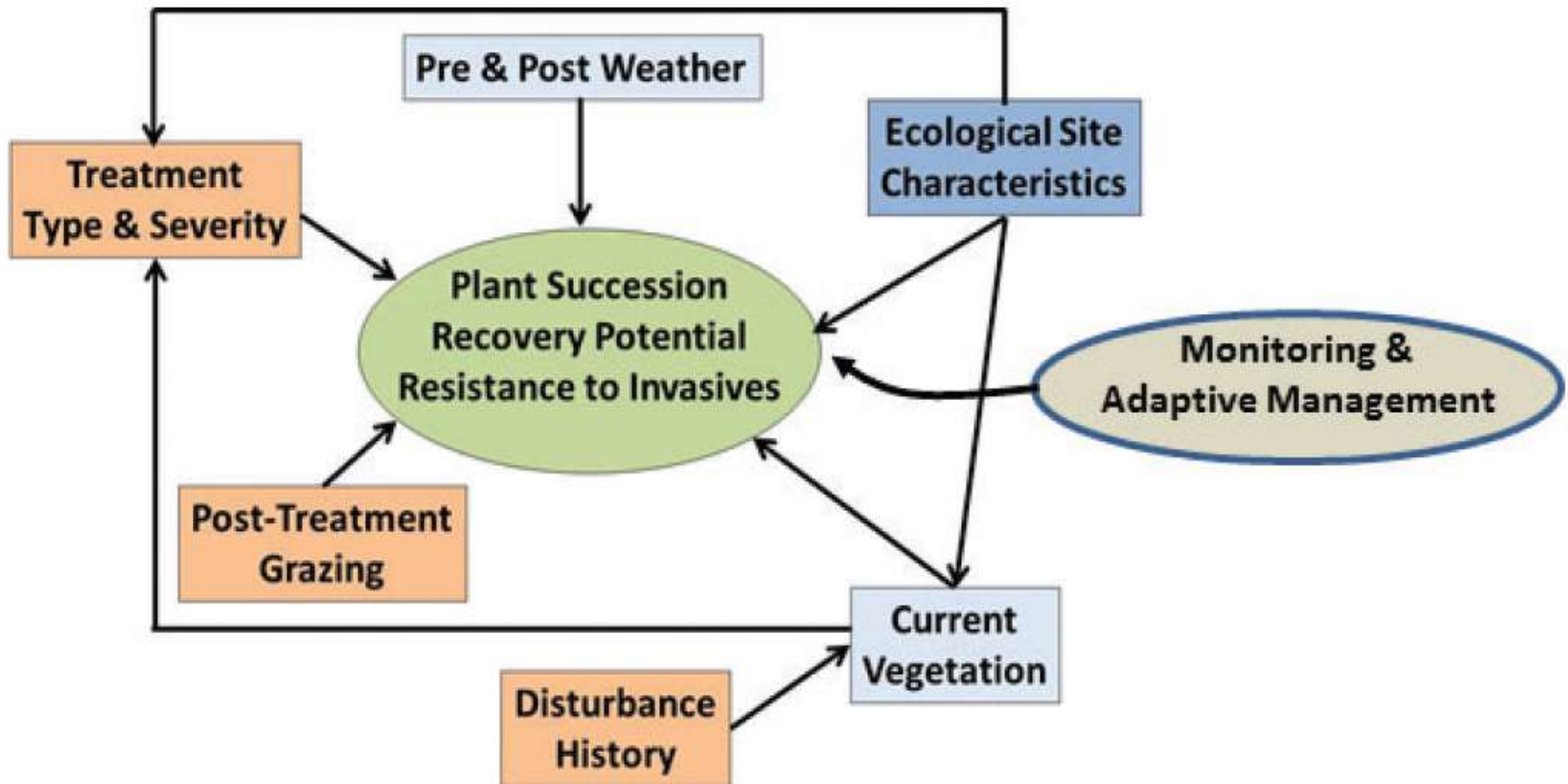
General Technical Report
RMRS-GTR-338

July 2015



**“Being a good ecologist often means being a good detective.”
~ Dr. Rick Miller**

Asking the right questions to predict vegetation response



Ecological Site Descriptions (ESDs)



- Physiographic, climatic, and soil features
- Plant community characteristics
- State-and-transition models
- Site interpretations

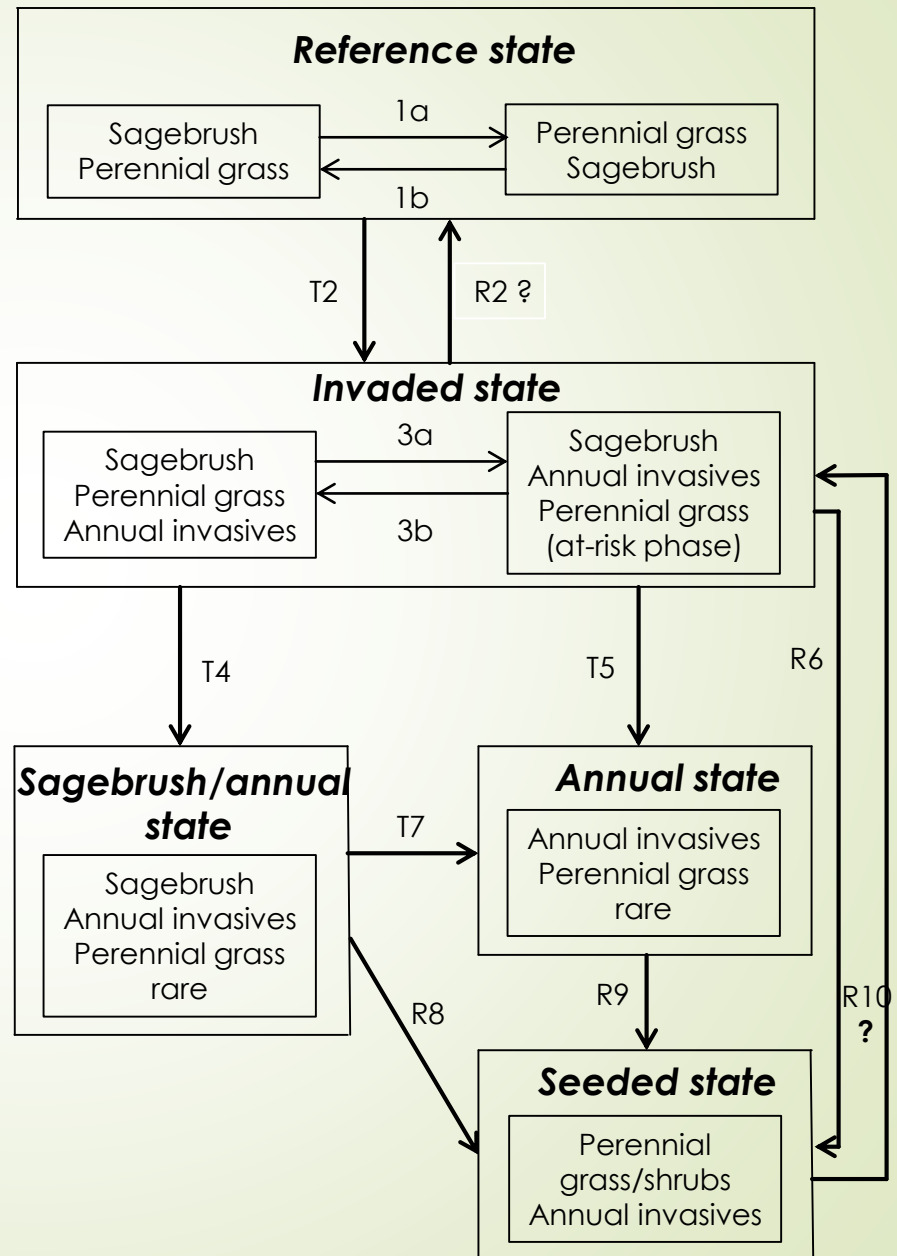
Provisional ESDS for Nevada:

<https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD>

Resilience Based State-and-Transition Models

- Ecological States
- Plant Communities
- Restoration pathways

Chambers et al. 2017

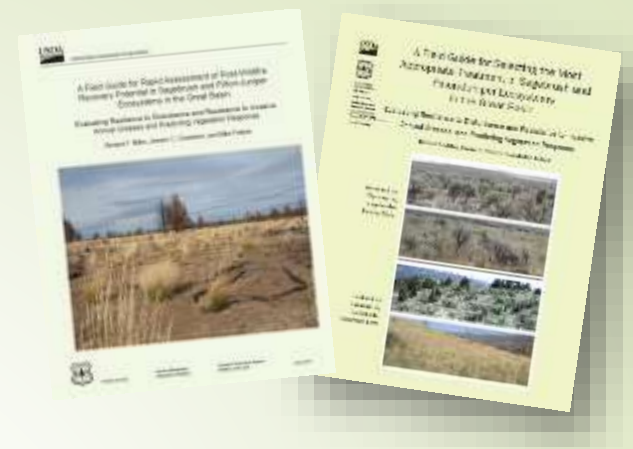


Field Score Sheet for Rating R&R

- Temperature
 - Soil temperature regime
 - Sagebrush subspecies
- Effective Moisture
 - PPT/soil moisture regime
 - Soil texture and depth
- Pre-Treatment/Wildfire Vegetation
 - Plant functional groups
- Disturbance or treatment severity adjustment

Score Sheet for Rating Resilience to Disturbance and Resistance to Invasive Annual Grasses in the Great Basin						
Ecological Site or Type Name: _____				PLOT SCORE† (Sample two to five plots per ecological site depending on size and variability of area.)		
%Area: _____ UTM: _____ (Use ecological site descriptions or guidelines for the MLRA with field assessment to complete score sheet.)						
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:	0=DRPG and POSE scarce to severely depleted (DRPG <2-3/m ² and/or less than 5% foliar cover)					
Deep-rooted perennial grasses (DRPG) (potentially dominant in shallow to deep soils >10-in)	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)					
Sandberg bluegrass (POSE) (potentially dominant in very shallow soils <10-in)	6=DRPG on soils >10-in deep depleted (2-3/m ² or about 5-10% foliar cover), and/or co-dominant with IAG; or on soils <10-in deep POSE and PF 5-15% foliar cover and co-dominant with IAG					
Perennial forbs (PF)	9=DRPG and PF dominant on soils >10-in deep; or POSE and PF dominant on soils <10-in deep.					
Invasive annual grasses (IAG)						
Pre-Fire Vegetation (PFV) Adjusted for Fire Severity (Estimated)						
C. Adjusted Pre-Fire Vegetation (If area will be prescribed burned, estimate potential fire severity based on fuels and burn prescription for each plot.)	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)						
Rating: Very low = <10, Low = 10-14, Moderate = 15-20, High = >20						

Temperature and Moisture



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)						

Web Soil Survey R&R Soils Report



Report — Resilience and Resistance Score Sheet Soils Report - Great Basin

Harney County Area, Oregon

1—Actem cobbly loam, 2 to 20 percent slopes

Map Unit Setting

Elevation: 4,200 to 6,000 feet

Mean annual precipitation: 10 to 12 inches

Mean annual air temperature: 43 to 45 degrees F

Frost-free period: 50 to 80 days

Major Land Resource Area: 23 - Malheur High Plateau

Map Unit Composition

Actem and similar soils: 85 percent

Minor components: 5 percent

Description of Actem

Taxonomic classification

Temperature regime: Frigid

Moisture regime: Aridic

Moisture subclass: Xeric

Taxonomic class: Clayey, montmorillonitic, frigid, shallow Xeric Argidurids

Typical profile

H1 - 0 to 2 inches: cobbly loam

H2 - 2 to 7 inches: clay

H3 - 7 to 15 inches: clay loam

H4 - 15 to 20 inches: cemented material

H5 - 20 to 30 inches: unweathered bedrock

Properties and interpretative groups

Parent material: Old alluvium and/or colluvium derived from igneous rock

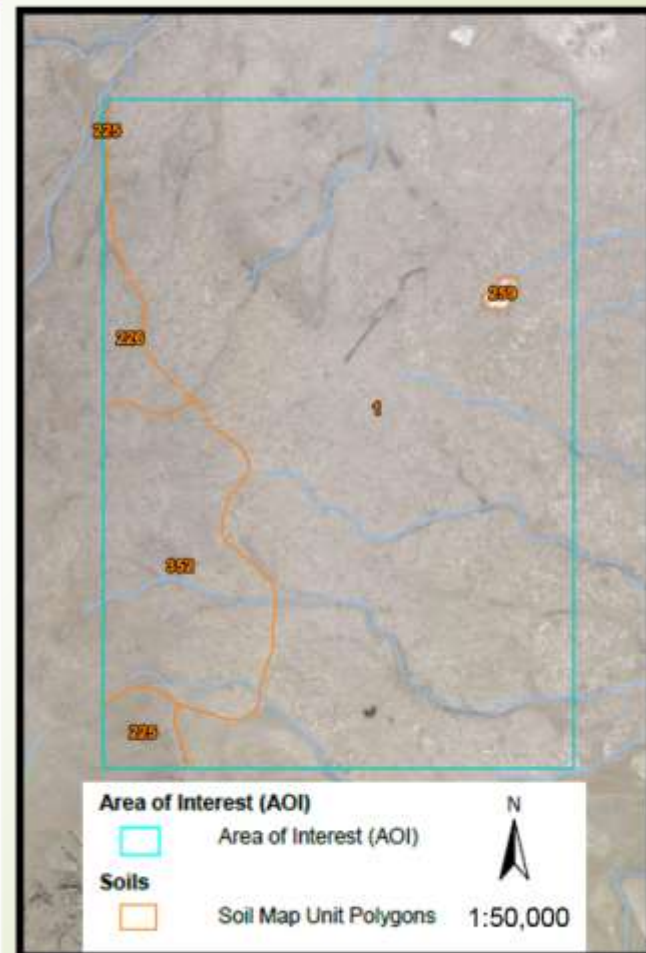
Depth to restrictive feature: 12 to 20 inches to duripan; 20 to 30 inches to lithic bedrock

Natural drainage class: Well drained

Depth to water table: More than 80 inches

Ecological site: CLAYEY 10-12 PZ (R023XY2200R)

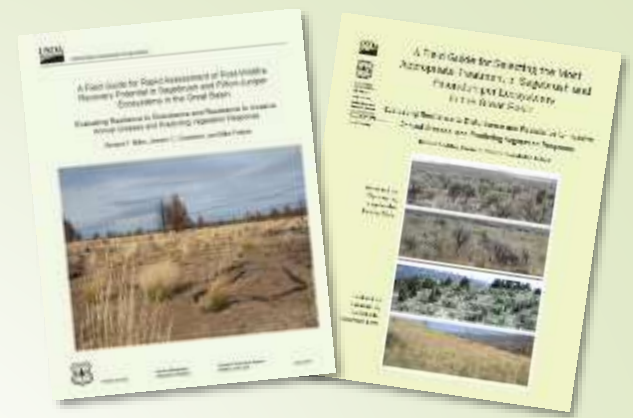
Common sagebrush species: Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*)



Field Verification



Pre-Treatment/Wildfire Vegetation



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), and/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.

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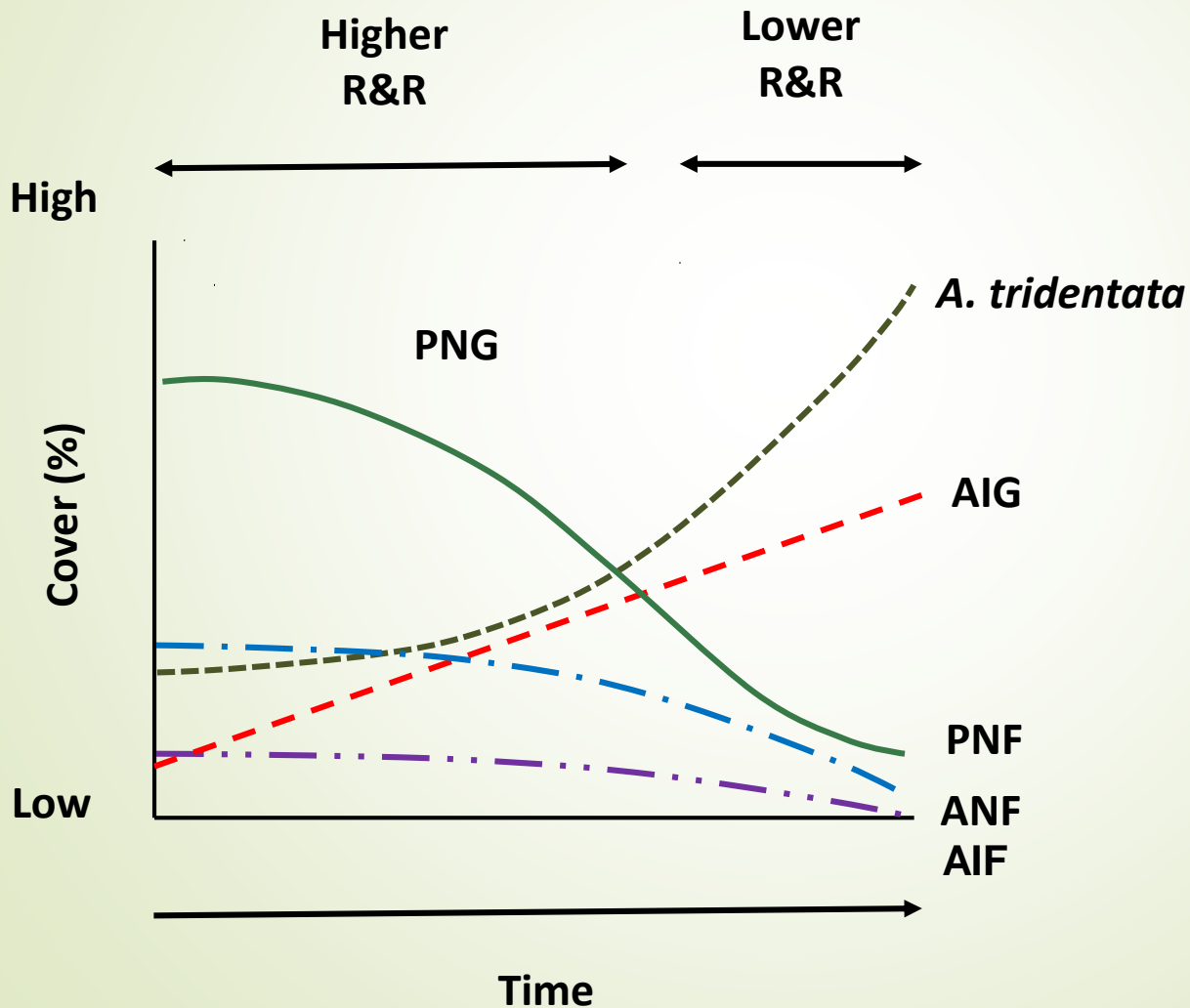
CONSERVE OUR WESTERN ROOTS



sagegrouseinitiative.com/roots

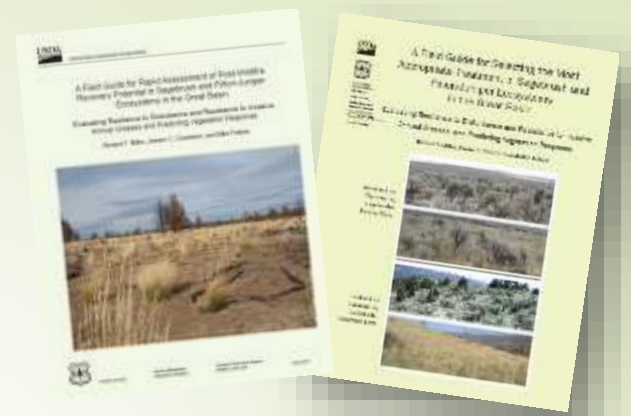
Illustrations by: Jeremy Maestas and Maja Smith

Pre-Treatment/Wildfire Vegetation



Chambers et al. 2017

Adjustment for Treatment/Wildfire Severity



Pre-Fire Vegetation (PFV) Adjusted for Fire Severity (Estimated)

C. Adjusted Pre-Fire Vegetation

(If area will be prescribed burned, estimate potential fire severity based on fuels and burn prescription for each plot.)

Low severity wildfire = PFV x 95%

Moderate severity wildfire = PFV x 80%

High severity wildfire = PFV x 20%

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Photo by: A. Hedrick, BLM

Rating: Very low ≤ 10 , Low = 10-14, Moderate = 15-20, High ≥ 20



But...it's really not just about the score.
It's about the thought process and discussion!

To manipulate or not?



Restoration



Prevention



Burn or not?



Post-fire rehab?



Applying R&R concepts at the site scale helps us:

- Predict vegetation responses
- Put the right strategies in right places
- Mitigate risks of undesired state shifts
- Communicate “why”



Questions



Photo by Bob Wick, BLM