

National Park Service
U.S. Department of the Interior
Upper Columbia Basin Network



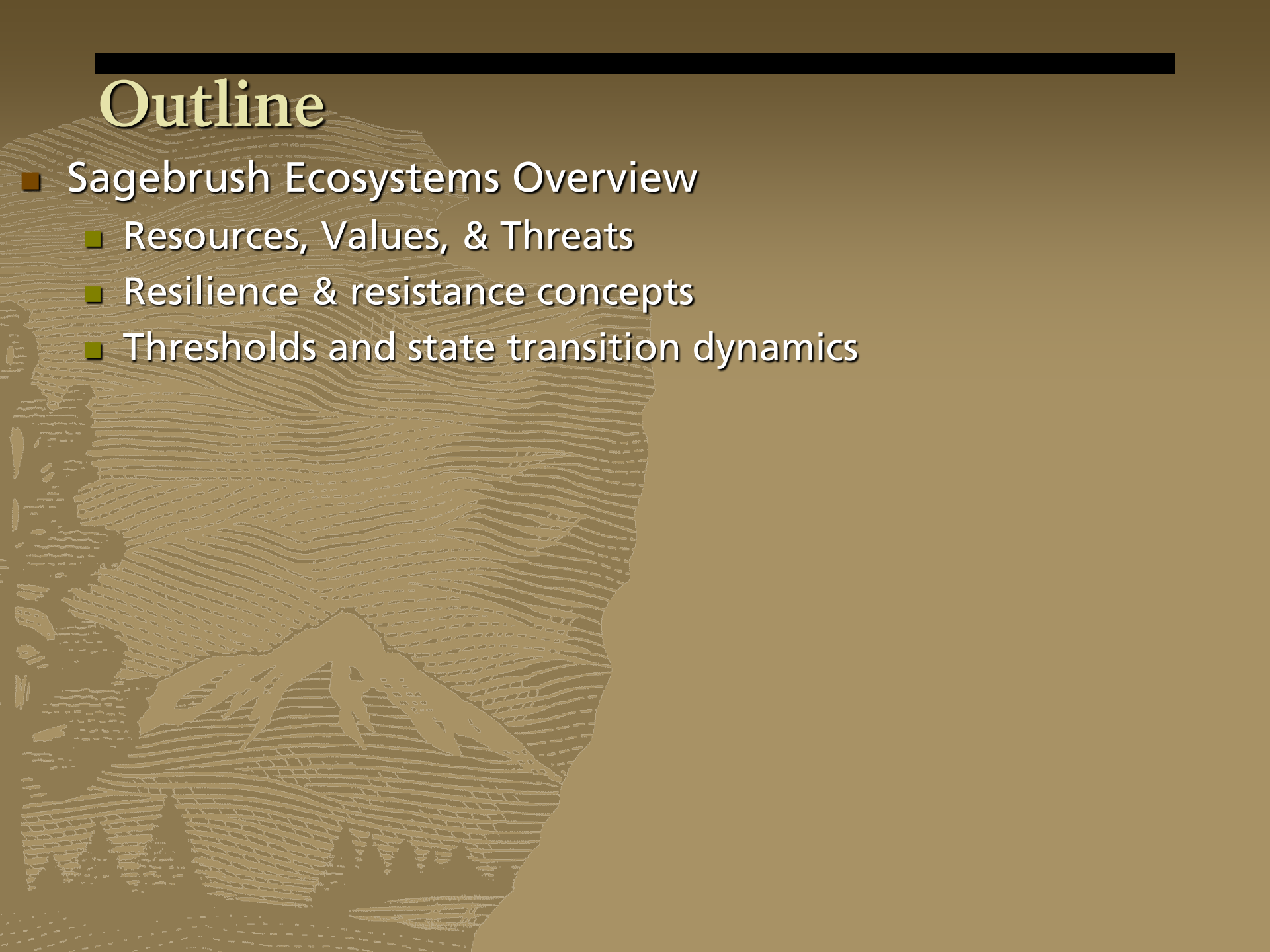
Operationalizing Resilience and Resistance Concepts for Conservation of Sagebrush Ecosystems in US National Parks

Tom Rodhouse & Jeff Lonneker
Upper Columbia Basin Network I&M Program
December 2, 2020

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Outline

- Sagebrush Ecosystems Overview
 - Resources, Values, & Threats
 - Resilience & resistance concepts
 - Thresholds and state transition dynamics



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- Sagebrush Ecosystems Overview
 - Resources, Values, & Threats
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 - Thresholds and state transition dynamics
- Focused Condition Assessment
 - Post-fire trends in John Day Fossil Beds (2011-2017)
 - Sagebrush ecosystems across NPS – a *GAP-ish* assessment
 - Empirical insights from 5 sagebrush steppe parks
 - Prioritizing park sagebrush ecosystems for protection, restoration, and triage
 - Examples from Lava Beds, Great Basin, City of Rocks

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 - Prioritizing park sagebrush ecosystems for protection, restoration, and triage
 - Examples from Lava Beds, Great Basin, City of Rocks
- Next Steps
 - Integrating into fire & park management operations planning

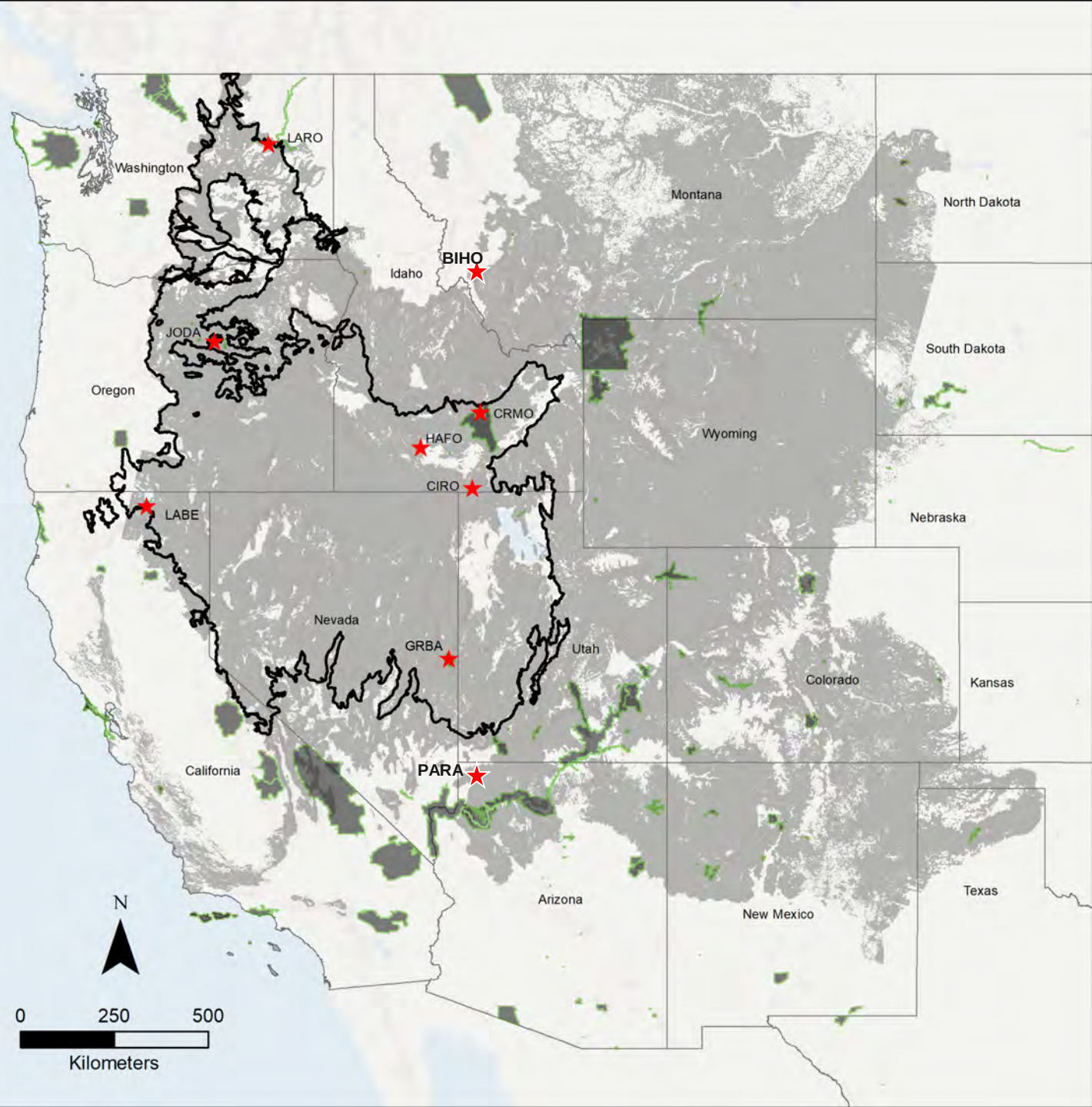
Acknowledgements

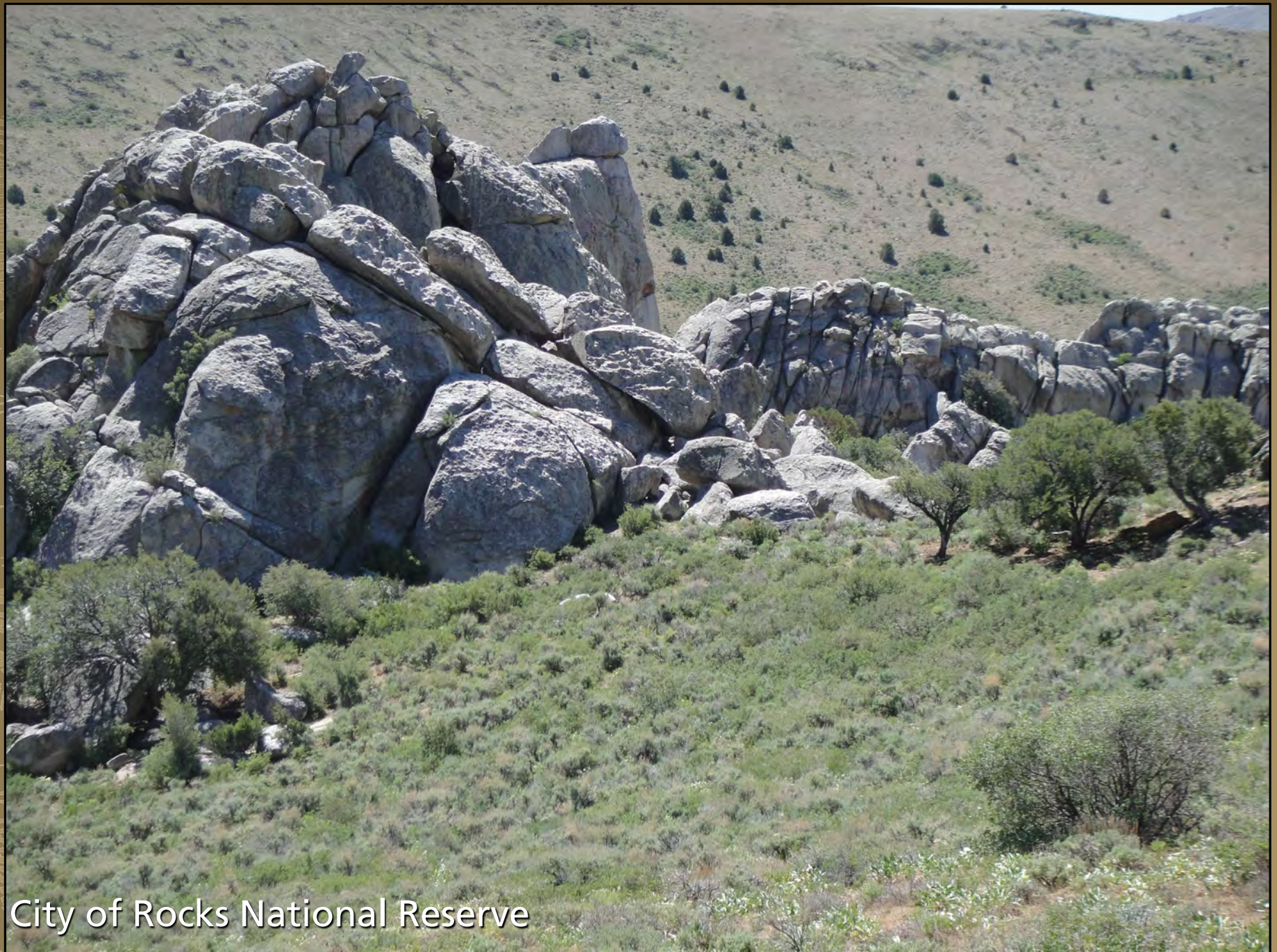
- NPS
 - WASO-NRSS
 - WRD-NRCA and FCA Program
 - IMD
 - BRD
 - PWR (DOI 8,9,10,12)
 - PWR Fire Reserve Fund
 - UCBN, GRYN, MOJN, KLMN
- USGS – Northern Rocky Mtn Science Center
 - Montana State University
- Oregon State University
 - Animal & Rangeland Sciences
 - Cascades (HERS Lab)
- USDA-ARS Burns, Oregon
- Walking Shadow Ecology – Mike Tercek

NPS Sagebrush Ecosystems



- Sagebrush ecosystems across the US (Rigge et al. 2020) **gray shading**
- NPS units outlined in **green**
- Floristic Great Basin (Miller et al. 2015) incl. Basin & Range, Columbia, & Snake River Plain ecoregions in **black** ★
- Studied parks





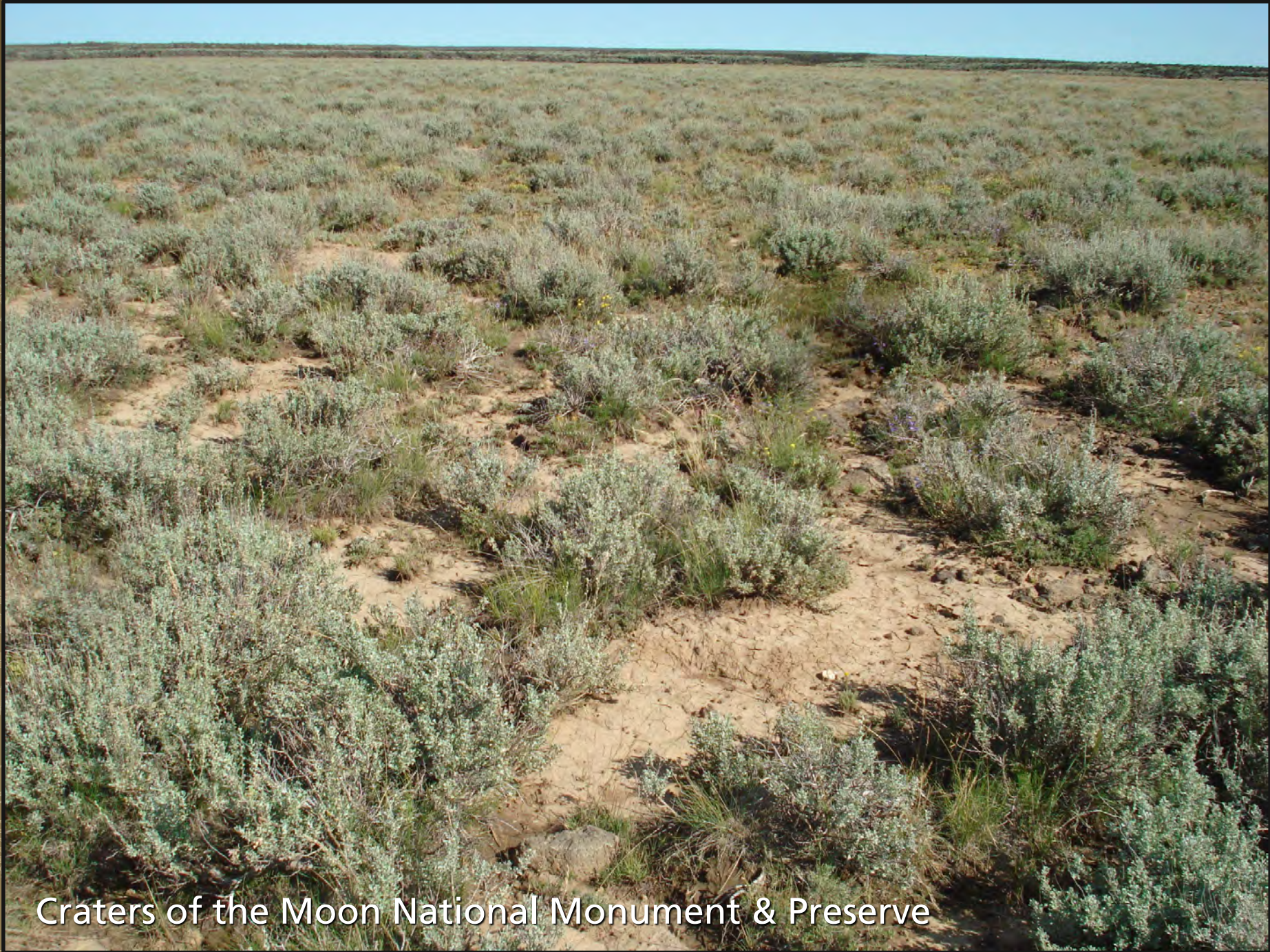
City of Rocks National Reserve



Great Basin National Park



(PARA) Grand Canyon-Parashant National Monument



Craters of the Moon National Monument & Preserve



Craters of the Moon National Monument & Preserve



John Day Fossil Beds National Monument



Hagerman Fossil Beds National Monument

Elevational Gradient

Topographic
Soil Moisture
and
Temperature
Gradients
(productivity)



High

Mid

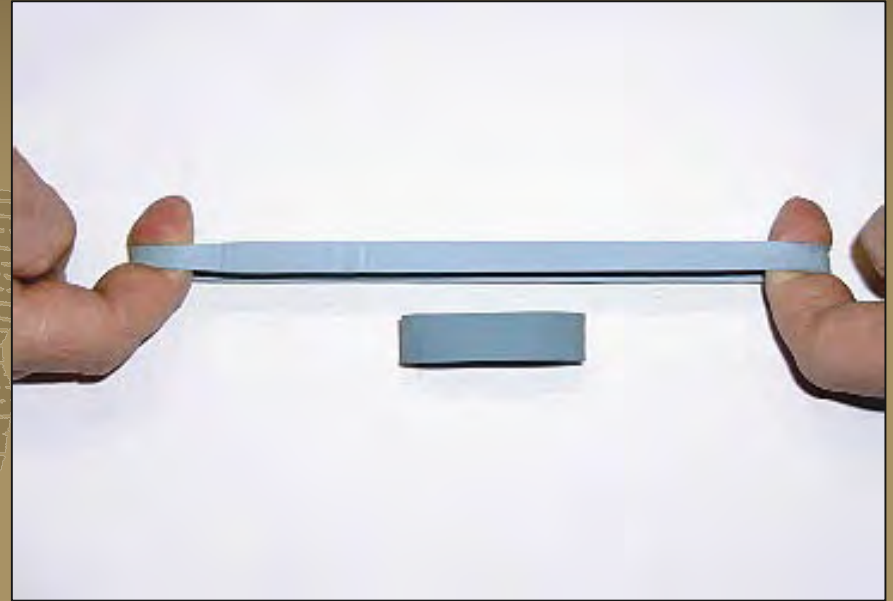
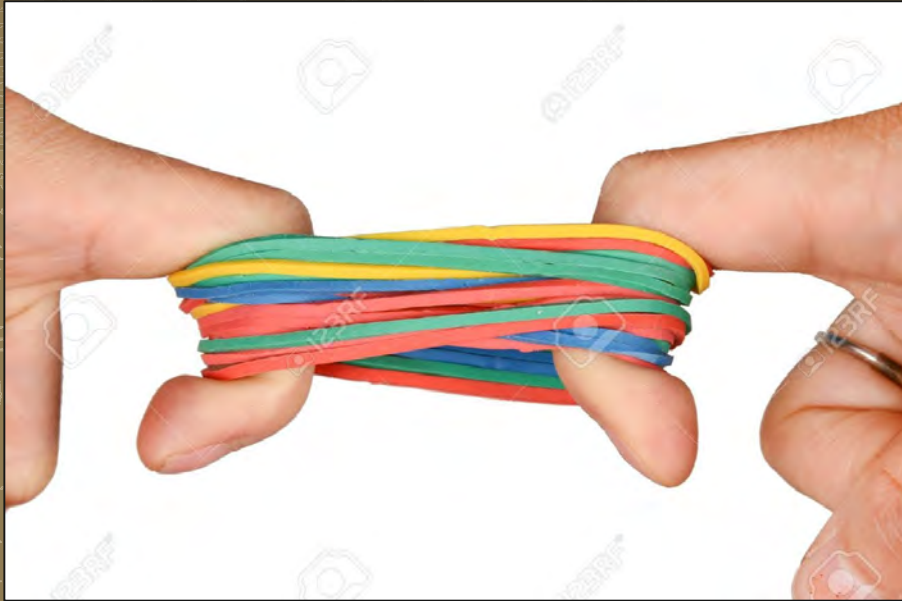
Low

Resilience to Disturbance
Resistance to Annual Grass
Invasion

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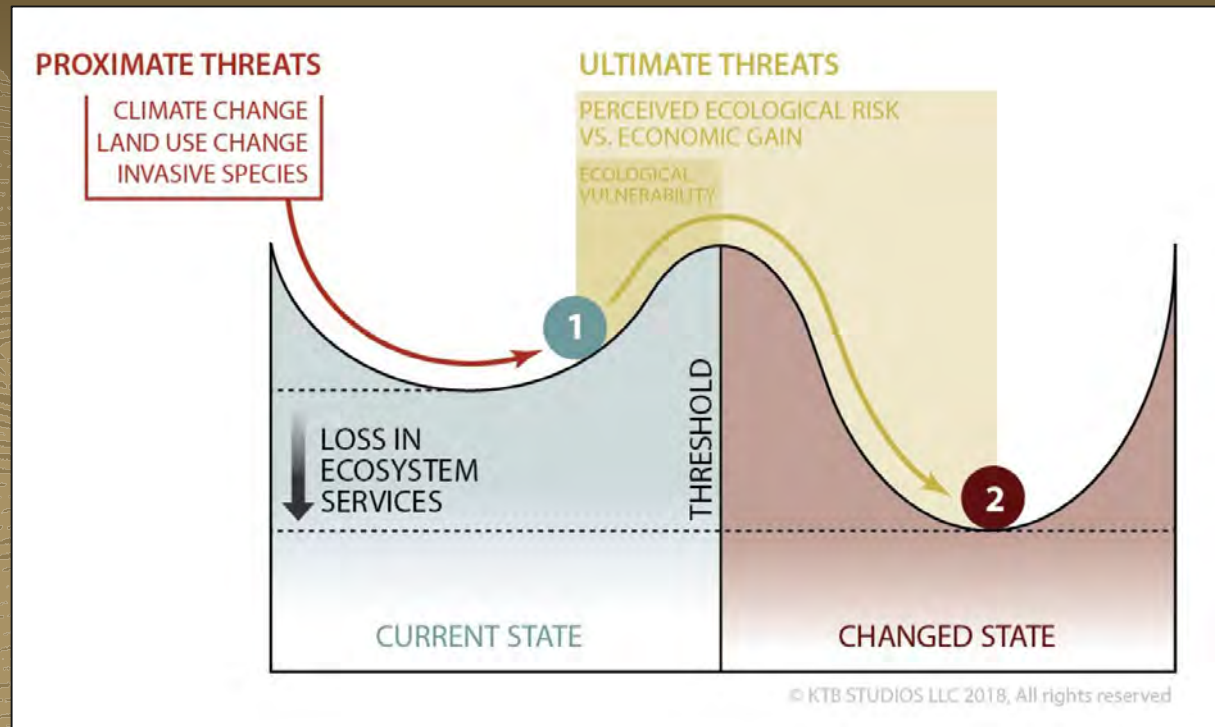
Resilience and Resistance



- 1) General ecosystem resilience to fire characterized by return to pre-fire structure and function
- 2) Resistance to annual grass invasion

see Chambers et al. 2019 *Frontiers in Ecology & Evolution*

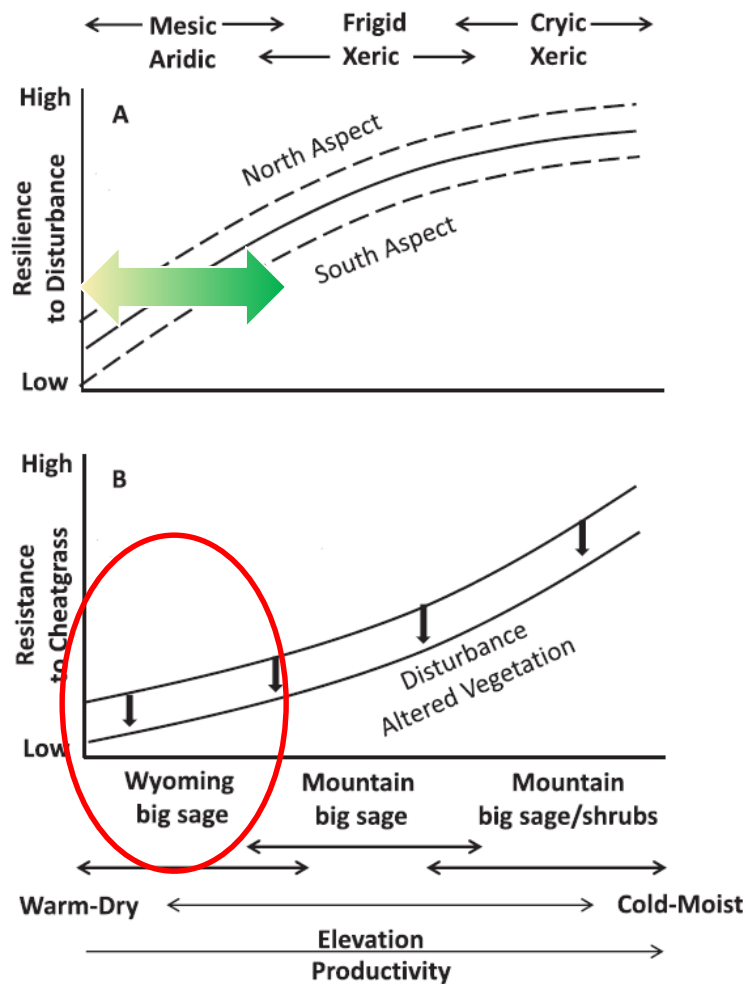
Thresholds & State Transitions



Restoration of degraded drylands
is often impossible -

Protection of remaining intact
sagebrush shrublands and steppe
is the conservation imperative!

see Hoover et al. 2020 Bioscience

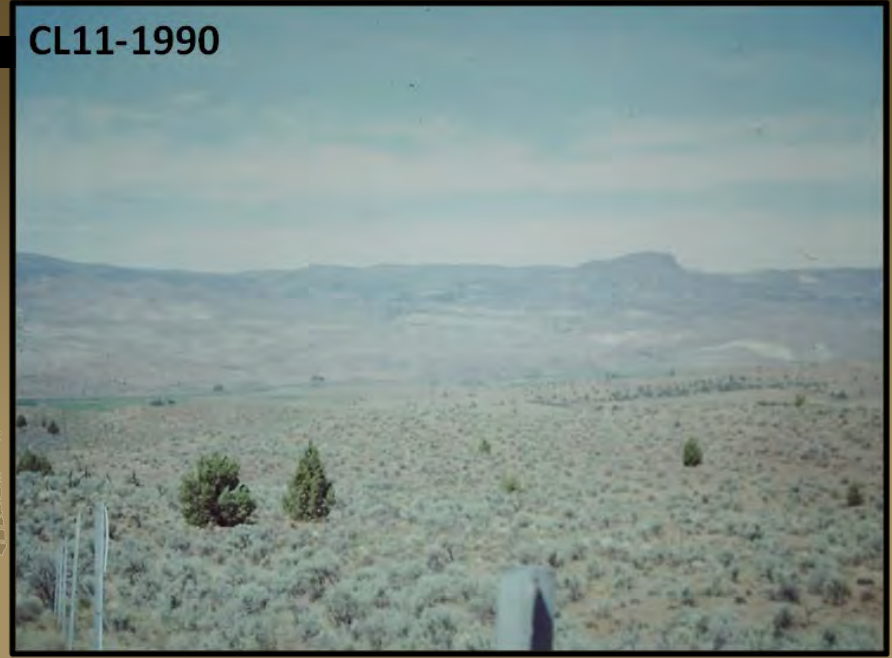


From Chambers et al. 2013
Ecosystems and Chambers et al.
2014 Rangeland Ecol. & Mgmt

CL11-1987



CL11-1990



CL11-2012



Clarno Unit of
John Day Fossil
Beds National
Monument (fires
in 1985, 1994,
1995, 2011)

Low-resilience
Wyoming-type
sagebrush
steppe

Loss of shrubs,
some native
perennial grass
recovery,
increased annual
grass

CL7-1987



CL7-1988



CL7-1990



CL7-2012



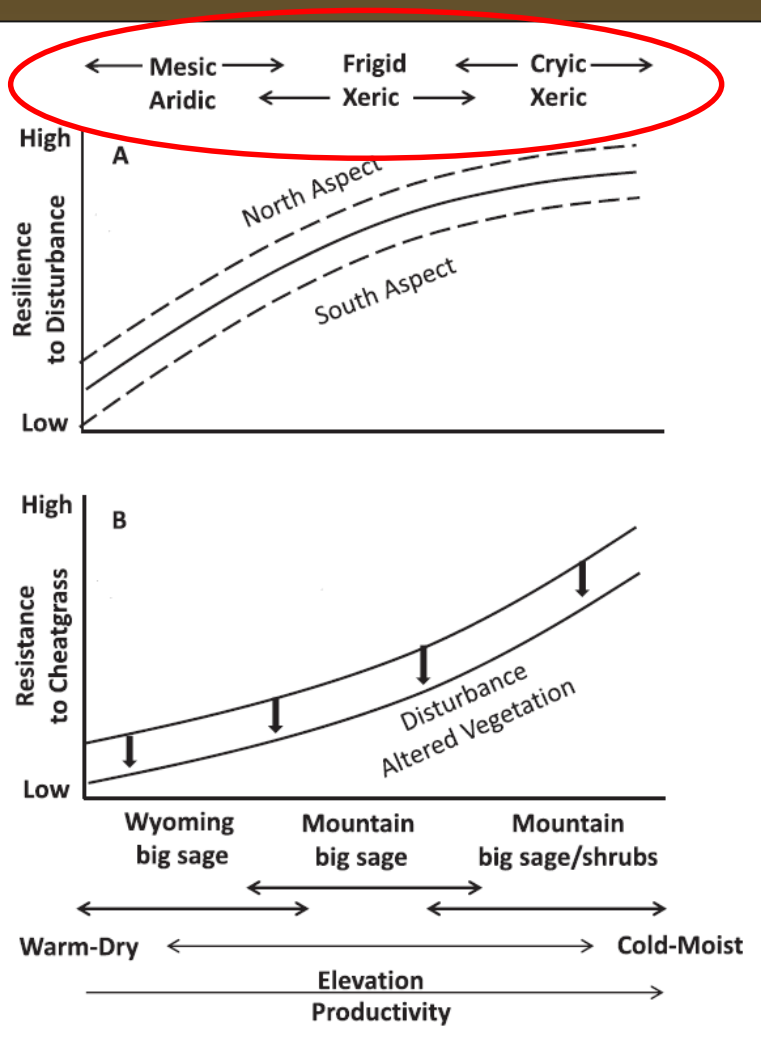
CL6-1987



North-facing slope,
substantial perennial
bunchgrass recovery,
minimal annual grass
invasion

CL6-2012

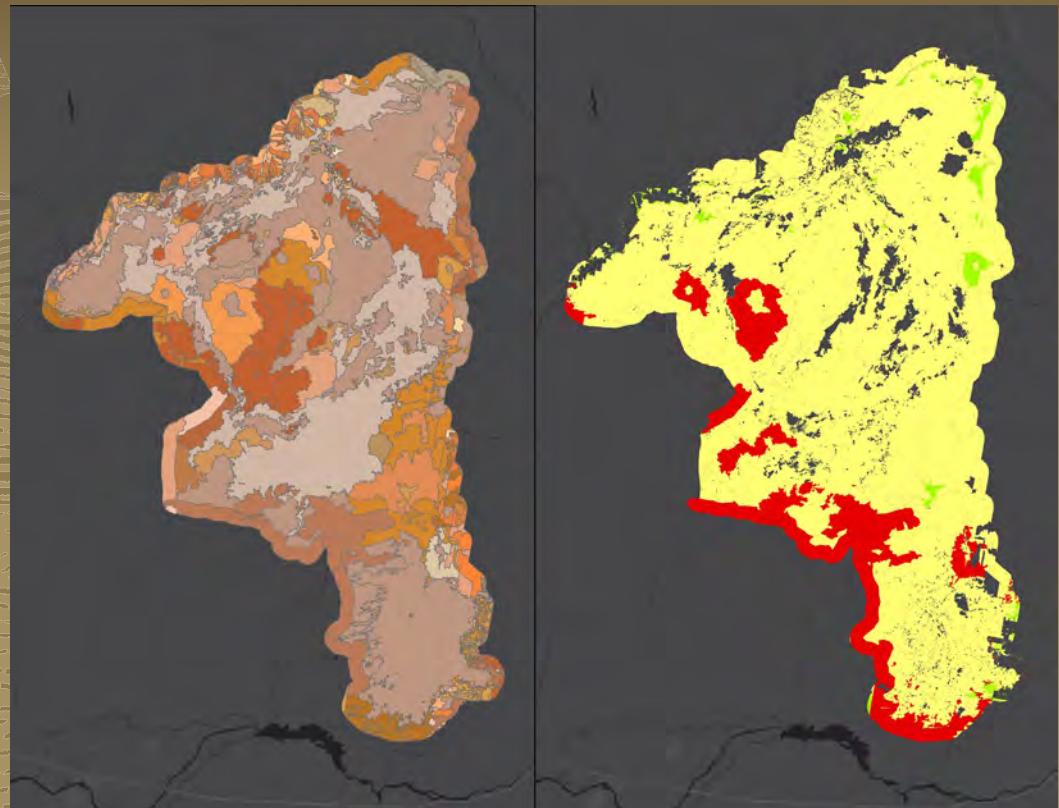




From Chambers et al. 2013
Ecosystems and Chambers et al.
2014 Rangeland Ecol. & Mgmt

Soils-based classification of potential resilience to disturbance (fire) and resistance to annual grass invasion

Craters of the Moon National Monument & Preserve soils inventory



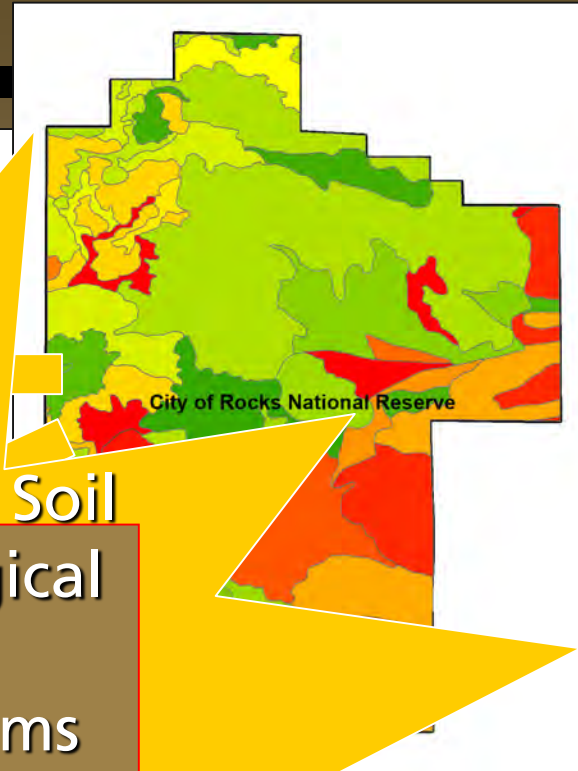
see Bradford et al. 2019 *Frontiers in Ecology & Evolution* & Maestas et al. 2016 *Rangelands*

Moisture Regime	Resistance				Moisture Regime	Resilience					
	Temperature Regime					Temperature Regime					
		mesic	frigid	blank		not used		mesic	frigid	blank	not used
	Aquic	moderate	high	high		high	Aquic	moderate	high	high	high
Udic				moderate	Udic				moderate		
Xeric	mod low	moderate	moderate	moderate	Xeric	low	moderate	moderate	moderate		
Aridic (torric)	low	moderate	low	low	Aridic (torric)	low	mod low	mod low	mod low		
no data	low			unknown	no data	low			unknown		
blank	low				blank	low					



1. Reference State

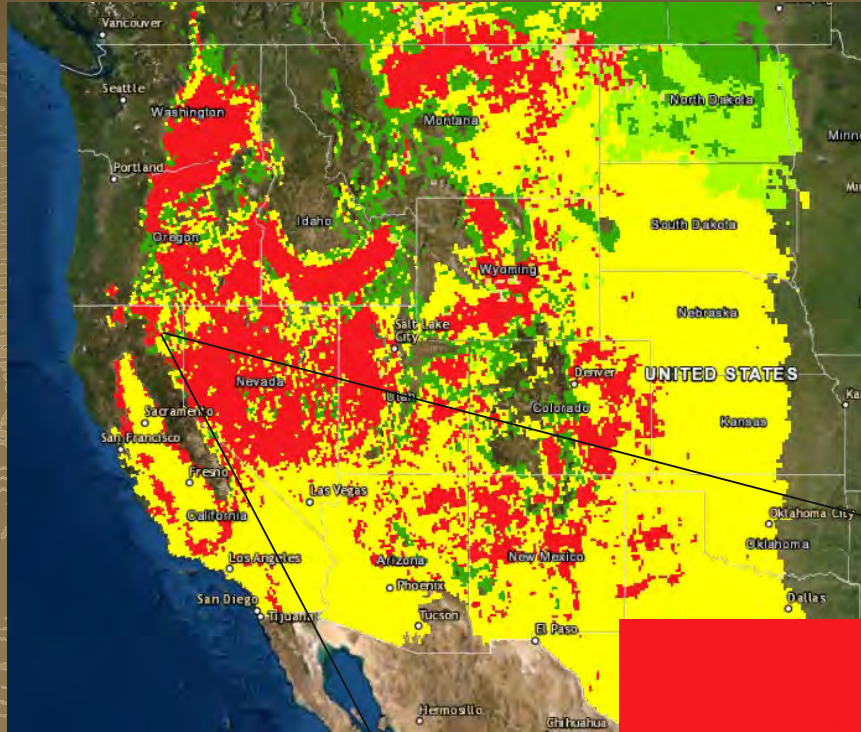
Large-stature perennial bunchgrasses dominated by bluebunch wheatgrass/Thurber's needlegrass (pathway to other phases dominated by sagebrush and western juniper are



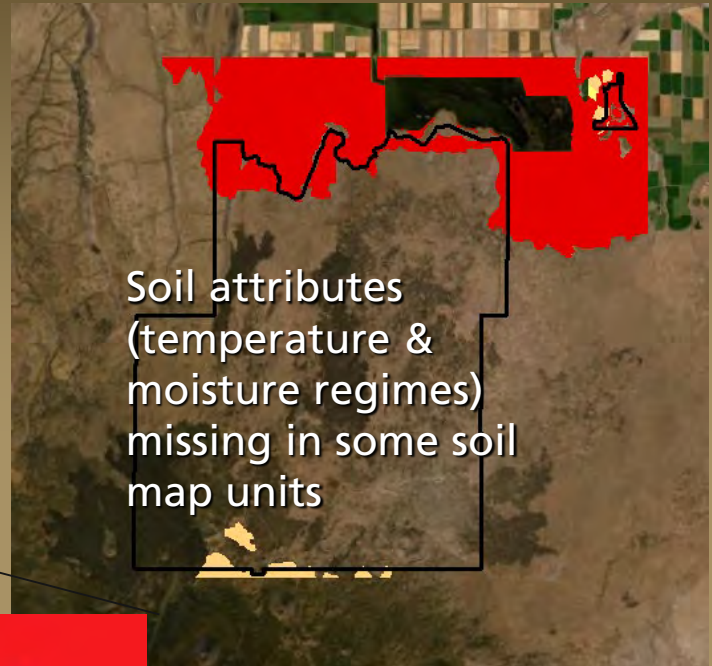
NPS Soils Inventories – Soil map units have ecological site descriptions with state-transition diagrams and attributes to classify potential resilience and resistance

see R. ... et al. ... tiers in Eco. & Evolu

Two Scales of Soil Surveys for Resilience Classifications



Bradford et al. 2019. Climate-driven shifts in soil temperature & moisture regimes suggest opportunities to enhance assessments of dryland resilience & resistance. *Frontiers in Ecology & Evolution*



Soil attributes (temperature & moisture regimes) missing in some soil map units



Finer-grain SSURGO (NPS [NRCS]) soil survey data

Coarse-grain STATSGO (NRCS) soil survey data, generalized to grid (10 km²) for climate change analysis

Sagebrush Ecosystems Focused Condition Assessment

Sagebrush Steppe Conservation

Resource Brief – September 2020

National Park Service
U.S. Department of the Interior

DOI Unified Regions 8,9,10,12



Sagebrush Steppe Focused Condition Assessment

DOI Unified Regions 8,9,10 (Pacific West) – BIHO, CIRO, CRMO, GRBA, HAFO, JODA, LABE, LARO, PARA

Importance: Resilience of A Threatened Ecosystem

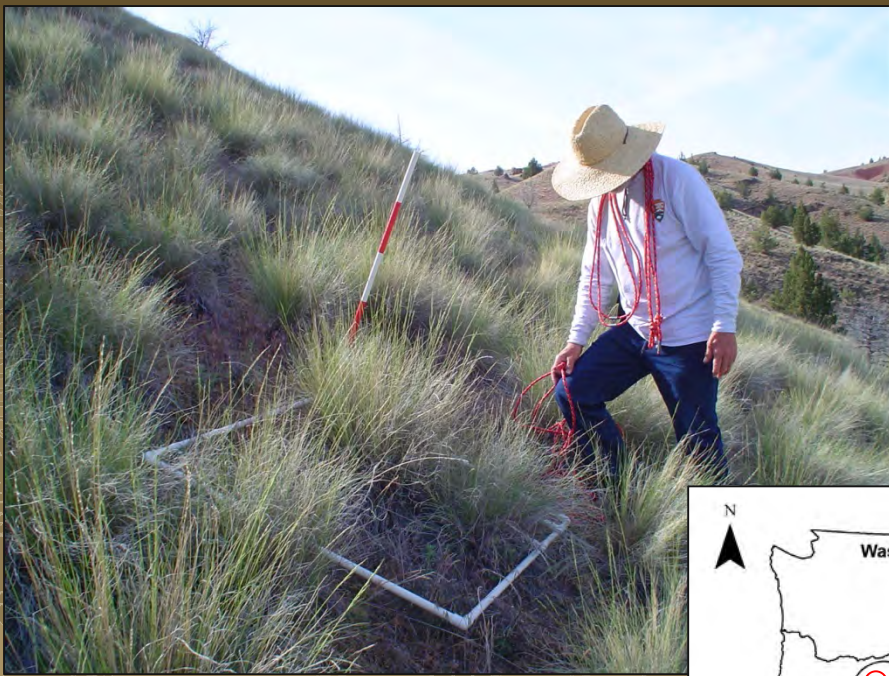
Sagebrush steppe is one of the most threatened ecosystems in the Intermountain West and not well represented within the parks and protected-area systems of the US. Substantial portions of sagebrush steppe have been converted to agriculture and heavily grazed rangeland, and remaining steppe is being invaded by weeds and altered by increasingly frequent large fires. This focused condition assessment supports strategic steppe conservation decision-making across NPS by assembling park geodatabases with the necessary information from previous park inventories, monitoring, and assessments for sagebrush steppe mapping. These maps are developed within the framework of ecosystem resilience to fire and resistance to annual grass invasion. Approaching park steppe conservation through the lens of resilience and resistance allows for intuitive prioritization of park landscapes and facilitates collaboration within NPS and among its partner organizations such as the Bureau of Land Management which manages sagebrush steppe adjacent to NPS lands.

Assessment Objectives

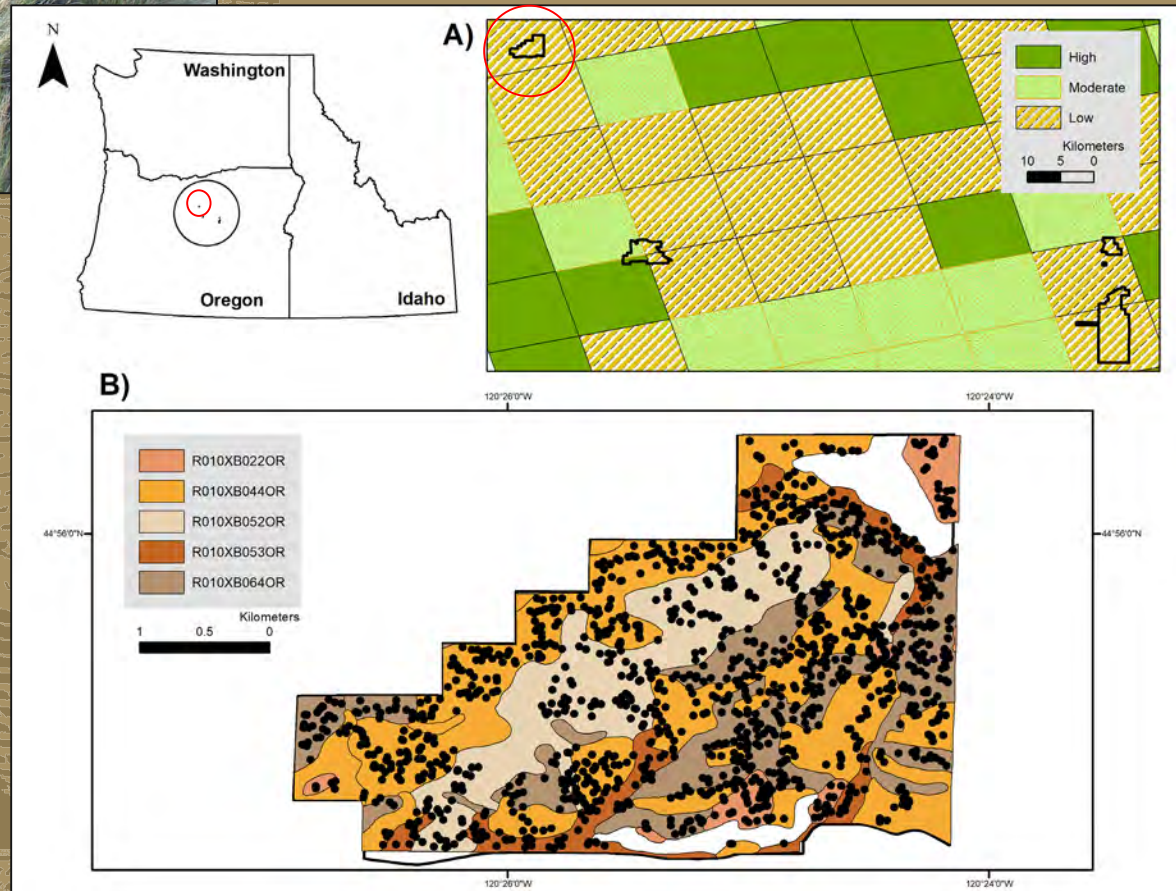
Our goal is to facilitate collaborative sagebrush steppe conservation across park lands and with neighbors across larger steppe landscapes with geographic mapping tools and a supporting scientific framework that makes NPS decision-making easier and more effective.



View from Bath Rock-City of Rocks National Reserve, Idaho. Sagebrush steppe makes up about 70% of the land within City of Rocks National Reserve (CIRO) and plays a major ecological role in supporting native plant species diversity and providing habitat for wildlife and scenic vistas.

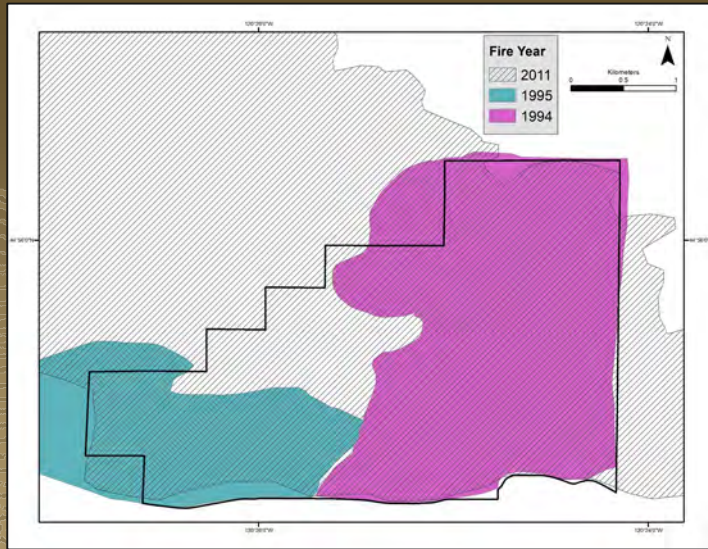


Rodhouse et al. 2020. Post-fire vegetation response in a repeatedly-burned low-elevation sagebrush steppe protected area provides insights about resilience and invasion resistance. *Frontiers in Ecology & Evolution* 8:584726.

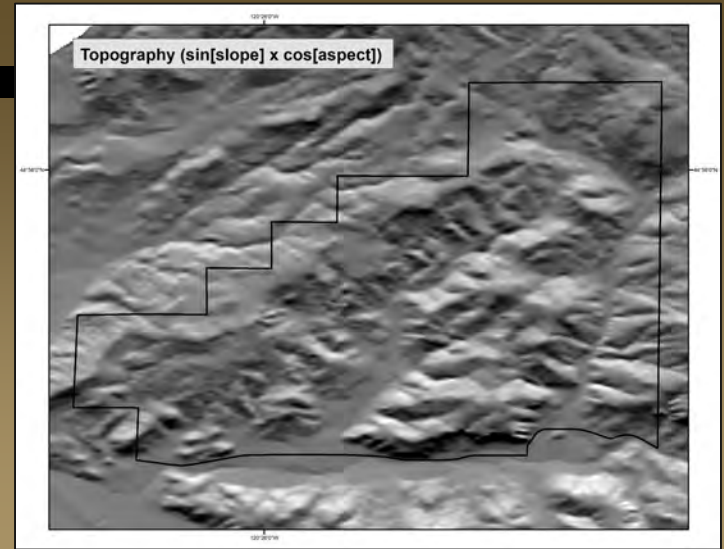


Is there grass species abundance (cover) variation among the 5 ecological sites, after accounting for topography, growing season water deficit, and burn severity?

2 perennial grasses –
needlegrass and wheatgrass
2 invasive annual grasses –
medusahead and cheatgrass

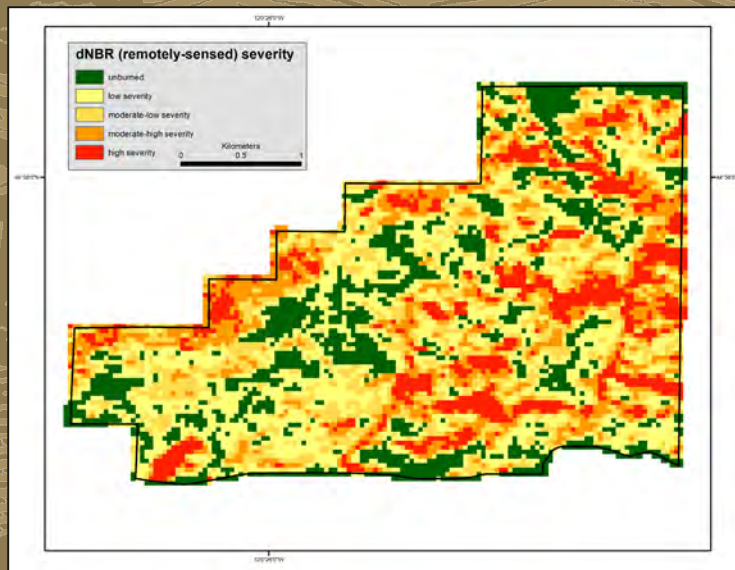


repeatedly burned (unplanned ignitions)

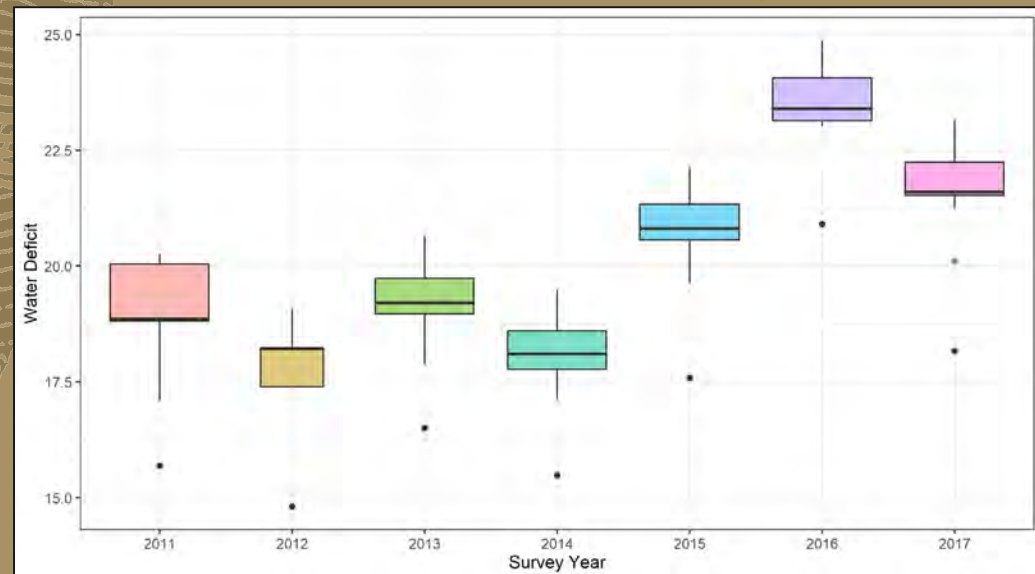


topographic heterogeneity

2011 burn severity



Annual variation in growing-season water deficit (mean Oct-May)



Hierarchical ordinal zero-augmented beta regression to model grass cover along gradients of topography, water deficit, burn severity, grouping by ecological site

(R package in process)

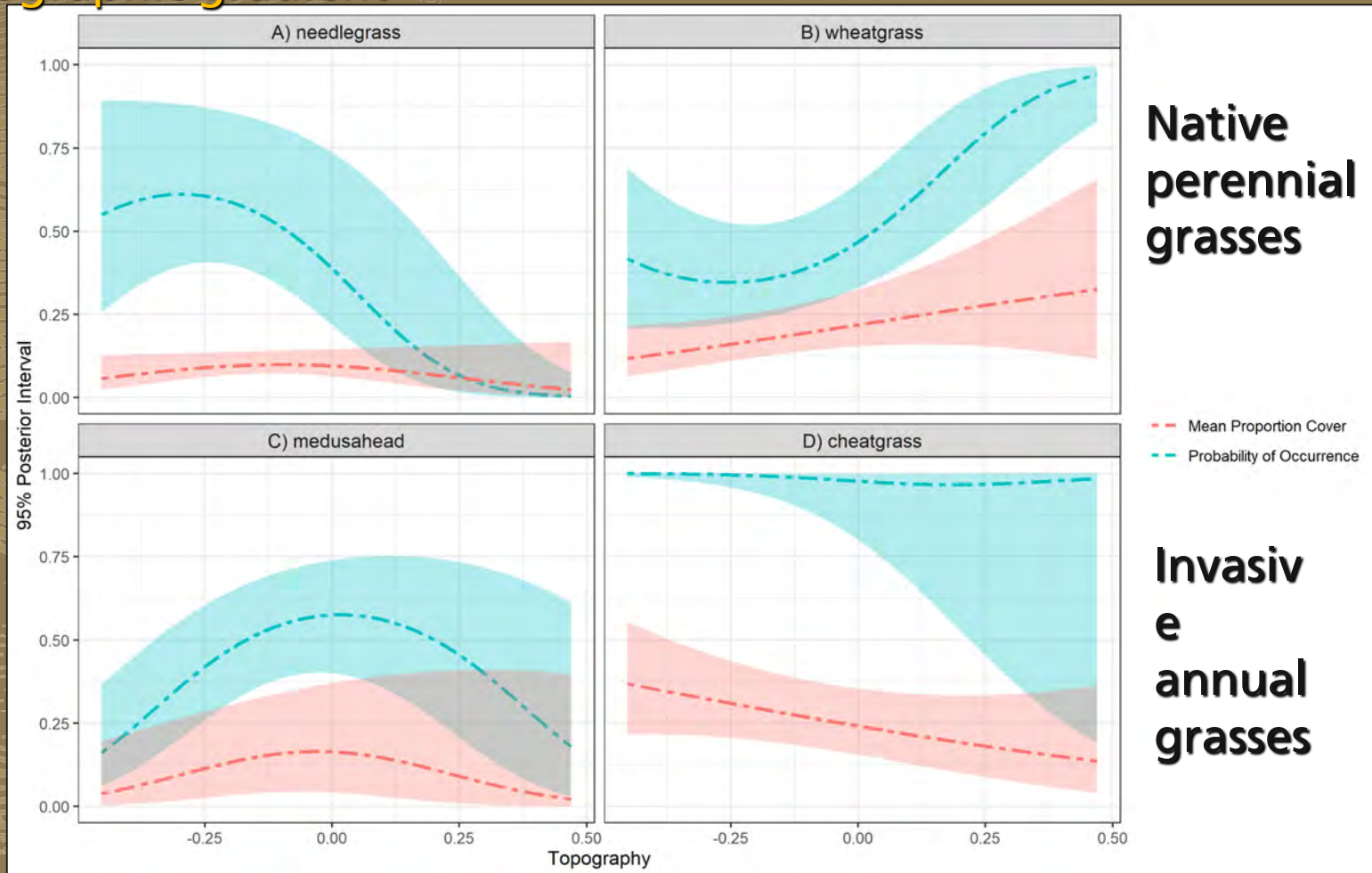
Irvine, K.M., W.J. Wright, E.K. Shanahan, and T.J. Rodhouse. 2019. Comprehensive framework for modeling plant cover class data. *Methods in Ecology and Evolution* 10:1749-1760.

Damgaard, C.F., and K.M. Irvine. 2019. Using the beta distribution to analyse plant cover data. *Journal of Ecology* 107:2747-2759.

Irvine, K.M., T.J. Rodhouse, and I. Keren. 2016. Extending ordinal regression using a latent zero-augmented beta distribution. *Journal of Agricultural, Biological, and Environmental Statistics* 21:619-640.

Irvine, K.M., and T.J. Rodhouse. 2010. Power analysis for trend in ordinal cover classes: implications for long-term vegetation monitoring. *Journal of Vegetation Science* 21:1153-1161.

Native perennial (needlegrass & wheatgrass) and non-native invasive annual grass occurrences & abundances (cover) **varied strongly along topographic gradient**



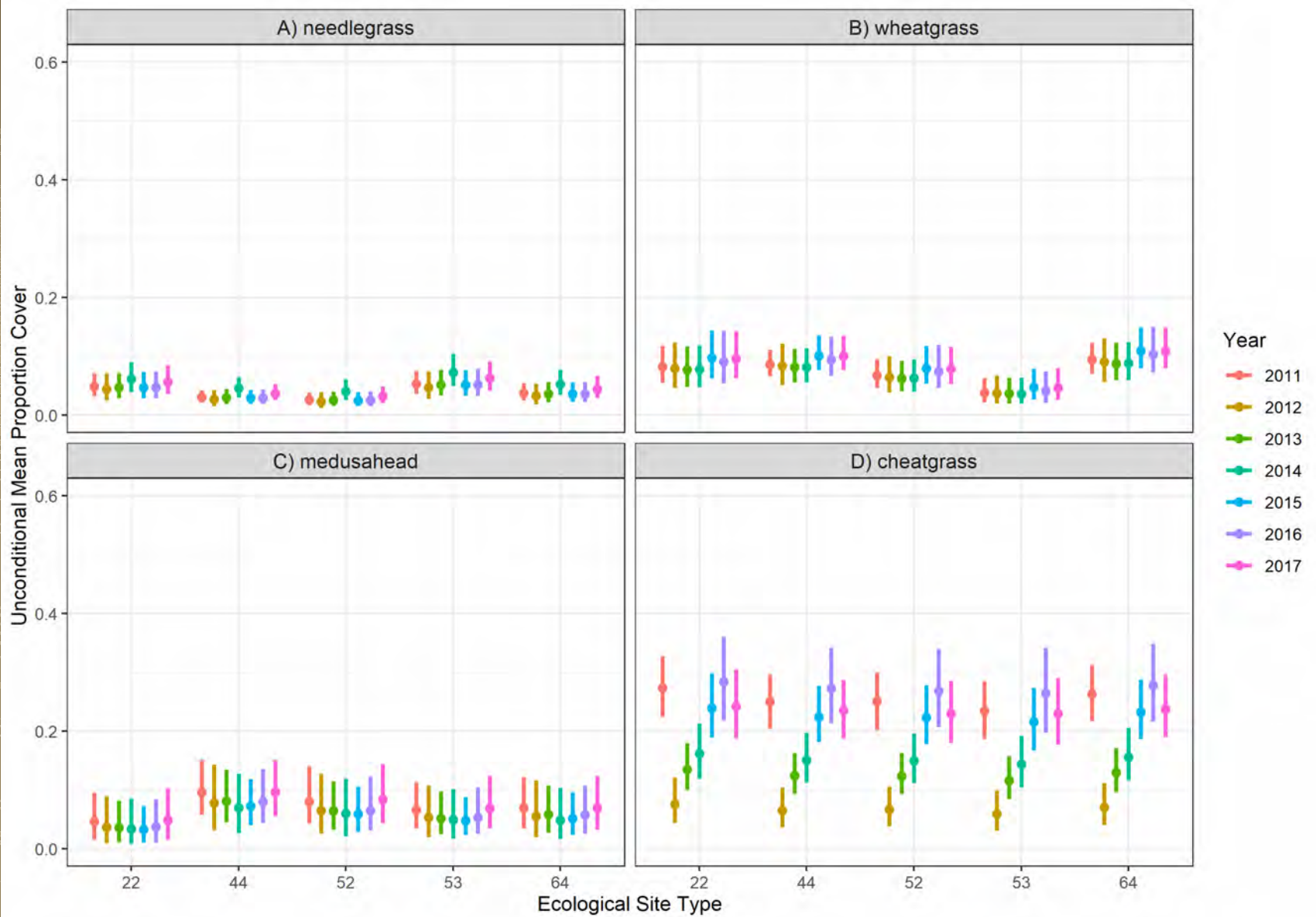
**Native
perennial
grasses**

**Invasive
annual
grasses**

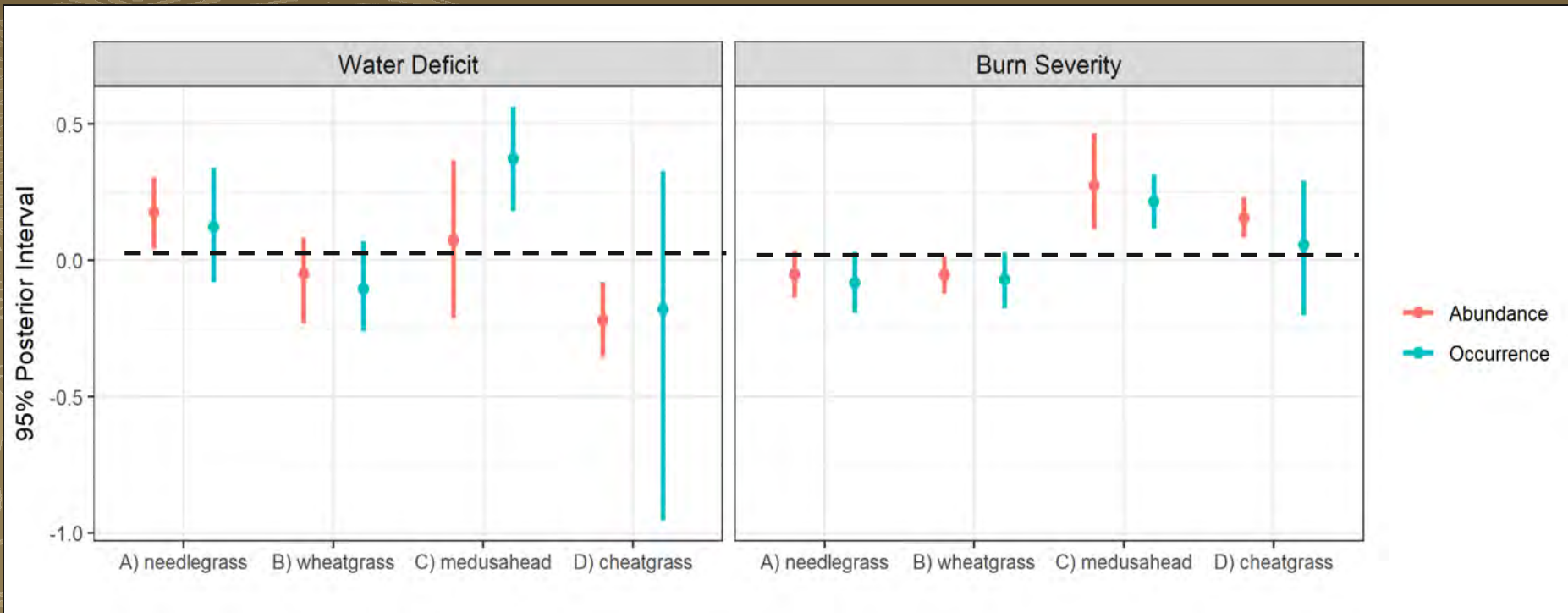
Steep south-facing
slopes

Flat
ground

Steep north-facing
slopes

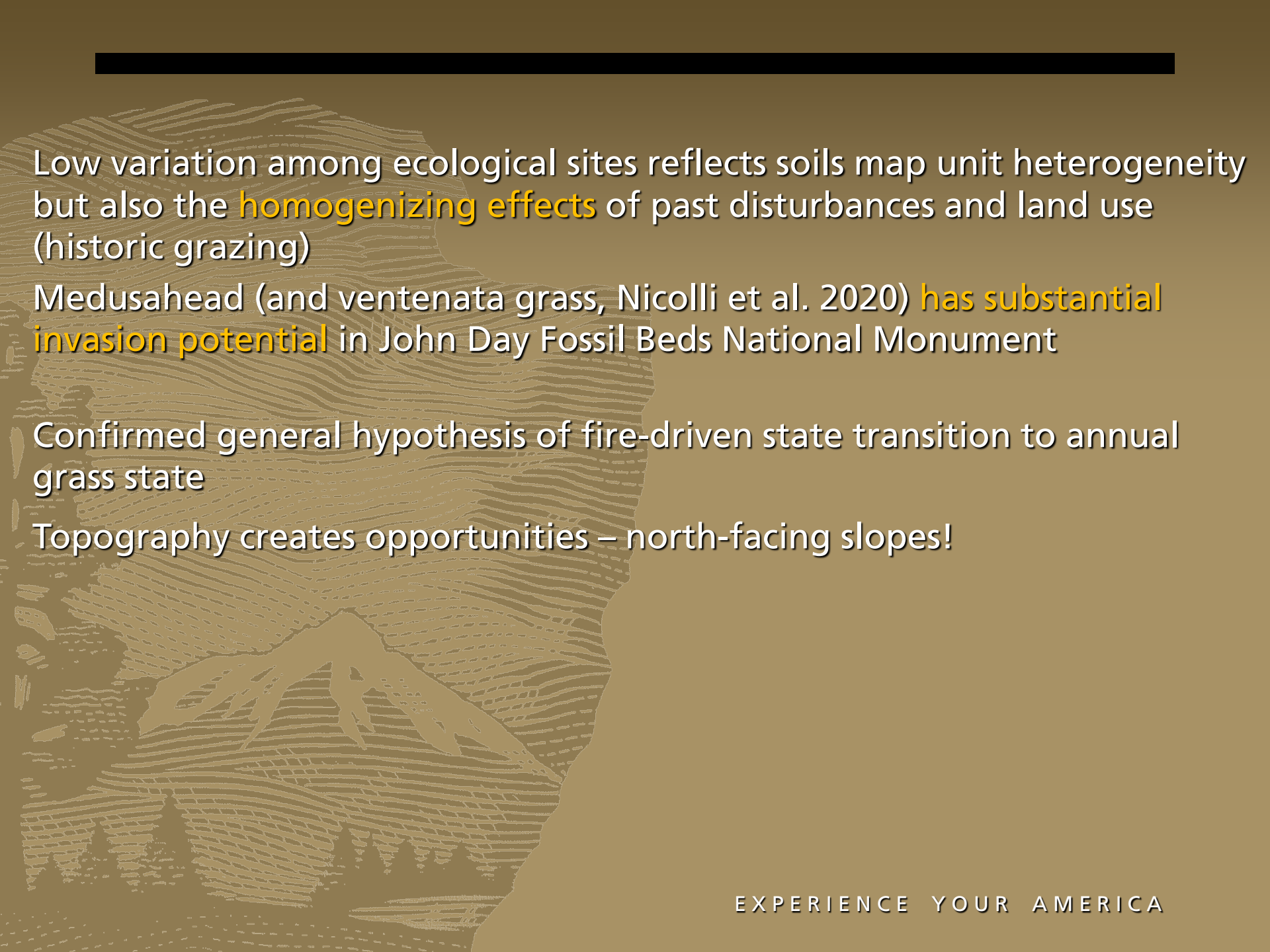


Native perennial (needlegrass & wheatgrass) and non-native invasive annual grass abundances (model-estimated unconditional mean cover) **showed no variation among ecological sites.**



Native perennial (needlegrass & wheatgrass) and non-native invasive annual grass occurrences & abundances (cover) contrasted strongly along water deficit and burn severity gradients.

Medusahead responded positively to water deficit and both invasives responded positively to burn severity

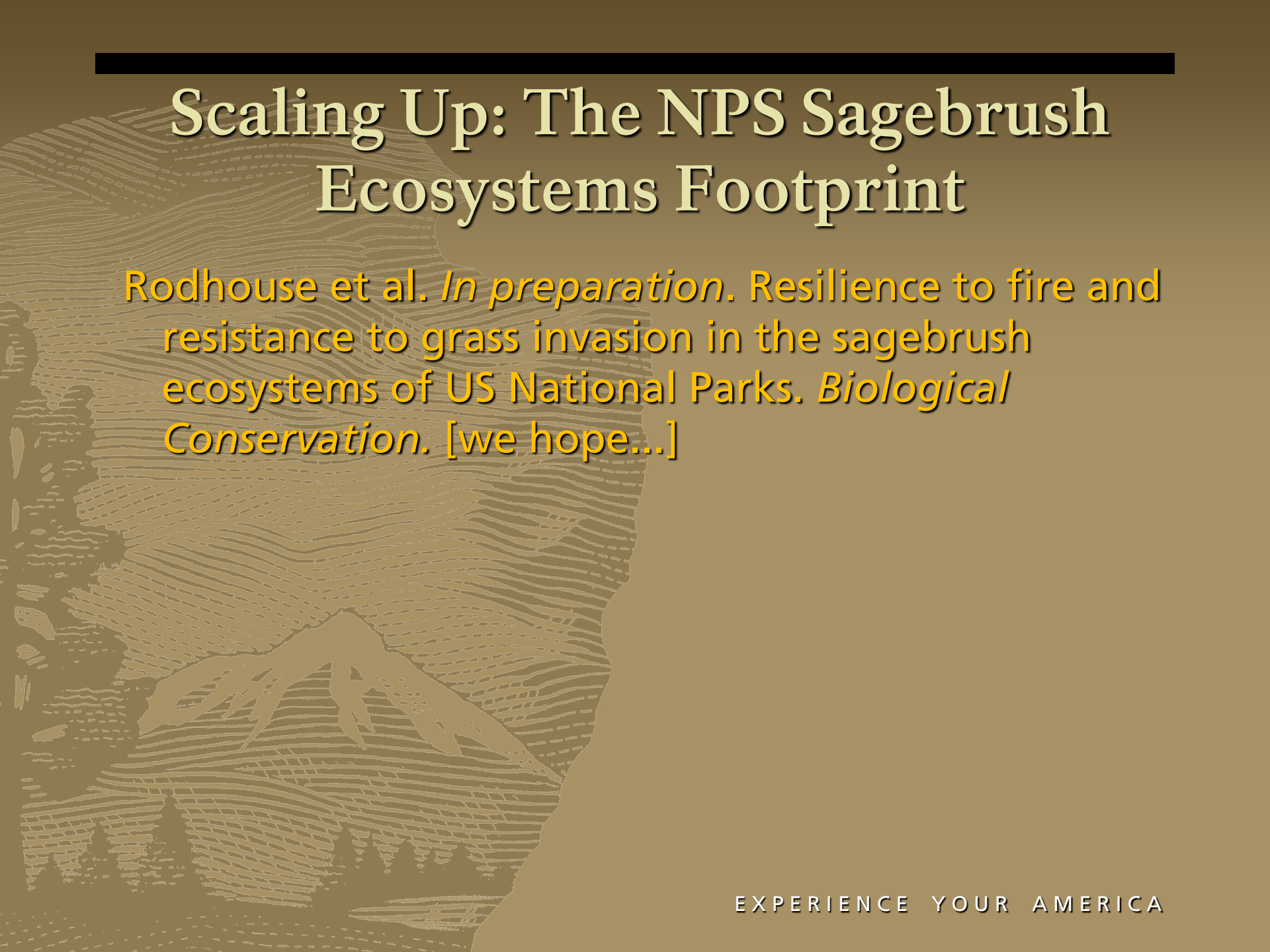


Low variation among ecological sites reflects soils map unit heterogeneity but also the **homogenizing effects** of past disturbances and land use (historic grazing)

Medusahead (and ventenata grass, Nicolli et al. 2020) **has substantial invasion potential** in John Day Fossil Beds National Monument

Confirmed general hypothesis of fire-driven state transition to annual grass state

Topography creates opportunities – north-facing slopes!



Scaling Up: The NPS Sagebrush Ecosystems Footprint

Rodhouse et al. *In preparation*. Resilience to fire and resistance to grass invasion in the sagebrush ecosystems of US National Parks. *Biological Conservation*. [we hope...]

NPS Role in the Conservation Network

Assess the importance of the NPS in the long-term conservation of sagebrush steppe environments.

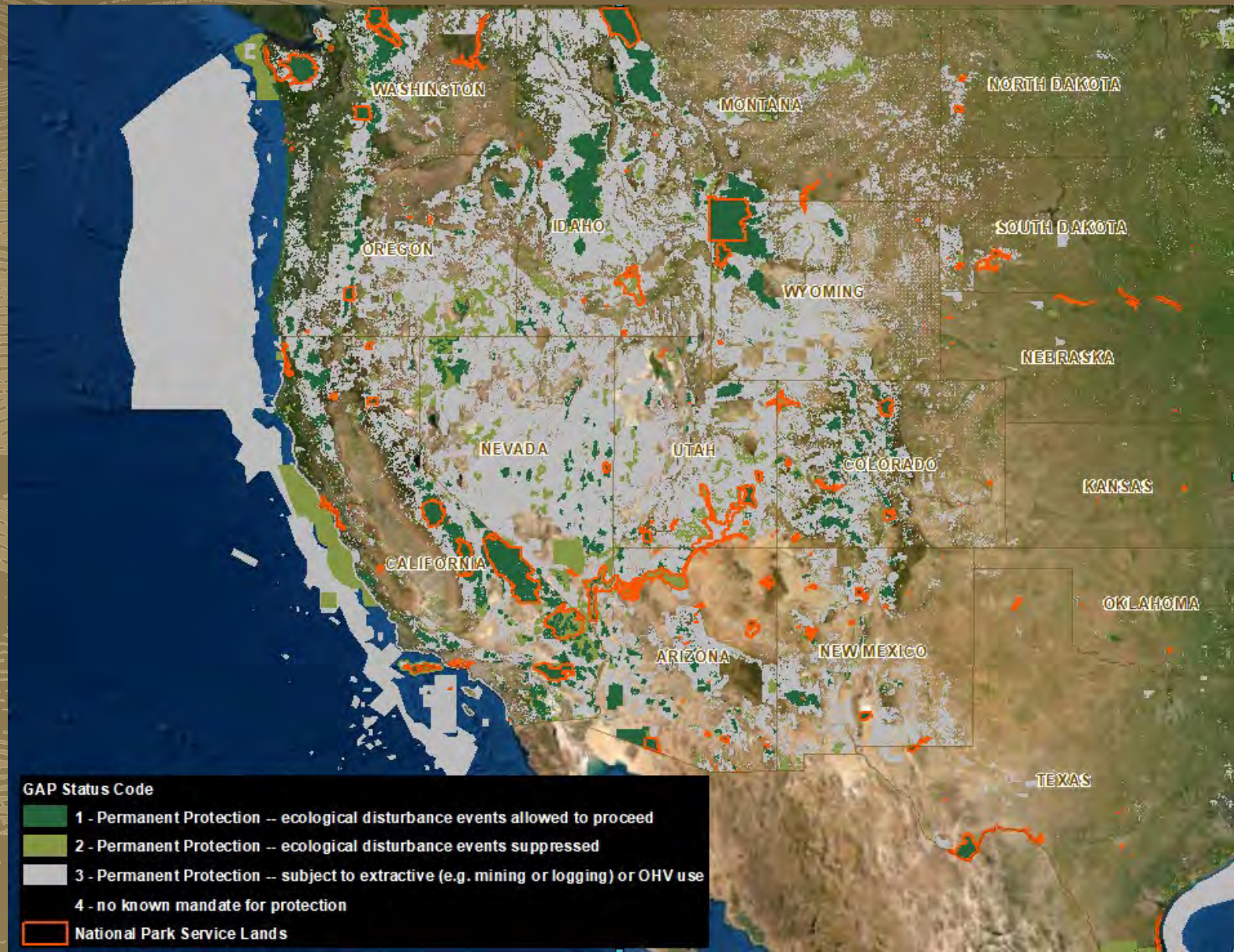
USGS PADUS version 1.4 (Gap Analysis Program)

- Provides a measurement of management intent, binned into 4 categories (Gap Status Codes).

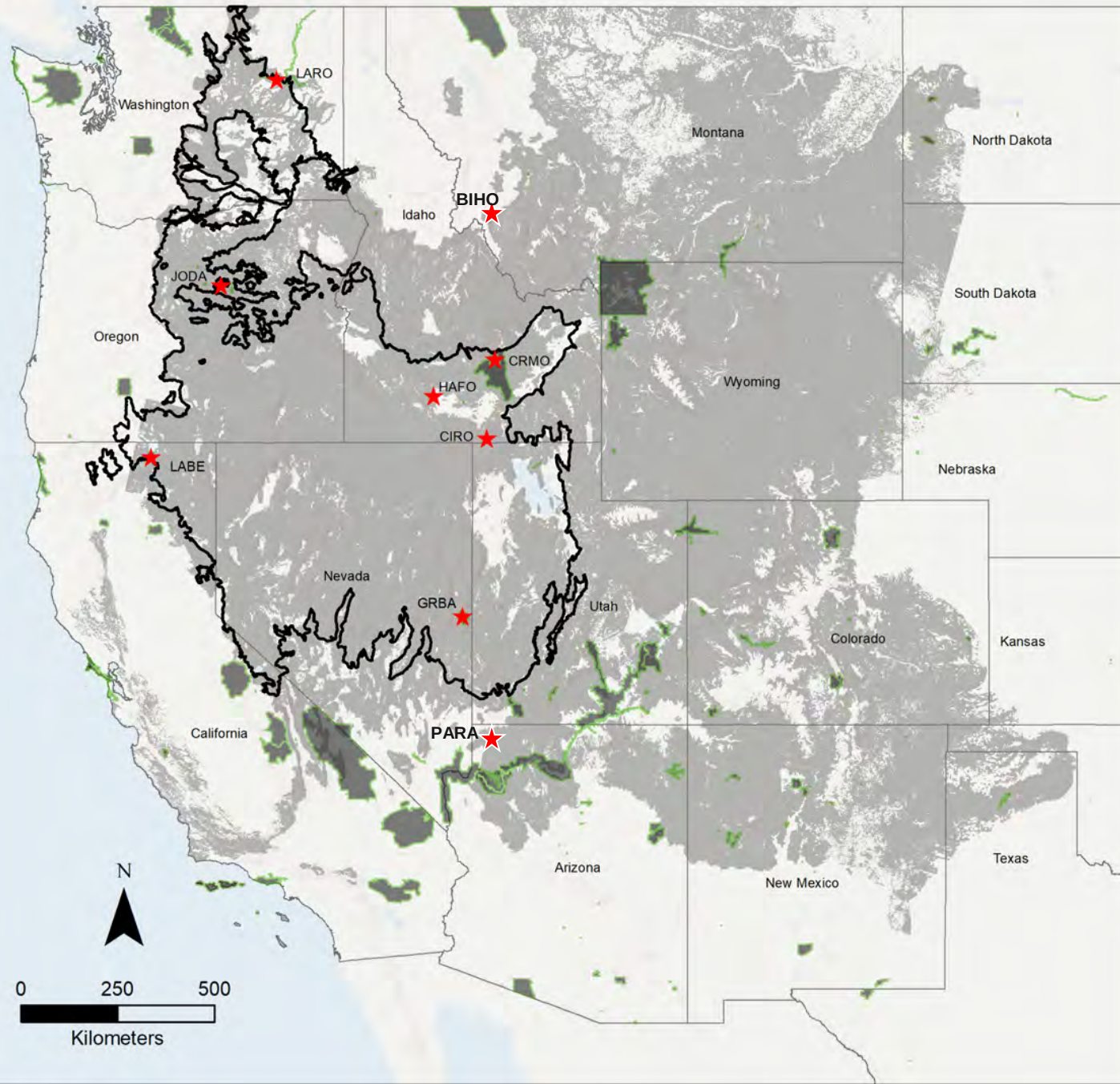
GAP Status Code

- 1 - Permanent Protection -- ecological disturbance events allowed to proceed**
- 2 - Permanent Protection -- ecological disturbance events suppressed**
- 3 - Permanent Protection -- subject to extractive (e.g. mining or logging) or OHV use**
- 4 - no known mandate for protection**

NPS Role in the Conservation Network



- Sagebrush ecosystems across the US (Rigge et al. 2020) **gray shading**
- NPS units outlined in **green**
- Floristic Great Basin (Miller et al. 2015) incl. Basin & Range, Columbia, & Snake River Plain ecoregions in **black**
- Studied parks ★



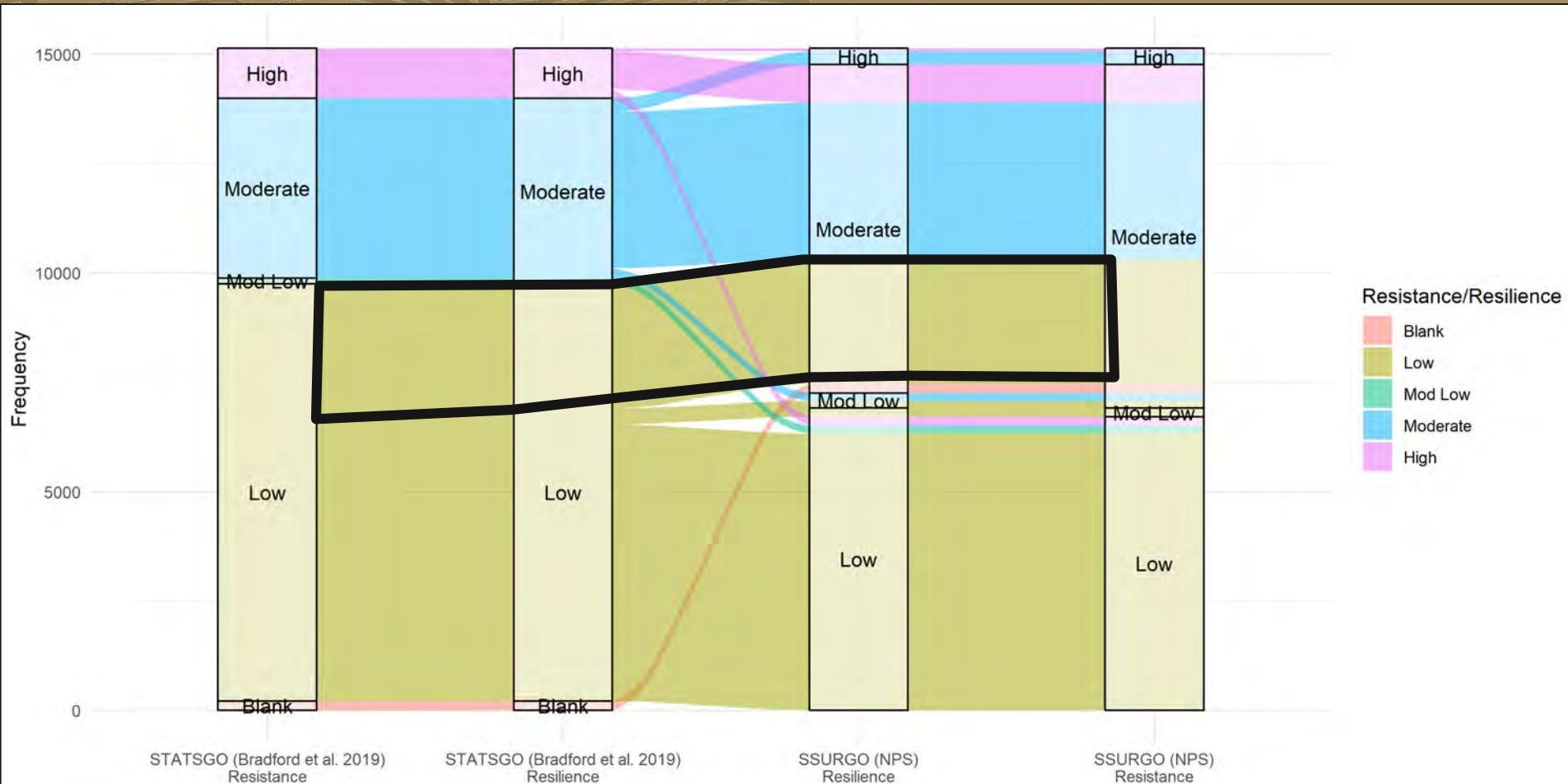
NPS Role in the Conservation Network

- 10% of mapped sagebrush shrublands and steppe (ecosystems) are in protected areas (GAP 1 & 2 & NPS).
- 90% of this is on federal lands.
- NPS contains only 1.2% of mapped sagebrush ecosystems but 11% of protected lands (GAP 1 & 2 & NPS)

Patterns Across 5 Steppe Parks

Alluvial diagrams map the “flow” through factor levels for each of 15,000 quadrats

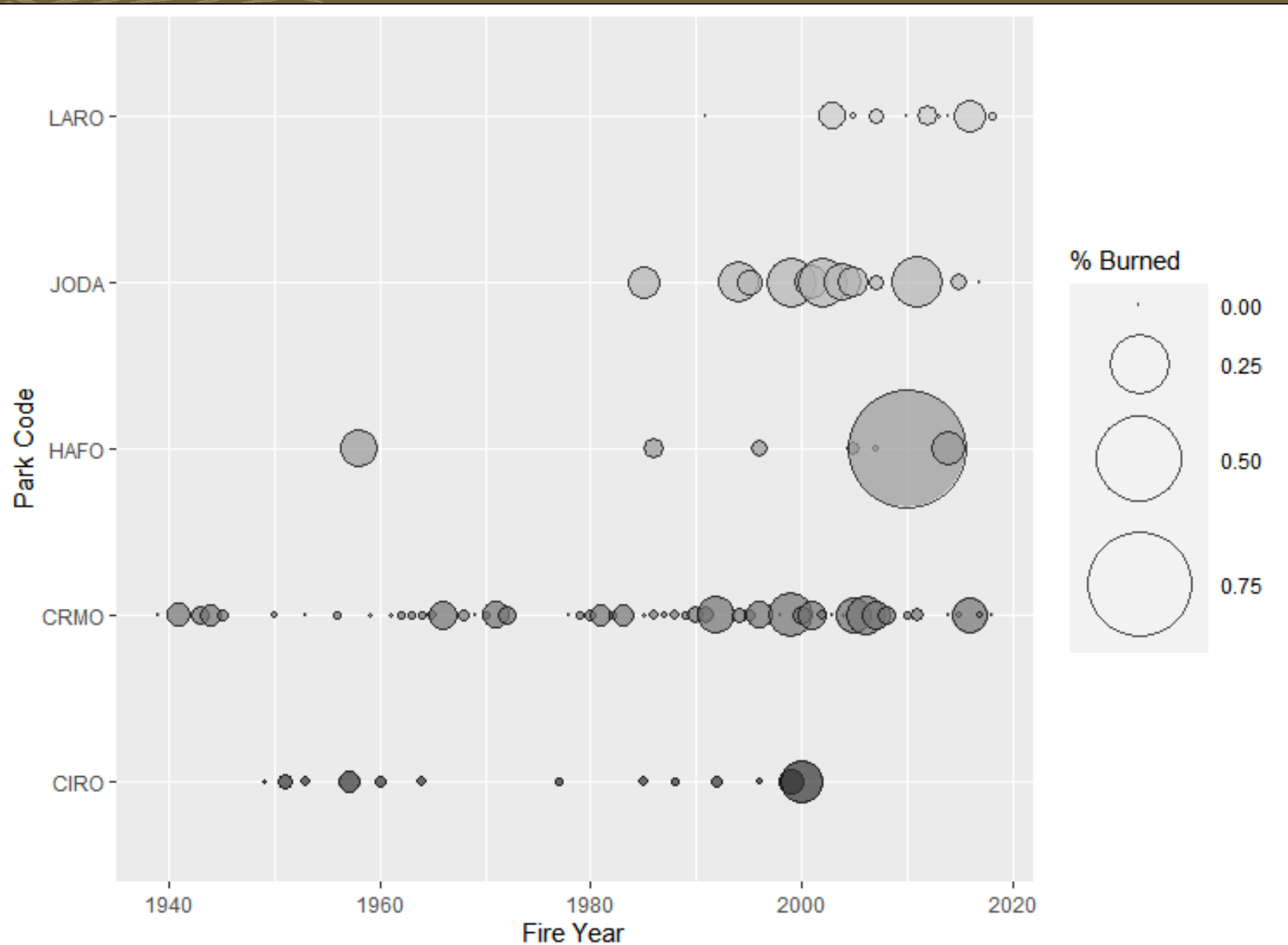
Resilience & resistance co-vary but resolution of soils classifications matters!



NPS Sagebrush Ecosystems

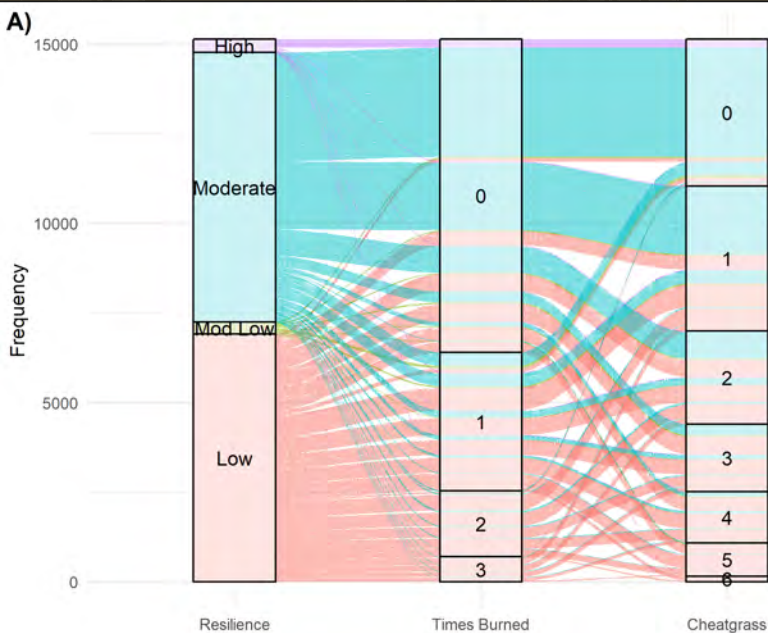
- 75 NPS units have some sagebrush ecosystem
- 30 have >15% of park area in sagebrush
- 15 have >25% sagebrush (the real “sage” parks...)
- The majority of NPS sagebrush ecosystems map to low (21%) or moderate (31%) resilience (43% outside of Bradford et al. 2019 assessment).
- Under climate change scenario (RCP 8.5) resilience shifts to moderate in many areas (due to shifts in precipitation)

Increasing fire frequency and size among five sagebrush steppe parks

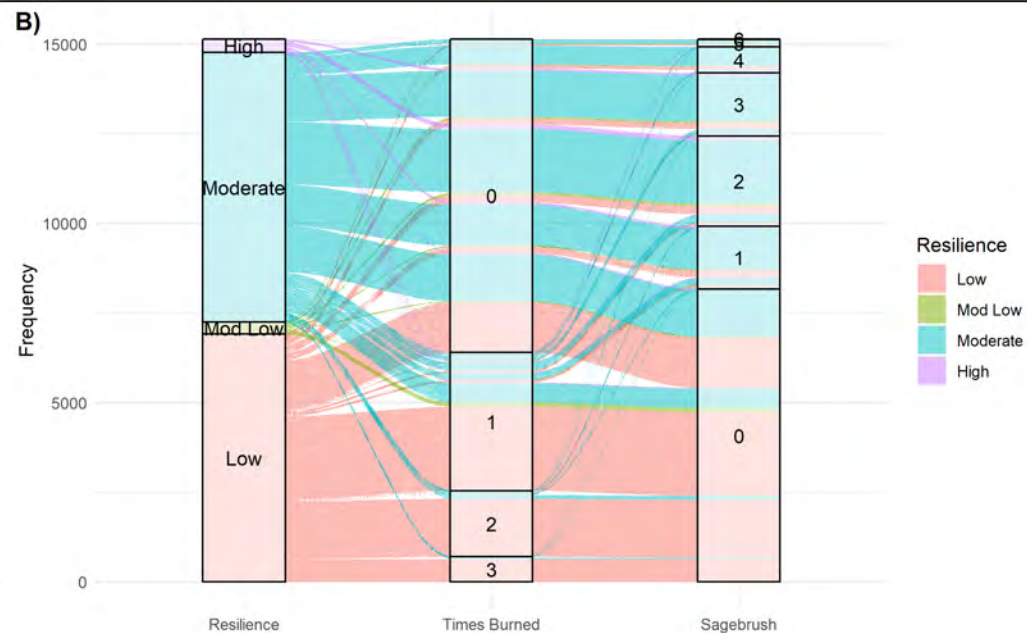


Low resilience burns more frequently, is heavily invaded by cheatgrass, and has lost sagebrush shrub overstory

Cheatgrass

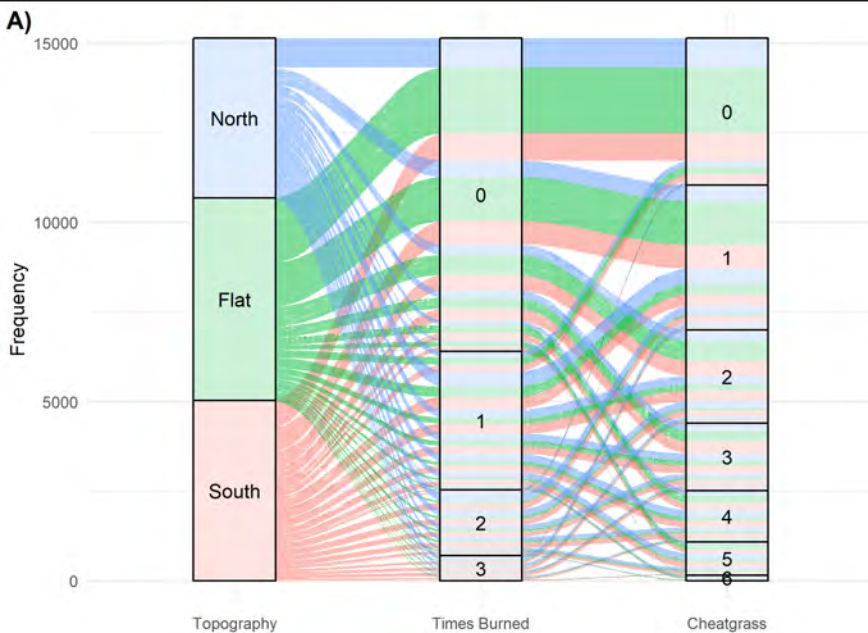


Sagebrush

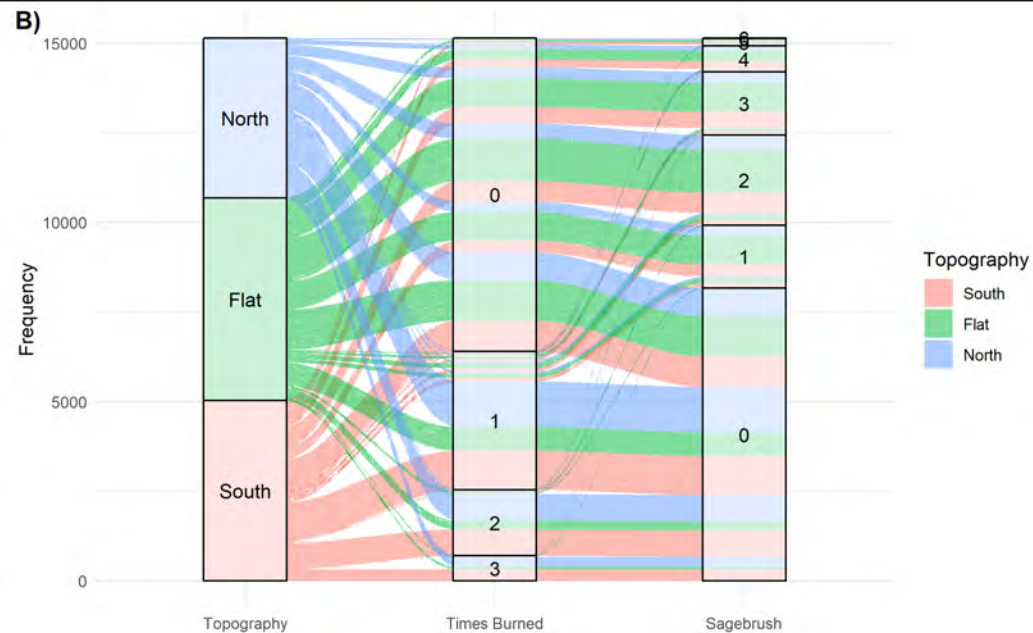


Topographic heterogeneity is substantial and creates opportunities for protection & restoration

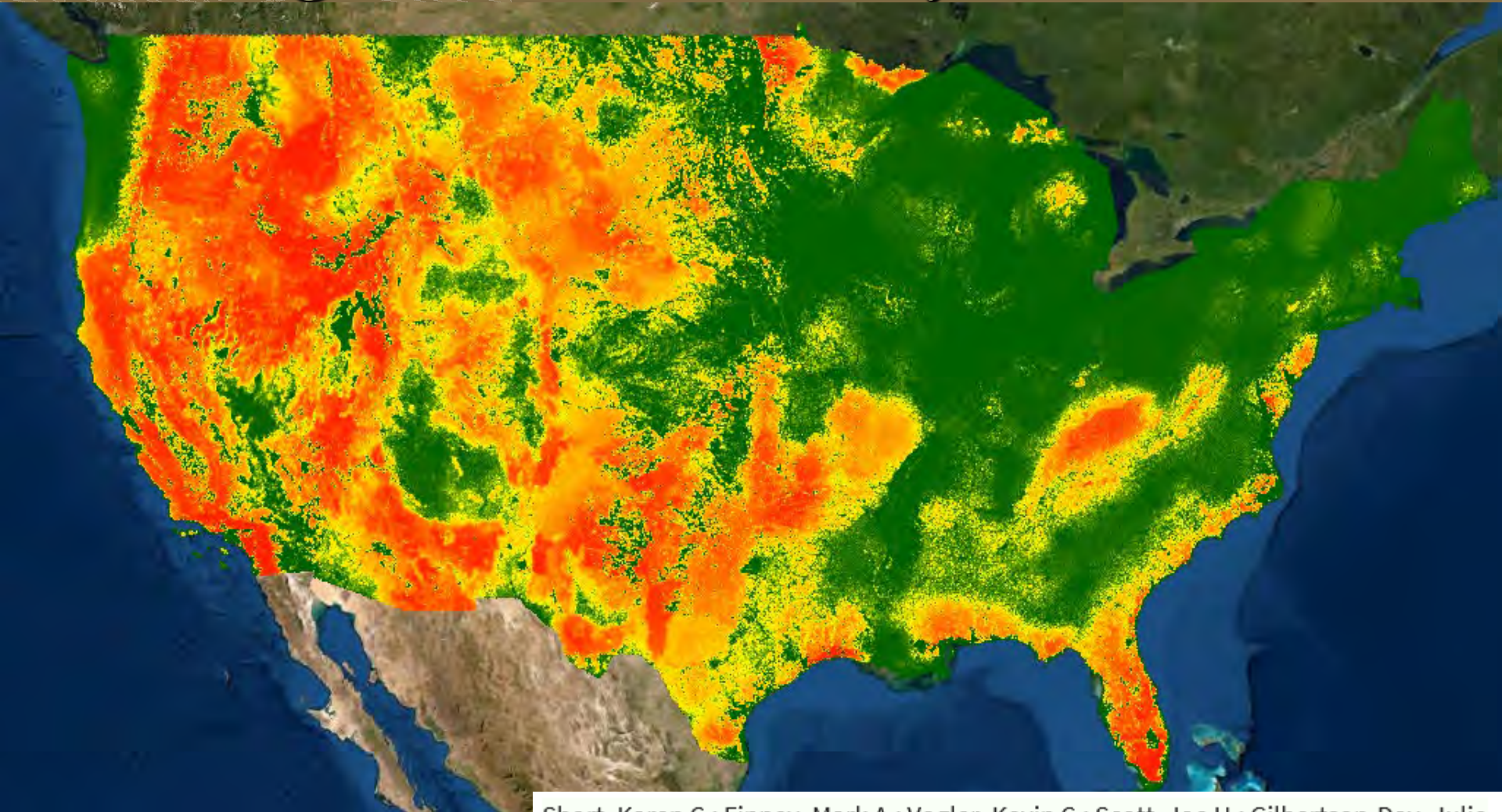
Cheatgrass



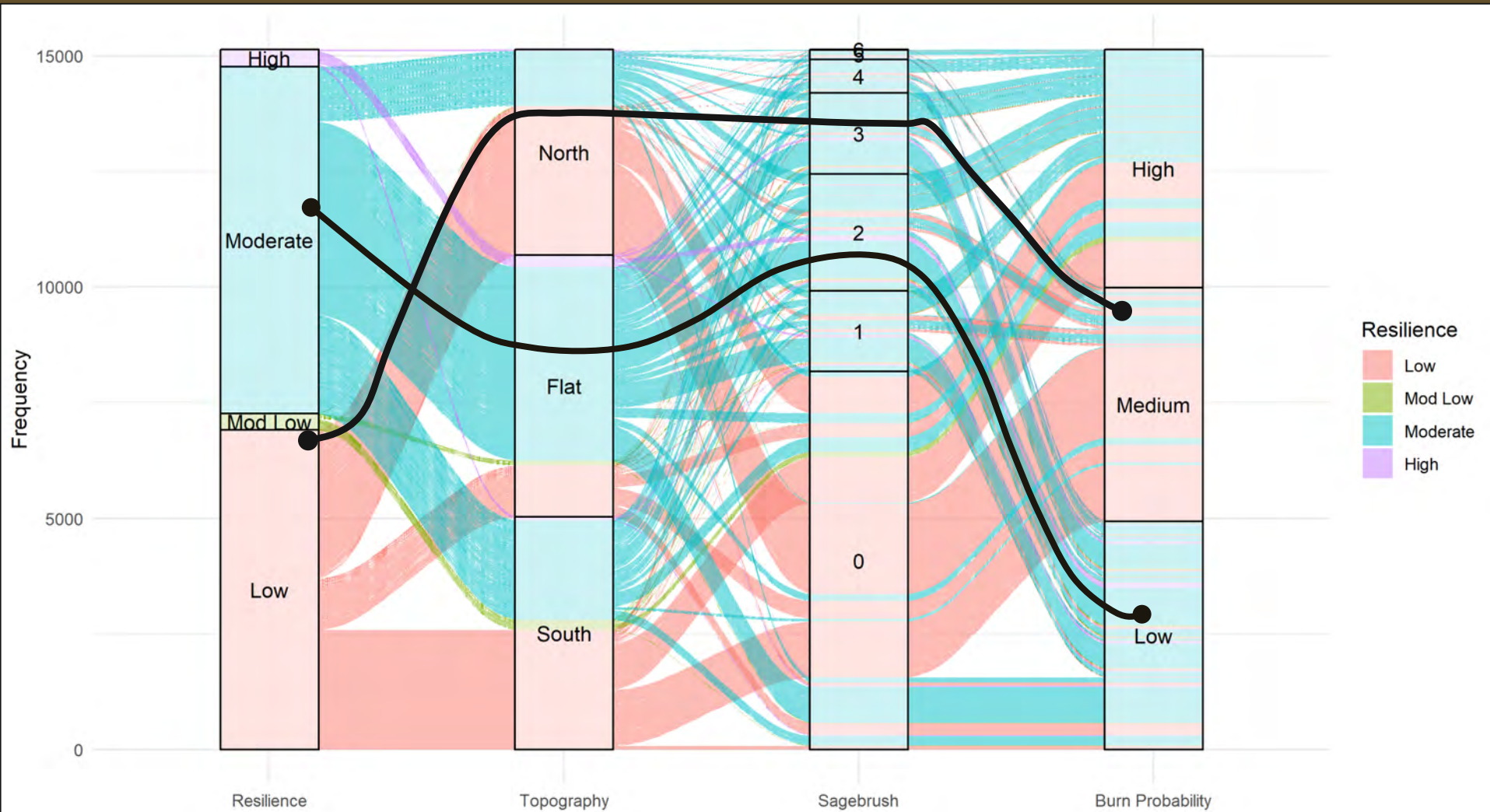
Sagebrush



Ignition Probability Dataset



Short, Karen C.; Finney, Mark A.; Vogler, Kevin C.; Scott, Joe H.; Gilbertson-Day, Julie W.; Grenfell, Isaac C. 2020. Spatial datasets of probabilistic wildfire risk components for the United States (270m). 2nd Edition. Fort Collins, CO: Forest Service Research Data Archive. <https://doi.org/10.2737/RDS-2016-0034-2>



We can combine resilience, topography, sagebrush cover, and burn (ignition risk) probability to map options and strategies for resource protection and restoration

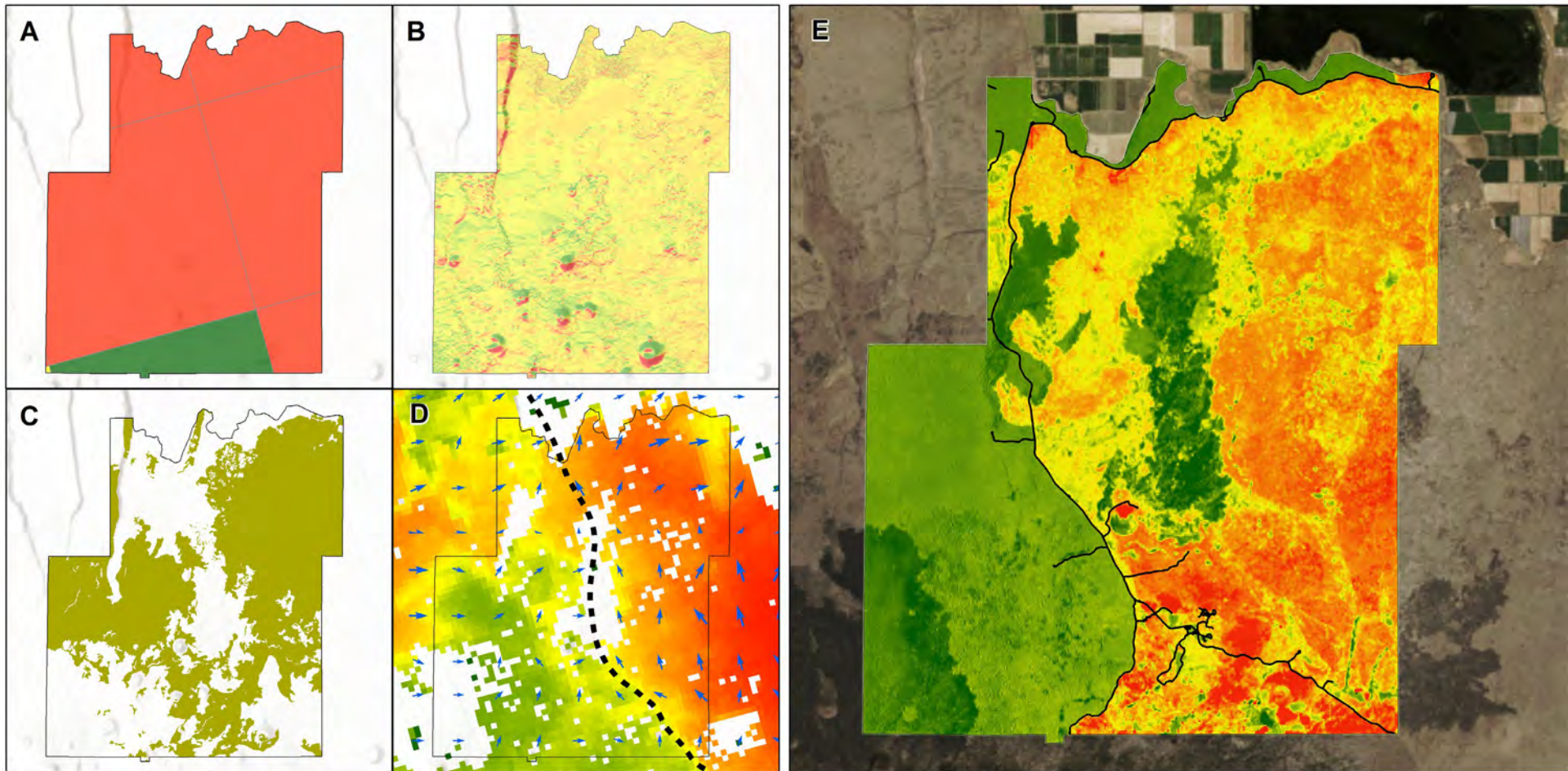
Short et al. 2020. USFS ...

Planning Example: Lava Beds National Monument

Resilience

Topography

2020 (July Complex) burn severity



Sagebrush cover

Burn (ignition) risk

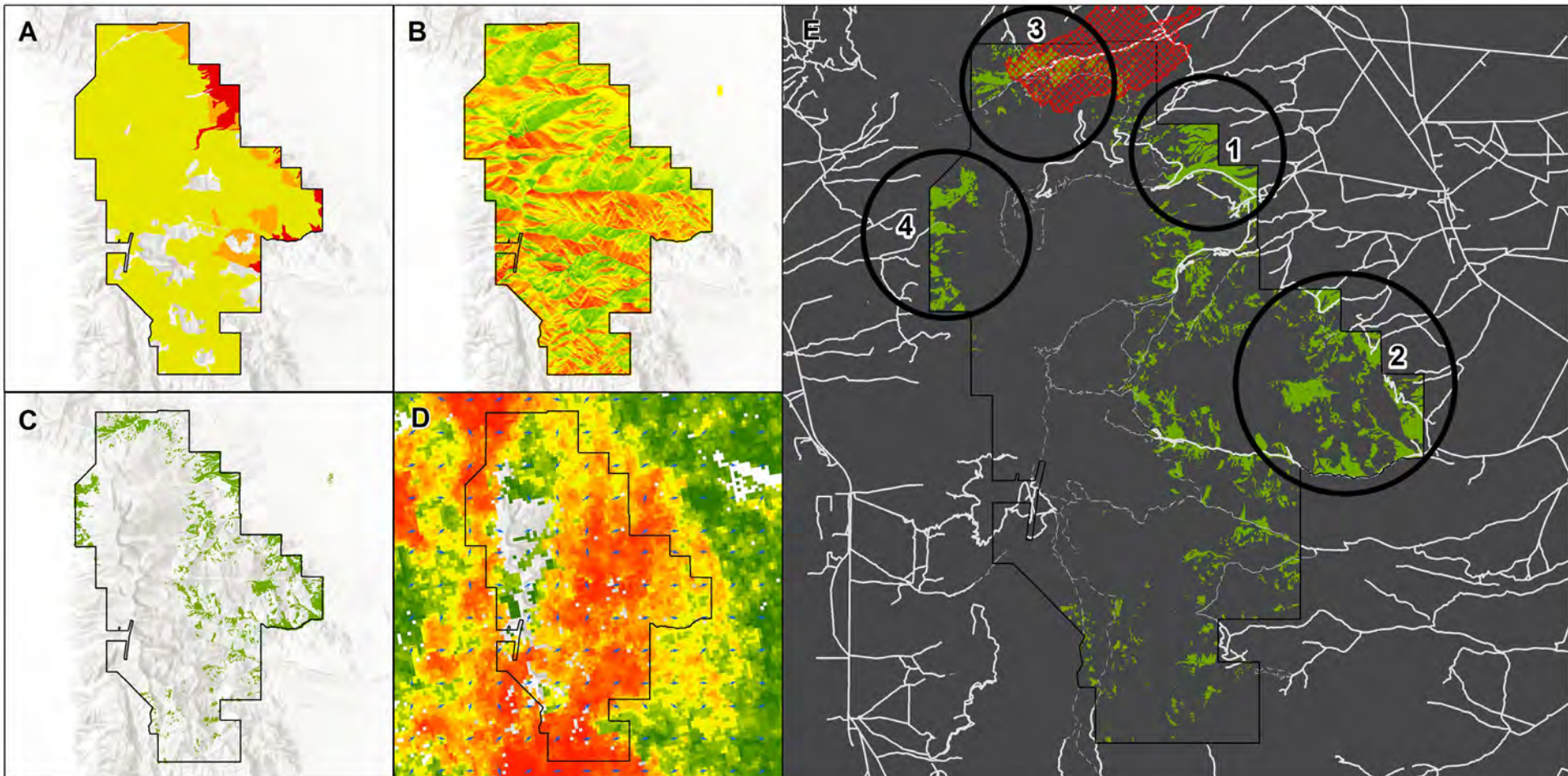
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Planning Example: Great Basin National Park

Resilience

Topography

Example prioritization strategy



Sagebrush cover

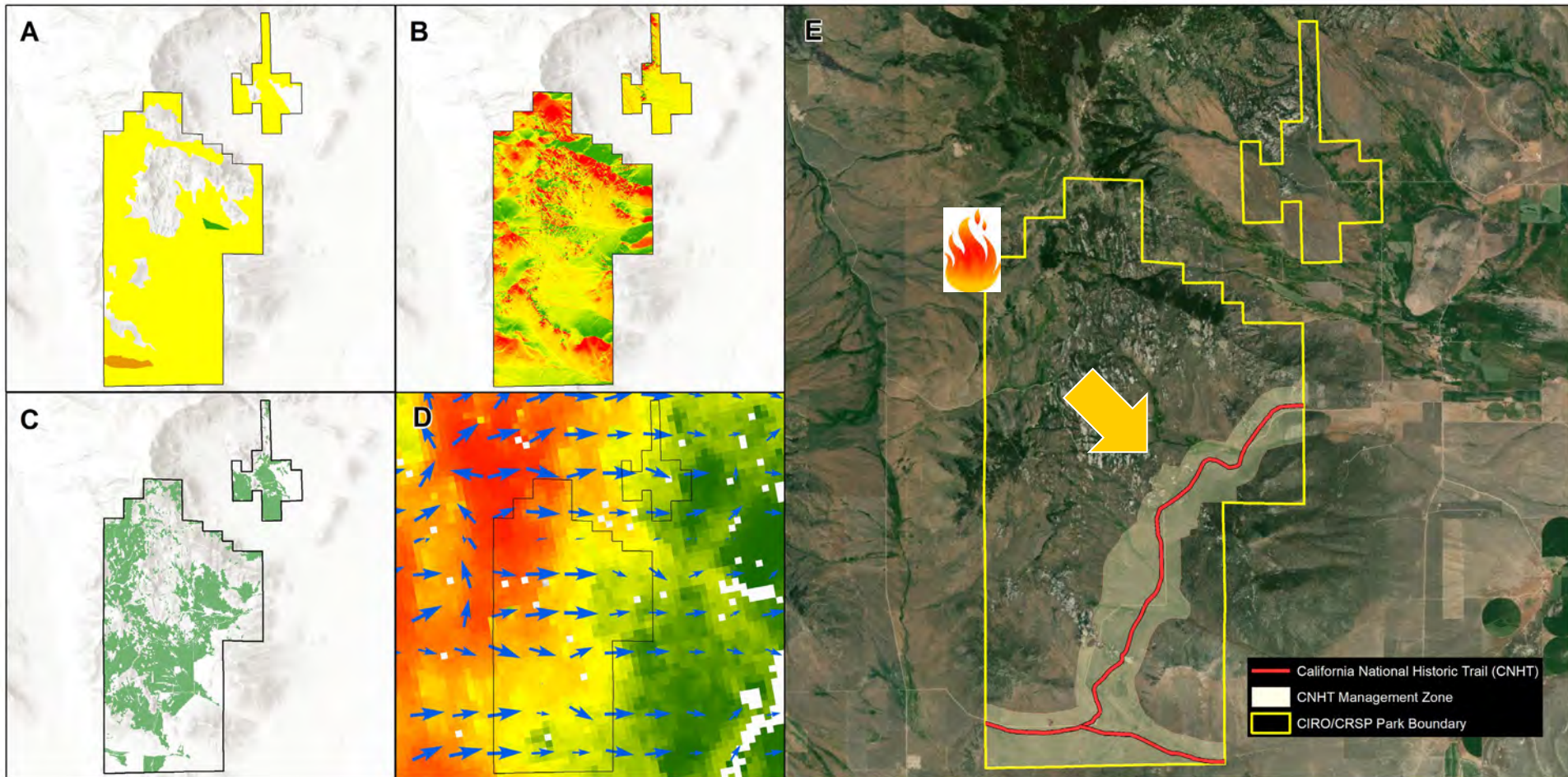
Burn (ignition)
risk

Planning Example: City of Rocks National Reserve

Resilience

Topography

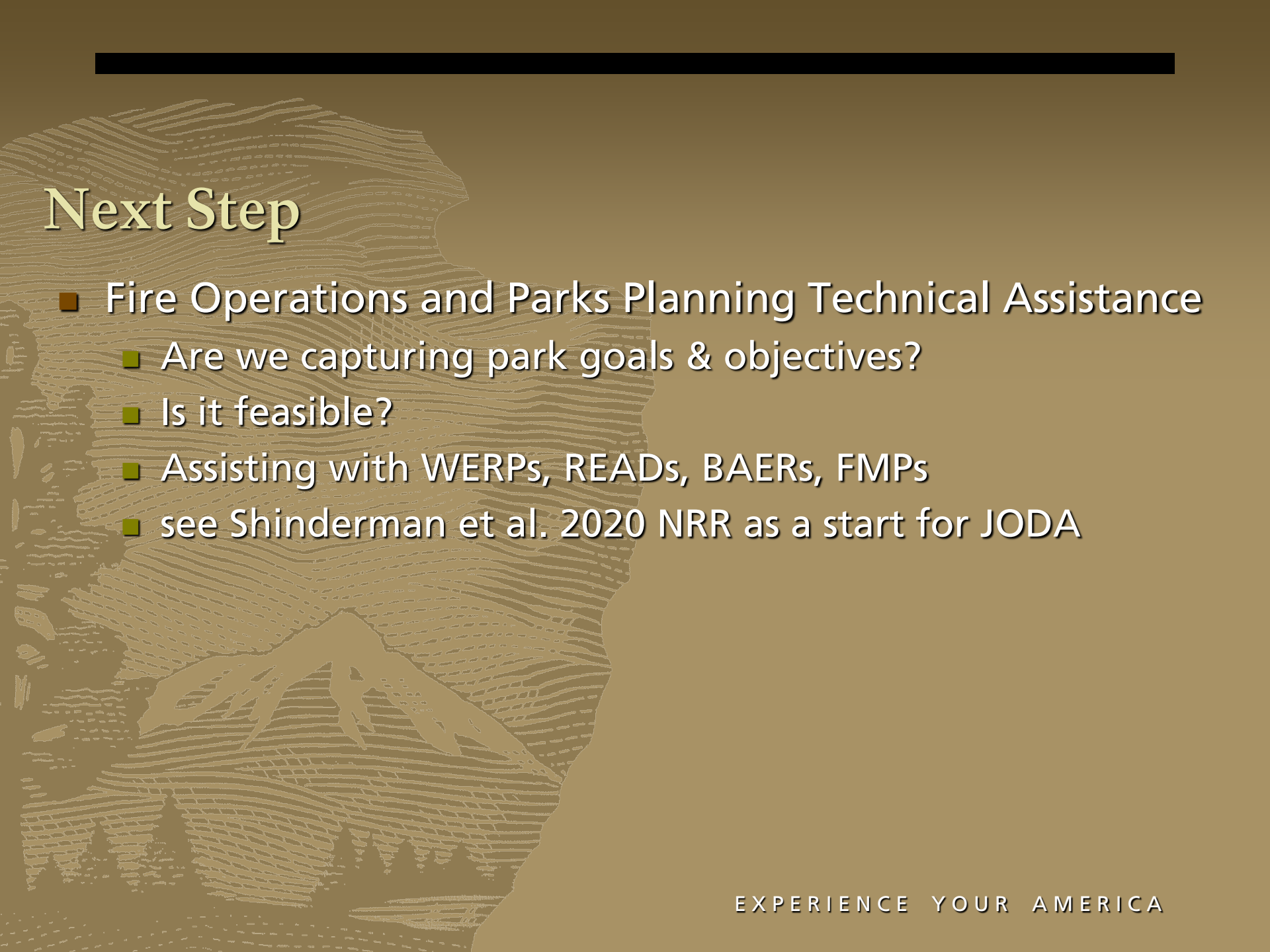
California Trail Cultural Landscape



Sagebrush cover

Burn (ignition) risk

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Next Step

- Fire Operations and Parks Planning Technical Assistance
 - Are we capturing park goals & objectives?
 - Is it feasible?
 - Assisting with WERPs, READs, BAERs, FMPs
 - see Shinderman et al. 2020 NRR as a start for JODA

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National Park Service
U.S. Department of the Interior

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A Decade of Sagebrush Park Science

1. Ellsworth & Kauffman. 2010. *Fire Ecology* Fire resiliency of native bunchgrasses in mountain big sagebrush in LABE
2. Powell et al. 2013. *PLoS One* fire-driven conversion of P-J woodlands and steppe to novel annual grasslands in CIRO
3. Rodhouse et al. 2014. *Ecosphere* model-assisted landscape prioritization in JODA
4. Hoh et al. 2014. *NPS Natural Resources Report* Strategic landscape plan for JODA
5. Reed-Dustin et al. 2016 & Mata-Gonzalez et al. 2018. *Rangeland Ecol & Mgmt* 15-yr prescribed fire trends from NPS fire-effects plots in JODA (2 papers)
6. Esposito et al. 2019. *Rangeland Ecol. & Mgmt* Geographic variation in resilience & resistance across JODA and CRMO
7. Ellsworth et al. 2020. *Ecosphere* Small-scale prescribed fire effects on native bunchgrasses in JODA
8. Nicolli et al. 2020. *Western North American Naturalist* Ventenata grass invasion in to low-elevation sagebrush steppe in JODA
9. Shinderman et al. 2020. *NPS Natural Resources Report* science and management synthesis for sagebrush steppe conservation in JODA
10. Rodhouse et al. 2020. *Frontiers in Ecology & Evolution* Post-fire vegetation response in a repeatedly-burned low-elevation sagebrush steppe protected area provides insights about resilience and invasion resistance in JODA

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Focused Condition Assessment

1. Shinderman et al. 2020. *NPS Natural Resources Report* science and management synthesis for sagebrush steppe conservation in JODA. (<https://irma.nps.gov/DataStore/Reference/Profile/2275579>)
2. Nicolli et al. 2020. *Western North American Naturalist* Ventenata grass invasion in to low-elevation sagebrush steppe in JODA. (<https://irma.nps.gov/DataStore/Reference/Profile/2271956>)
3. Rodhouse et al. 2020. Post-fire vegetation response in a repeatedly-burned low-elevation sagebrush steppe protected area provides insights about resilience and invasion resistance. *Frontiers in Ecology & Evolution* 8:584726. (<https://irma.nps.gov/DataStore/Reference/Profile/2278547>)
4. Rodhouse et al. *In preparation*. Resilience to fire and resistance to grass invasion in the sagebrush ecosystems of US National Parks. *Biological Conservation*.
5. September 2020 FCA project resource brief update. (<https://irma.nps.gov/DataStore/Reference/Profile/2279328>)
6. Assemblage of park (BIHO, CIRO, CRMO, GRBA, HAFO, JODA, LABE, LARO, PARA) geodatabases to support planning. (<https://irma.nps.gov/DataStore/Reference/Profile/2272485>)