Fuel treatments and fuel breaks considering invasive-fire-climate dynamics

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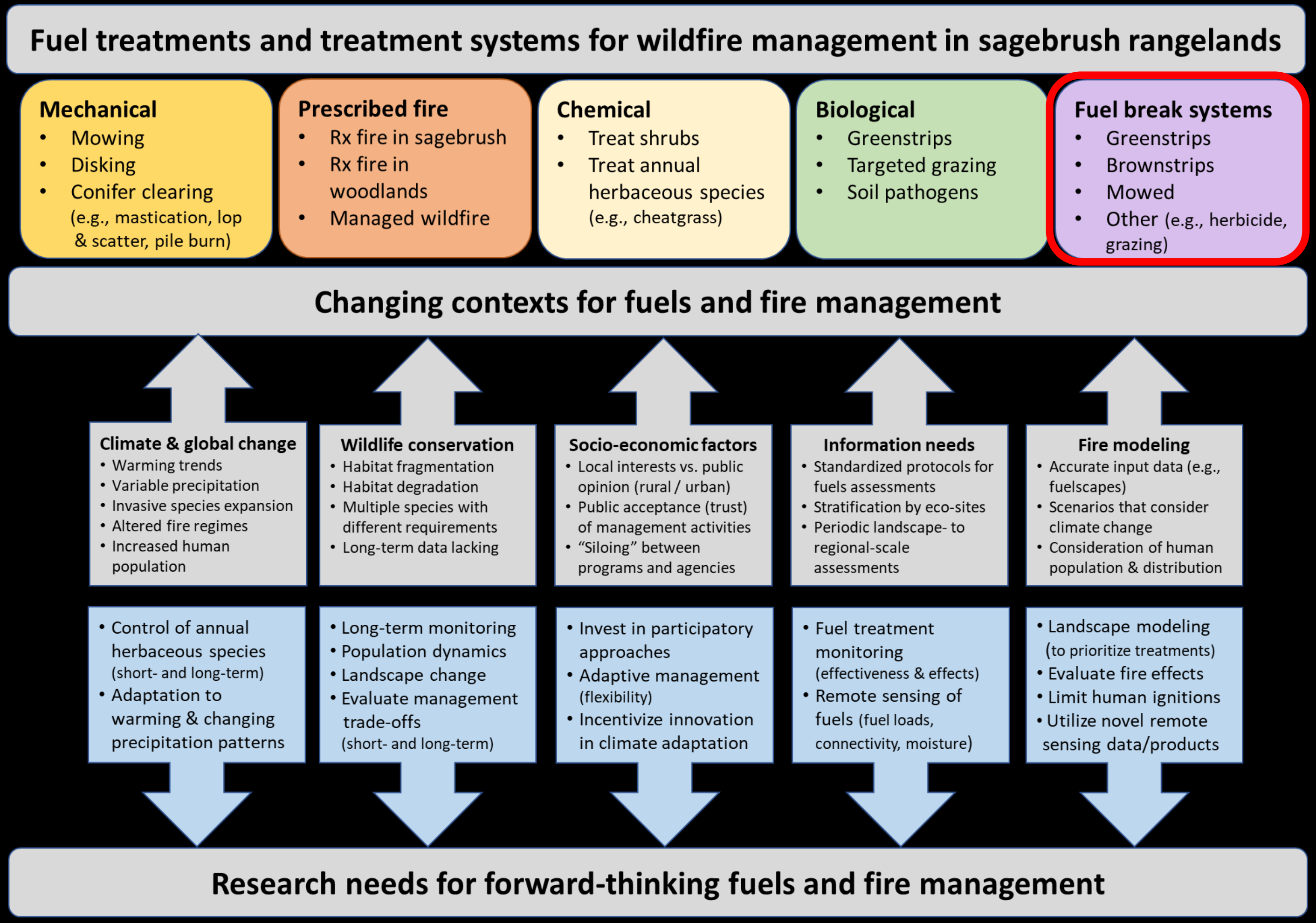
Fuel treatments in sagebrush ecosystems

A ***fuel treatment*** is intended to manipulate or reduce fuels to modify fire behavior and mitigate potential negative impacts of wildfire.

Vegetation is modified to reduce the amount, volatility, or structure of fuels, resulting in a decrease in wildfire intensity and/or rate of spread.



Shinneman, D. J., E. K. Strand, M. Pellant, J. T. Abatzoglou, M. W. Brunson, N. F. Glenn, J. A. Heinrichs, M. Sadegh, and N. M. Vaillant. 2023. Future Direction of Fuels Management in Sagebrush Rangelands. Rangeland Ecology & Management 86:50–63.

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Altered Fire Regimes: Invasive grass-fire cycle

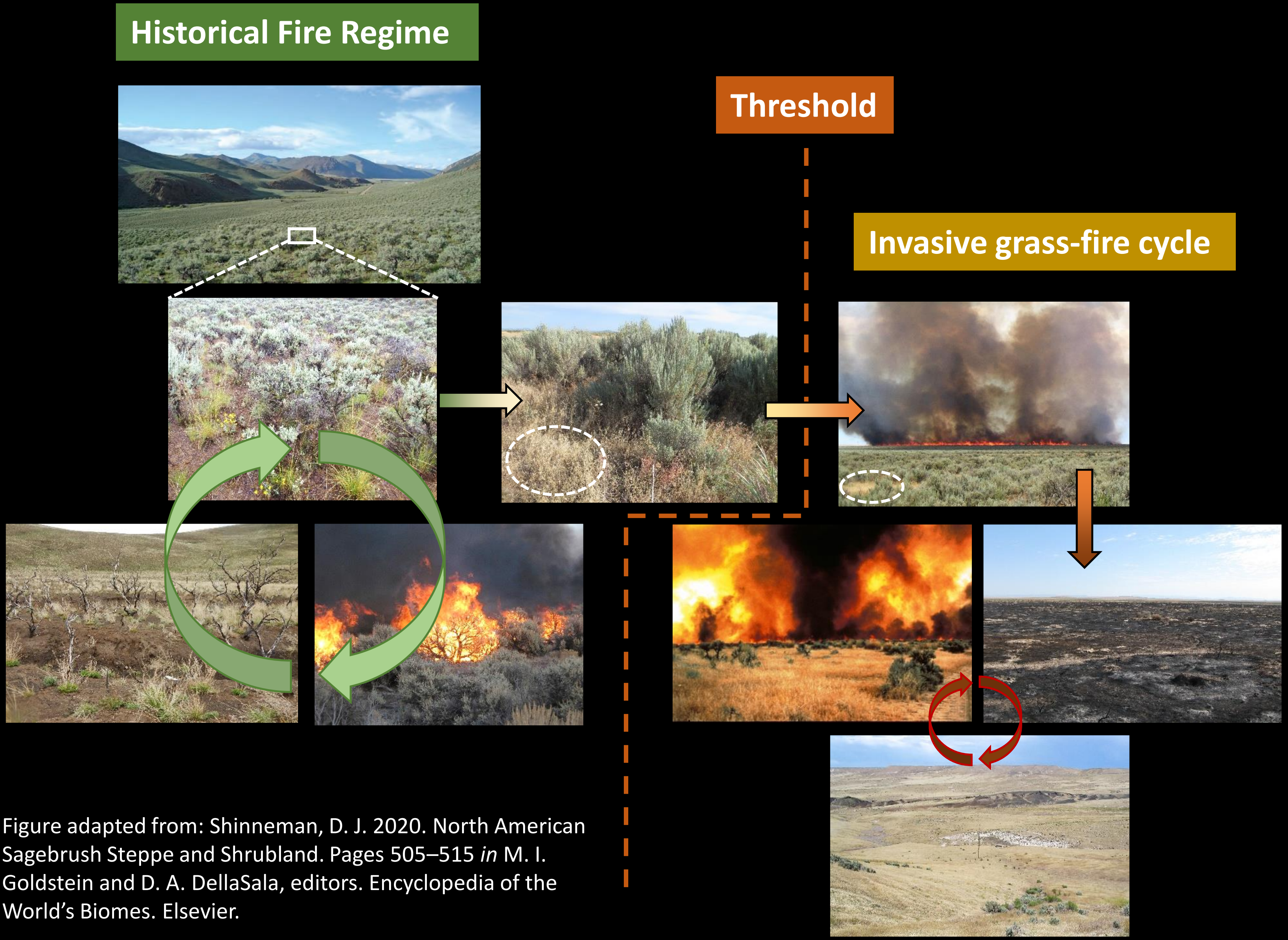

Figure adapted from: Shinneman, D. J. 2020. North American Sagebrush Steppe and Shrubland. Pages 505–515 *in* M. I. Goldstein and D. A. DellaSala, editors. Encyclopedia of the World's Biomes. Elsevier.

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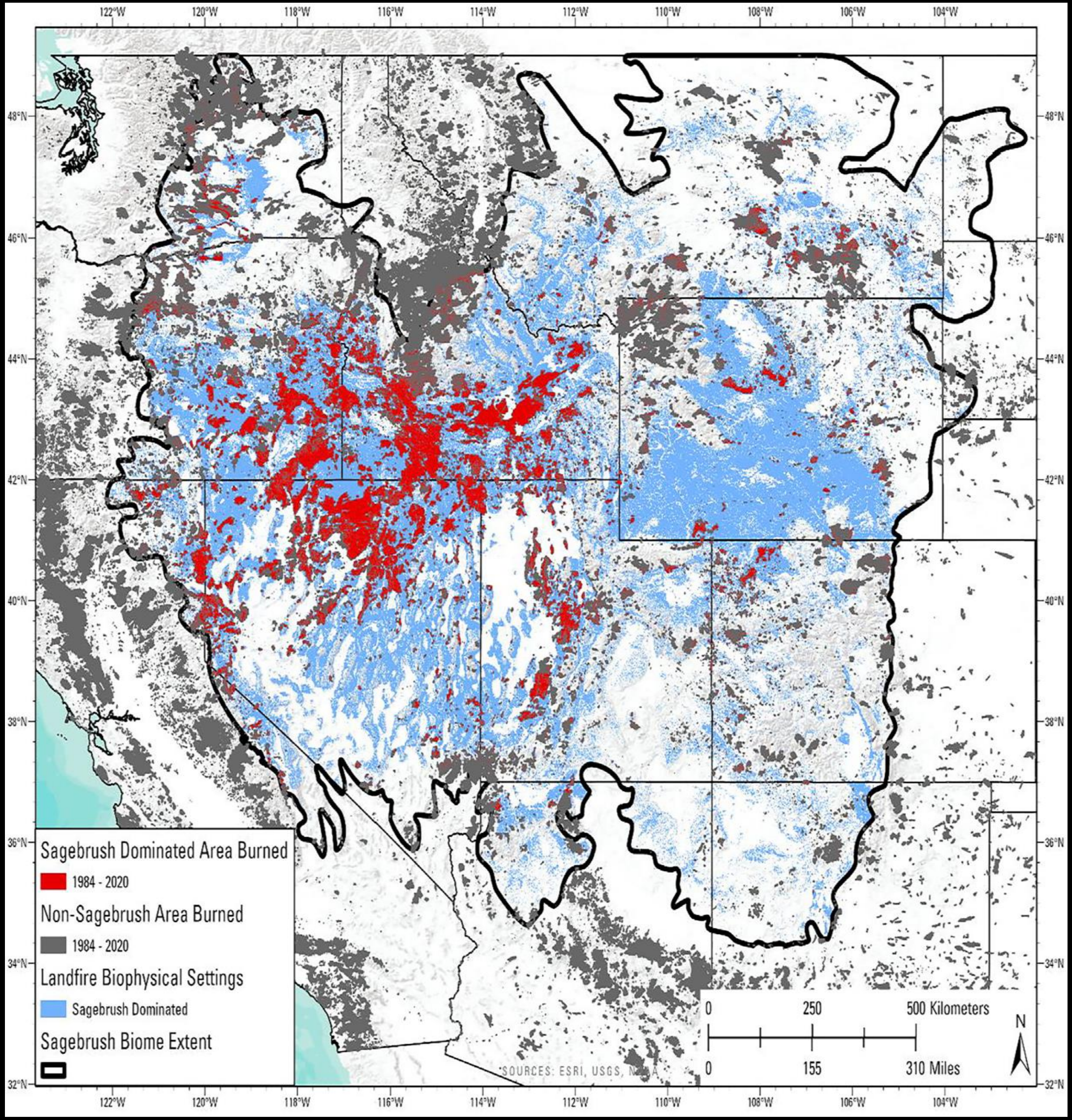

Altered Fire Regimes

Cheatgrass dominated areas

- more likely to burn (multiple times)
- have shorter fire return intervals
- support larger fires

e.g., Balch et al. 2013, Brooks et al. 2015, Bradley et al. 2018

From: Crist, et al. 2023. Trends, Impacts, and Cost of Catastrophic and Frequent Wildfires in the Sagebrush Biome. Rangeland Ecology & Management 89:3–19.

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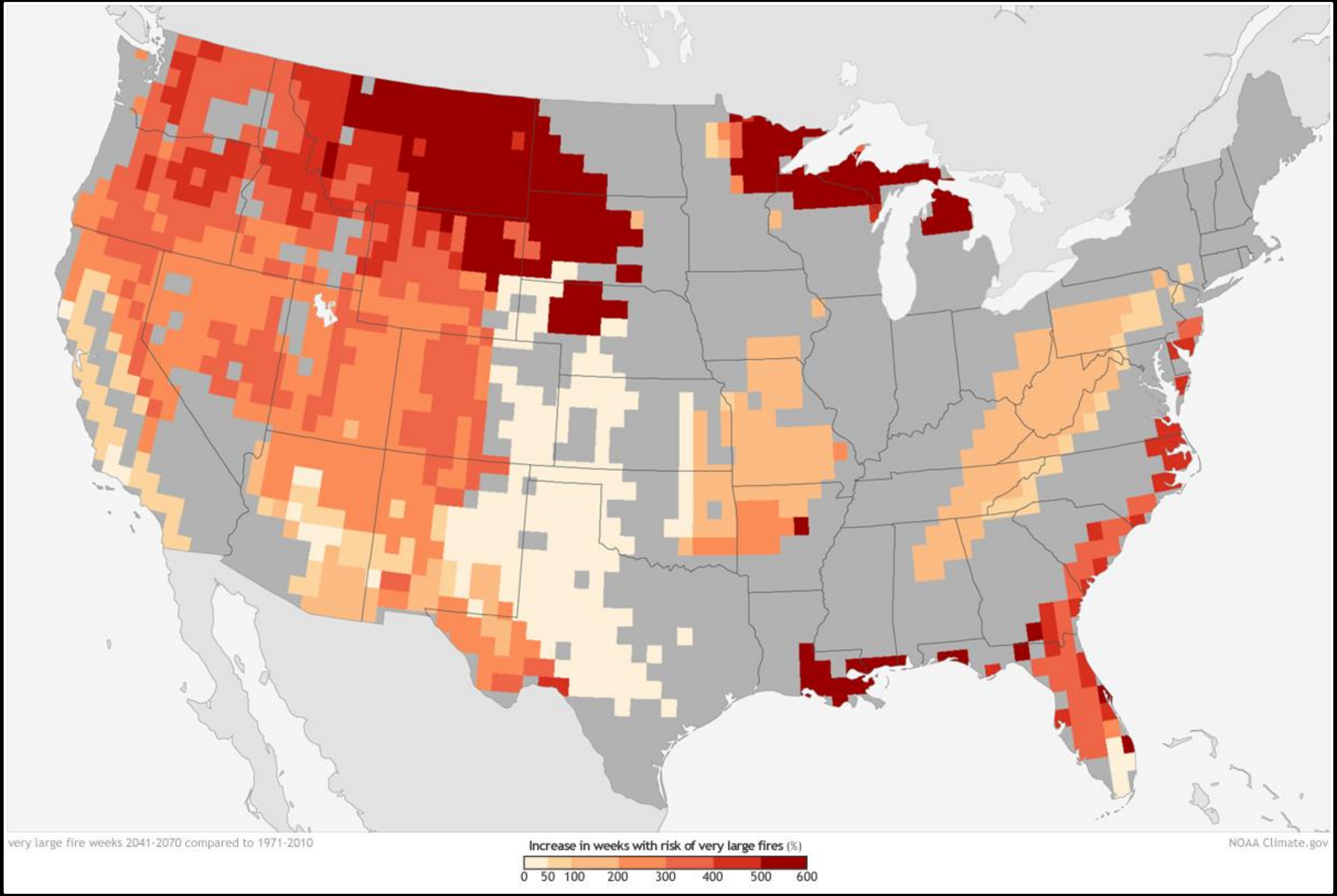
Future Fire Regimes under climate change



Very large fire weeks 2041-2070 compared to 1971-2010 https://www.climate.gov/media/6401

Barbero, R.; Abatzoglou, J.T.; Larkin, N.K.; Kolden, C.A.; Stocks, B. 2015. Climate change presents increased potential for very large fires in the contiguous United States. International Journal of Wildland Fire.

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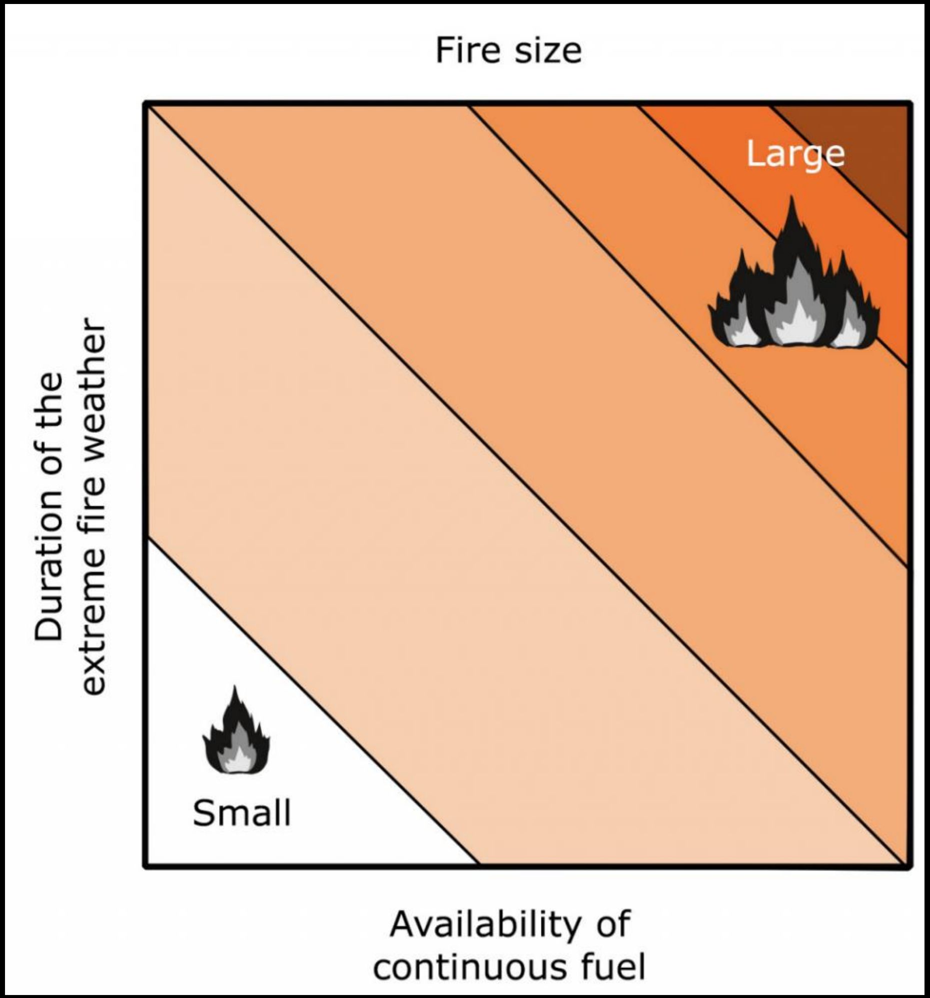
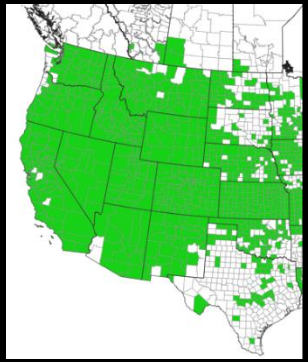
Future fire-fuel-climate feedbacks

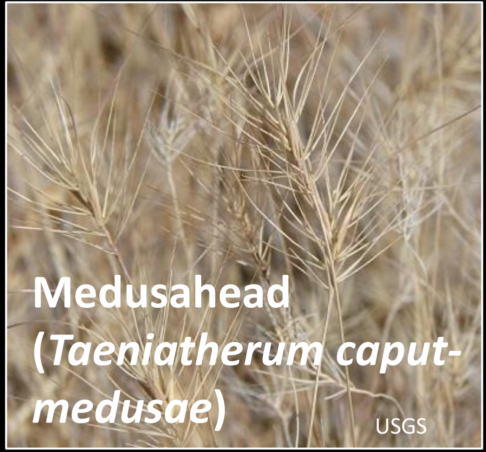
How might changing fuels affect future fire regimes under more extreme climate?

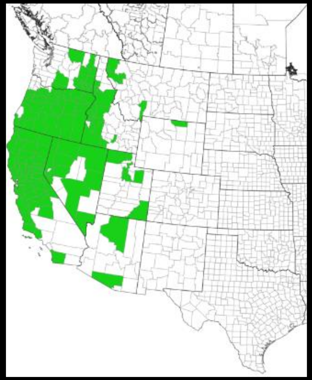
- Complex, long-term future interactions between climate, fire, and vegetation
- Positive feedback loops



Pausas and Keeley. 2021. *Frontiers in Ecology and the Environment* 19:387–395.







Future climate will affect the distribution and productivity of exotic species that alter fuel conditions and fire regimes

EDDMapS. 2021. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed November 28, 2021.

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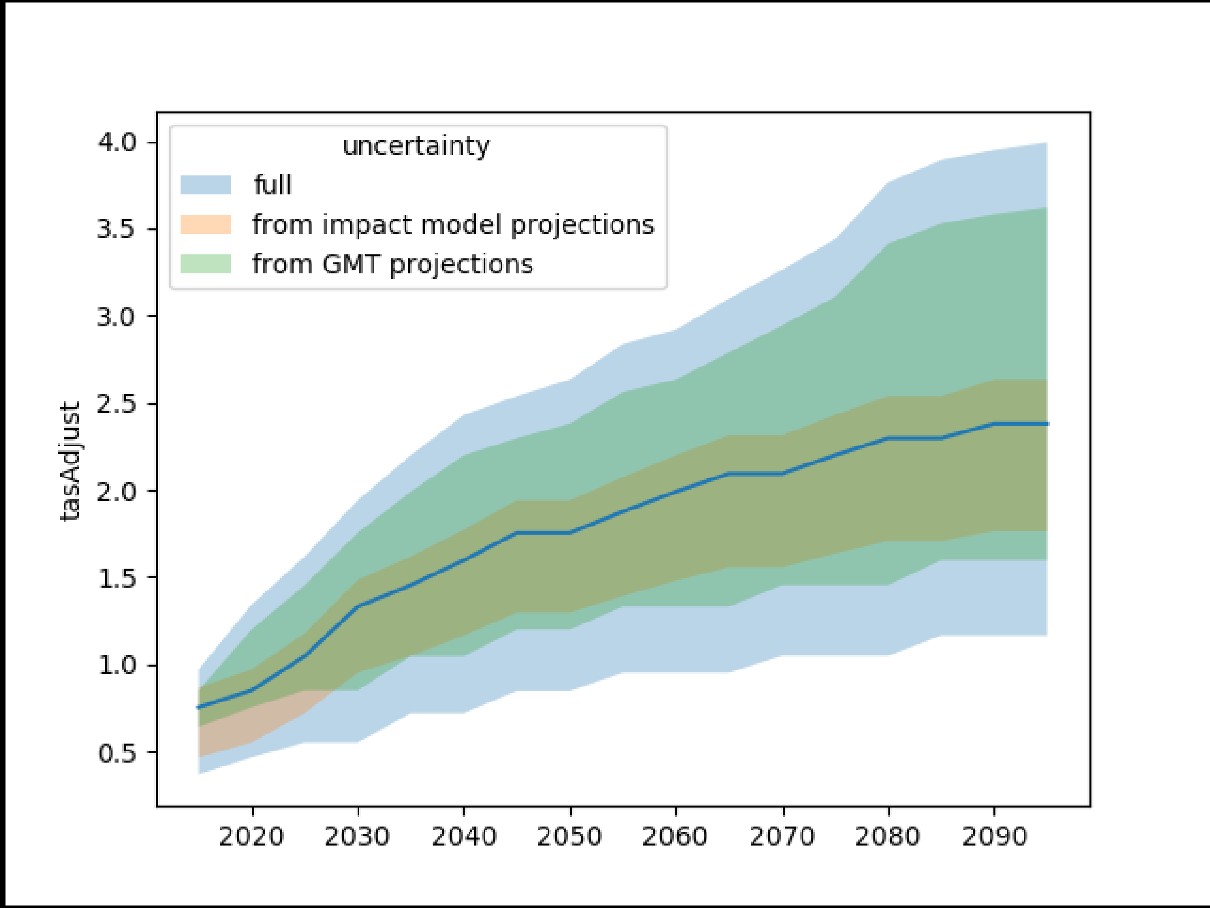
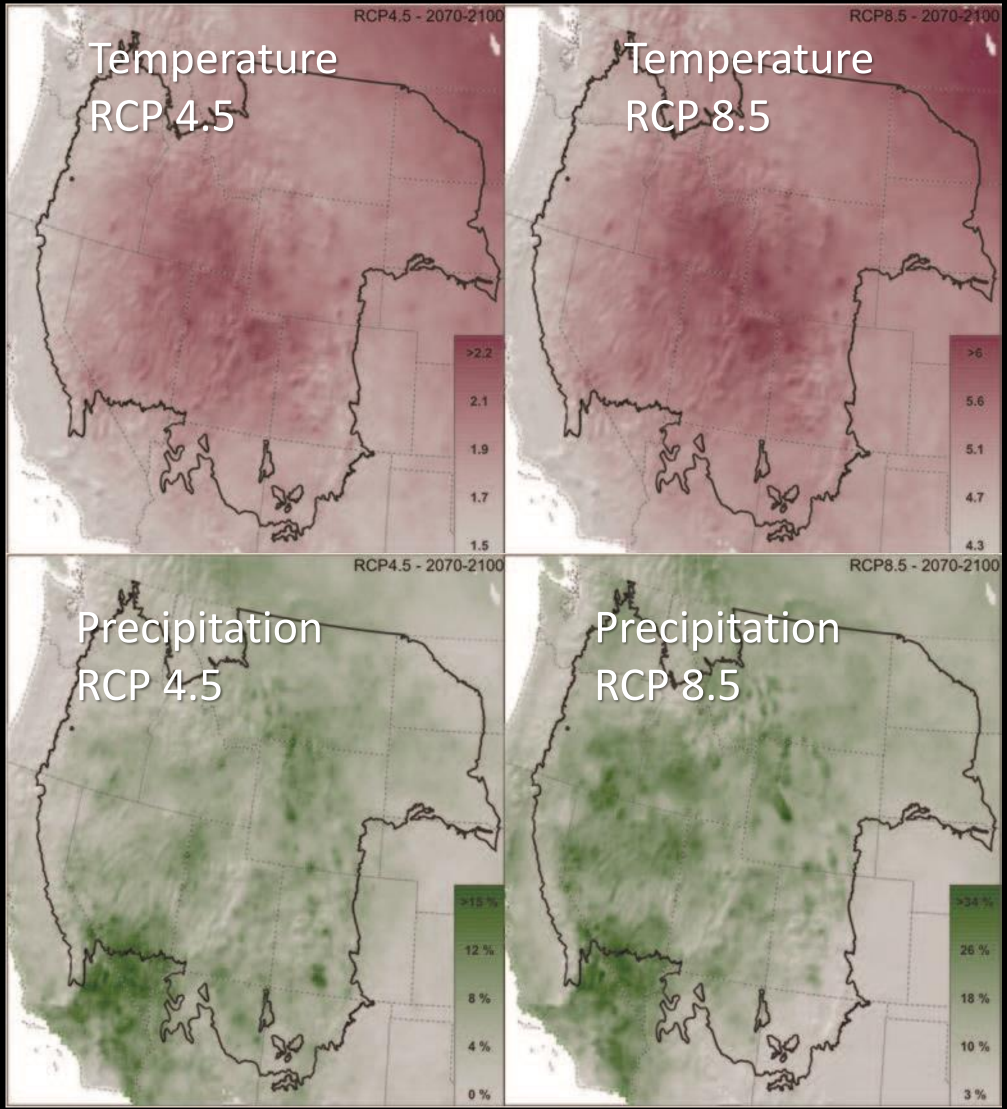
Uncertainty under future climate change

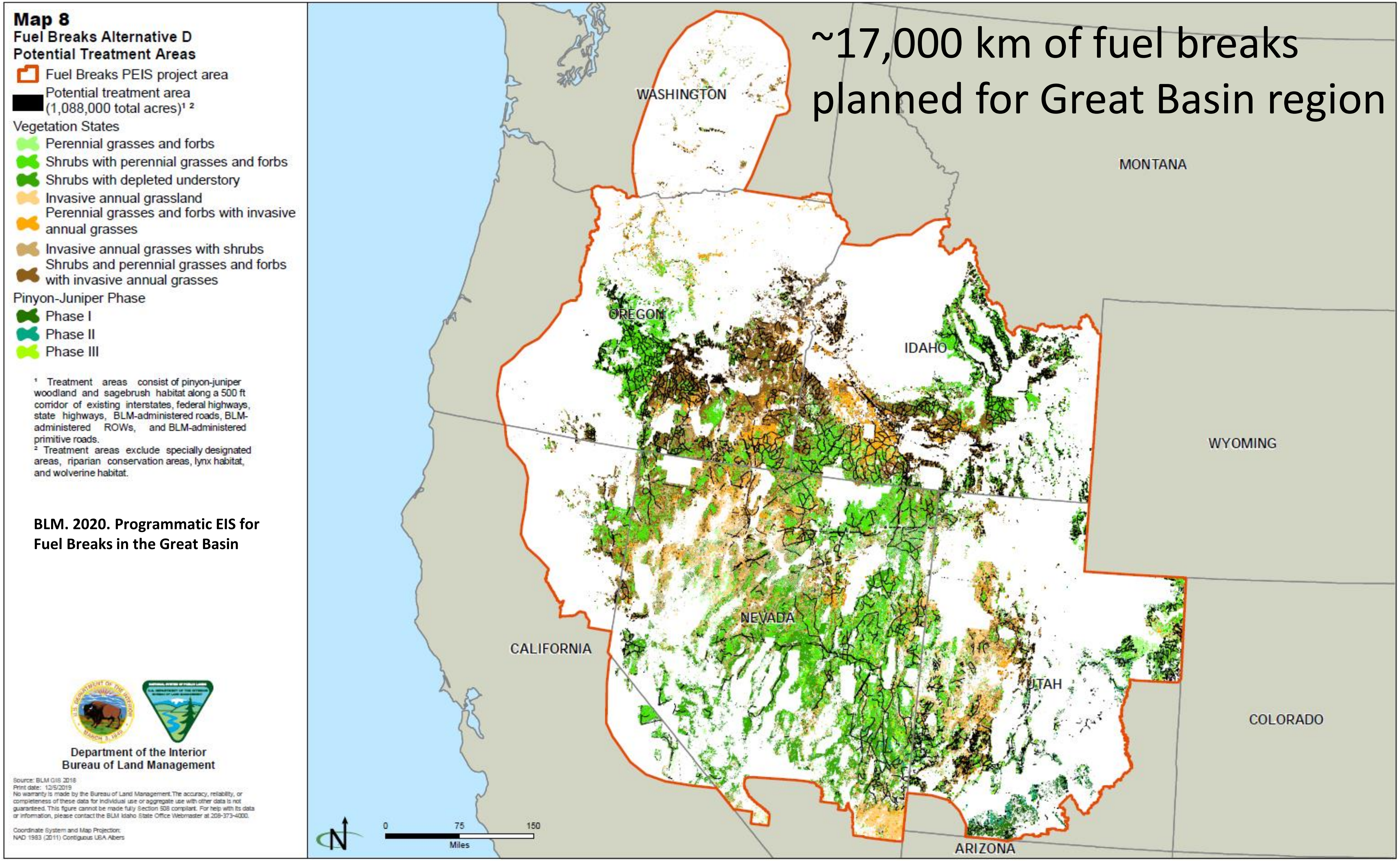


https://climate-impact-explorer.climateanalytics.org/methodology/#three-visualization



Projected changes in mean annual precipitation and mean annual temperature for 2070–2100 over the distribution of big sagebrush ecosystems. Maps show median climate value from a set of 11 climate models (Adapted from: Chambers et al. 2017. USFS RMRS-GTR-360)

~17,000 km of fuel breaks planned for Great Basin region



BLM. 2020. Programmatic EIS for Fuel Breaks in the Great Basin

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Three main types of linear fuel breaks

Mowed

Brown Strips

Green Strips

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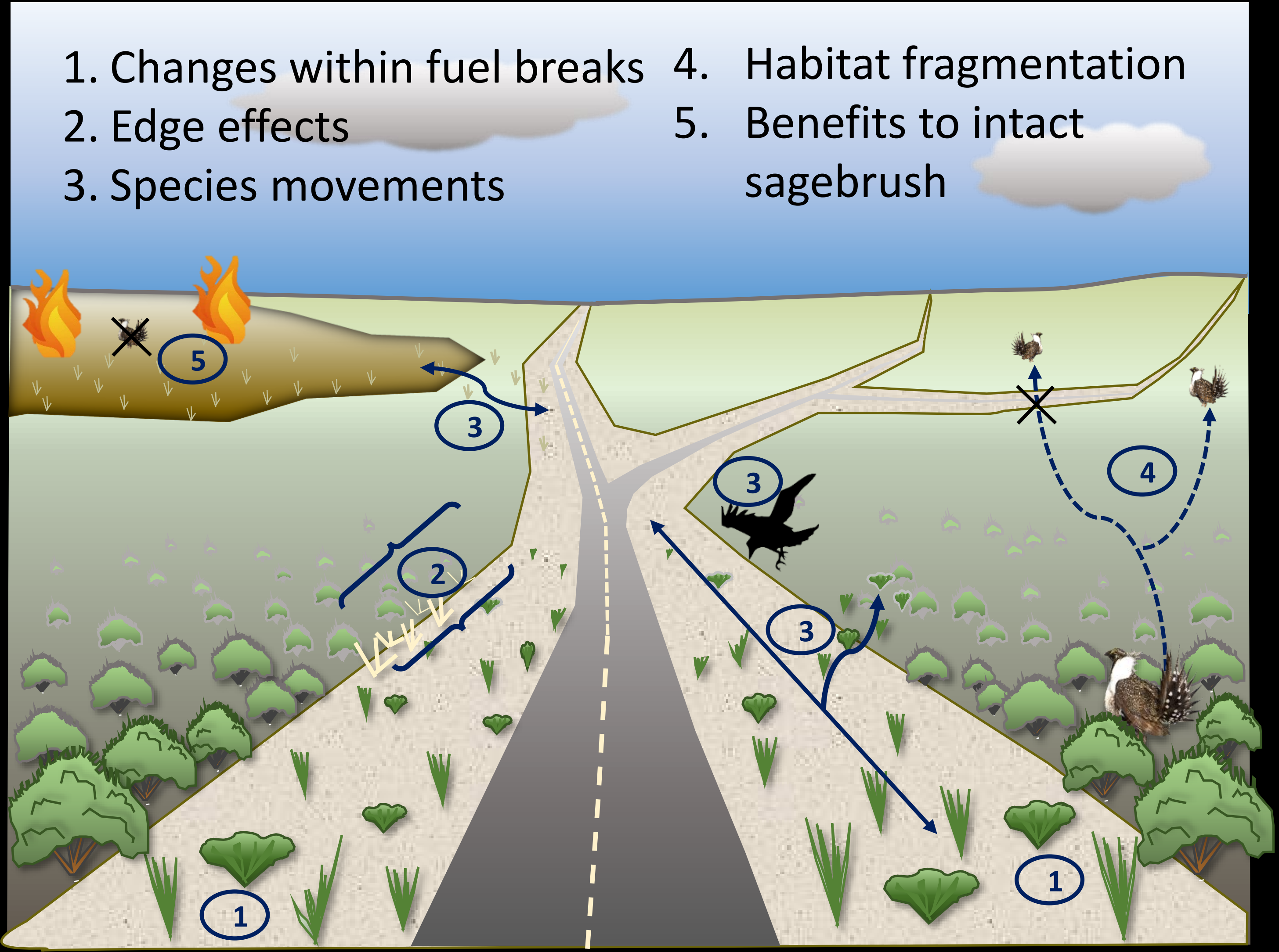
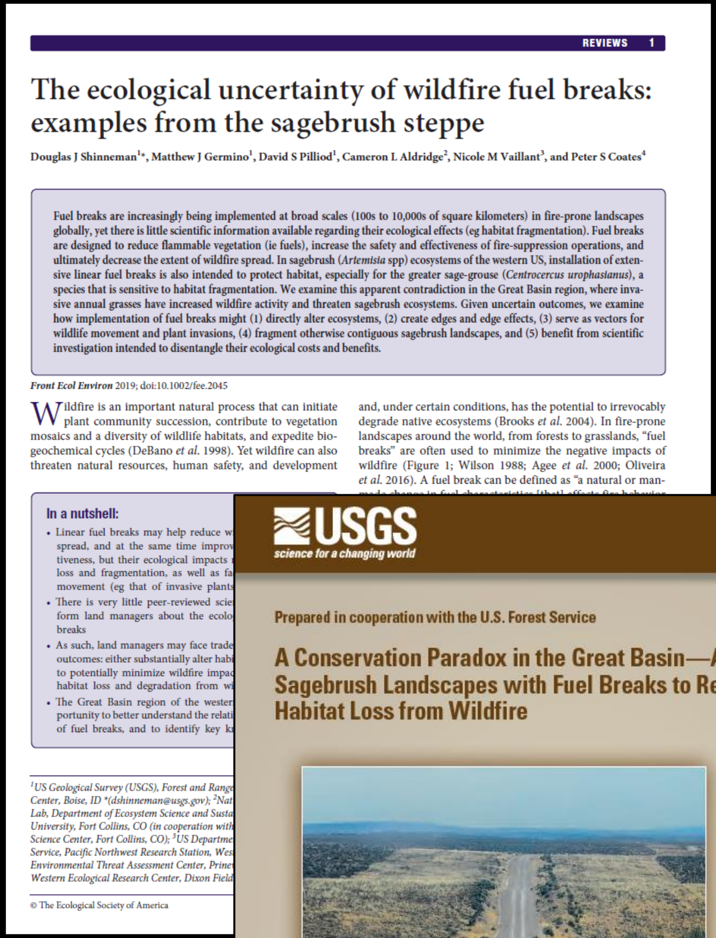
Photos: BLM, USGS

Fuel Break Effects




REVIEWS 1

The ecological uncertainty of wildfire fuel breaks: examples from the sagebrush steppe

Douglas J Shinneman[1*], Matthew J Germino[1], David S Pilliod[1], Cameron L Aldridge[2], Nicole M Vaillant[3], and Peter S Coates[4]

Fuel breaks are increasingly being implemented at broad scales (100s to 10,000s of square kilometers) in fire-prone landscapes globally, yet there is little scientific information available regarding their ecological effects (eg habitat fragmentation). Fuel breaks are designed to reduce flammable vegetation (ie fuels), increase the safety and effectiveness of fire-suppression operations, and ultimately decrease the extent of wildfire spread. In sagebrush (*Artemisia* spp) ecosystems of the western US, installation of extensive linear fuel breaks is also intended to protect habitat, especially for the greater sage-grouse (*Centrocercus urophasianus*), a species that is sensitive to habitat fragmentation. We examine this apparent contradiction in the Great Basin region, where invasive annual grasses have increased wildfire activity and threaten sagebrush ecosystems. Given uncertain outcomes, we examine how implementation of fuel breaks might (1) directly alter ecosystems, (2) create edges and edge effects, (3) serve as vectors for wildlife movement and plant invasions, (4) fragment otherwise contiguous sagebrush landscapes, and (5) benefit from scientific investigation intended to disentangle their ecological costs and benefits.

Front Ecol Environ 2019; doi:10.1002/fee.2045

Wildfire is an important natural process that can initiate plant community succession, contribute to vegetation mosaics and a diversity of wildlife habitats, and expedite biogeochemical cycles (DeBano *et al.* 1998). Yet wildfire can also threaten natural resources, human safety, and development and, under certain conditions, has the potential to irrevocably degrade native ecosystems (Brooks *et al.* 2004). In fire-prone landscapes around the world, from forests to grasslands, "fuel breaks" are often used to minimize the negative impacts of wildfire (Figure 1; Wilson 1988; Agee *et al.* 2000; Oliveira *et al.* 2016). A fuel break can be defined as "a natural or man-

In a nutshell:

- Linear fuel breaks may help reduce w spread, and at the same time improv tiveness, but their ecological impacts loss and fragmentation, as well as fa movement (eg that of invasive plants
- There is very little peer-reviewed scie form land managers about the ecolo breaks
- As such, land managers may face trade outcomes: either substantially alter habi to potentially minimize wildfire impac habitat loss and degradation from wi
- The Great Basin region of the wester portunity to better understand the relati of fuel breaks, and to identify key k

*[1]US Geological Survey (USGS), Forest and Range Center, Boise, ID *(dshinneman@usgs.gov); [2]Nat Lab, Department of Ecosystem Science and Susta University, Fort Collins, CO (in cooperation with Science Center, Fort Collins, CO); [3]US Departme Service, Pacific Northwest Research Station, Wes Environmental Threat Assessment Center, Prine Western Ecological Research Center, Dixon Field*

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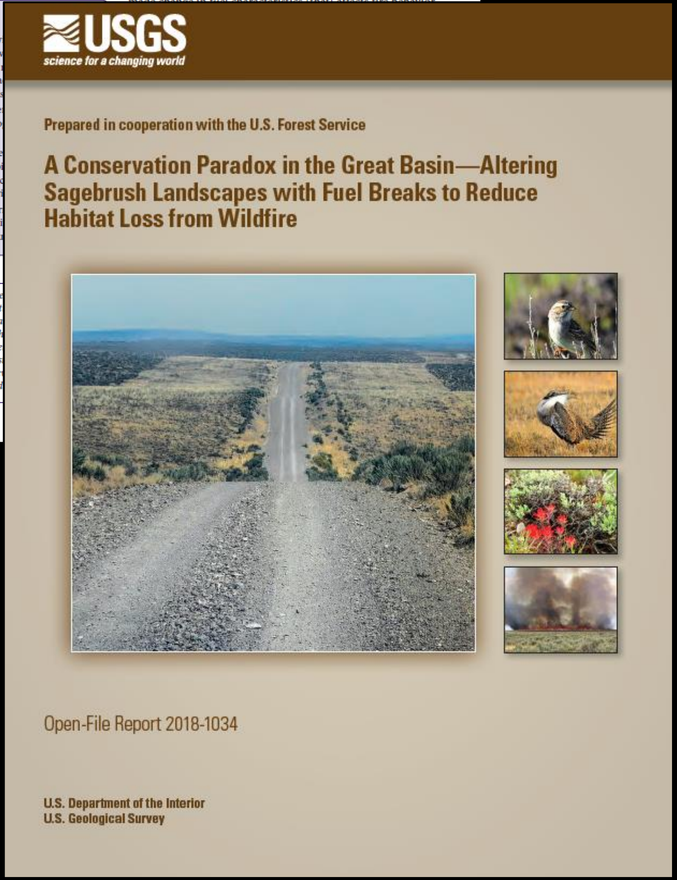

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Figure adapted from: Shinneman, et al. 2019. The ecological uncertainty of wildfire fuel breaks: examples from the sagebrush steppe. Frontiers in Ecology and the Environment 17:279–288.

Challenges of fuels management given uncertainties in climate / environmental response

Where are the best places to put fuel treatments?

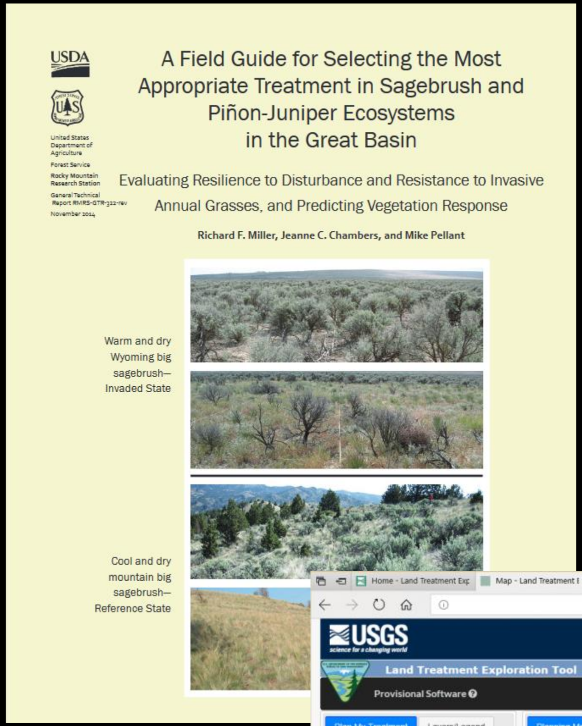
How sustainable will they be over time?

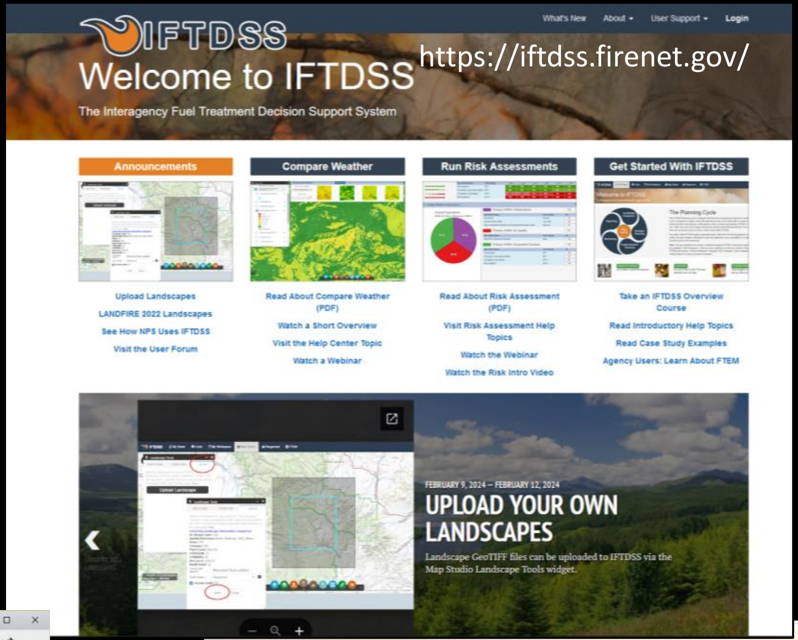
Will they be effective under more extreme fire conditions?

What are their benefits and risks?

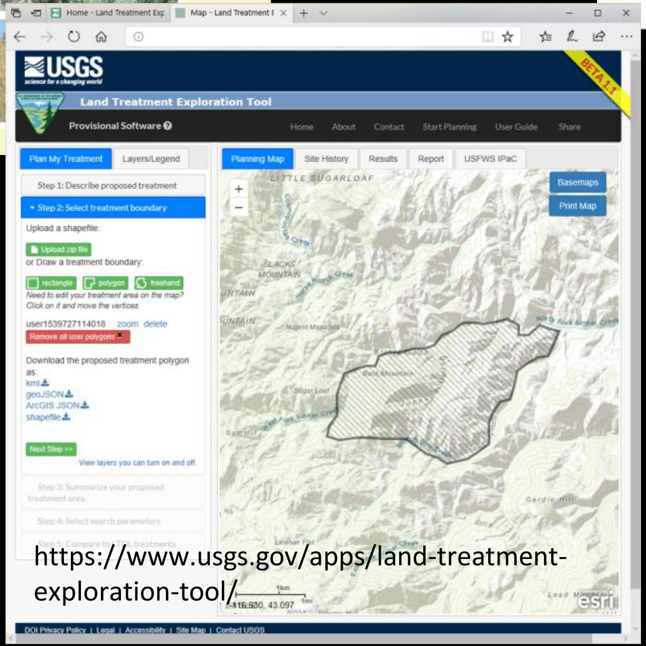
Photos: BLM

Resources and tools for planning fuel treatments

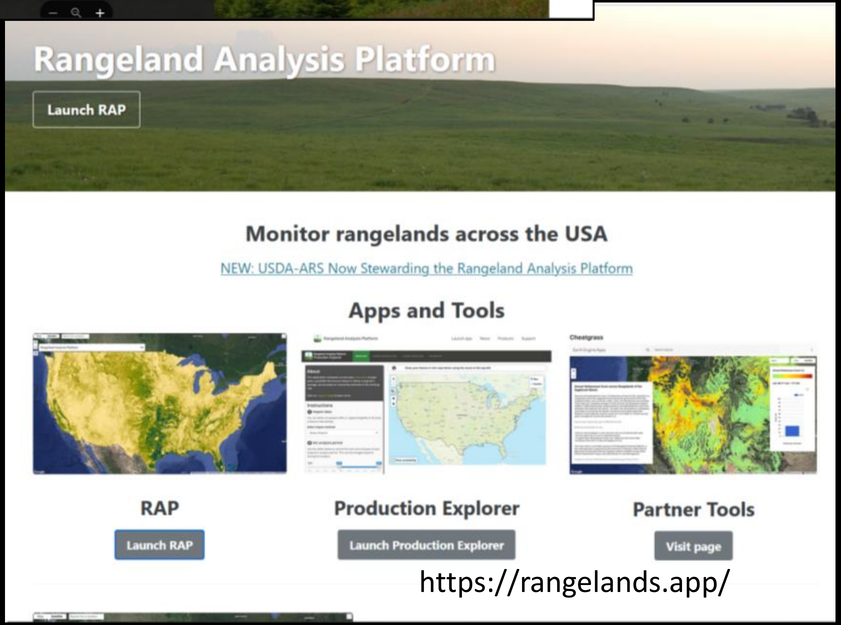




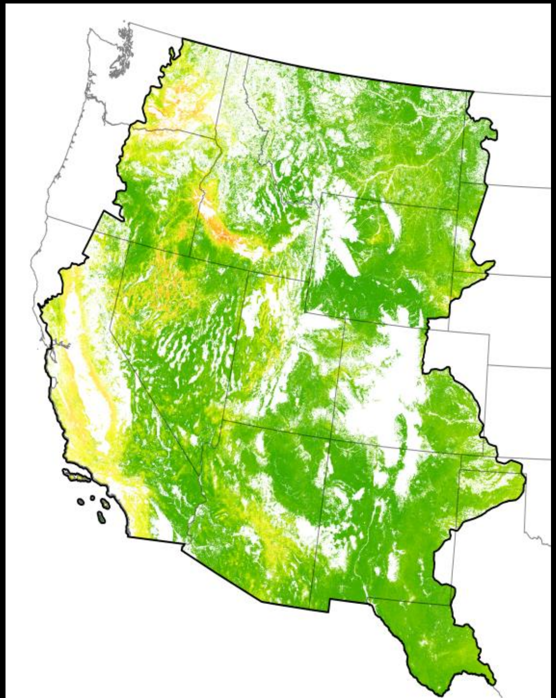
https://iftdss.firenet.gov/



https://www.usgs.gov/apps/land-treatment-exploration-tool/



https://rangelands.app/

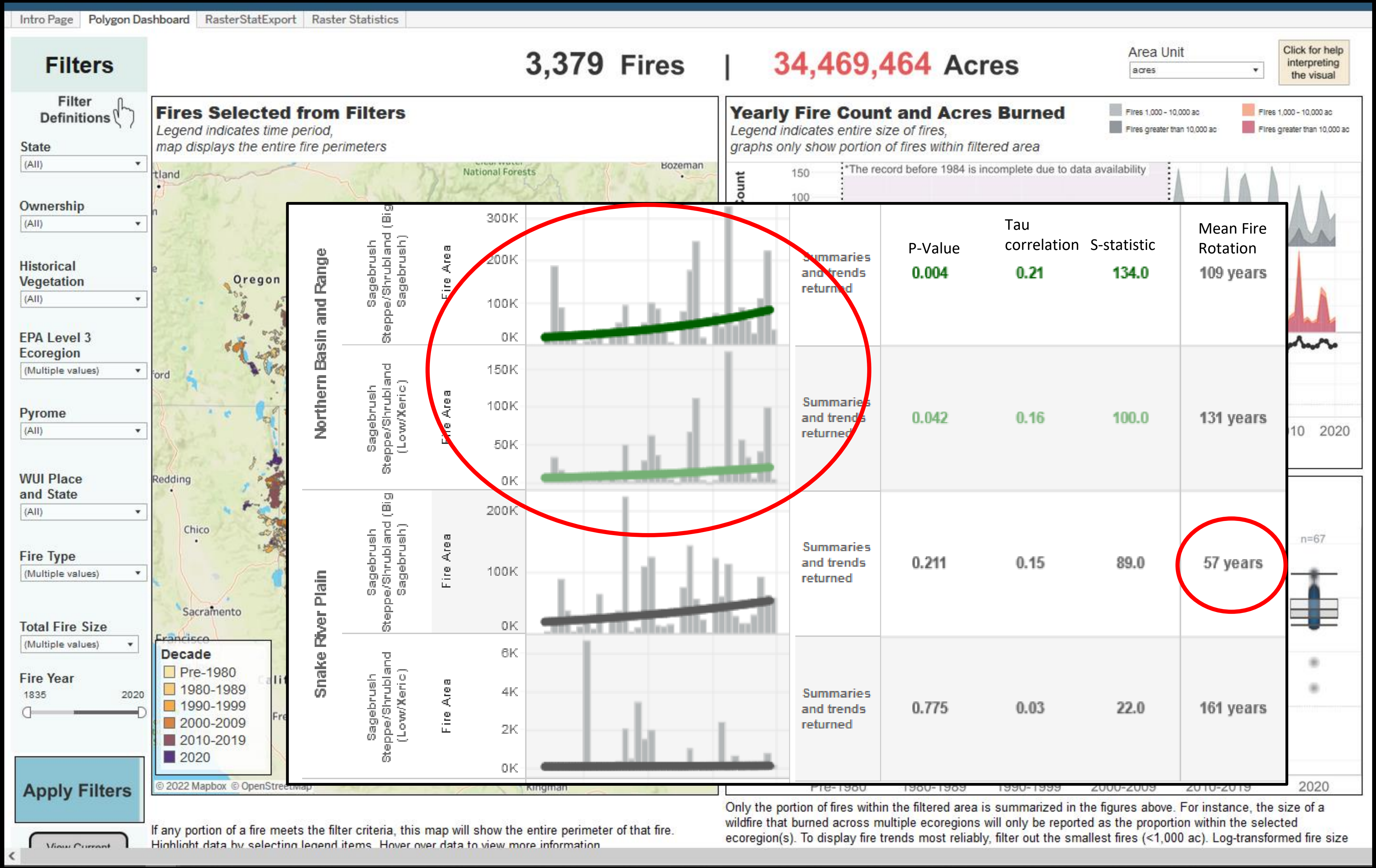

Early Estimates of Exotic Annual Grass (EAG) in the Sagebrush Biome, USA

Dahal et al. 2024. USGS data release, https://doi.org/10.5066/P1Y5TZBM.

Resources and tools - Wildland Fire Trends Tool (WFTT)

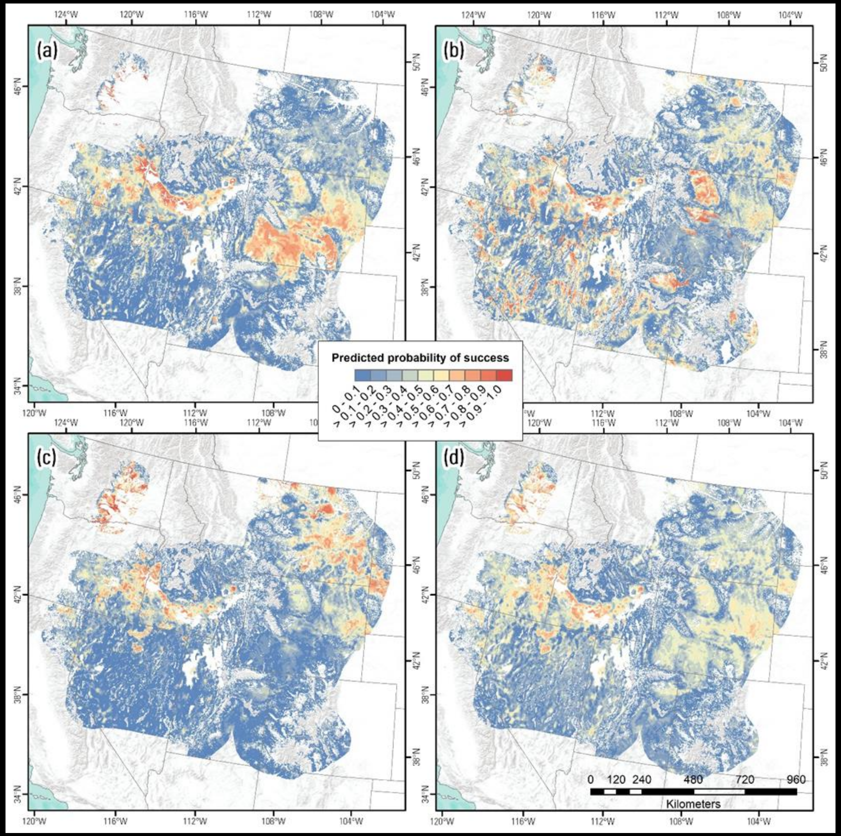
Jeffries, M., D. Shinneman, J. Welty, and D. Pilliod. 2021. Wildland Fire Trends Tool: A data visualization and analysis tool to meet land management needs and facilitate scientific inquiry.

https://geonarrative.usgs.gov/wftt/



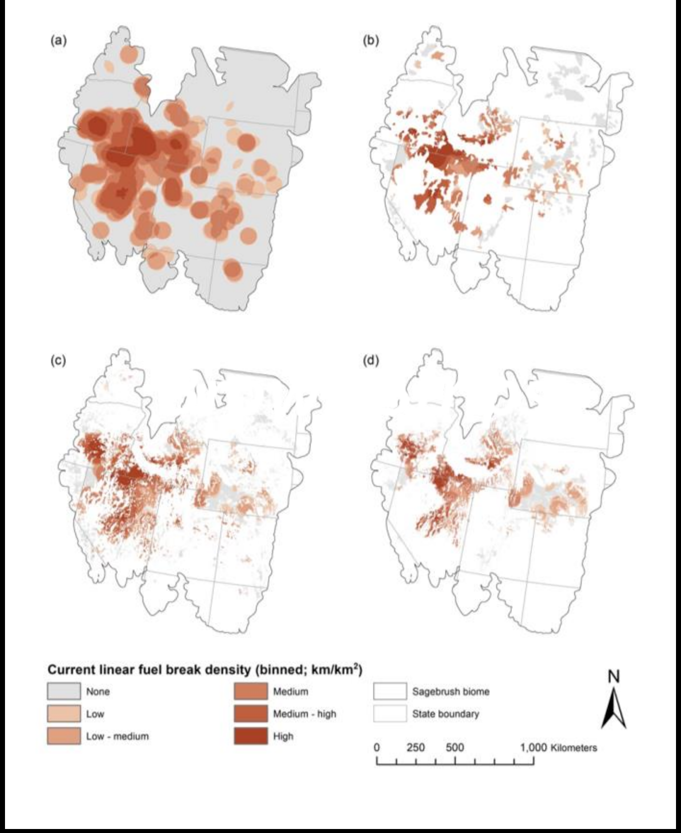
Fuel break effects and effectiveness – spatial analysis

Retrospective assessments of success



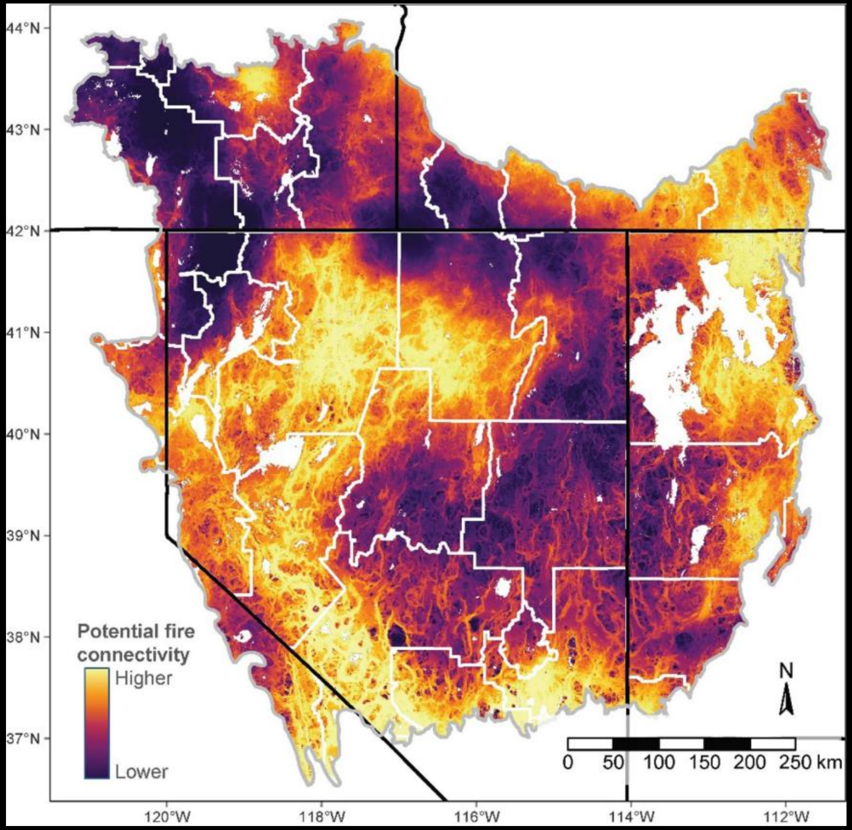
Weise, C. L., B. E. Brussee, P. S. Coates, D. J. Shinneman, M. R. Crist, C. L. Aldridge, J. A. Heinrichs, and M. A. Ricca. 2023. A retrospective assessment of fuel break effectiveness for containing rangeland wildfires in the sagebrush biome. *Journal of Environmental Management* 341:117903.

Impacts on wildlife habitat



Roche, M.; Saher, D.J.; Buchholtz, E.; Crist, M.; Shinneman, D.; Aldridge, C.; Brussee, B.; Coates, P.; Weise, C.; Heinrichs, J. (In review). Ecological trade-offs associated with fuel breaks in the sagebrush ecosystem. *Fire Ecology*.

Relationship to fire connectivity



Buchholtz, E. K., J. Kreitler, D. J. Shinneman, M. Crist, and J. Heinrichs. 2023. Assessing large landscape patterns of potential fire connectivity using circuit methods. Landscape Ecology 38:1663–1676.

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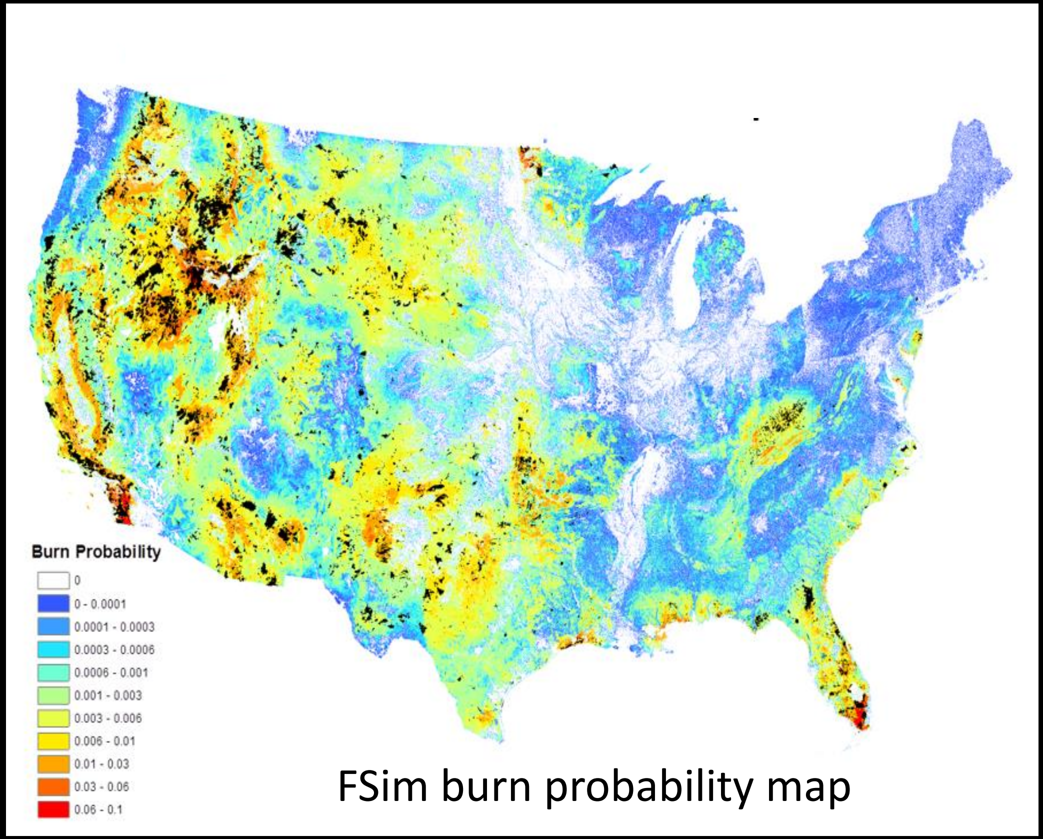
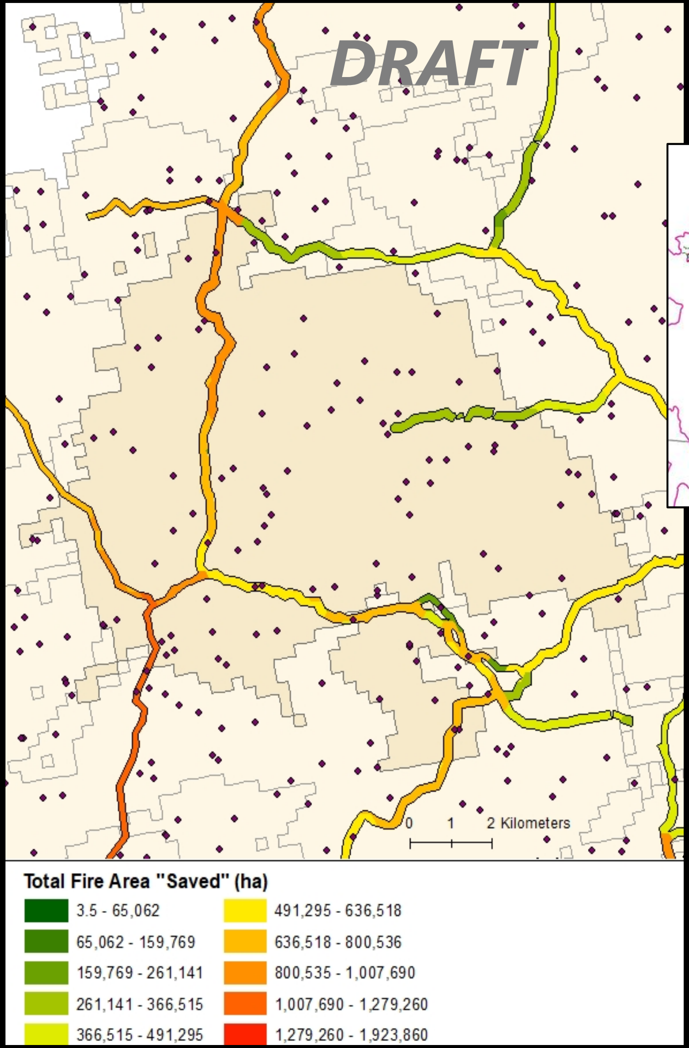
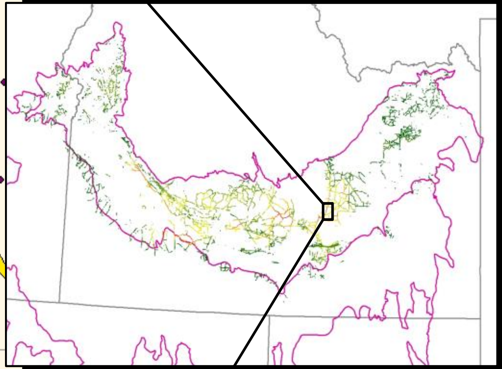
Fuel Break planning: Optimization of network design



FSim burn probability map





Total fire area "avoided" summed for each fuel break segment (Shinneman, et al. in prep.)

Input for ForSys Scenario planning model for multi-objective fuel management planning

Climate change and fuel treatment monitoring

Determining treatment success at reducing fuels and impacting fire behavior

Assessing adequacy of retreatment frequency

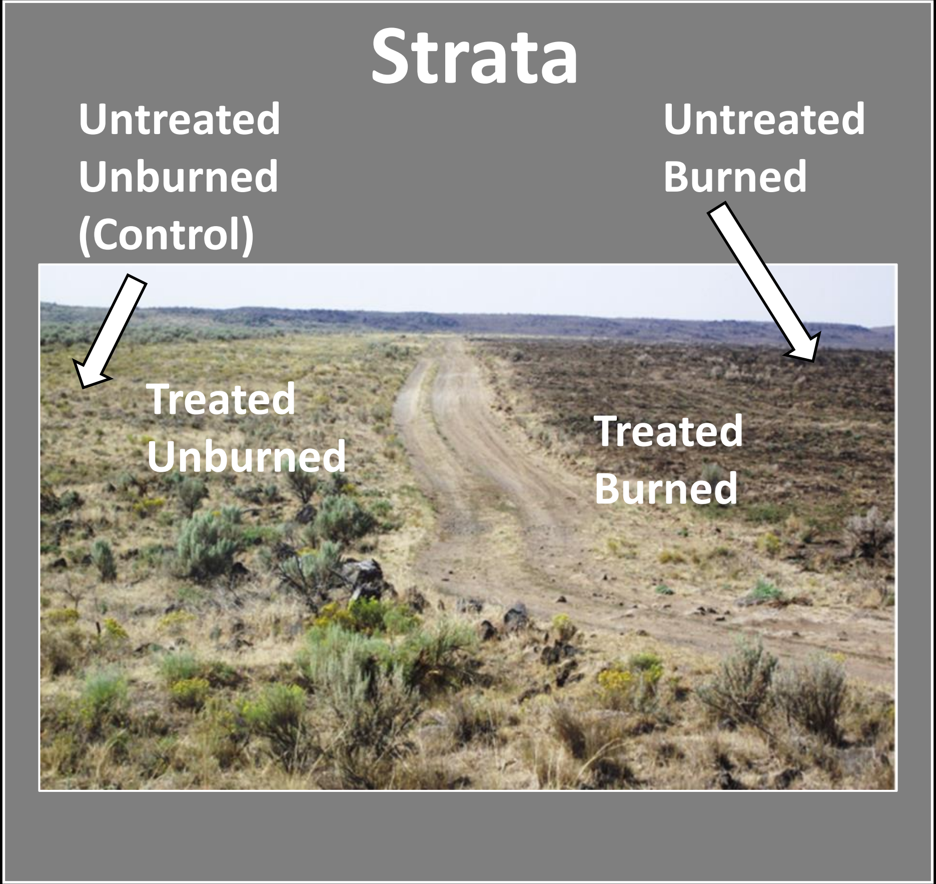
Detecting increase in fire-prone exotics

Identifying changes in wildlife use

Adaptive Management

Forage kochia planting invaded by cheatgrass

Monitoring fuel break treatment effects



	Unburned →	Once-burned →	Thrice-burned

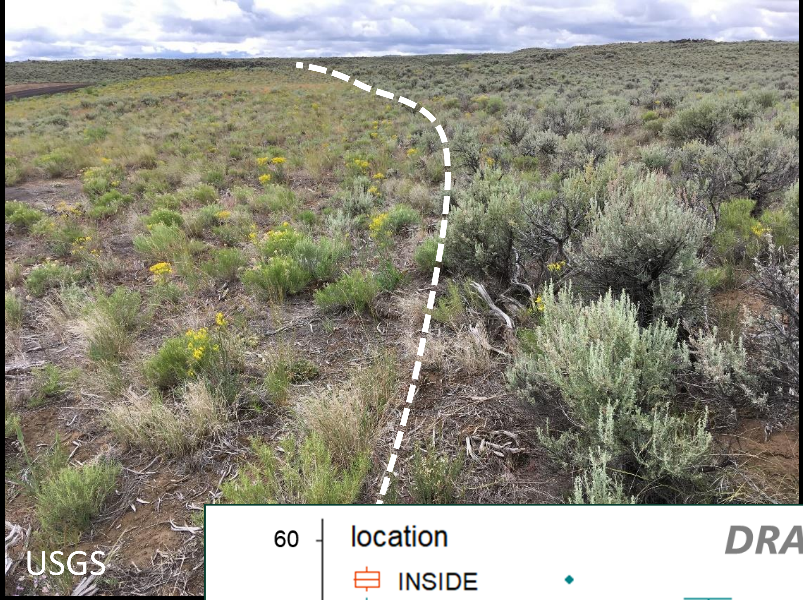
Big sagebrush (*Artemisia tridentata*)

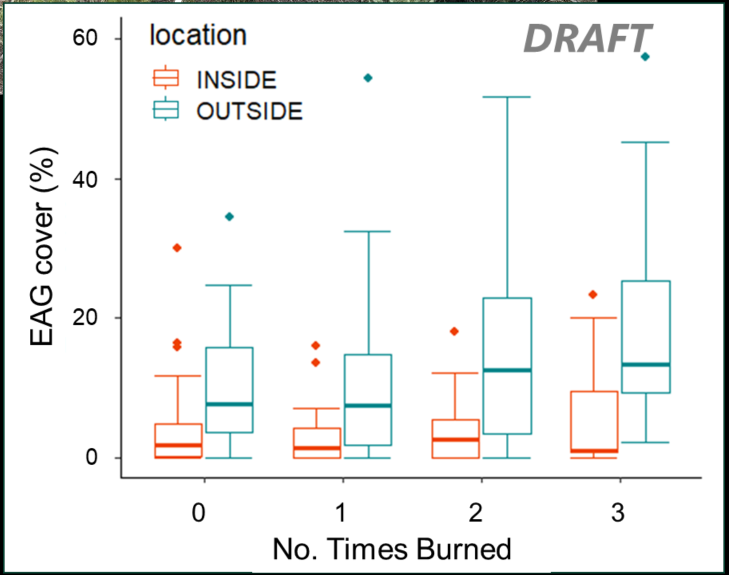
Scabland sagebrush (*Artemisia rigida*)

Adapted from: Shinneman, D. J., S. K. McIlroy, and M.-A. de Graaff. 2021. Disentangling the effects of multiple fires on spatially interspersed sagebrush (Artemisia spp.) communities. Journal of Vegetation Science 32:e12937.

Monitoring Fuel Breaks – Effects on species abundance

- Interactions between number of times burned and treatment - beneficial reduction exotic annual grasses (EAG) in fuel breaks
- Increase in exotic annual grass cover near the outer fuel break edges
- Increasing density of resprouting shrubs in fuel breaks





Shinneman et al. in prep.

Monitoring Fuel Breaks – effects on fire behavior

- Factors influencing fire behavior
  - Year since treatment X treatment type (Ellsworth et al. 2022)
  - Fire weather conditions X EAG or sagebrush cover (Price and Germino 2023)

- Risks of treatment (trade-offs)
  - Increased herbaceous surface fuels following treatments increased rate of surface fire spread & flame length (Williams et al. 2023)

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DOI: 10.1002/ecs2.4064
ECOSPHERE
ARTICLE
Special Feature: Sagebrush Steppe Treatment Evaluation Project

Fuel reduction treatments reduce modeled fire intensity in the sagebrush steppe

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[2]USDA Agricultural Research Service,

Abstract
Increased fire size and frequency coupled with annual grass invasion pose major challenges to sagebrush (*Artemisia* spp.) ecosystem conservation, which

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journal homepage: www.elsevier.com/locate/jenvman
Research article

Variability in weather and site properties affect fuel and fire behavior following fuel treatments in semiarid sagebrush-steppe

Samuel "Jake" Price, Matthew J. Germino *
US Geological Service, Forest and Rangeland Ecosystem Science Center, Boise ID, 83702, USA

ARTICLE INFO
Keywords:
Exotic annual grasses
Fire modeling
Fuel-treatments
Sagebrush
Soil
Climate

ABSTRACT
Fuel-treatments targeting shrubs and fire-prone exotic annual grasses (EAGs) are increasingly used to mitigate increased wildfire risks in arid and semiarid environments, and understanding their response to natural factors is needed for effective landscape management. Using field-data collected over four years from fuel-break treatments in semiarid sagebrush-steppe, we asked 1) how the outcomes of EAG and sagebrush fuel treatments varied with site biophysical properties, climate, and weather, and 2) how predictions of fire behavior using the Fuel Characteristic Classification System fire model related to land-management objectives of maintaining fire

Williams et al. Fire Ecology (2023) 19:46
https://doi.org/10.1186/s42408-023-00201-7
Fire Ecology
Association for Fire Ecology
ORIGINAL RESEARCH
Open Access

Fuel treatments in shrublands experiencing pinyon and juniper expansion result in trade-offs between desired vegetation and increased fire behavior

Claire L. Williams[1*], Lisa M. Ellsworth[1], Eva K. Strand[2], Matt C. Reeves[3], Scott E. Shaff[4], Karen C. Short[5], Jeanne C. Chambers[6], Beth A. Newingham[7] and Claire Tortorelli[8]

Abstract
Background Native pinyon (*Pinus* spp.) and juniper (*Juniperus* spp.) trees are expanding into shrubland communities across the Western United States. These trees often outcompete with native sagebrush (*Artemisia* spp.) associated species, resulting in increased canopy fuels and reduced surface fuels. Woodland expansion often results in longer fire return intervals with potential for high severity crown fire. Fuel treatments are commonly used to prevent continued tree infilling and growth and reduce fire risk, increase ecological resilience, improve forage quality and quantity, and/or improve wildlife habitat. Treatments may present a trade-off; they restore shrub and herbaceous cover and decrease risk of canopy fire but may increase surface fuel load and surface fire potential. We measured the accumulation of surface and canopy fuels over 10 years from ten sites across the Intermountain West in the Sagebrush Steppe Treatment Evaluation Project woodland network (www.SageSTEP.org), which received prescribed fire or mechanical (cut and drop) tree reduction treatments. We used the field data and the Fuel Characteristic Classification System (FCCS) in the Fuel and Fire Tools (FFT) application to estimate surface and canopy fire behavior in treated and control plots in tree expansion phases I, II, and III.

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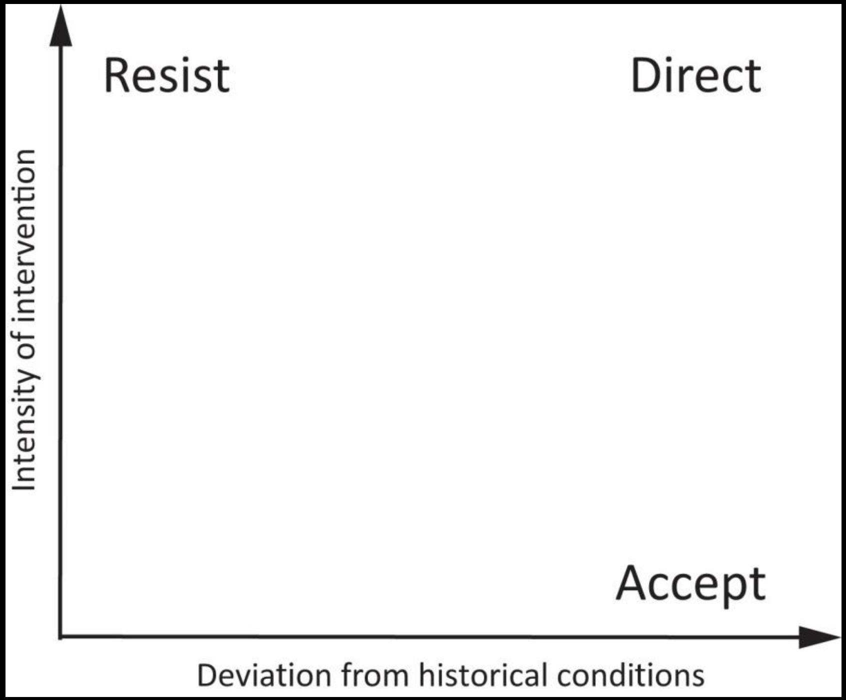
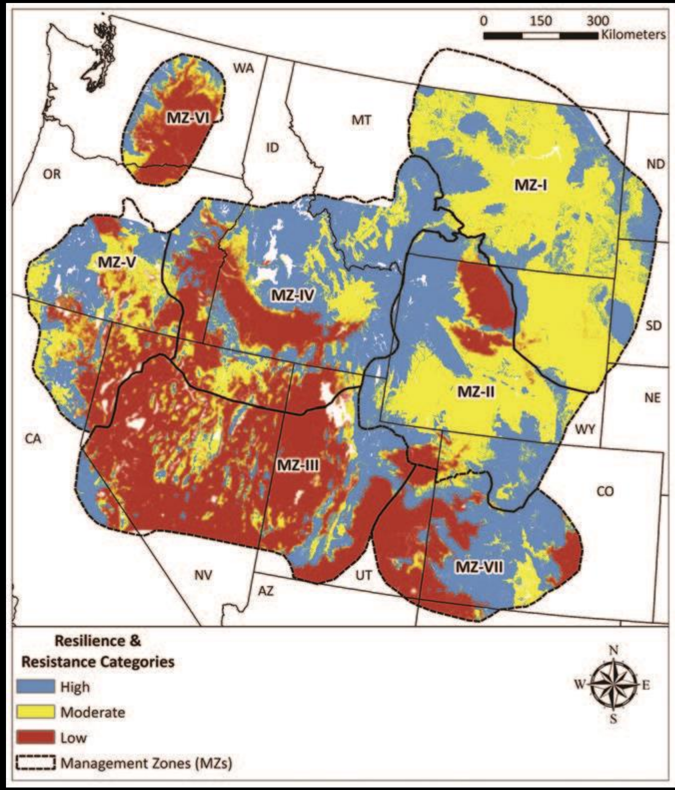
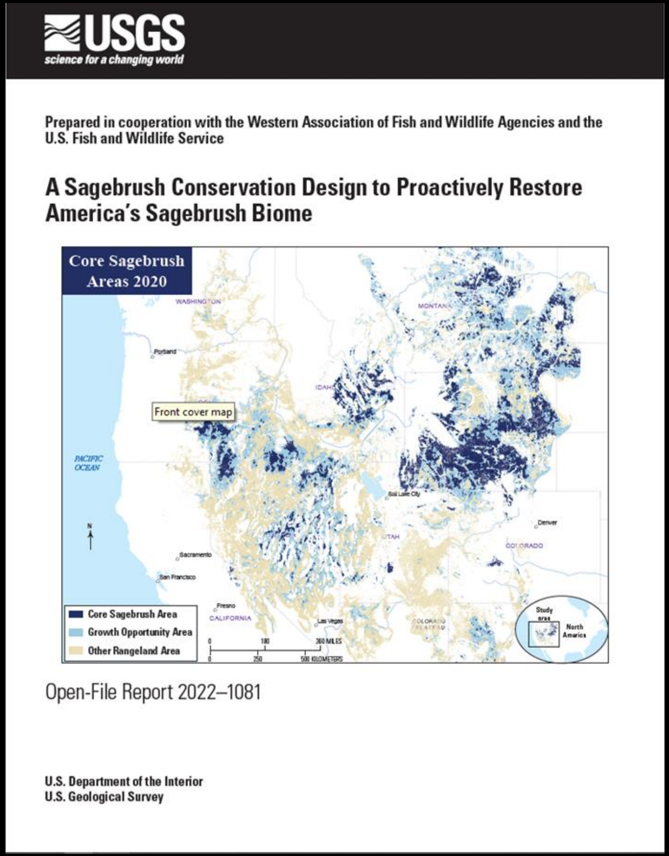
Considering fuel treatments within the RAD Framework



Schurmann *et al.* 2022. BioScience, 72: 16–29.
https://doi.org/10.1093/biosci/biab067



Chambers, *et al*. 2017. Gen. Tech. Rep. RMRS-GTR-360. Fort Collins, CO: USDA Forest Service



Doherty et al. 2022. A sagebrush conservation design to proactively restore America's sagebrush biome: U.S. Geological Survey Open-File Report 2022–1081, https://doi.org/ 10.3133/ ofr20221081.

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