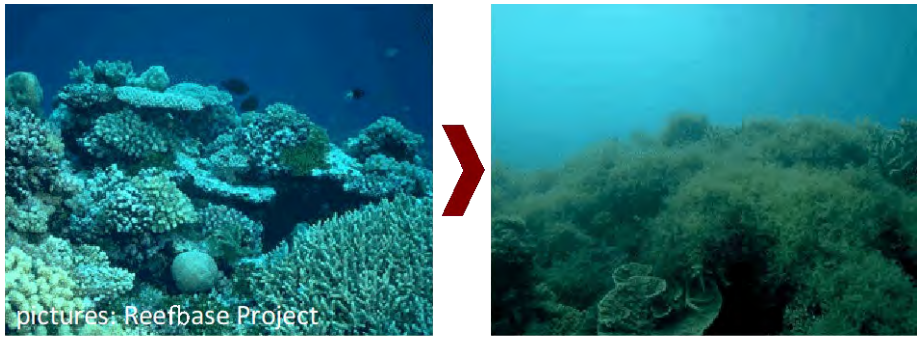
A New Grassland Conservation Initiative

NE NRCS State Technical Committee Meeting

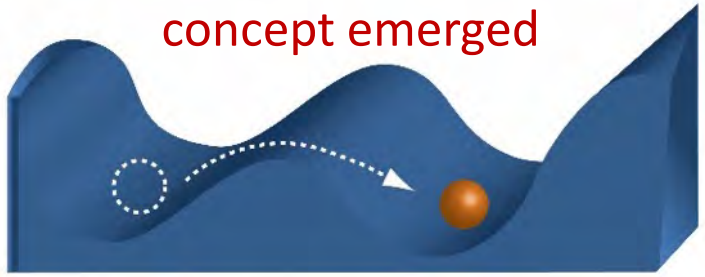
Dirac Twidwell
Associate Professor
University of Nebraska

A grand challenge for the 21st century is to avoid undesirable transitions that are so severe that their consequences go beyond the traditions of any single discipline.



How can we provide earlier warning of state transitions?

Because the scales at which transitions occur this century will be unprecedented since resilience concept emerged



Generalized resilience indicators have been a major pursuit in recent years in the science because of their potential to provide earlier warning of ecological change *(Roberts et al. 2019 Nature CC; Allen et al. 2019 Nature Sustainability; Garmestani et al. 2019 PNAS)*

comment

Resilience reconciled

Resilience scholarship continues to inspire opaque discourse and competing frameworks often inconsistent with the complexity inherent in social–ecological systems. We contend that competing conceptualizations of resilience are reconcilable, and that the core theory is useful for navigating sustainability challenges.

Craig R. Allen, David G. Angeler, Brian C. Chaffin, Dirac Twidwell and Ahjond Garmestani

Resilience as an emergent property (Holling's resilience): The amount of change a system can withstand before it crosses a threshold and fundamentally changes.

This definition accounts for the potential of a system to exist in alternative states.

Whether alternative states actually existed was still a major theoretical debate 20 years ago.

Subsumes other definitions of resilience based on a rate (bounce-back) or a process (build resilience/build health).

Journal of Applied Ecology

Journal of Applied Ecology 2016, 53, 625–635 doi: 10.1111/1365-2664.12634

REVIEW: QUANTIFYING RESILIENCE

Quantifying spatial resilience

Craig R. Allen[1*], David G. Angeler[2], Graeme S. Cumming[3†], Carl Folke[4,5], Dirac Twidwell[6] and Daniel R. Uden[7]

"Spatial resilience is the contribution of spatial attributes to the feedbacks that generate resilience in ecosystems and other complex systems."

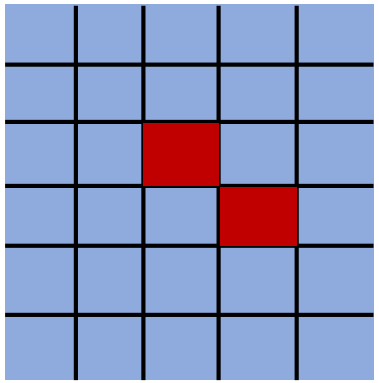
Table 1. Internal and external components of spatial resilience (Cumming 2011b)

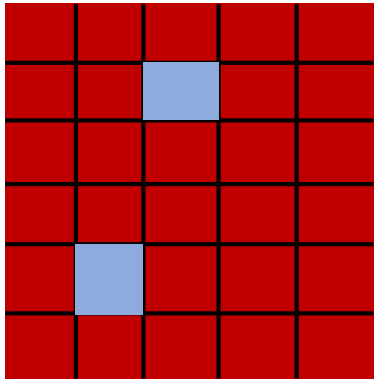
Internal elements	External elements
Internal arrangement of components	Context (area influencing system)
System morphology	System footprint (area influenced by system)
Number and nature of boundaries	Connectivity
Spatial variation in phase	Dispersal of organisms
Properties of location	Spatial feedbacks
	Spatial subsidies

What is our spatial game plan for tackling rangeland management problems?

Level 1	Level 2	Level 3	Level 4	Level 5
Invasive Annual Grass Free	Trace (1-5% IAG cover), perennials intact	Mild Infestation (6-25% IAG cover), perennials intact	Moderate Infestation (26-50% IAG cover), some perennials missing	Invasive Annual Grass Dominated (>51% IAG cover), perennials rare
Prevention				
Maintenance				
	Eradication			
???		Intensive Management		
			Restoration	
				Containment

Adapted from Mealor et al. 2013 – Cheatgrass Management Handbook





But….

- How do we incorporate scale and landscape context?
- Where are undesired state changes actually happening through time?

Bottomline….

- Our current management is not performing to expectations
- We need game plan to win (*right practices, right places*)
- RAP data can be one piece of the puzzle

The Problem of Pattern and Scale

"The problem of pattern and scale is the central problem in ecology, unifying population biology and ecosystems science, and marrying basic and applied ecology. Applied challenges... require the interfacing of phenomena that occur on very different scales of space, time, and ecological organization. Furthermore, **there is no single natural scale at which ecological phenomena should be studied**; systems generally show characteristic variability on a range of spatial, temporal, and organizational scales." (Simon Levin 1992)

Prolonged Instability Prior to a Regime Shift

Trisha L. Spanbauer[1]*, Craig R. Allen[2], David G. Angeler[3], Tarsha Eason[4], Sherilyn C. Fritz[1], Ahjond S. Garmestani[4], Kirsty L. Nash[5], Jeffery R. Stone[6]

1 Department of Earth and Atmospheric Sciences and School of Biological Sciences, University of Nebraska–Lincoln, Lincoln, Nebraska, United States of America, **2** U.S. Geological Survey, Nebraska Cooperative Fish and Wildlife Research Unit, School of Natural Resources, University of Nebraska–Lincoln, Lincoln, Nebraska, United States of America, **3** Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden, **4** Office of Research and Development, National Risk Management Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio, United States of America, **5** Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Queensland, Australia, **6** Department of Earth and Environmental Systems, Indiana State University, Terre Haute, Indiana, United States of America

Early Warnings for State Transitions

Caleb P. Roberts [a,b], Dirac Twidwell [a,*], Jessica L. Burnett [b], Victoria M. Donovan [a], Carissa L. Wonkka [a], Christine L. Bielski [a,b], Ahjond S. Garmestani [c], David G. Angeler [d], Tarsha Eason [c], Brady W. Allred [e], Matthew O. Jones [e], David E. Naugle [e], Shana M. Sundstrom [b], Craig R. Allen [f]

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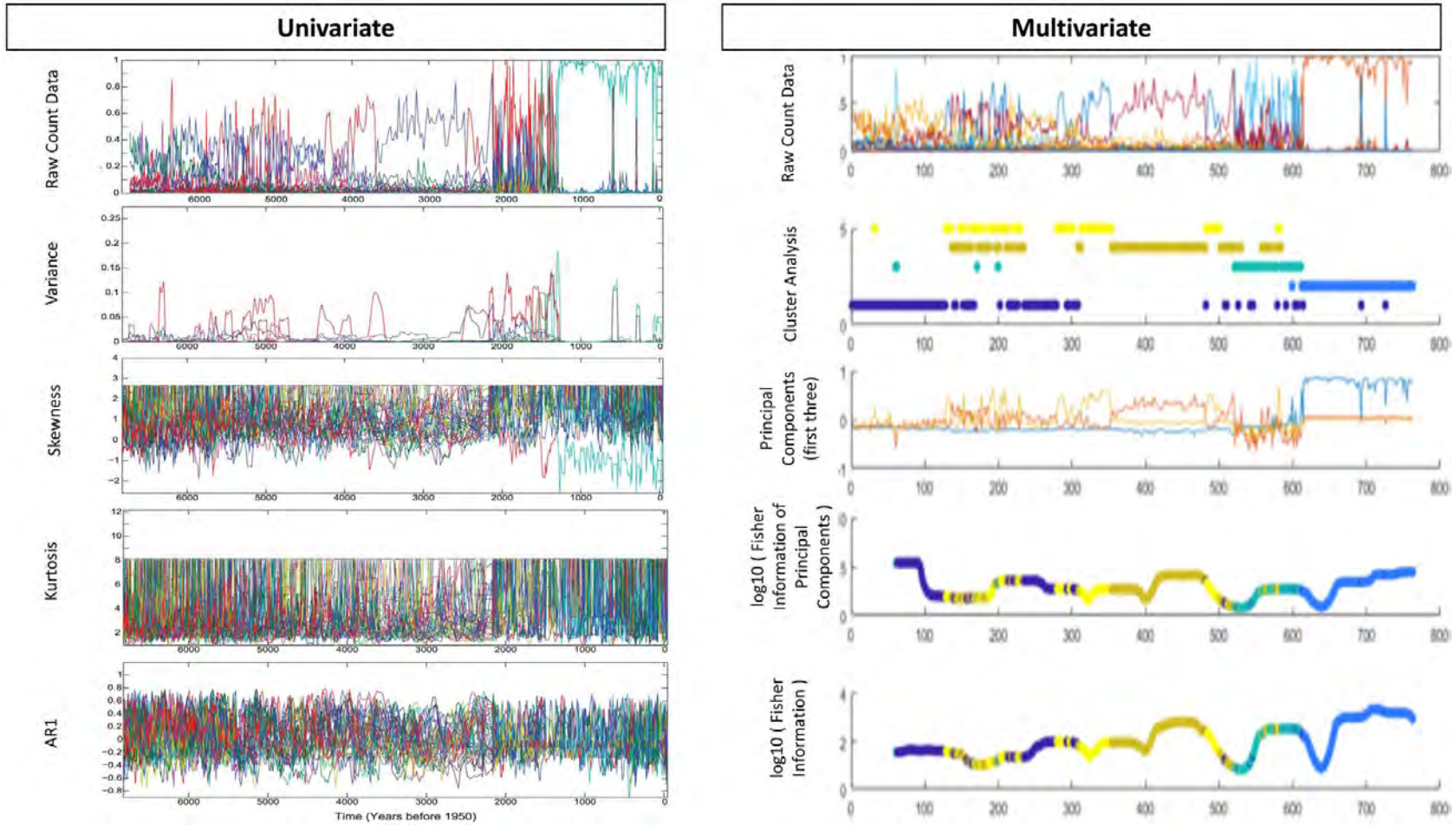
[b] *Nebraska Cooperative Fish and Wildlife Research Unit, University of Nebraska, School of Natural Resources, Hardin Hall, Lincoln, NE 68583-0961, USA*
[c] *U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH 45268, USA*
[d] *Swedish University of Agriculture Sciences, Department of Aquatic Sciences and Assessment, Uppsala, Sweden, PO Box 7050*
[e] *University of Montana, WA Franke College of Forestry and Conservation, Missoula, MT 59812, USA*
[f] *U.S. Geological Survey, Nebraska Cooperative Fish and Wildlife Research Unit, Hardin Hall, Lincoln, NE 66583-0984, USA*



"Of the indicators used, we found that univariate species-level indicators were weak predictors of regime shifts."

But this knowledge only reflects changes over time. Real solutions and real impacts also require an understanding of the spatial scale of the problem.

Transitions in nature exhibit strong spatial order, but we have lacked the technology and data to detect and image spatial change

frontiers in Ecology and Evolution

ORIGINAL RESEARCH
published: 29 October 2019
doi: 10.3389/fevo.2019.00407

Spatial Imaging and Screening for Regime Shifts

Daniel R. Uden[1,2*], Dirac Twidwell[1,3], Craig R. Allen[2,3], Matthew O. Jones[4], David E. Naugle[4], Jeremy D. Maestas[5] and Brady W. Allred[4]

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British Ecological Society

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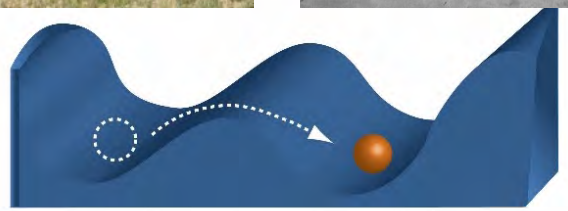
Classical view of transitions in nature

Time (not space)



Four major advances in spatial resilience/regimes

- Ecological regimes represent self-replicated patterns in structure and function that are conserved in space and time.
- The scale of replication is what we commonly use in ecology to assign the identify of a patch, landscape, ecoregion, or biome.
- All ecological regimes are finite in space; thus, where one regime ends another begins
- As regimes transition, their spatial context breaks-down and gives a signal of spatial irregularity.

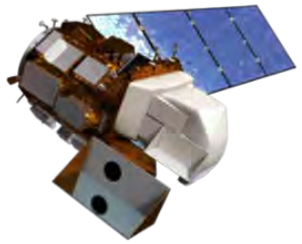
These serve as the basis for our ability to understand the spatial context of ecological regimes, their scale of occurrence, and how they transition…

…and with this understanding, we can better manage to avoid undesirable transitions.

Rangeland Analysis Platform (RAP)

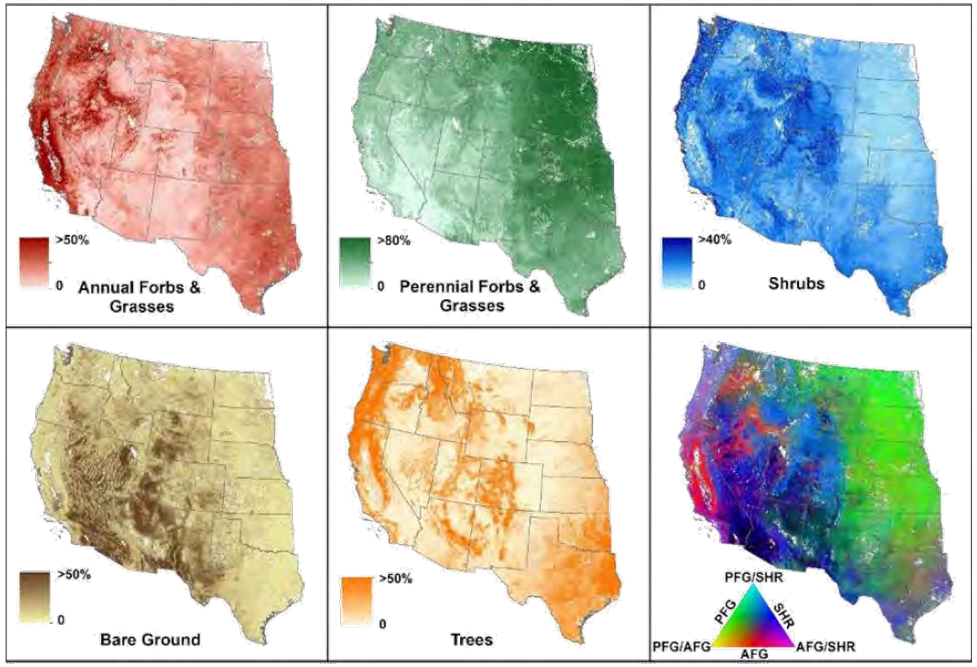
- Percent cover
- Western U.S. rangelands
- Random Forest algorithm
- Free online: https://rangelands.app/rap

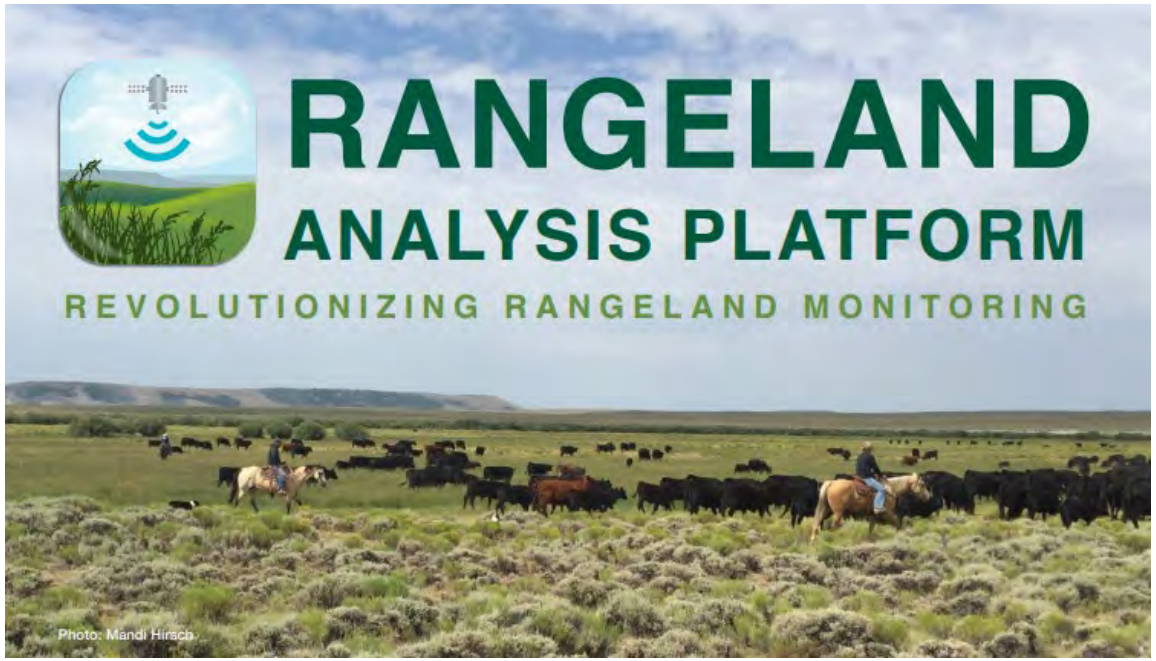
Field Plots + **Landsat** + **Cloud-Computing**



Google Earth Engine

30-m Resolution Percent Cover Maps (Available annually from 1984-Present)





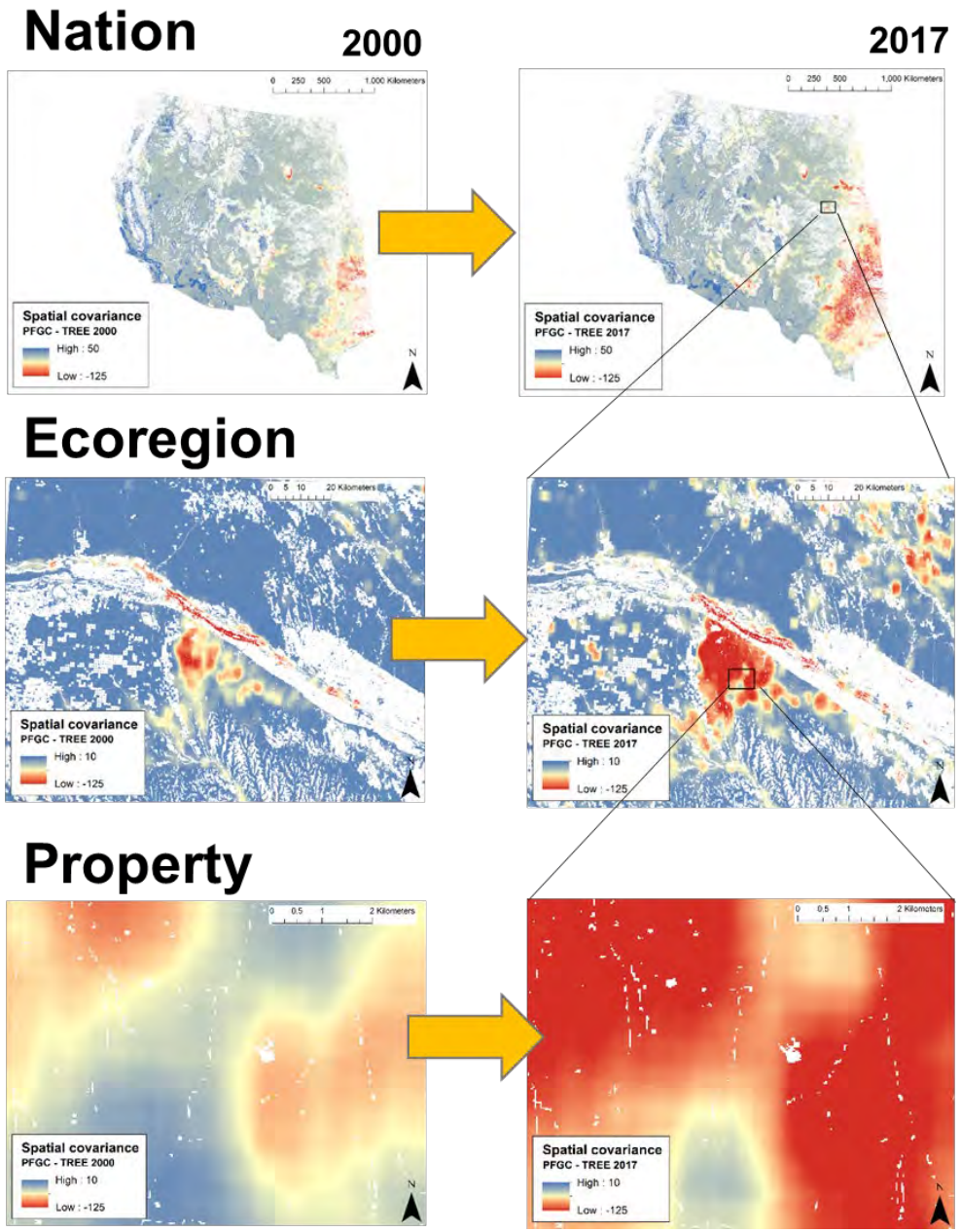
Jones et al. 2018

frontiers
in Ecology and Evolution

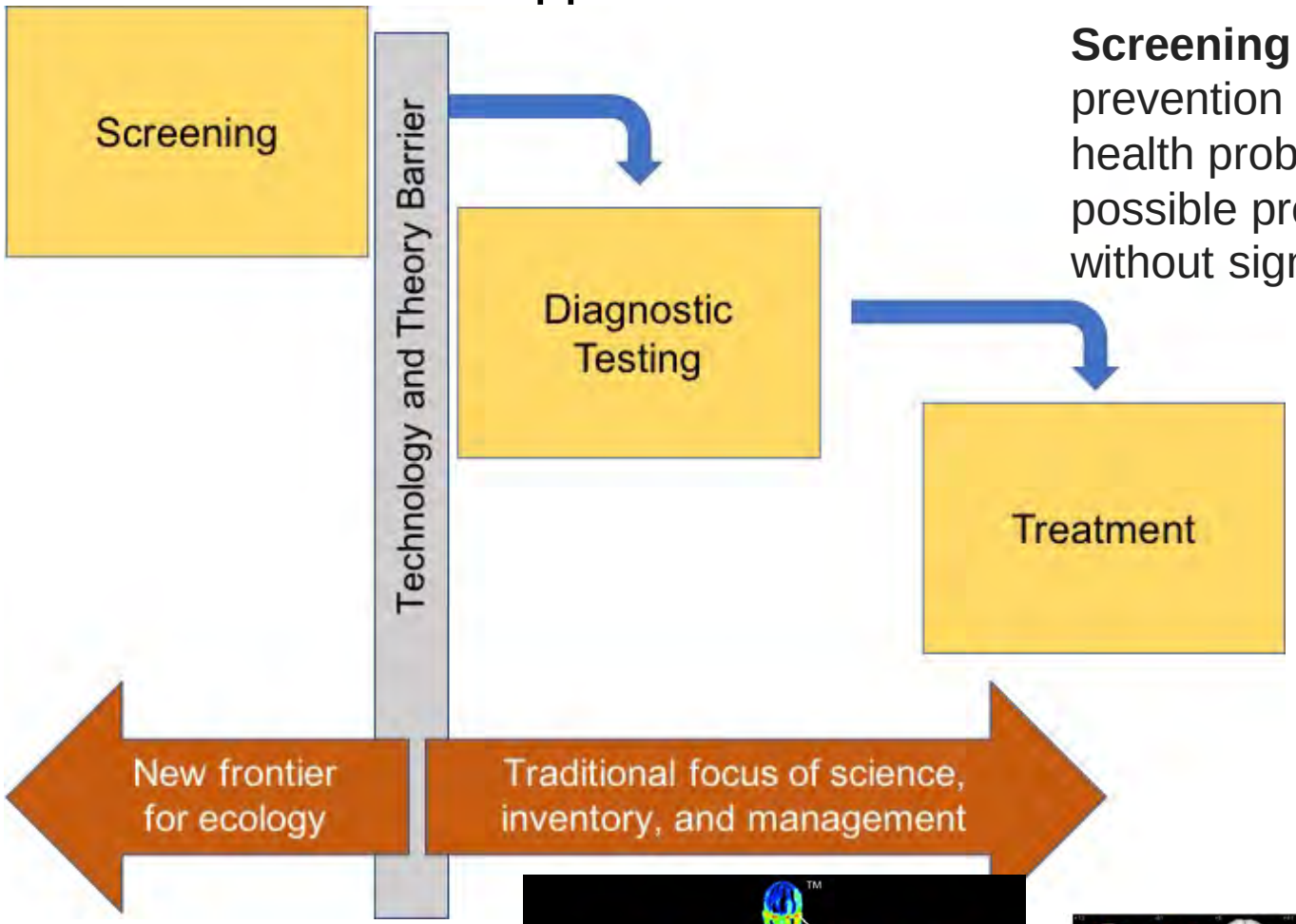
Spatial Imaging and Screening for Regime Shifts

Daniel R. Uden[1,2], Dirac Twidwell[1,3], Craig R. Allen[2,3], Matthew O. Jones[4], David E. Naugle[4], Jeremy D. Maestas[5] and Brady W. Allred[4]*

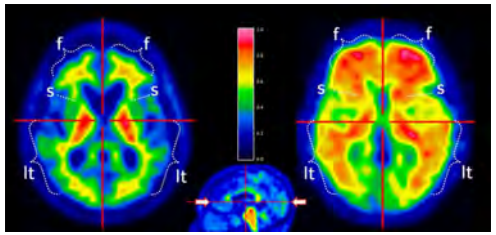
- Image vegetation state boundaries
- Track transitions over space, time, and scale
- Built with RAP data
- Computed in moving window algorithm
- Utilizes cloud-computing (Google Earth Engine)
- Property-to-national extents
- 19 years
- 10 functional group combinations
- 1,140 images for national analysis
- 4,320 computing hours for largest window

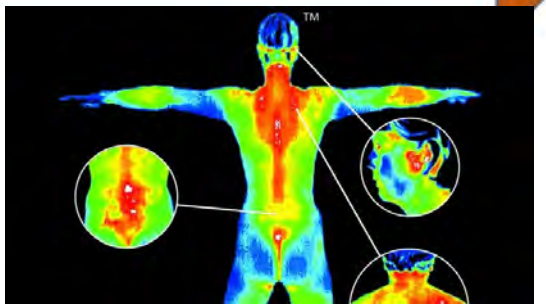


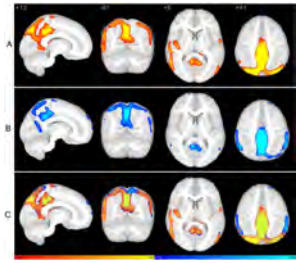
New technologies and computational power now make it possible to screen for rangeland transitions at scales needed to support individual landowners to federal planning



Screening is a strategy used in medicine for prevention and early detection of potential health problems. Screening identifies the possible presence of a disease in individuals without signs or symptoms.







Uden et al. 2019 Frontiers in Ecol. Evol.

Pioneering an approach to screen for transitions and implement large-scale resilience planning in rangelands

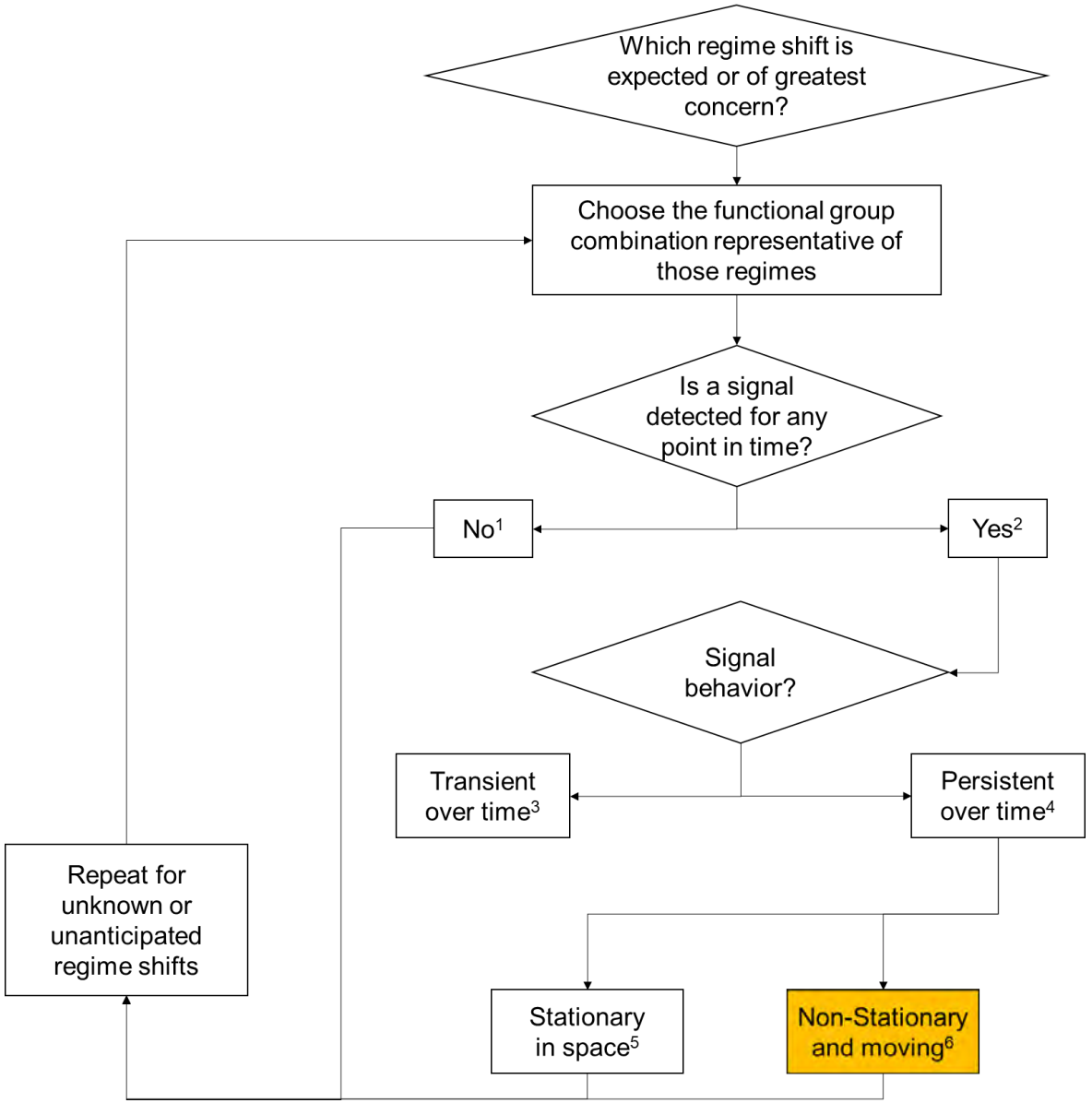
What is large scale resilience planning?

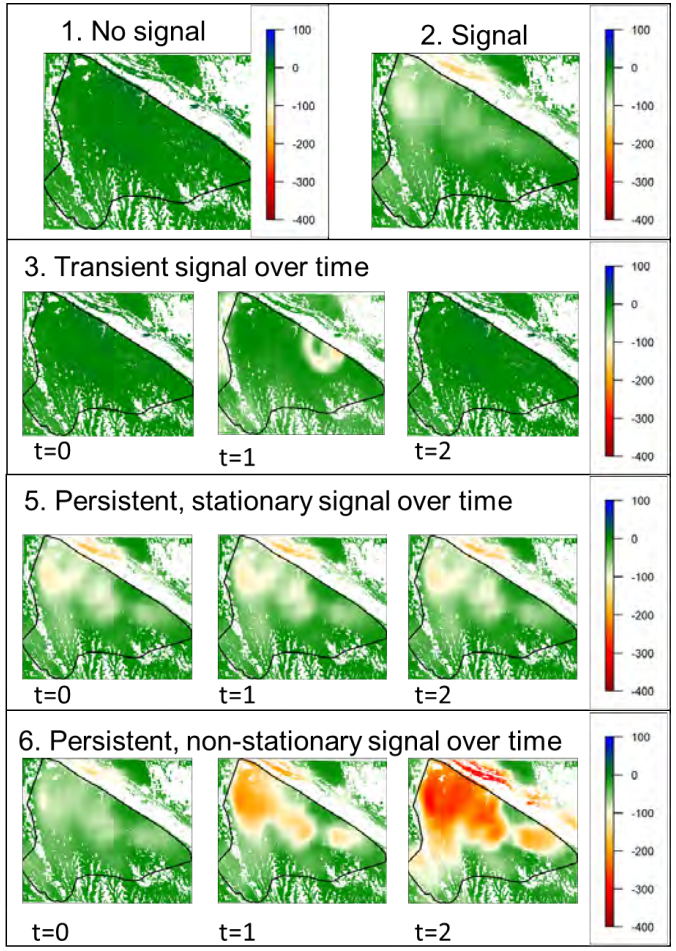
Large scale resilience planning emphasizes the conservation and protection of systems at large scales. Local management becomes compromised when the larger system is changing (shown for increasing woody dominance in the map as areas turn red).

New screening tools now make it possible to track transitions in vegetation at an unprecedented range of scales.

Problematic rangeland transitions have three important signals:

1. Persistent in space and time
2. Non-stationary (moving in space over time)
3. Transcend scale (increase in size/spatial scale over time)





Uden et al. 2019 Frontiers in Ecol. Evol.

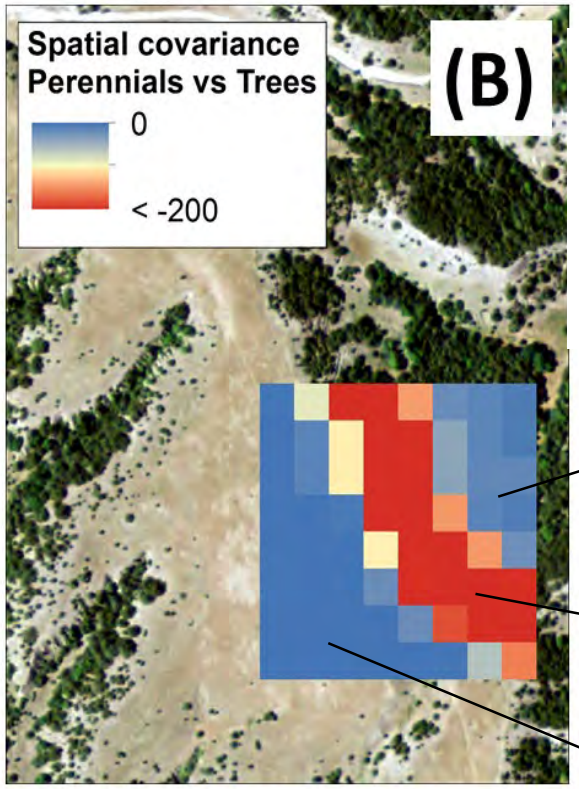
Pioneering an approach to screen for transitions and implement large-scale resilience planning in rangelands

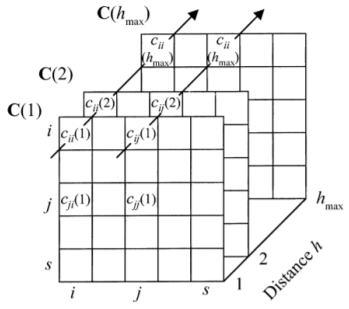
Questions

1. Where do alternative states occur? Where does one end and another begin?
2. How do we understand the scale of transitions ?
3. Where are state transitions happening over time?

Brief methodology overview

1. Use spatial covariance to detect spatial transitions separating states
2. Repeat across scales ranging from local to regional
3. Test whether spatial transitions separating states are non-stationary over time and moving in space





Tree state

Transition (Spatial)

Grass state

Overview of spatial computation

- 18 years
- 10 functional group combos
- 5 window sizes ranging from local properties to regional scales
- 900 images for national analysis
- 4,320 computing hours for largest window

Overview of temporal computation

- Run non-stationarity test
- Determine best model of temporal change

When the higher values of one functional group correspond to the lower values of an alternate functional group, then spatial covariance is negative. In other words, the functional groups exhibit opposing spatial behavior and do not coexist (given the spatial scale of analysis). A non-stationary boundary moves over time, causing one state to expand at the expense of the neighboring state.

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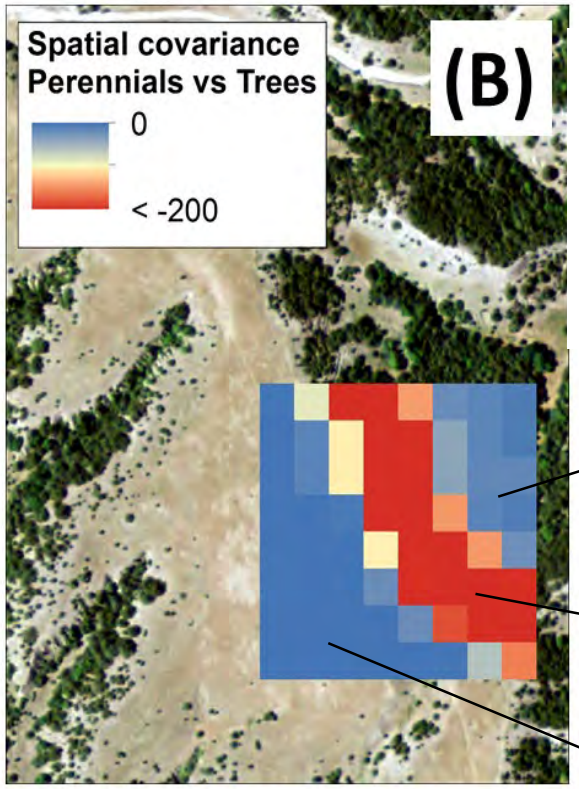
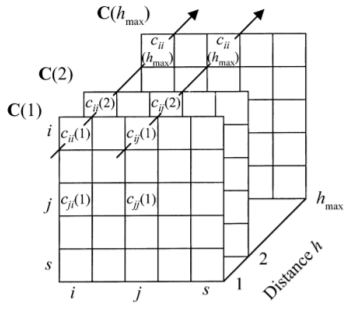
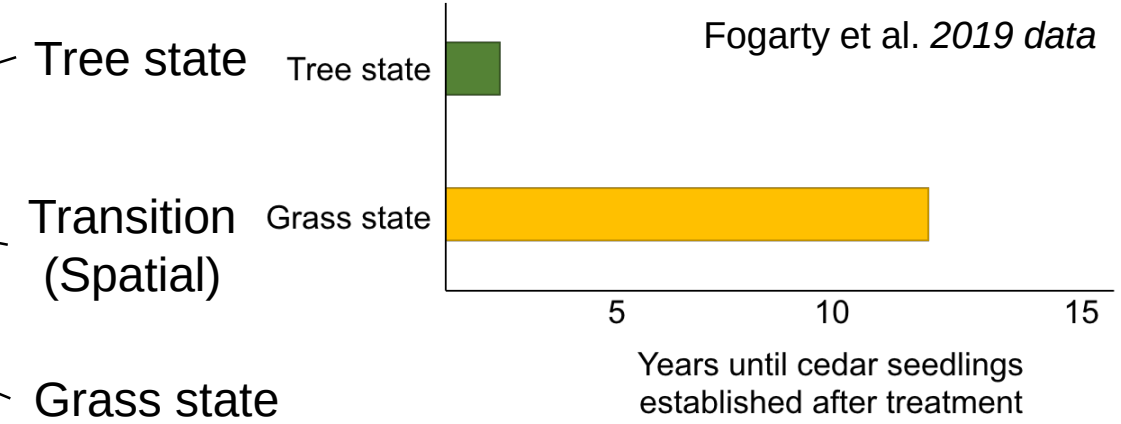




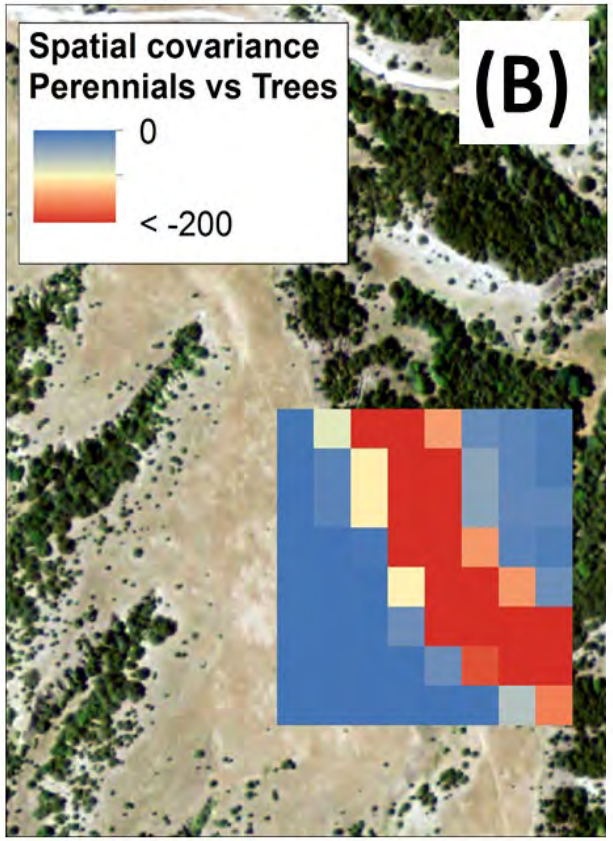
Why is it so important to understand what state you are in?

…because it compromises management and conservation expenditures

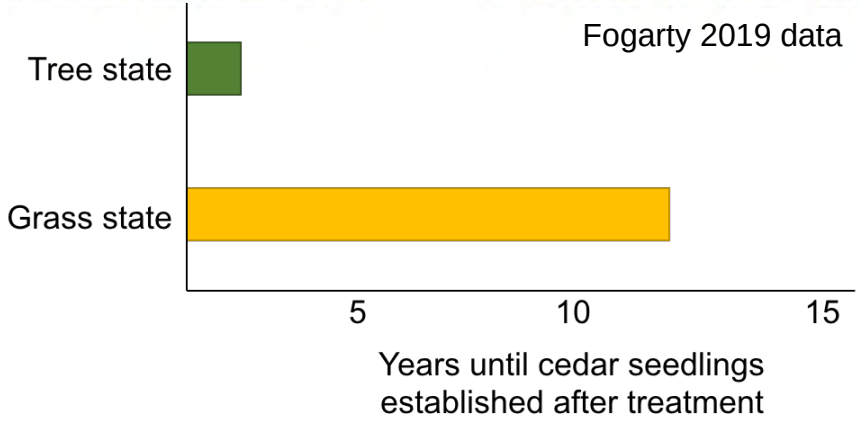


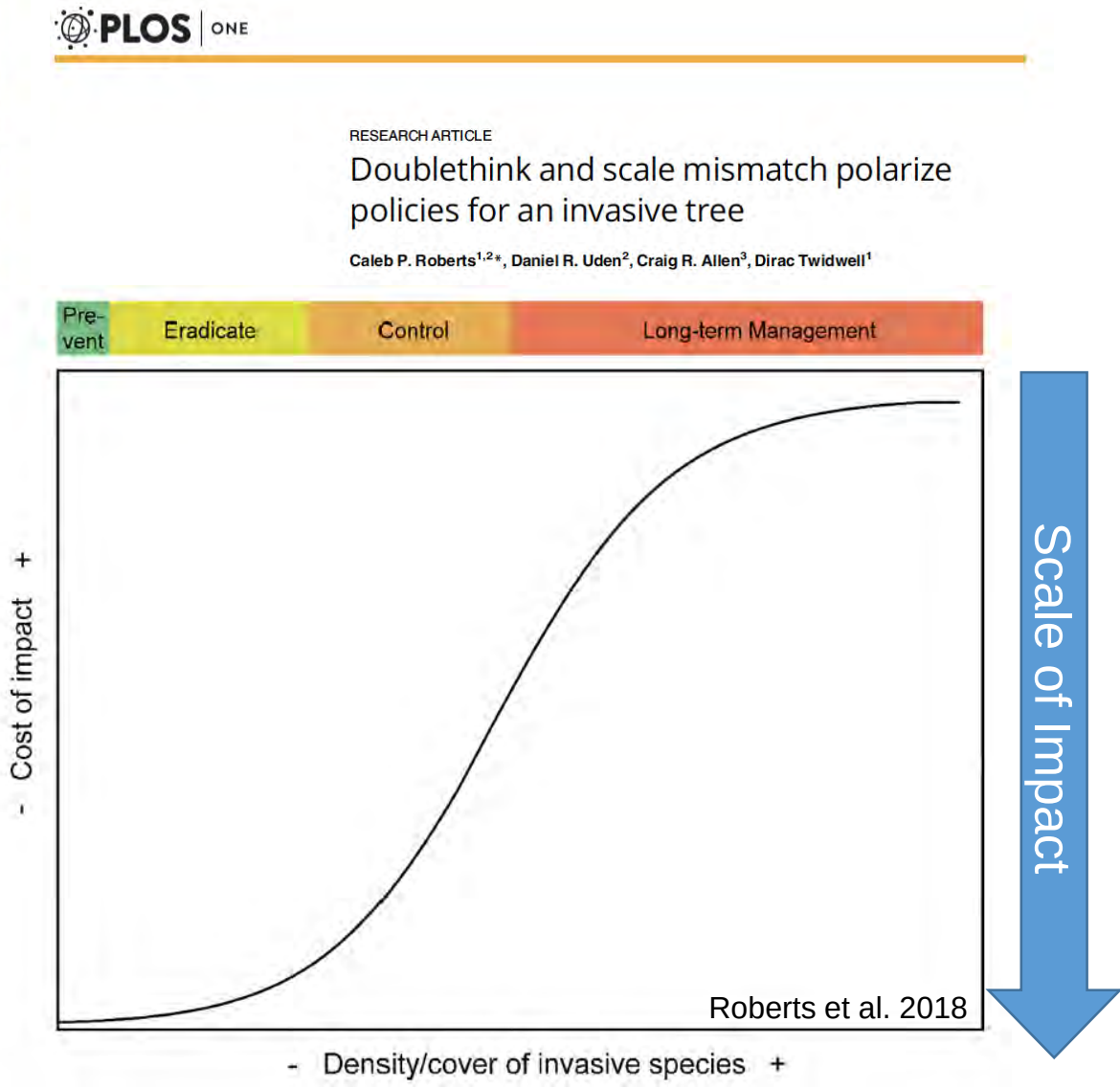
When the higher values of one functional group correspond to the lower values of an alternate functional group, then spatial covariance is negative. In other words, the functional groups exhibit opposing spatial behavior and do not coexist (given the spatial scale of analysis). A non-stationary boundary moves over time, causing one state to expand at the expense of the neighboring state.

Waiting to act until a state transition occurs often leads to hysteresis, which reduces project lifespans



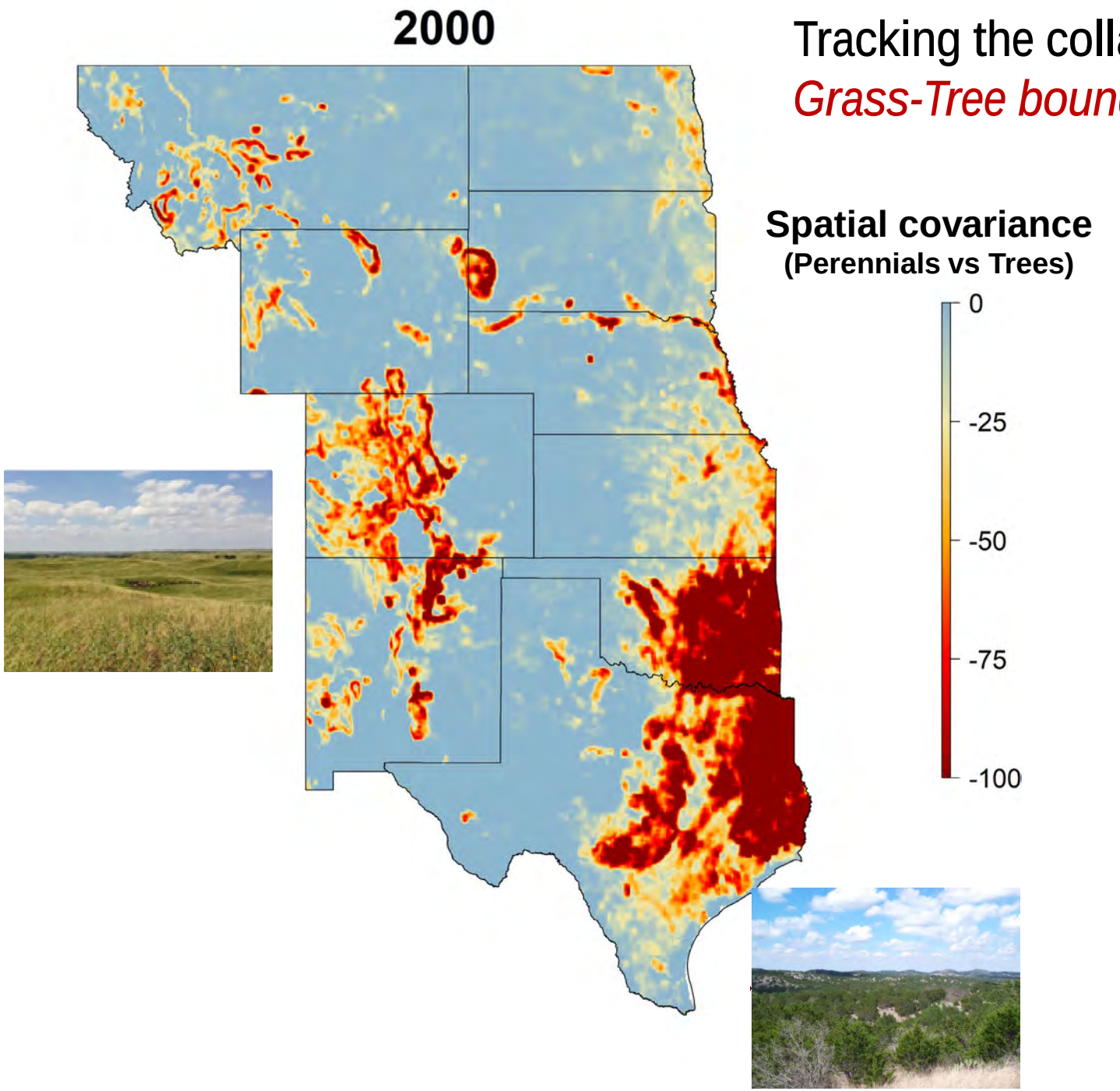
Fogarty 2019 data





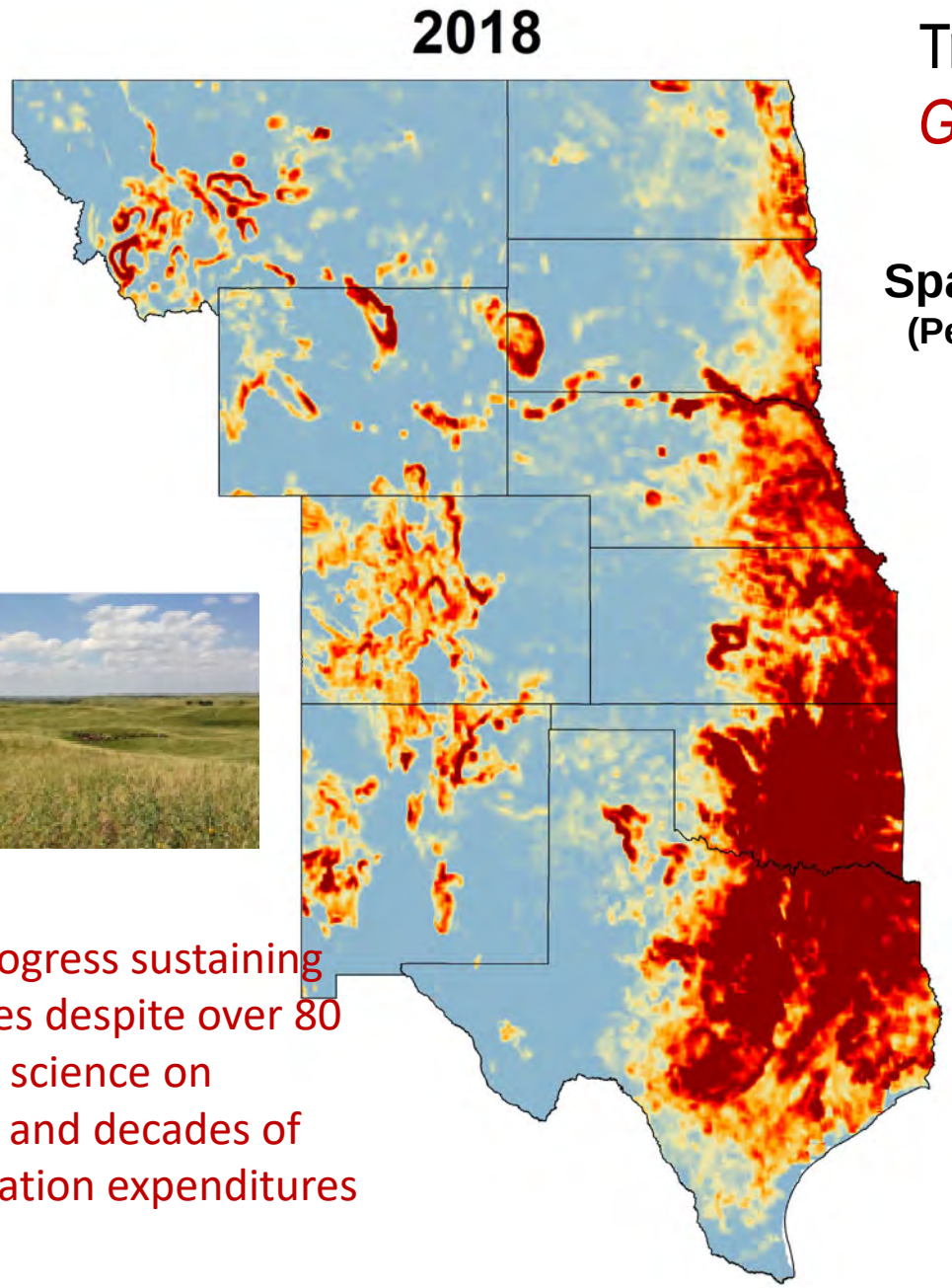
Tracking the collapse of a terrestrial biome

Grass-Tree boundary in 2000

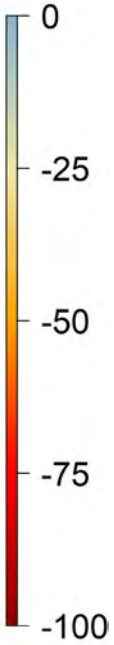


Tracking the collapse of a terrestrial biome

Grass-Tree boundary in 2018



Spatial covariance
(Perennials vs Trees)

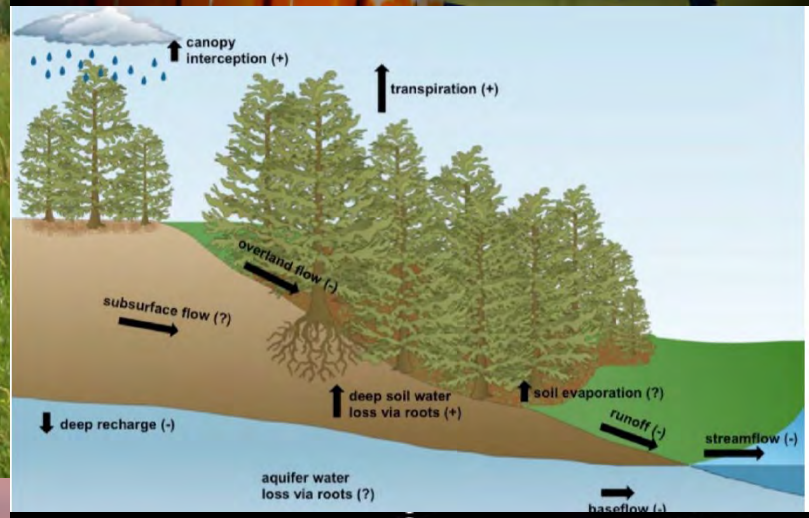


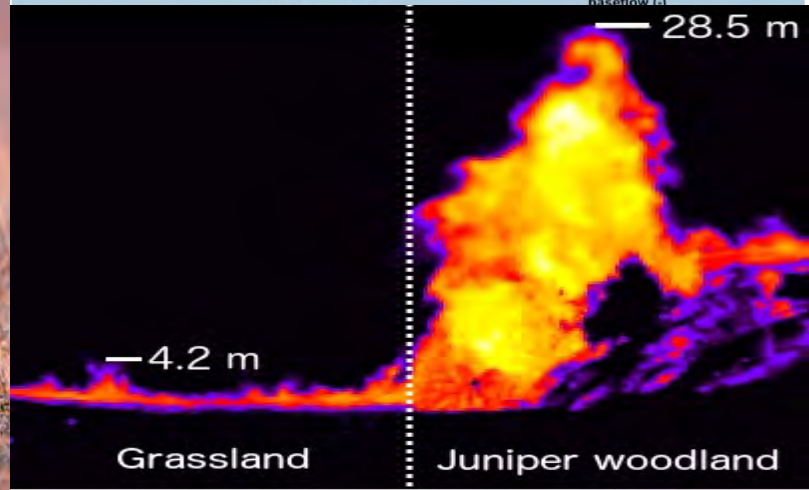
Little progress sustaining resources despite over 80 years of science on impacts and decades of conservation expenditures

$25 Million = mean annual conservation expenditures for brush management from 2004-2008 (NRCS CEAP)

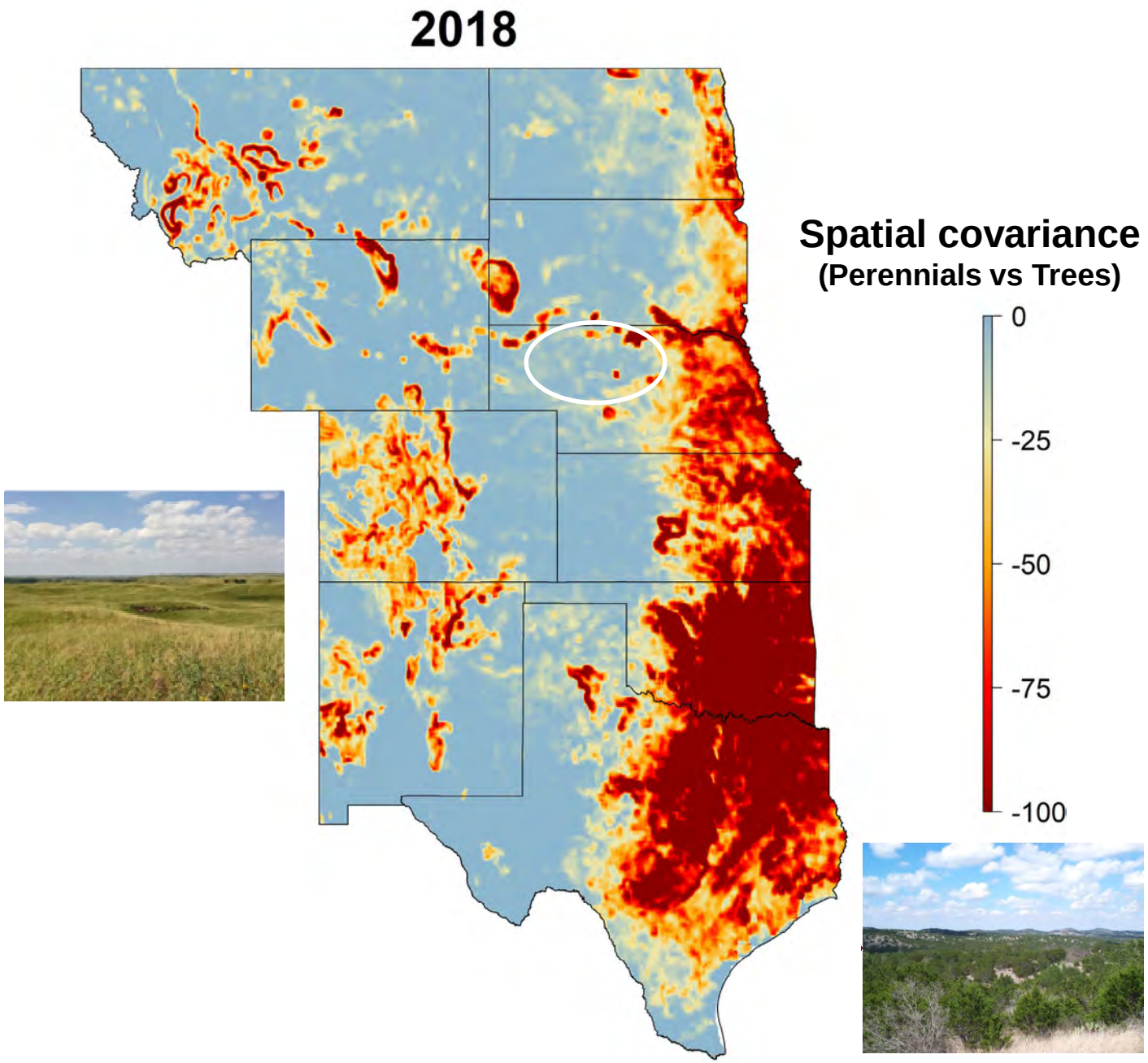
Southern Plains:	$164.5 M
Southern Mountain:	$59.6 M
Pacific:	$25.9 M
Northern Plains:	$12.5 M
Northern Mountain:	$8.5 M

Systems-level consequences: Rancher livelihoods, Wildfire danger, Human health, Water, Endangered species, School funding, Regulatory pressure





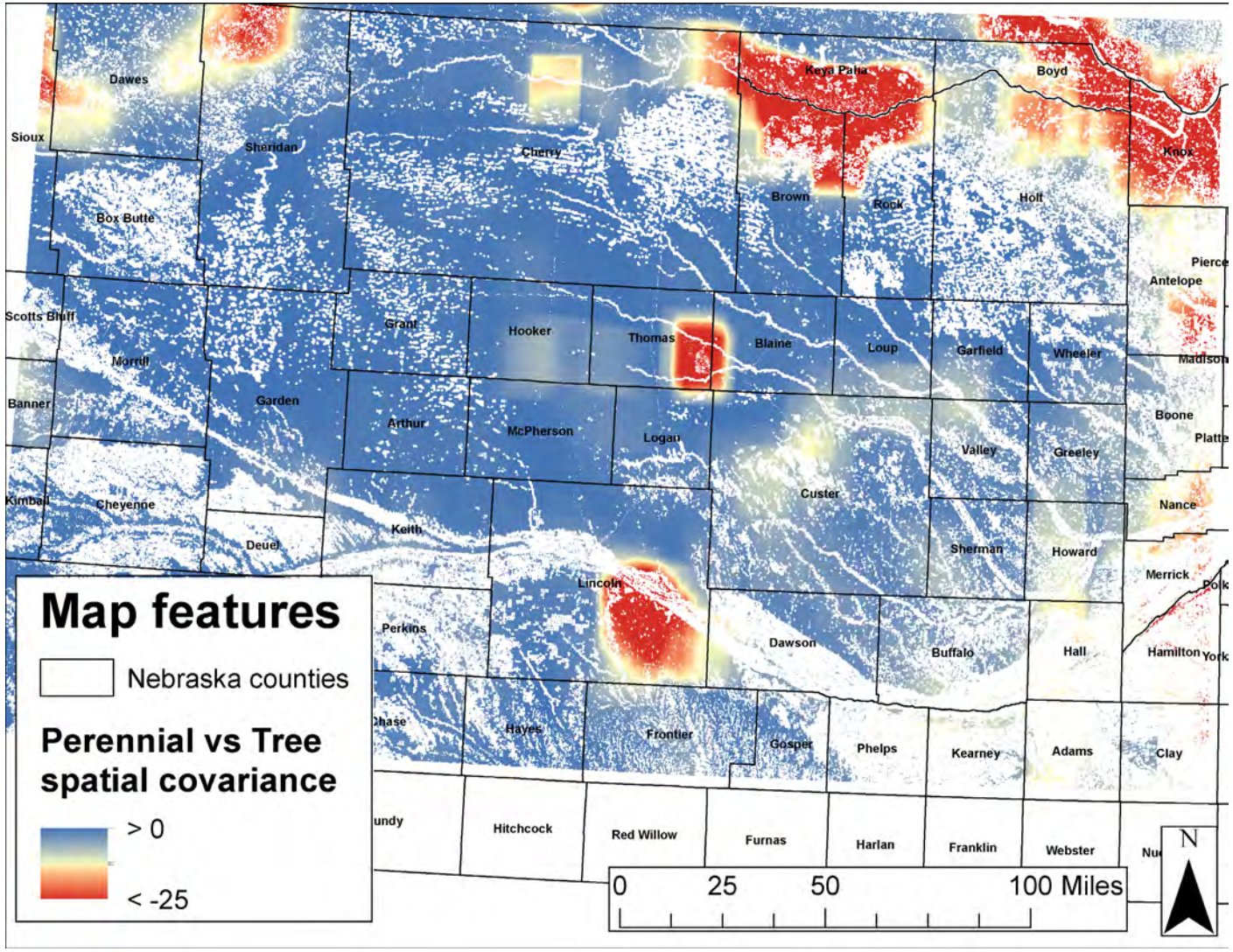
Screening for Woody Transitions for cross-scale resilience planning



Transitions in the “uninvadable” Sandhills

Grass-Tree transition boundary

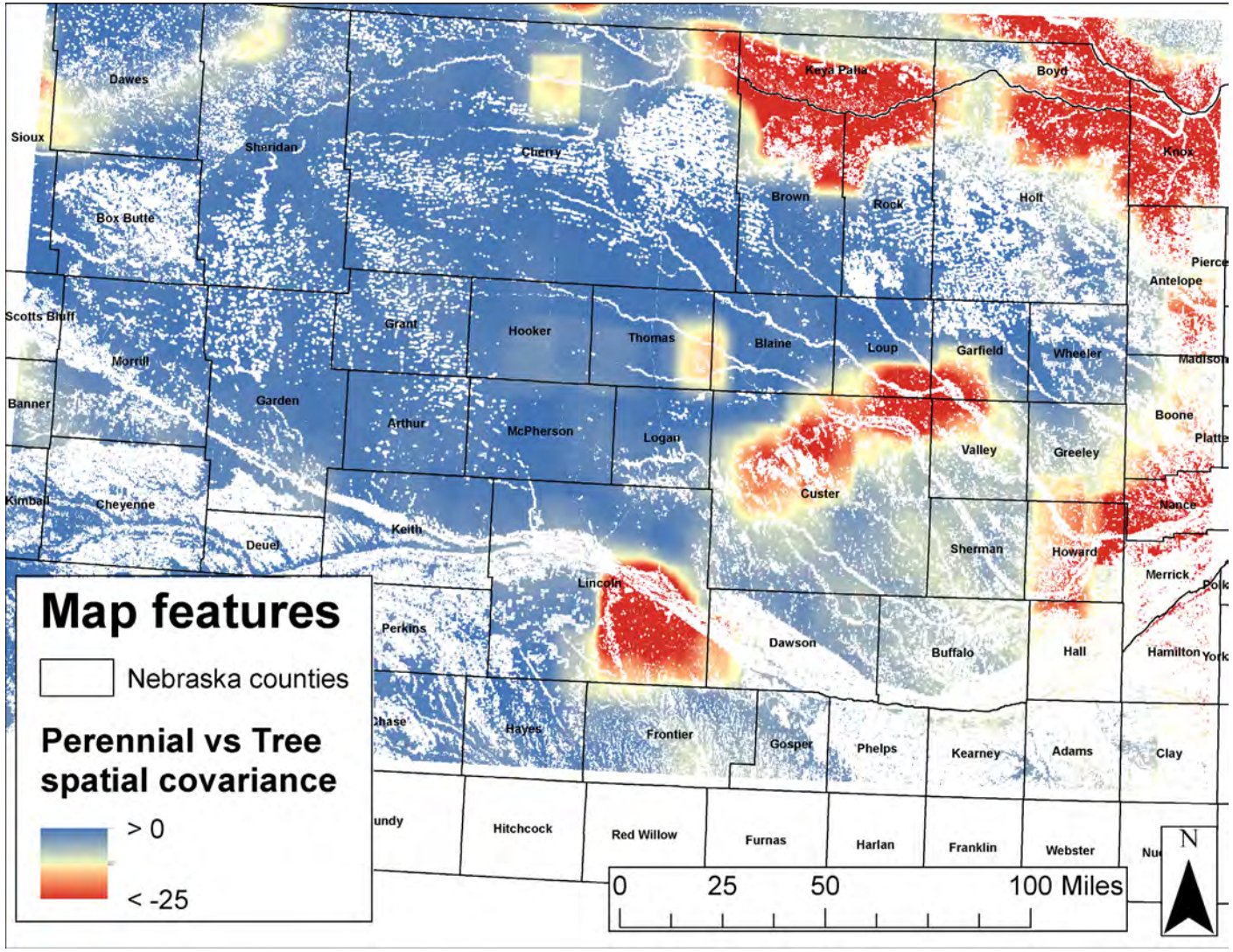
2002



Transitions in the “uninvadable” Sandhills

Grass-Tree transition boundary

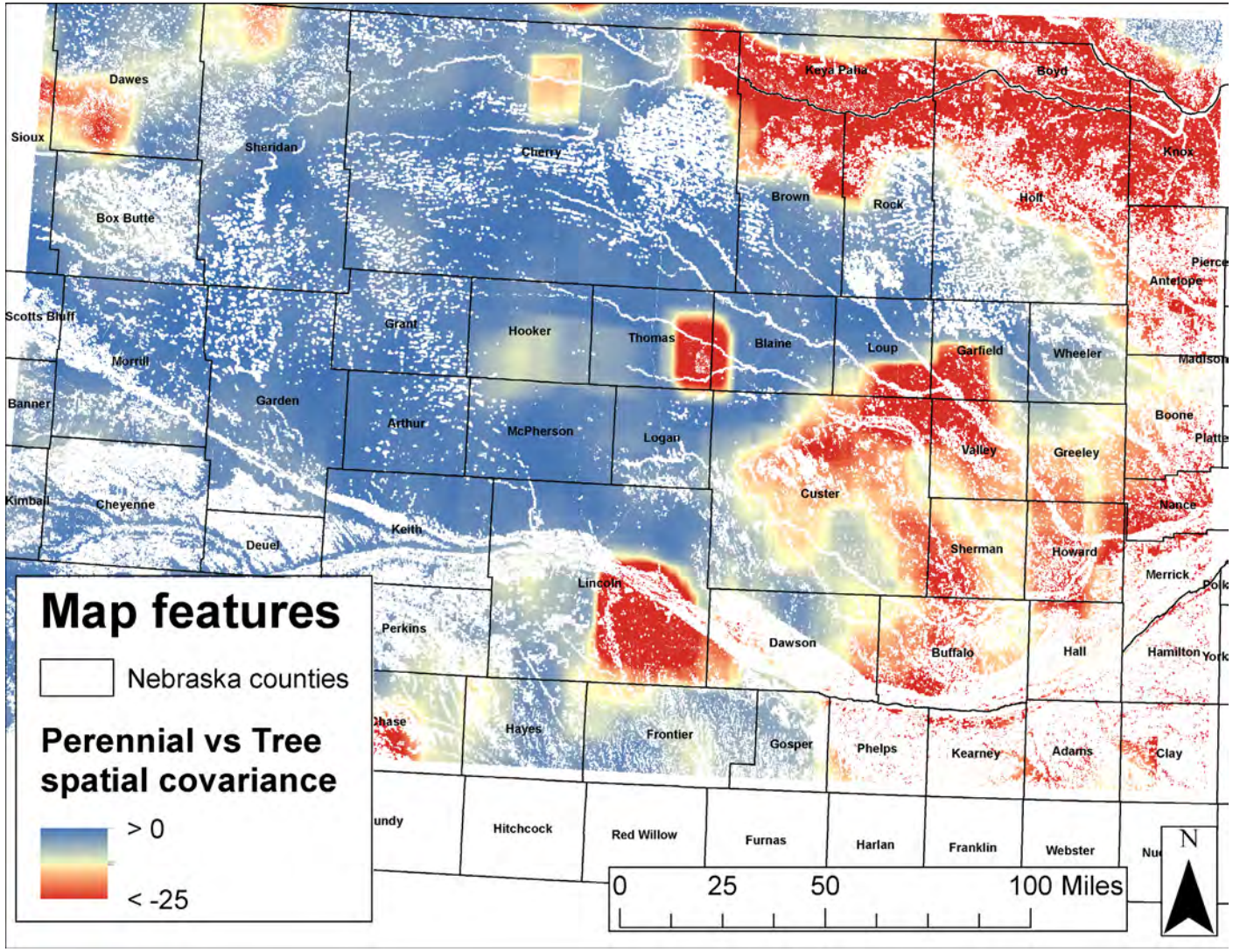
2007



Transitions in the “uninvadable” Sandhills

Grass-Tree transition boundary

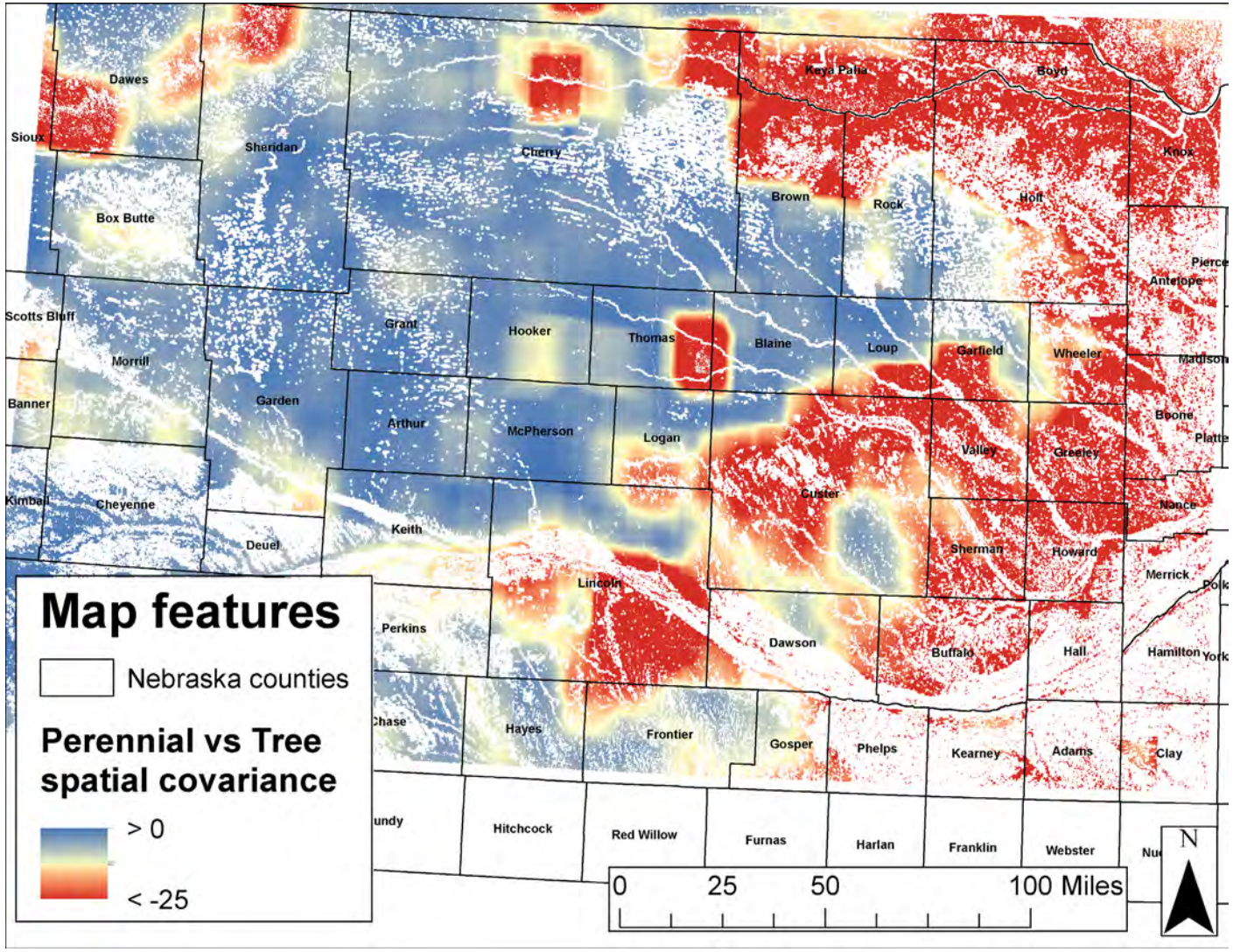
2012



Transitions in the “uninvadable” Sandhills

Grass-Tree transition boundary

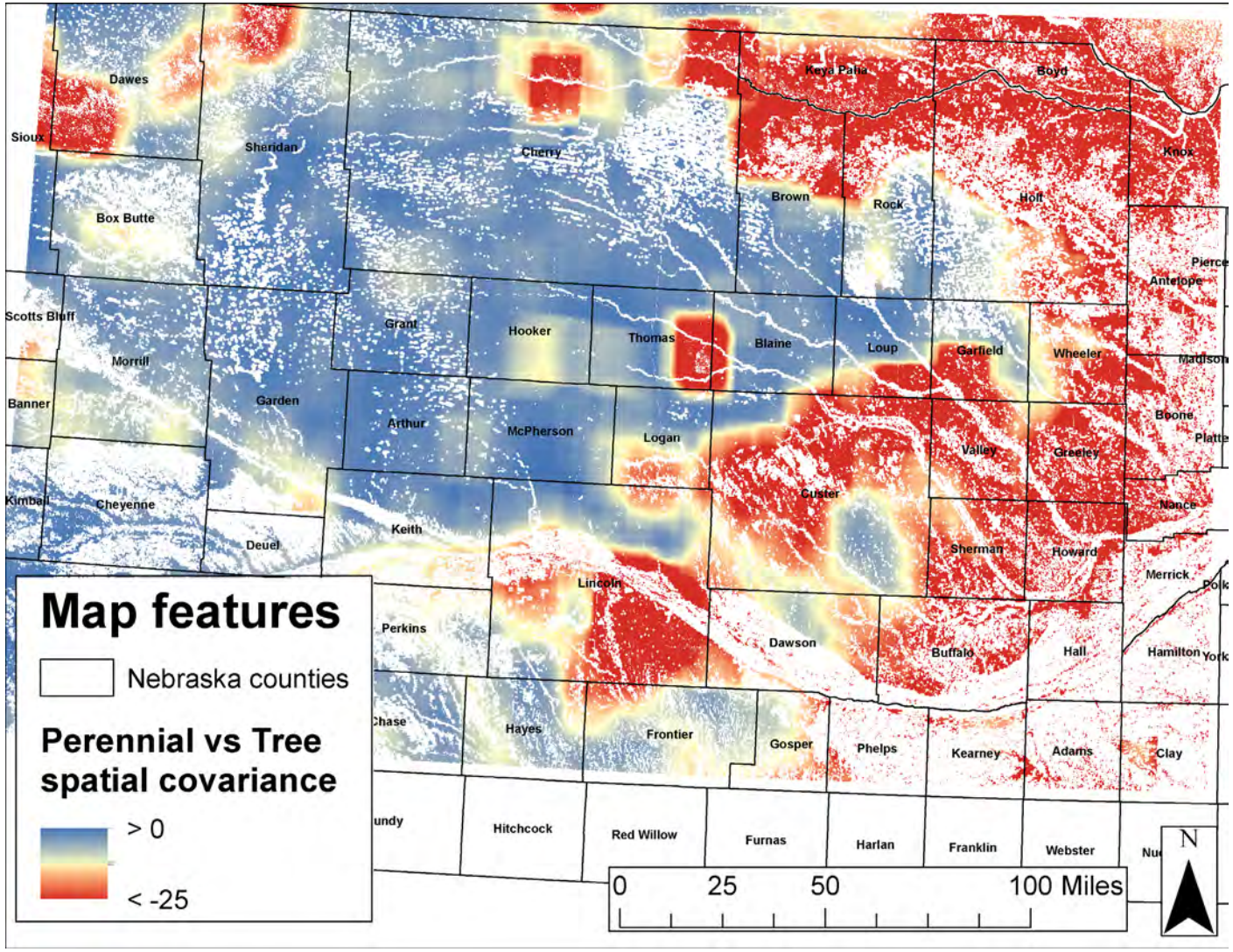
2017



Transitions in the “uninvadable” Sandhills

Grass-Tree transition boundary

2017

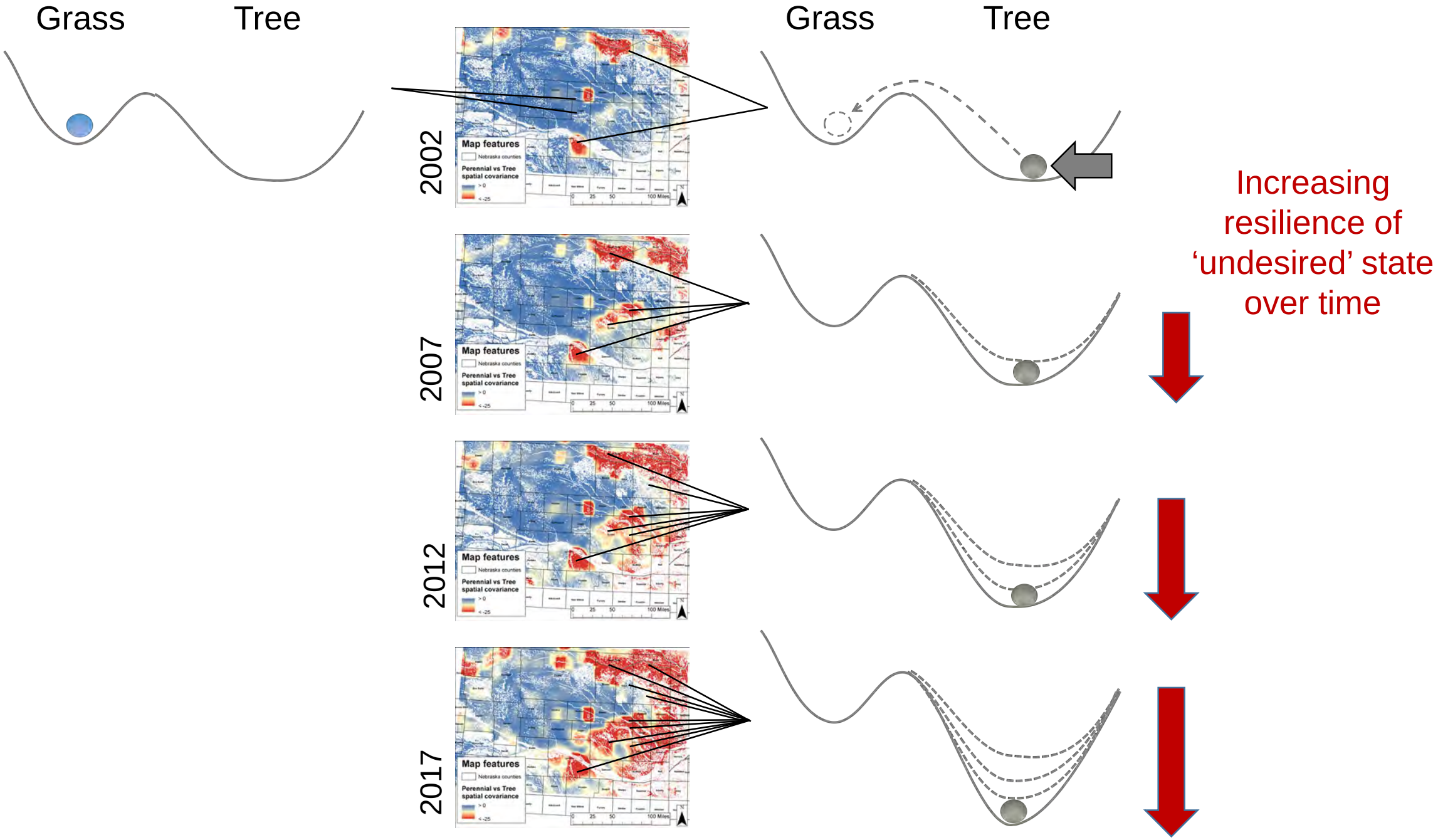


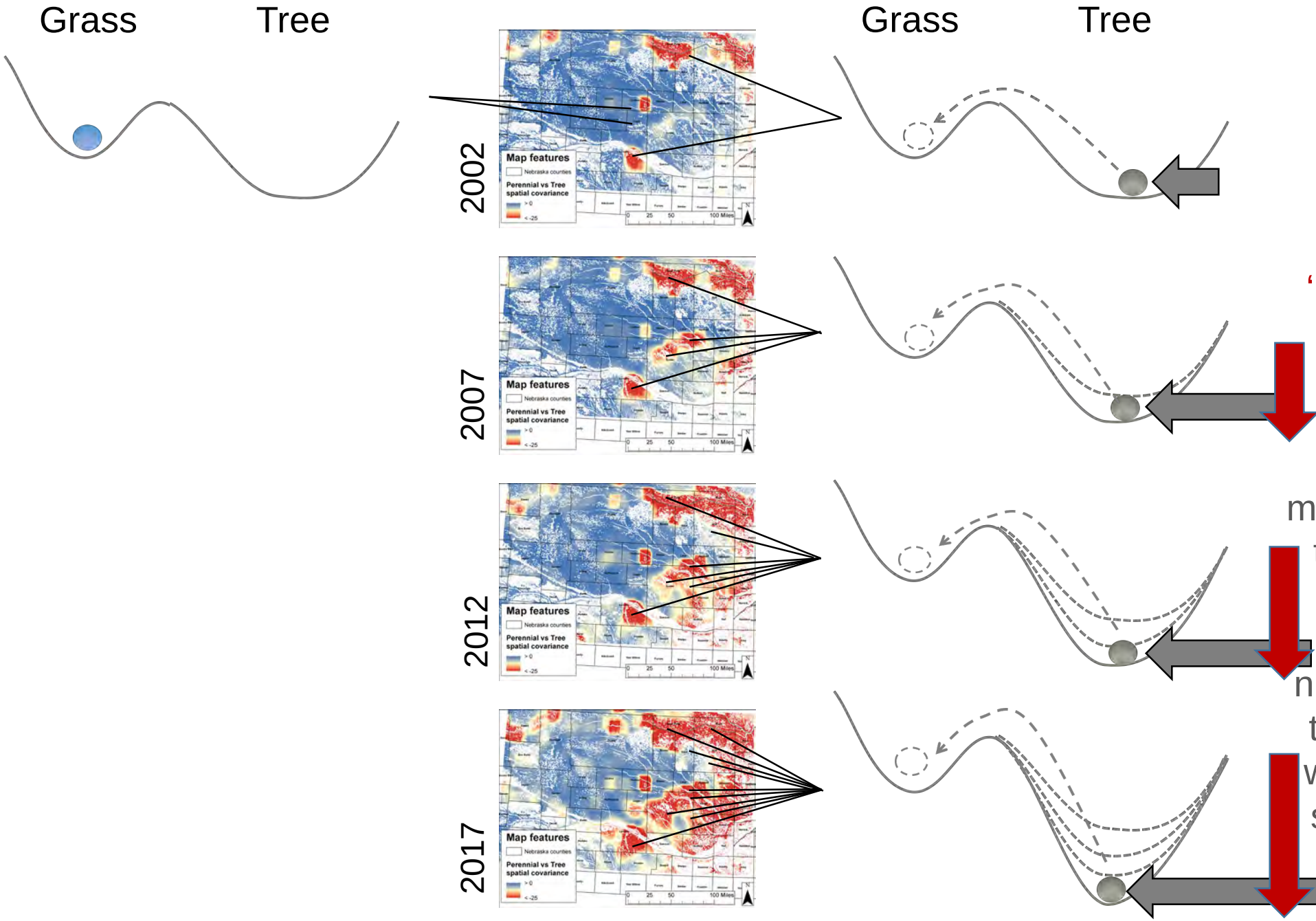
Why are we not focusing on conserving the “blue”?
Not identified as a “resource concern” so we prioritize *improvement* programs in a system that is collapsing

100% of state expenditures spent in locations within the regional transition zone of tree dominance (red)

Can we continue to justify this approach when the intact core (blue) of our rangelands are being compromised?

This approach is a central failure of the old range model, fails to understand pattern and process, and instead chases environmental problems


Grass
Tree
Grass
Tree
2002
2007
2012
2017
Map features
Nebraska counties
Perennial vs Tree spatial covariance
> 0
< -25
0 25 50 100 Miles
Increasing resilience of 'undesired' state over time

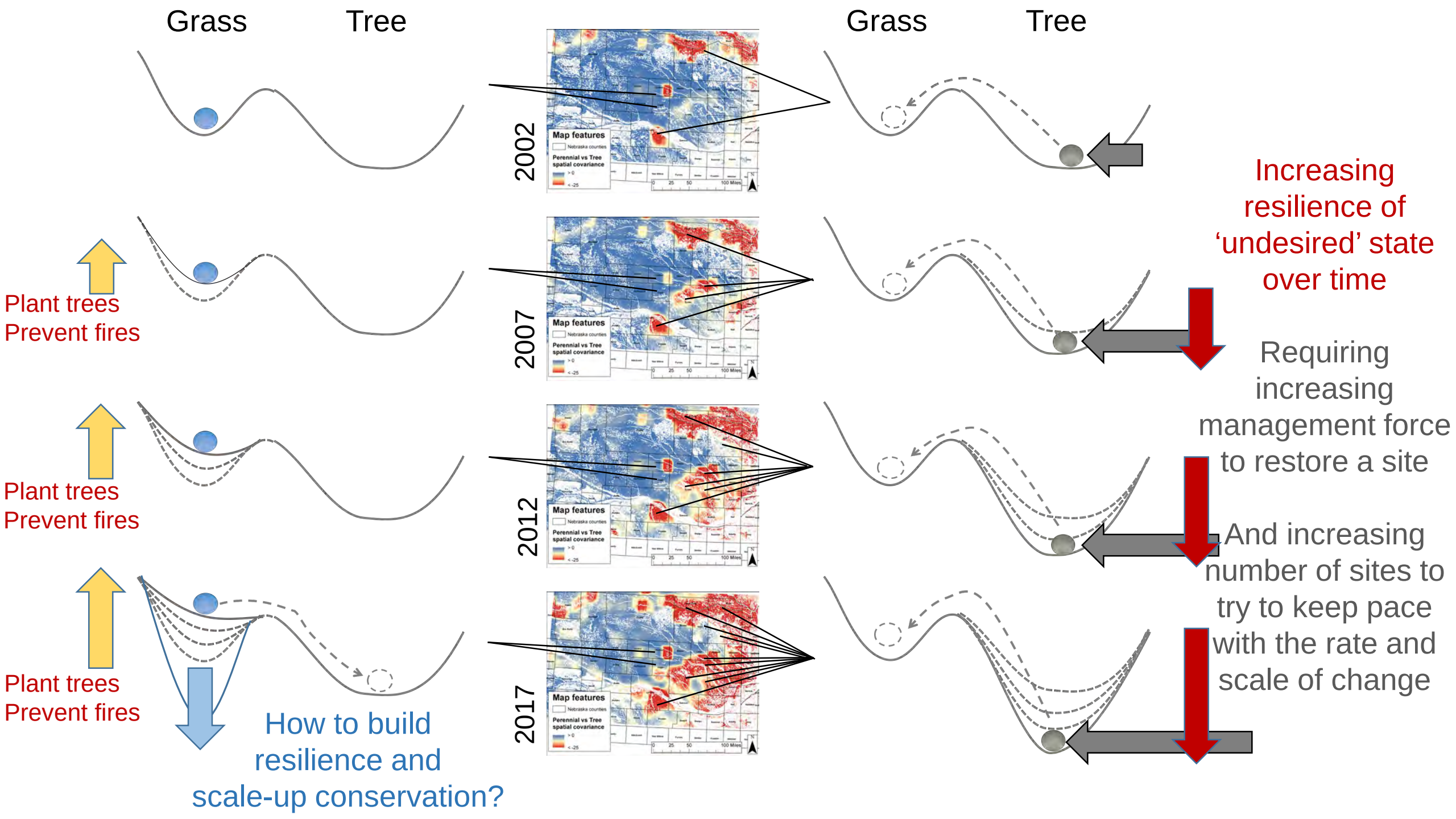


Increasing resilience of 'undesired' state over time

Requiring increasing management force to restore a site

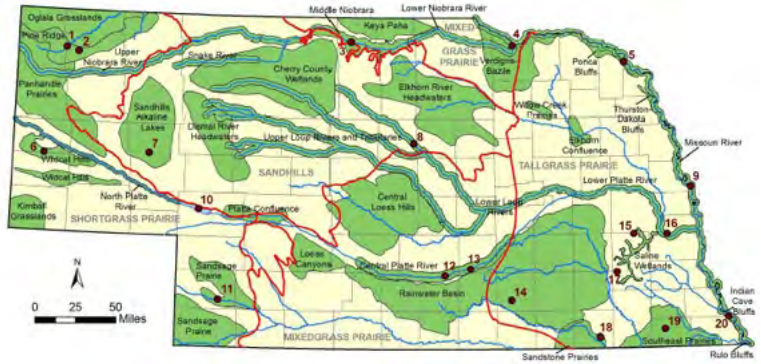
And increasing number of sites to try to keep pace with the rate and scale of change

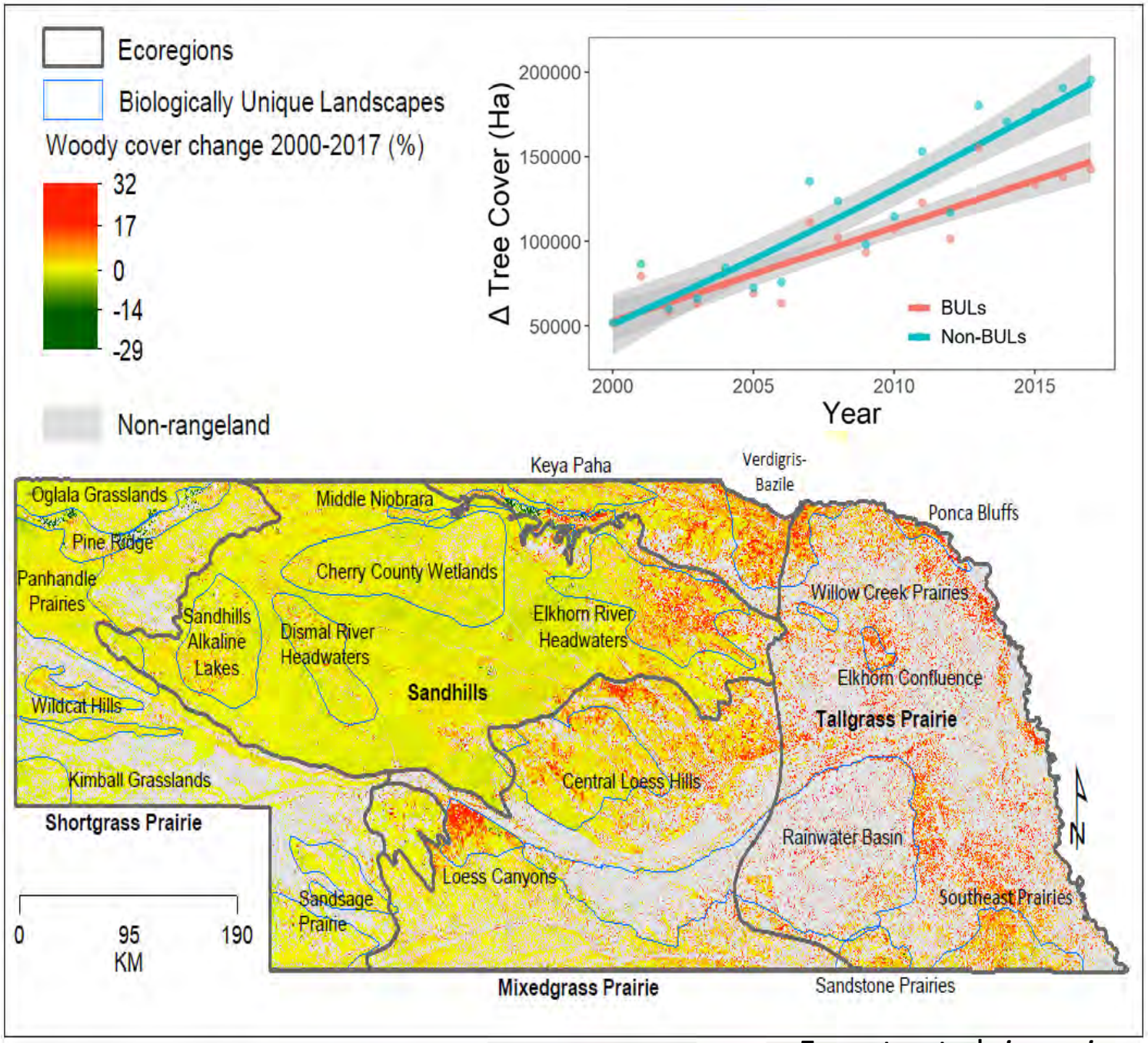
There are no examples of regional success with this tactic in the Great Plains


Grass
Tree
Grass
Tree
2002
2007
2012
2017
Map features
Nebraska counties
Perennial vs Tree spatial covariance
Plant trees
Prevent fires
Plant trees
Prevent fires
Plant trees
Prevent fires
How to build resilience and scale-up conservation?
Increasing resilience of 'undesired' state over time
Requiring increasing management force to restore a site
And increasing number of sites to try to keep pace with the rate and scale of change

Statewide evaluation of woody encroachment trends in Nebraska's Biologically Unique Landscapes

Nebraska Natural Legacy Project

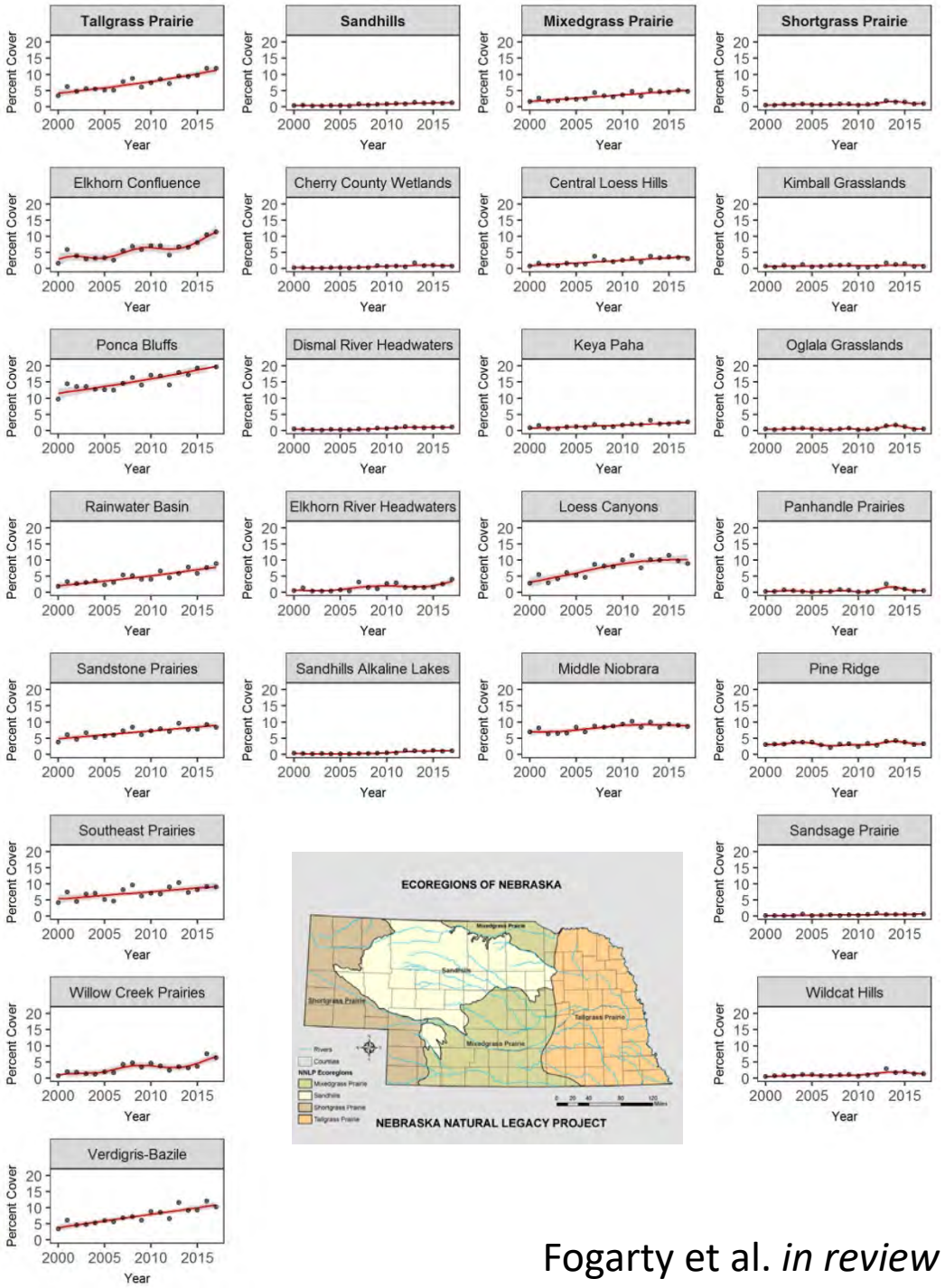




Fogarty et al. *in review*

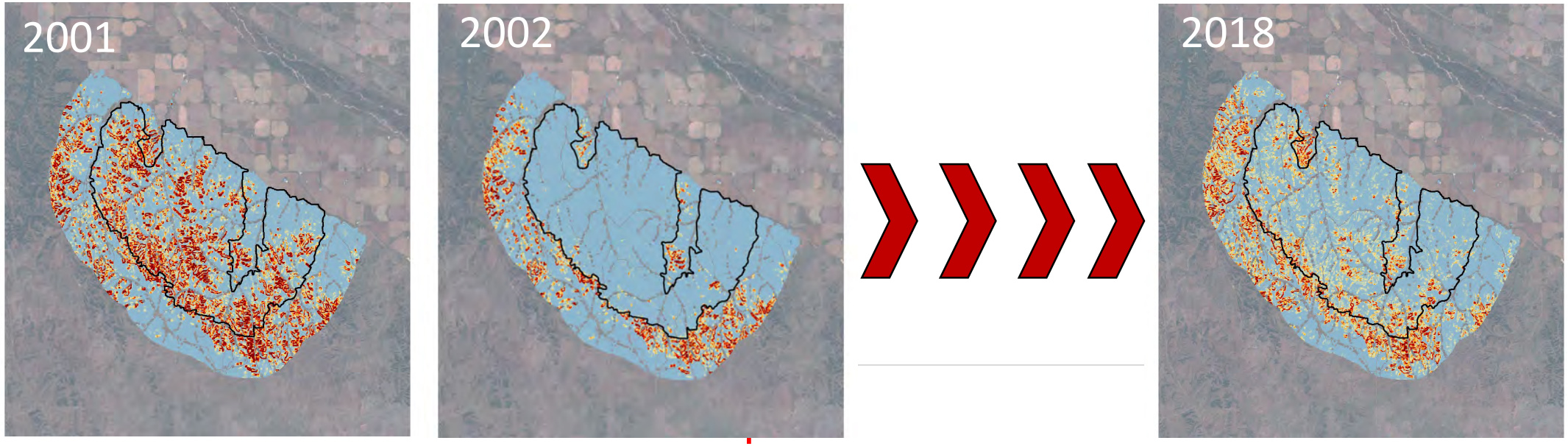
Summary of BUL Assessment (2000-2017)

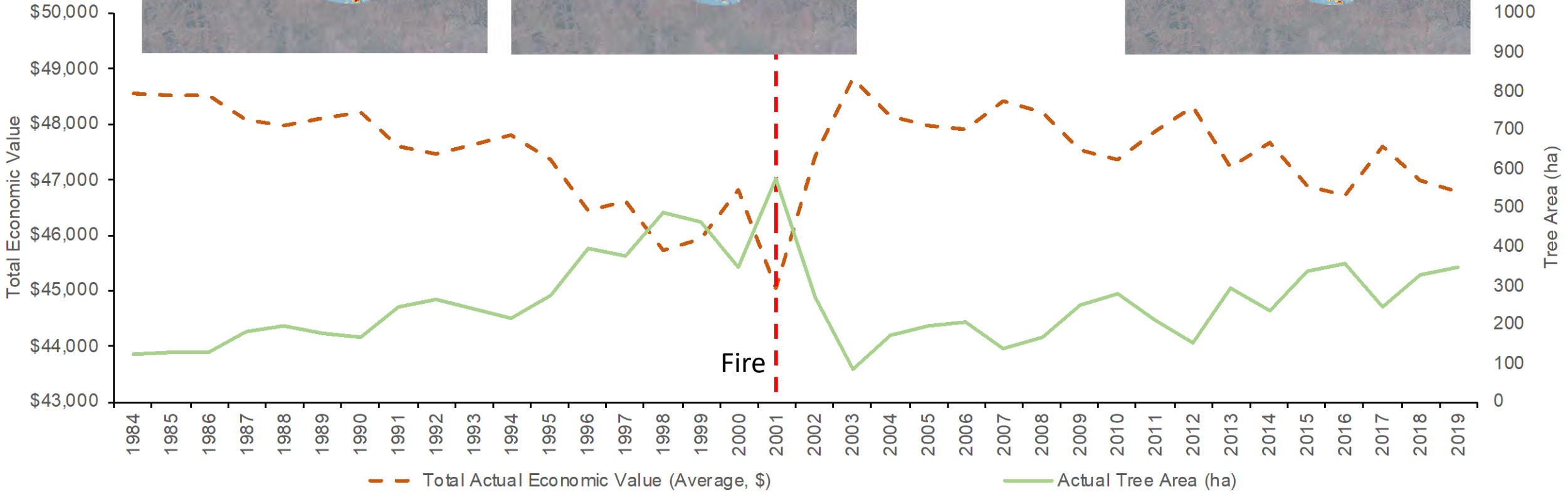
- All BULs in the tallgrass prairie zone are transitioning to tree dominance.
- All BULs in the mixedgrass prairie zone have increased in tree cover since 2000.
- All Sandhills BULs have increased in tree cover (at early stages of woody transitions).
- BULs in the shortgrass prairie zone are currently the most stable.
- No BUL showed declines in tree cover over past 2 decades.



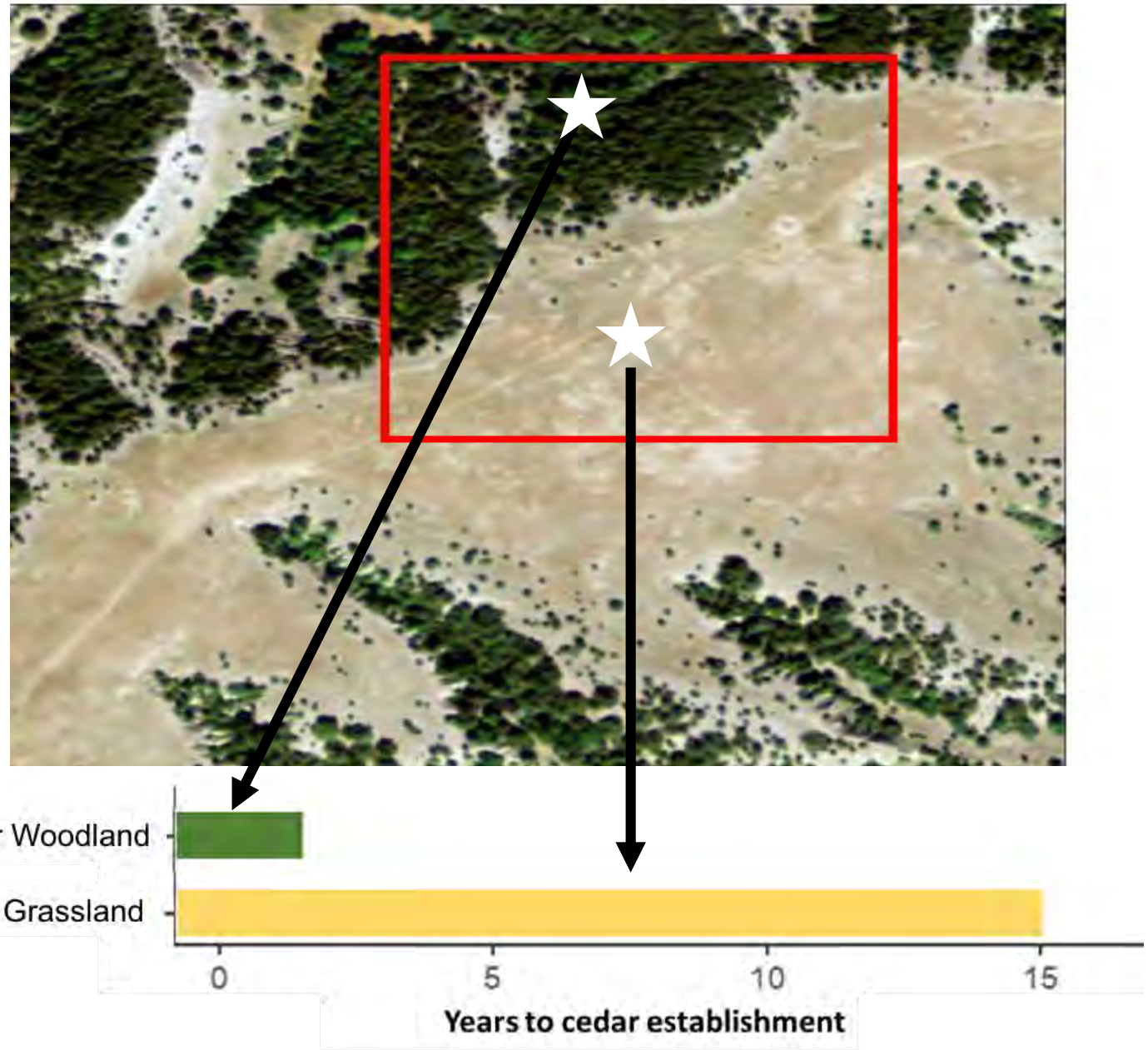
Fogarty et al. *in review*

Tracking economic impact of woody encroachment on grazing-based income



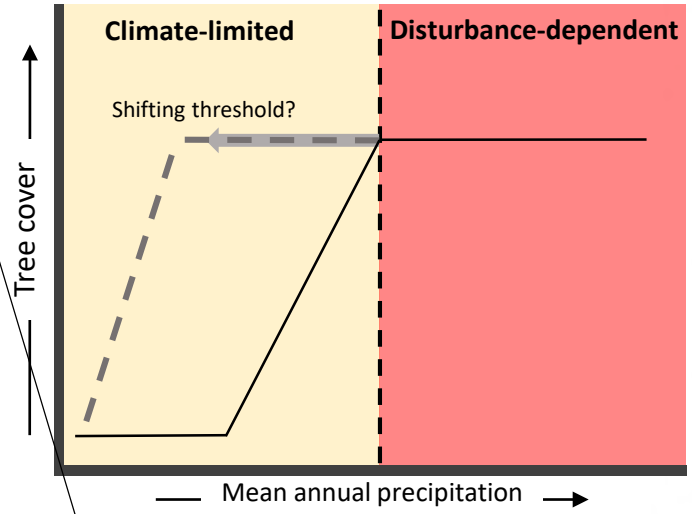


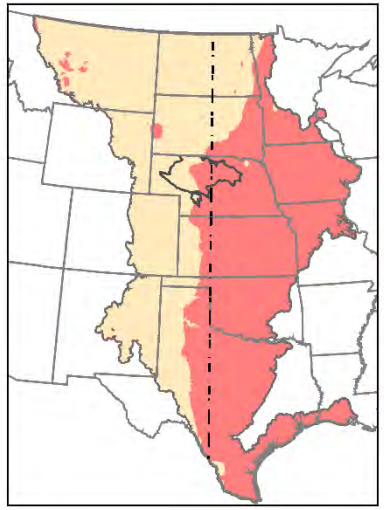
Waiting to respond <u>increases risk, shortens return on investments, and costs ranchers more money</u> than preventing establishment

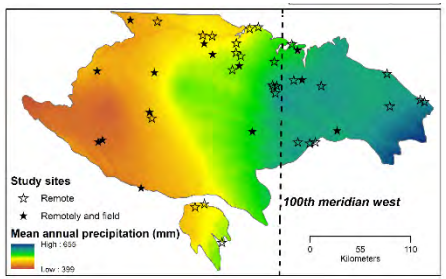


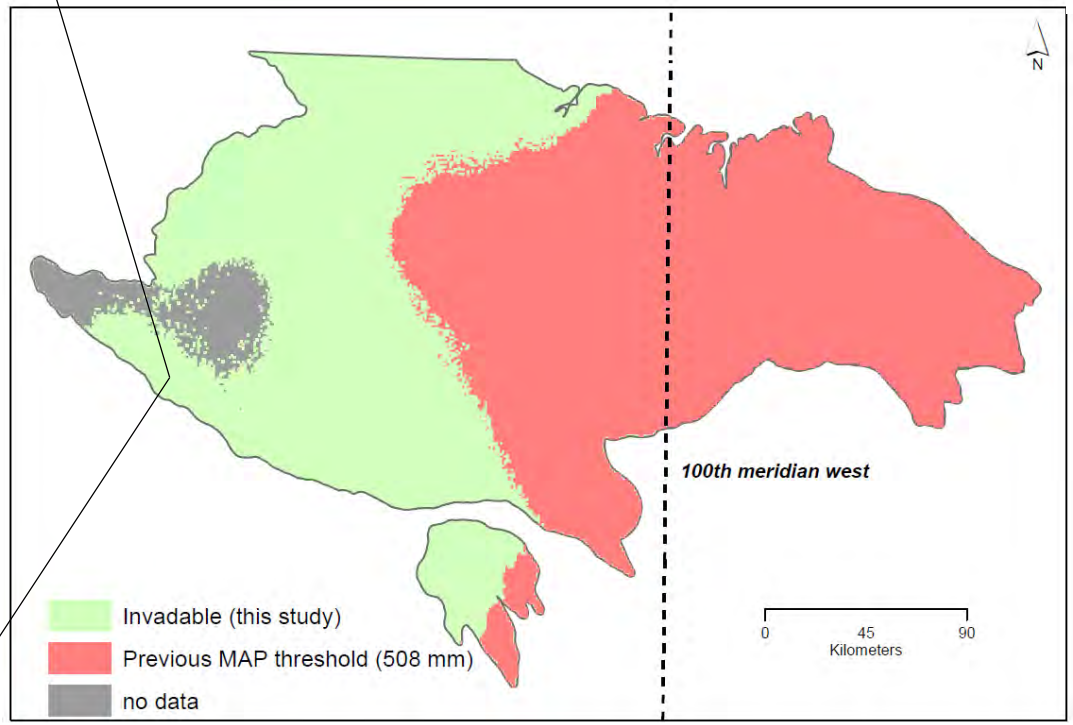
Denial about woody encroachment potential comes from 1890s – 1920s science.

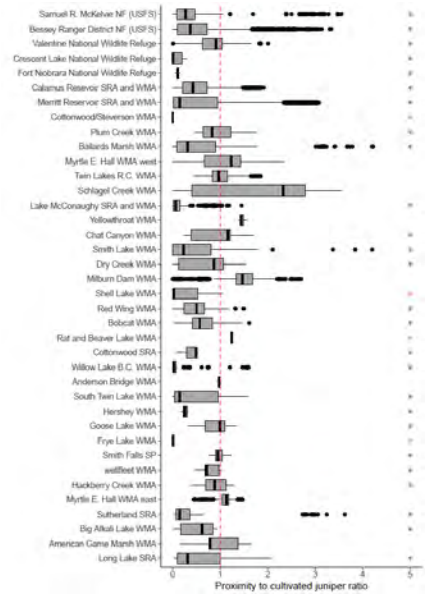
Eastern redcedar encroachment was observed across the western Sandhills where a seed source was present



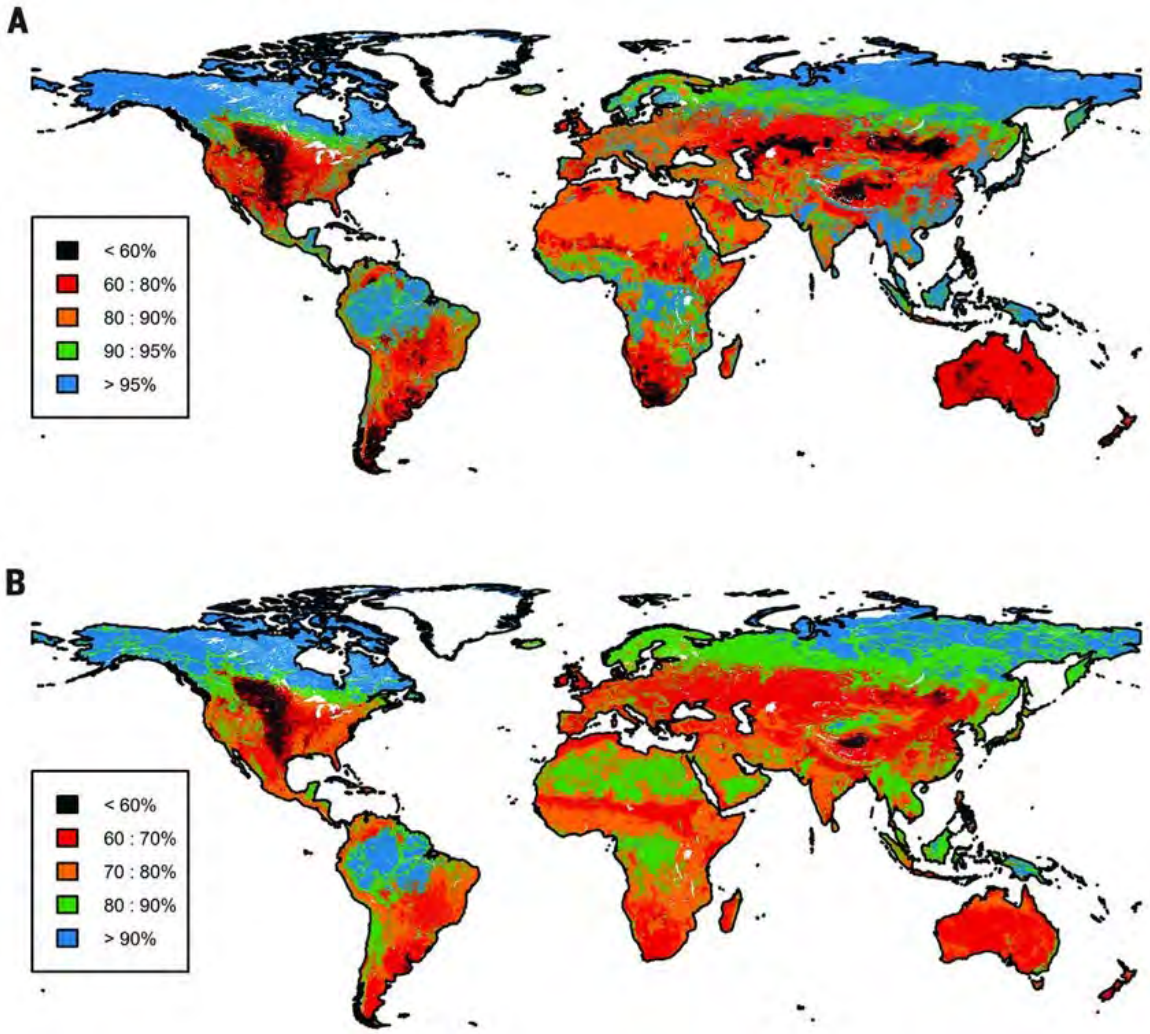






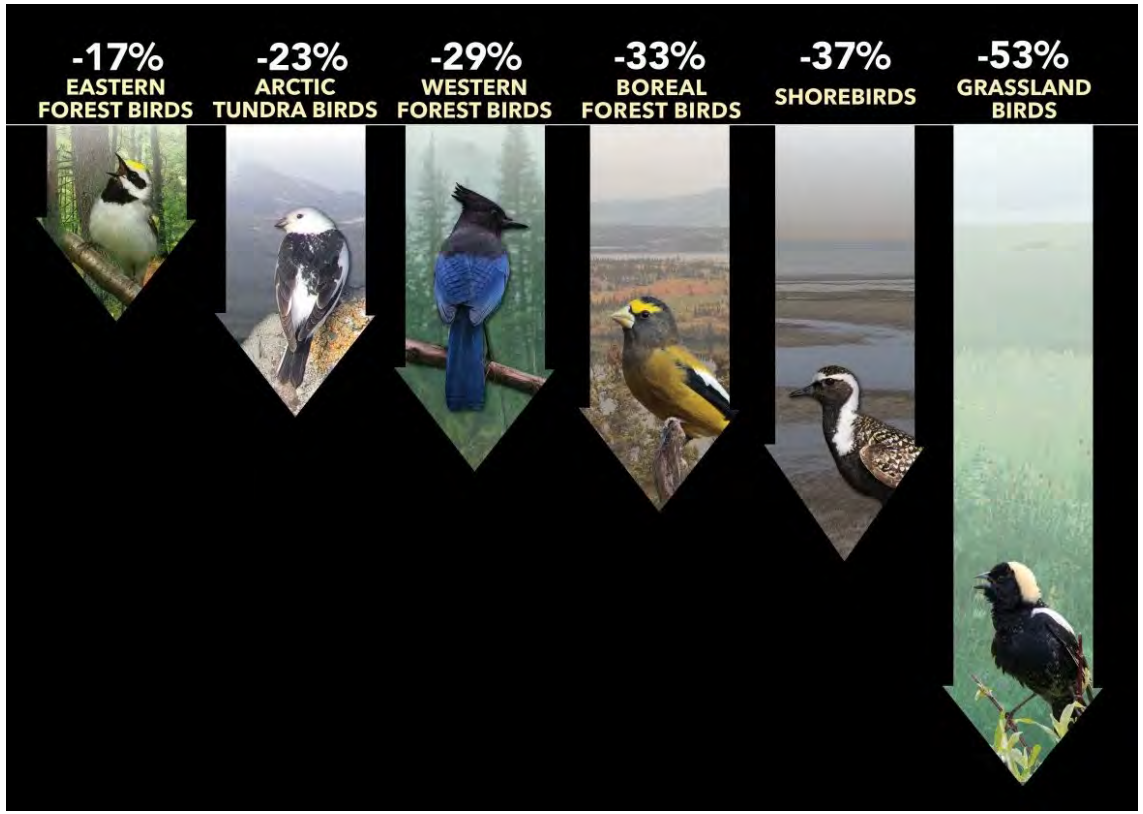


“Global grassland biodiversity crisis”



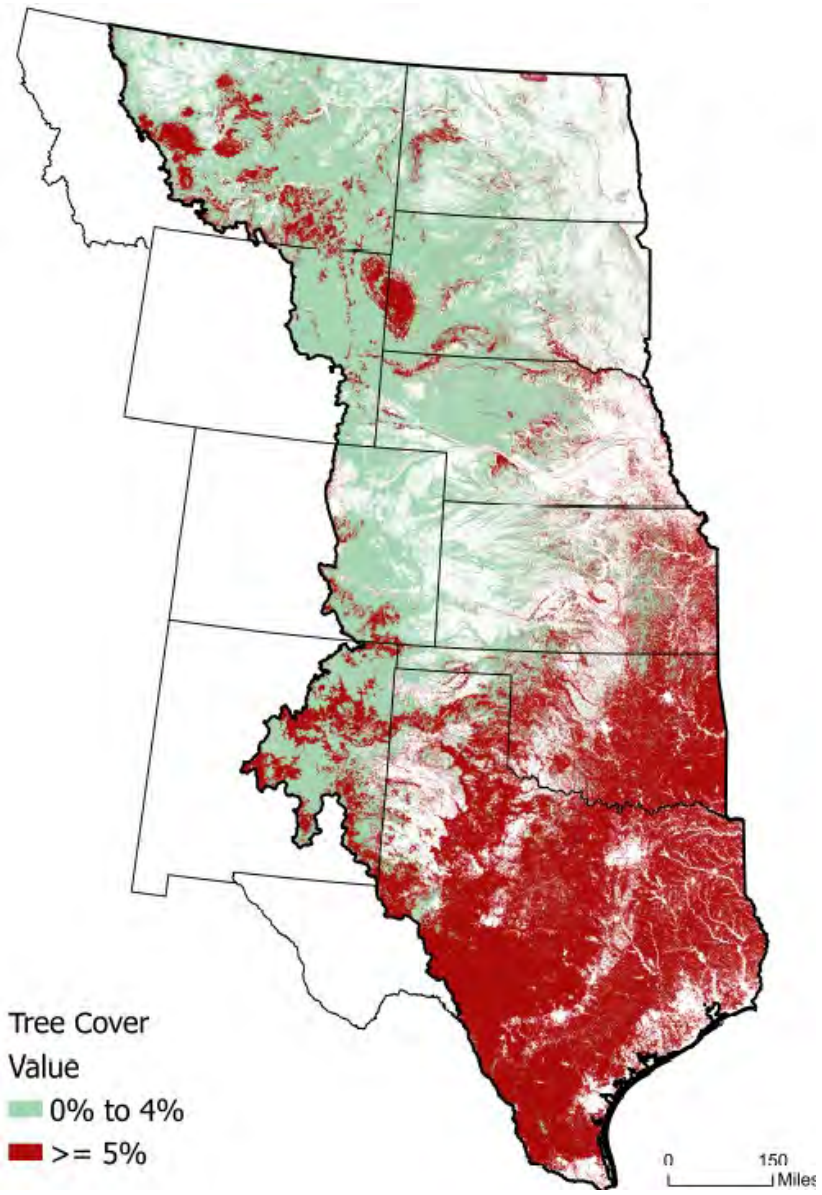
Total abundance (A) and biodiversity (B) of endemic species remaining in each biome

Newbold *et al.* 2016 Science



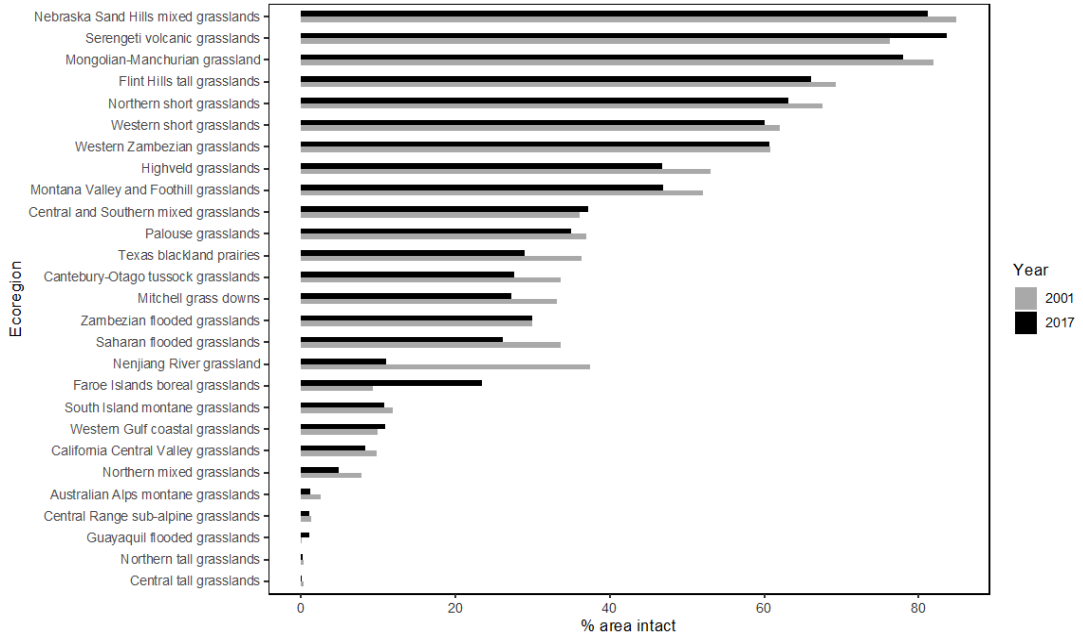
Rosenburg *et al.* 2019 Science

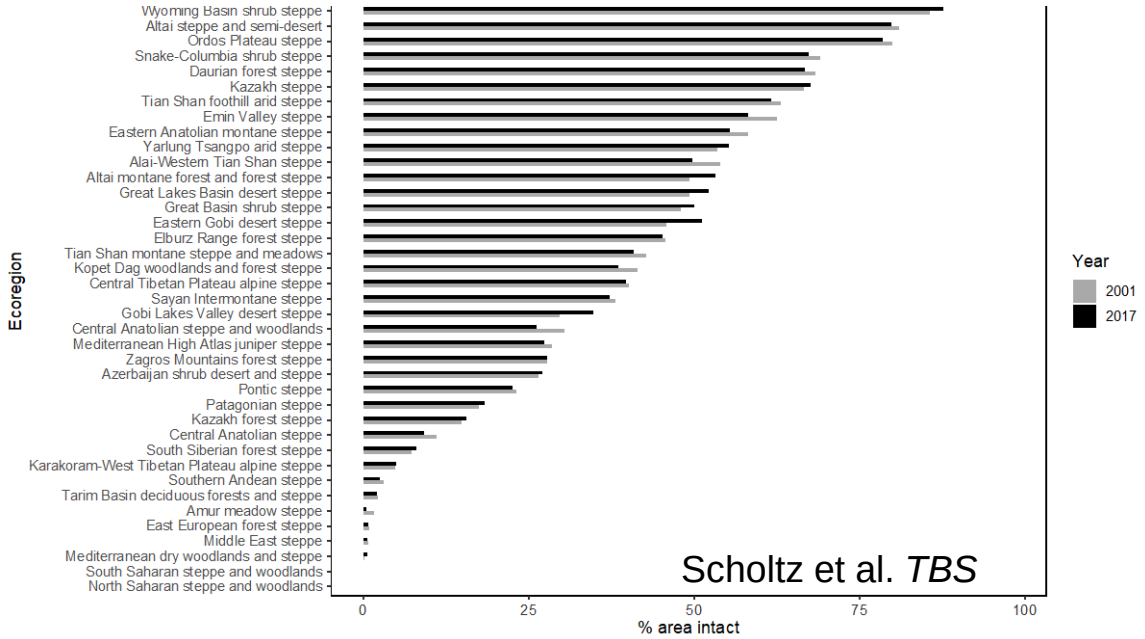
The Last Grasslands



(RAP tree cover <5%; 480-m aggregate)

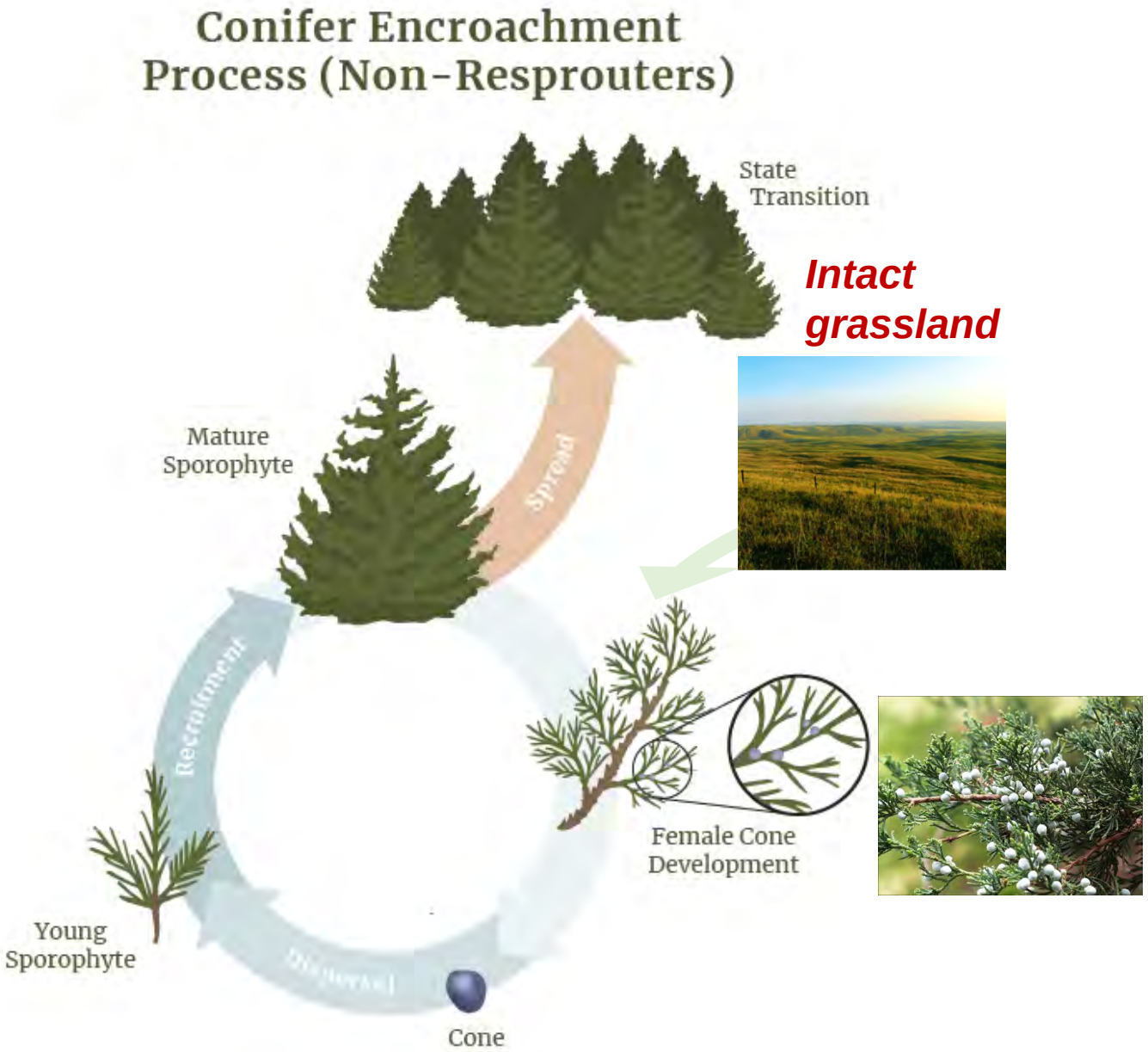
Nebraska still has some of the **most intact** grasslands remaining in the world (2000 – 2017).





Scholtz et al. *TBS*

More Effective Management: Manage the Invasion Process (Earlier)



	WPE Pathway	Description	Management philosophy
New Proactive Focus	Intact	Treeless grassland with no incoming seed	*Good Ole' Days*
	Dispersal phase	Treeless grassland compromised by incoming seed	*High Maintenance, Boundary Management*
	Recruitment phase	Early-successional brush; immature seedlings present	*Early Detection, Rapid Response*
Reactive Focus	Encroachment phase	Spread by mature reproducing plants (management trap)	*Game of Risk*
	State transition	State transition to woody dominance	*Restore, Transform, or Opportunistic*

MYTH of Restoration

Restoration treatment

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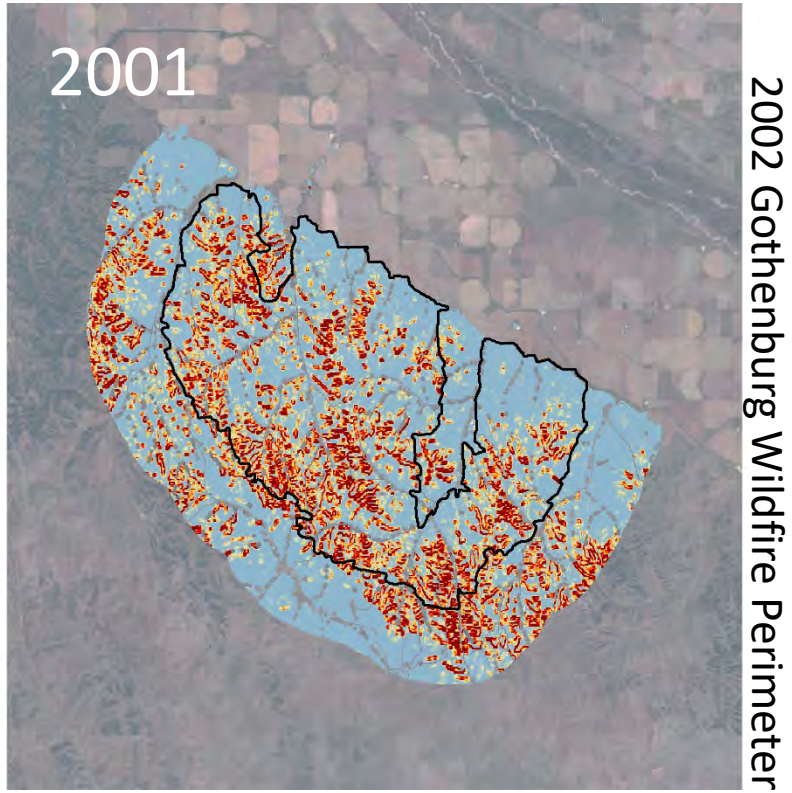
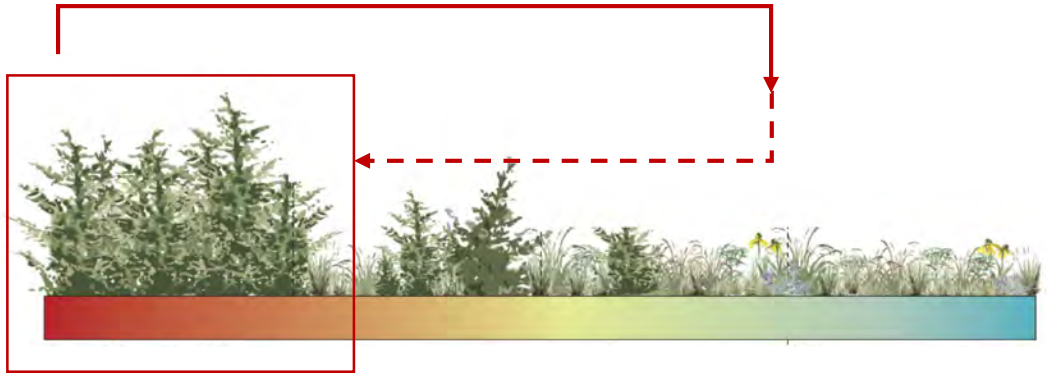
Reality of a Single Restoration



Restoration treatment



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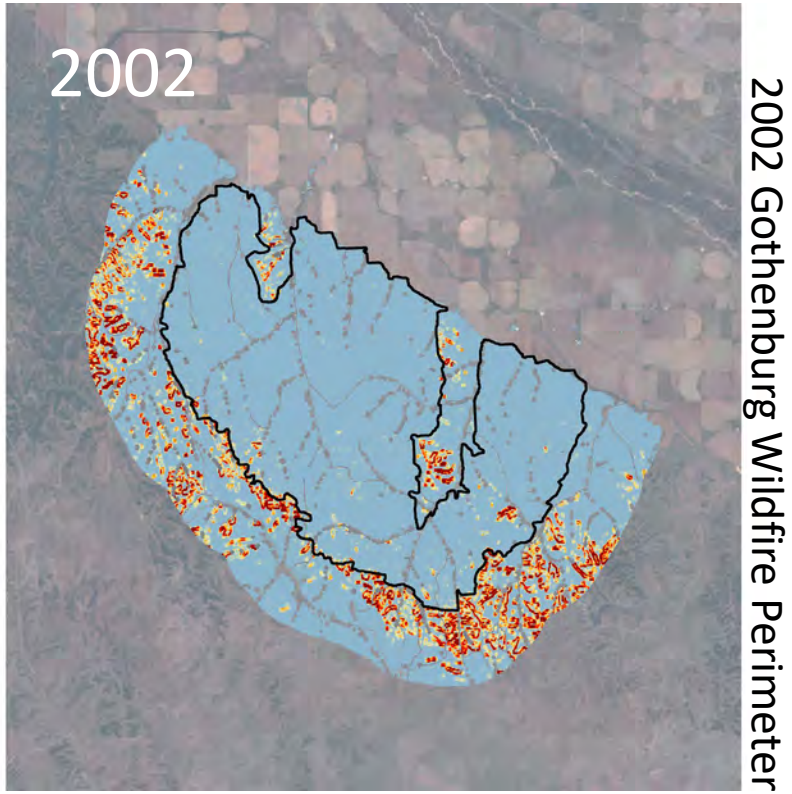
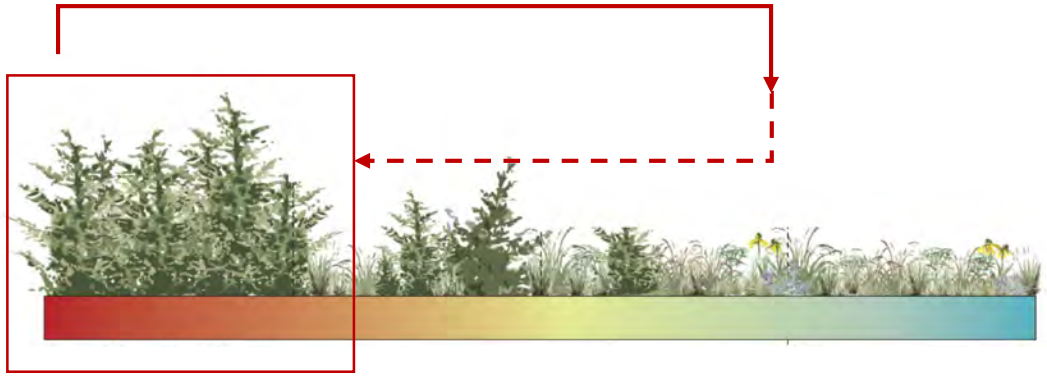


Restoration treatment



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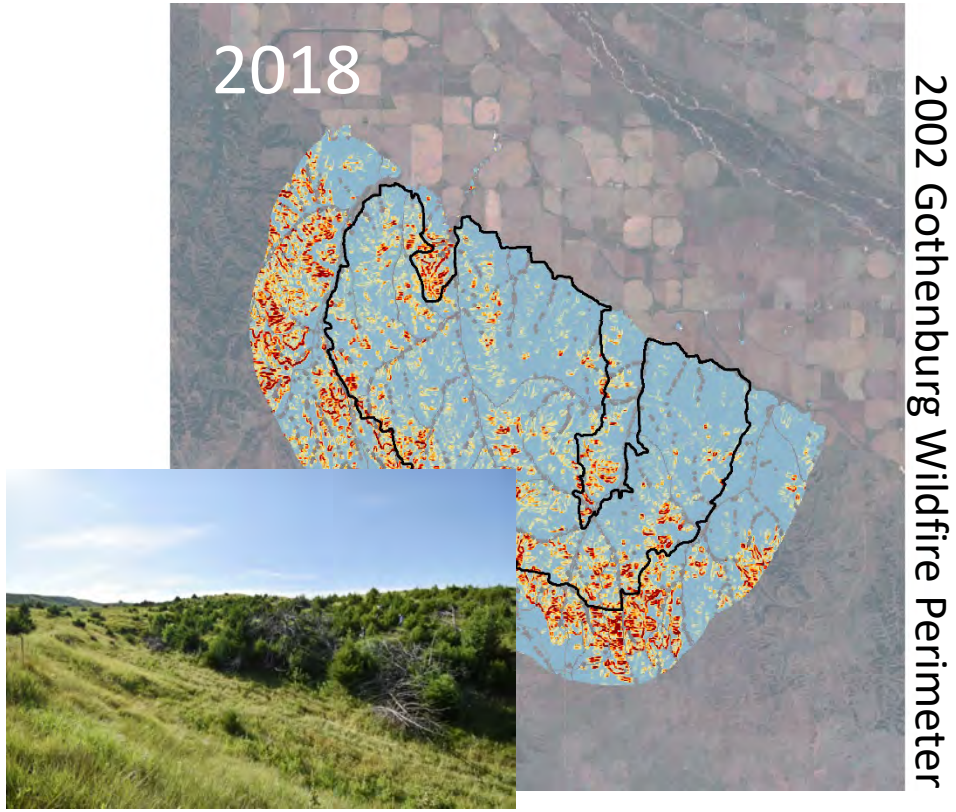
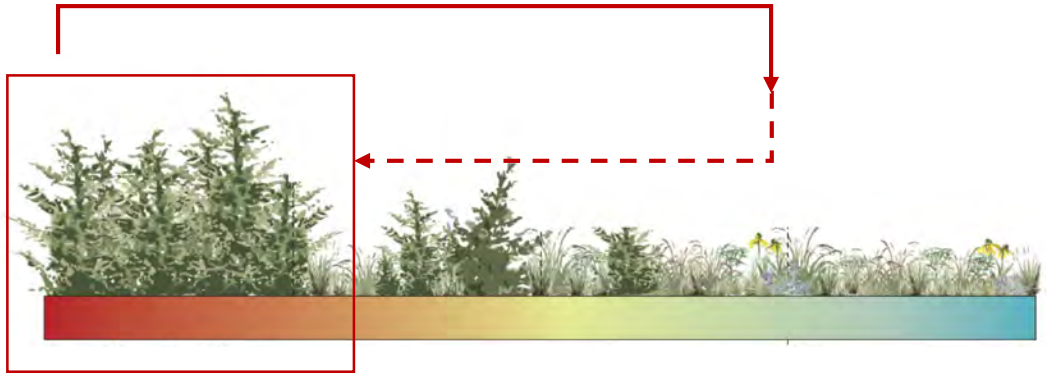


Restoration treatment



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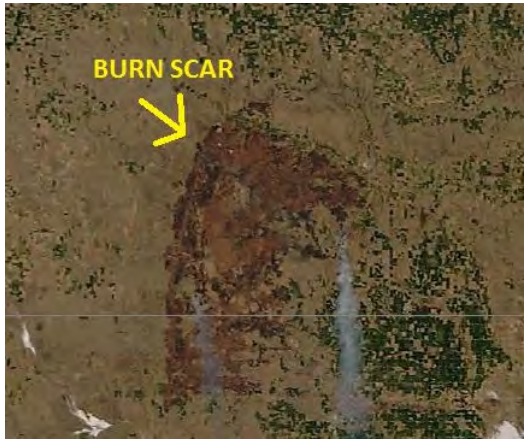
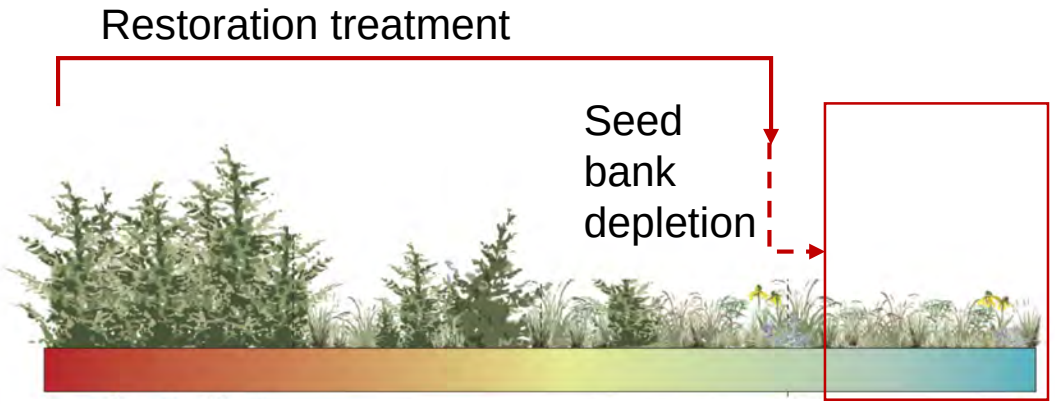
Rehabilitating Rangelands

(multiple interventions needed)

Burley, ID Wildfire (2020)



2016 Anderson Creek KS/OK Wildfire



	WPE Pathway	Description	Management philosophy
Seed bank depletion	Intact	Treeless grassland with no incoming seed	*Good Ole' Days*
	Dispersal phase	Treeless grassland compromised by incoming seed	*High Maintenance, Boundary Management*
	Recruitment phase	Early-successional brush; immature seedlings present	*Early Detection, Rapid Response*
	Encroachment phase	Spread by mature reproducing plants (management trap)	*Game of Risk*
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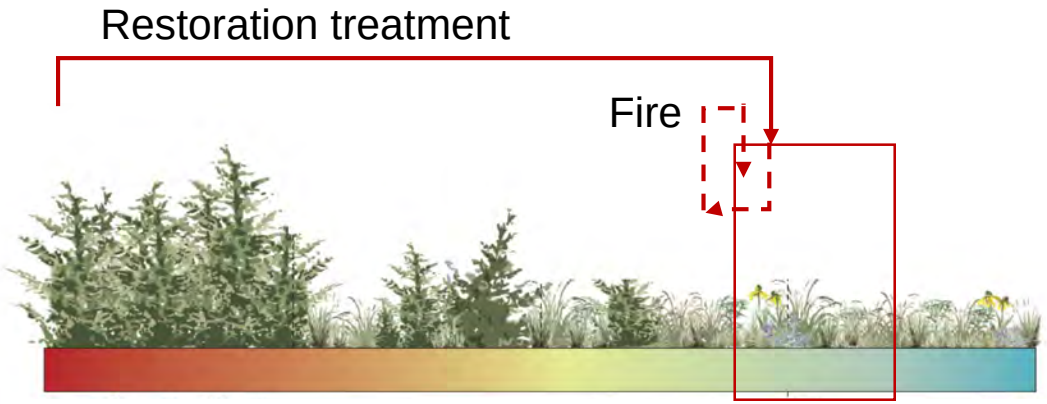
Rehabilitating Rangelands

(multiple interventions needed)

**Only fire keeps conifers in the dispersal trap by consuming cones*



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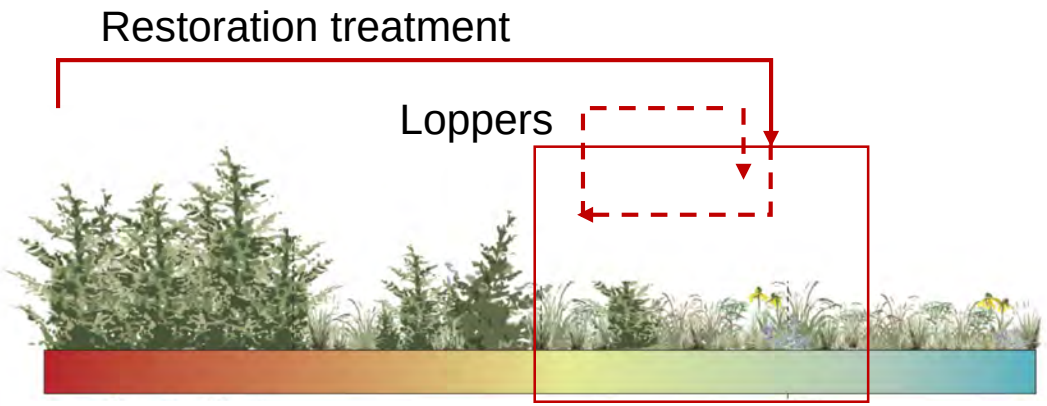
Rehabilitating Rangelands

(multiple interventions needed)



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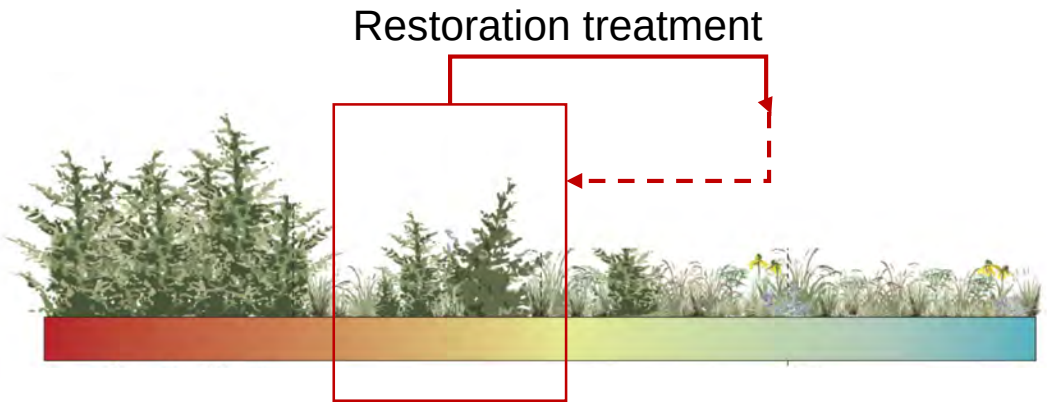
Containment: A Game of Risk



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The Easy Way

WPE Pathway	Description	Management philosophy
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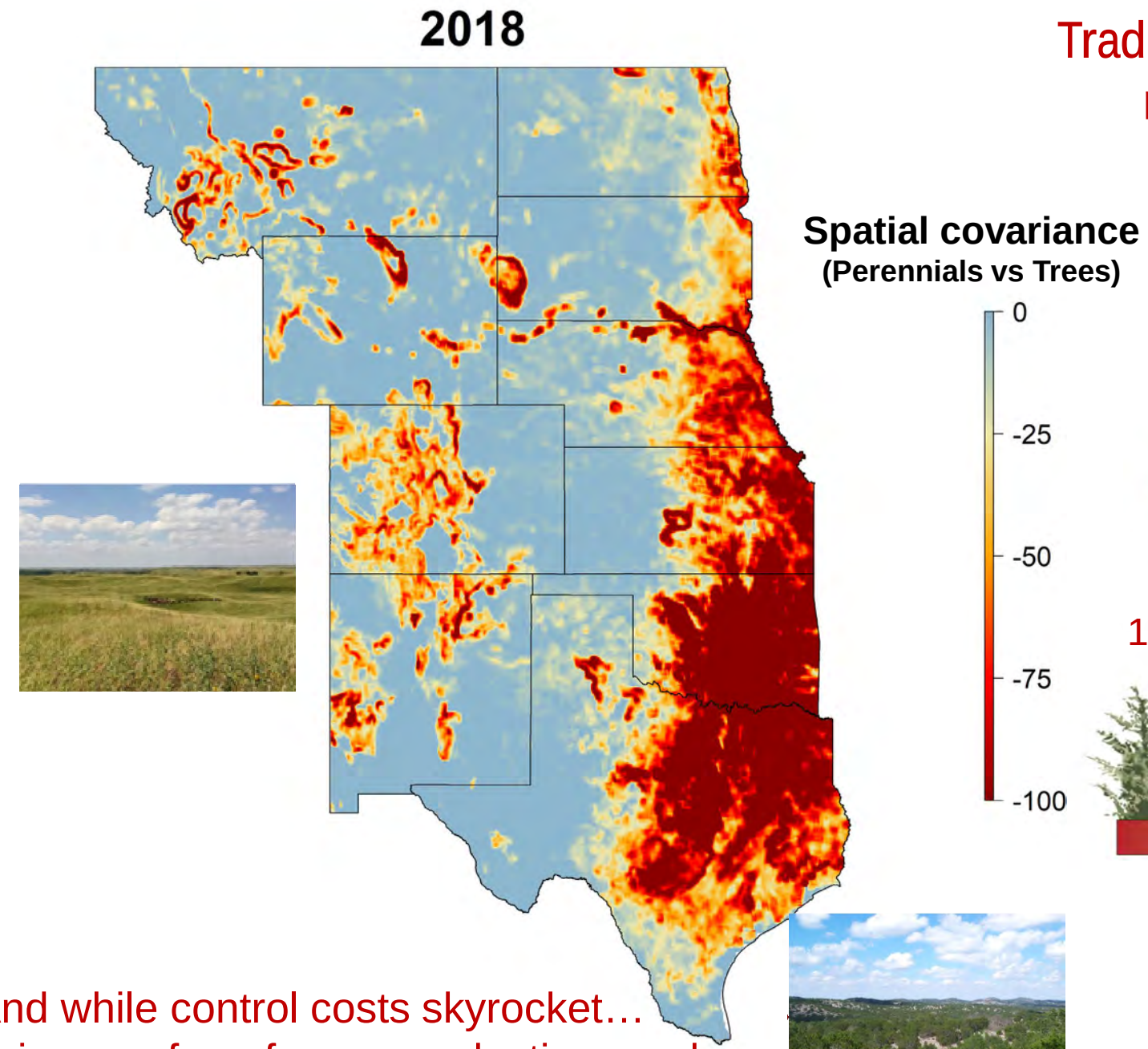
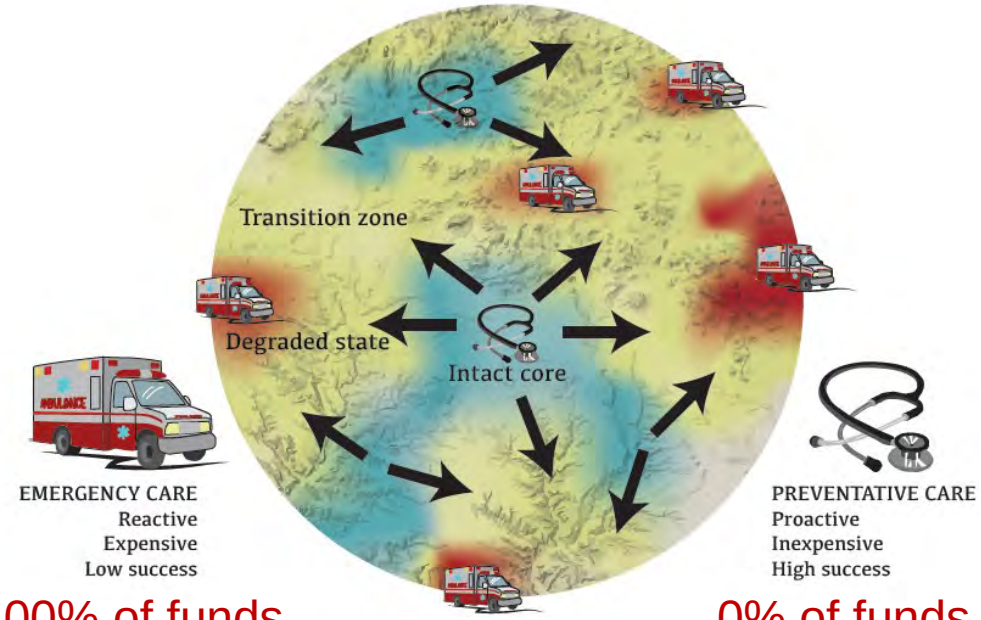
State transition	State transition to woody dominance	*Restore, Transform, or Opportunistic*

Traditional guidance is reactive and forces management to occur everywhere





100% of funds

0% of funds

to treat 5,000 acres

@ \$150 ac^{-1} = \$750,000

@ \$1,000 ac-1 = \$5,000,000

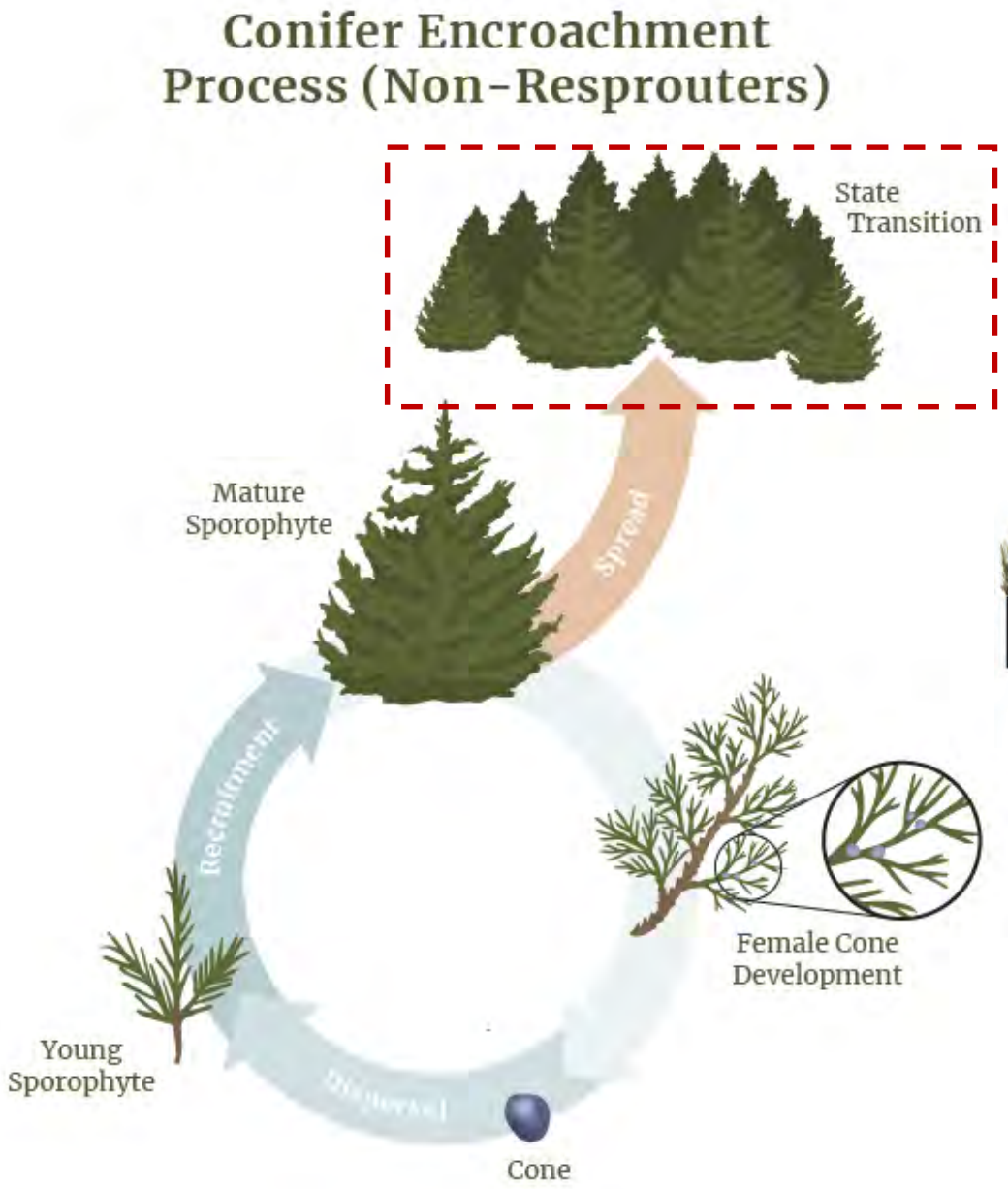
to treat 500,000 acres (40% of Sandhills)

@ \$150 ac^{-1} = \$75 Million

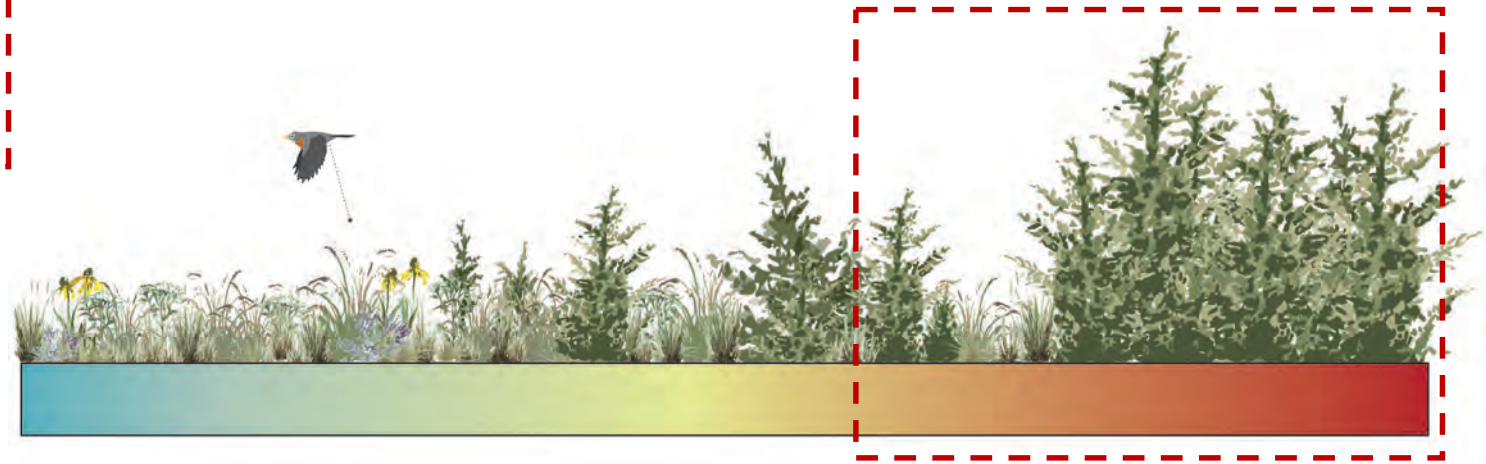
And while control costs skyrocket…

…income from forage production crashes

When does this threat become a resource concern?

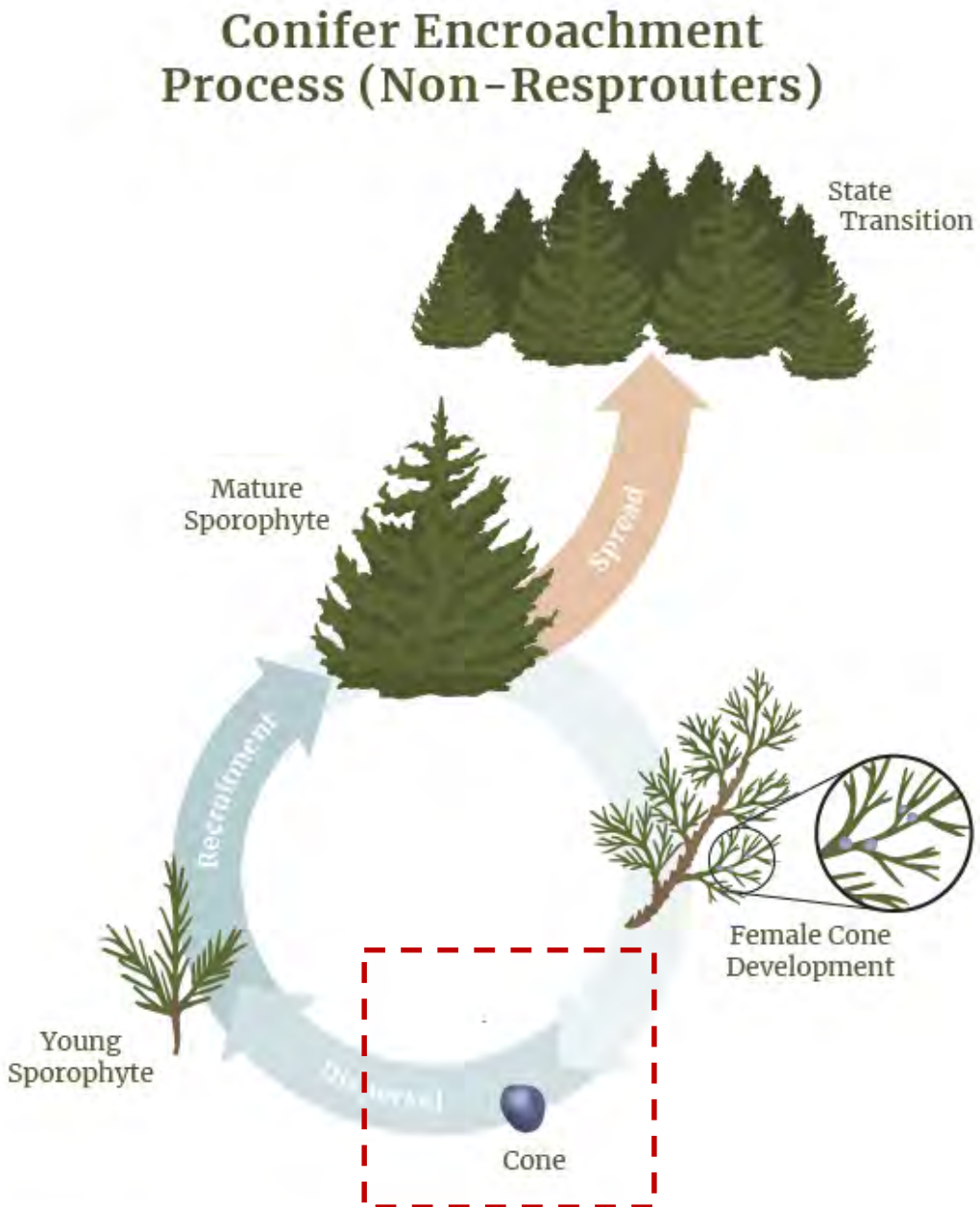


Old guidance

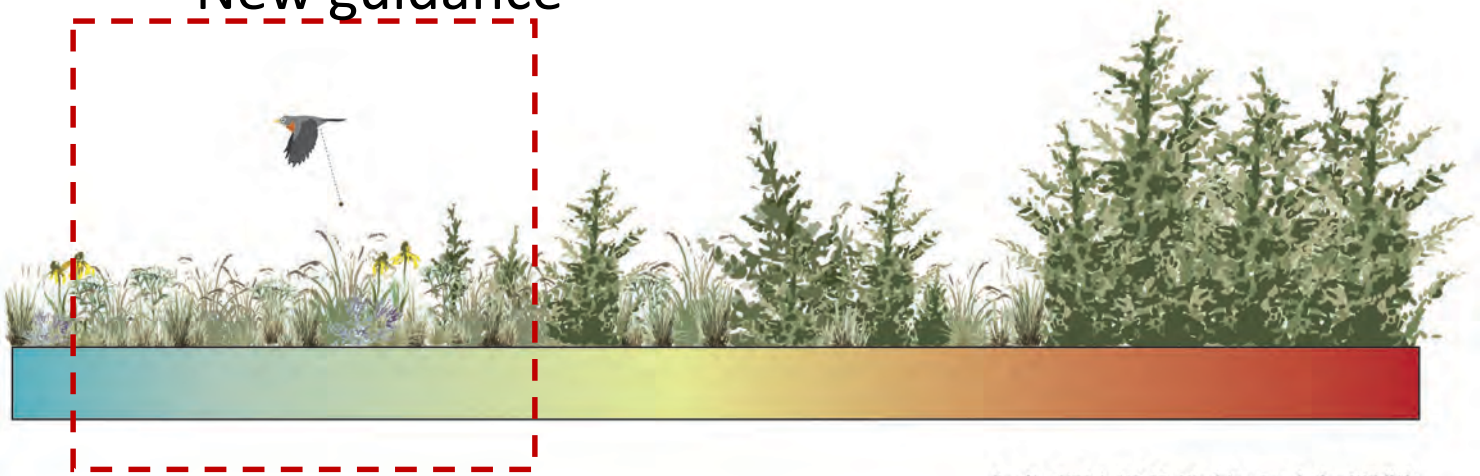


Credit: USDA-NRCS, Working Lands for Wildlife

When does this threat become a resource concern?



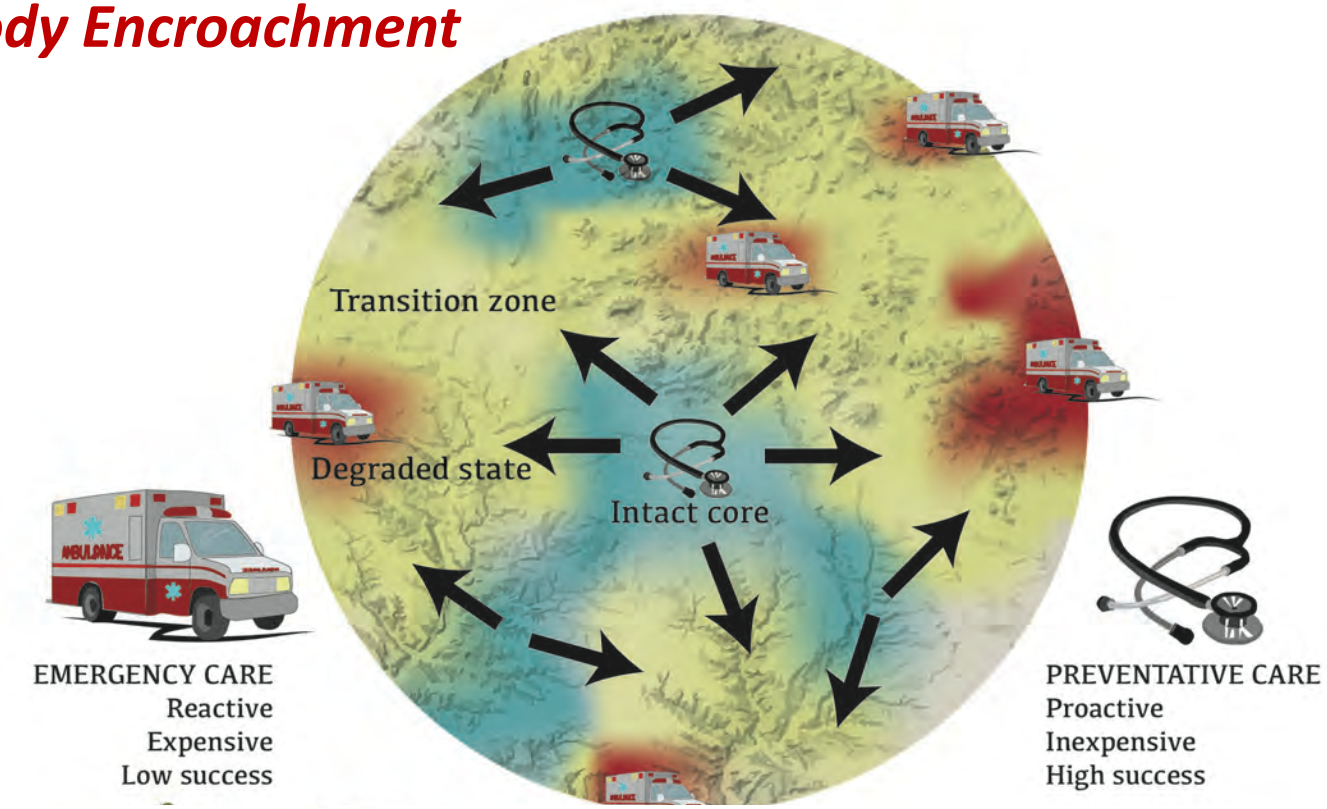
New guidance

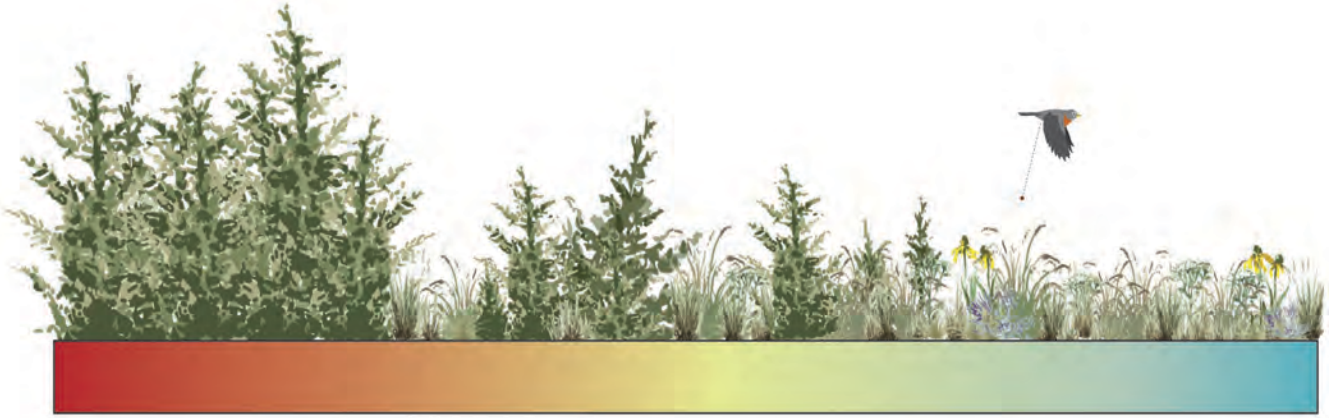


Credit: USDA-NRCS, Working Lands for Wildlife

Protect the Core → Defend the Core → Grow the Core

New Guidelines for Managing Woody Encroachment

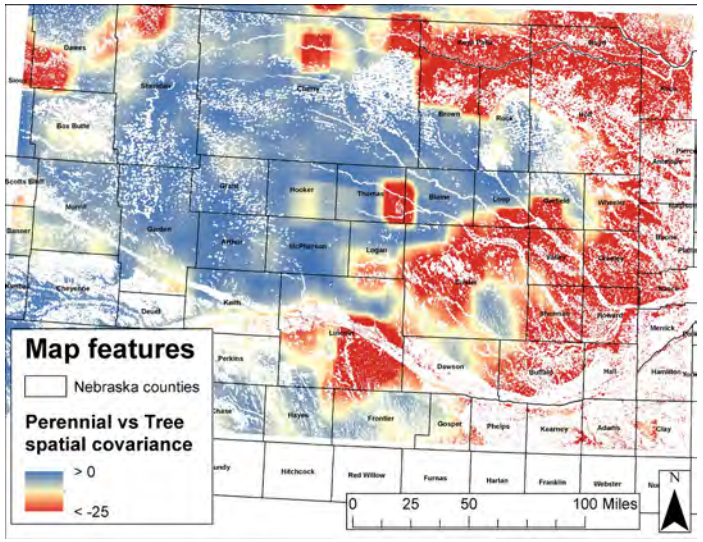




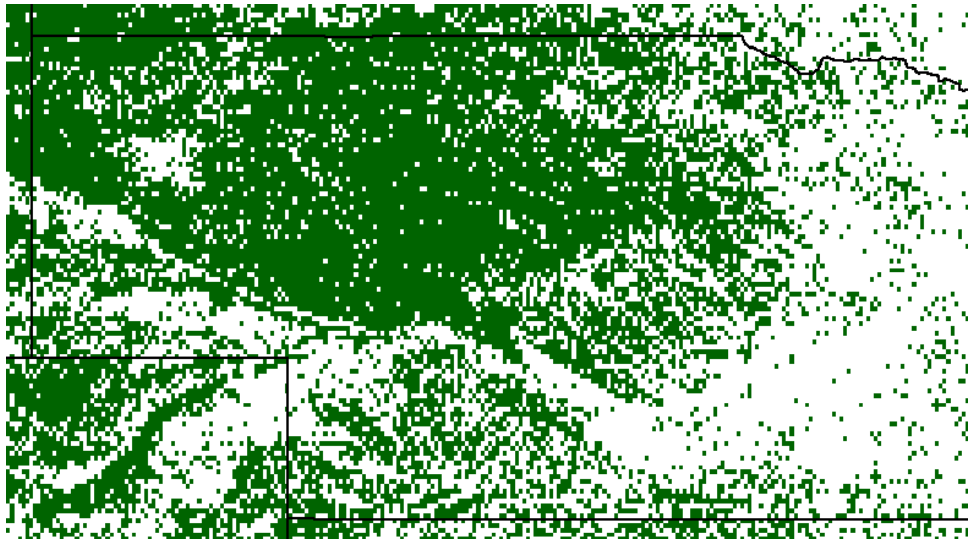
Building resilience in grasslands

Landowner Led, Science Informed, Agency Supported

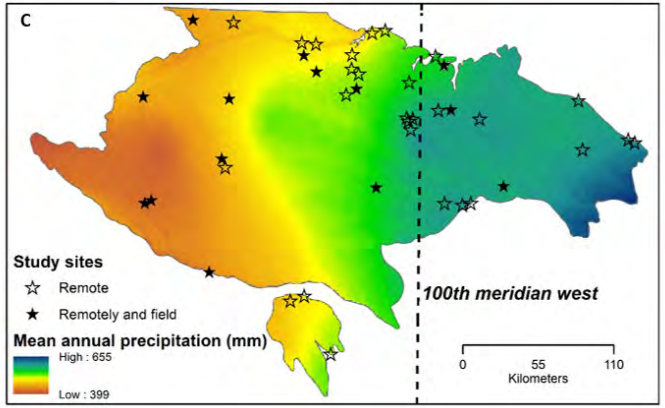
1. Identify the existing transition between grass-tree regional states via screening



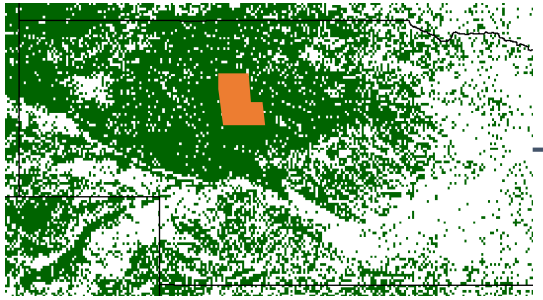
2. Locate an intact core area to anchor conservation efforts (treeless region; e.g. using RAP)



3. Refine location with field inventories to identify incipient invasion within the core that is undetectable by technology

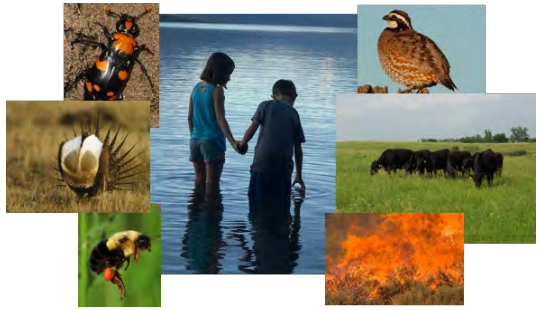


4. Identify strategic areas with managers that have the cultural will to act to scale-up conservation efforts



5. Co-produce scenarios for customized solutions

6. Track outcomes, adapt over time, and grow the core with success stories



Science Support for a New Grassland Conservation Initiative:
Nebraska, Oklahoma, Kansas, South Dakota NRCS

Science Support for Ramping Up Conservation in the Great Plains to Address Encroachment of Woody Species

25 April 2020

CCG Application submitted to Nebraska NRCS via NRCSNEBProposal@nrcs.usda.gov

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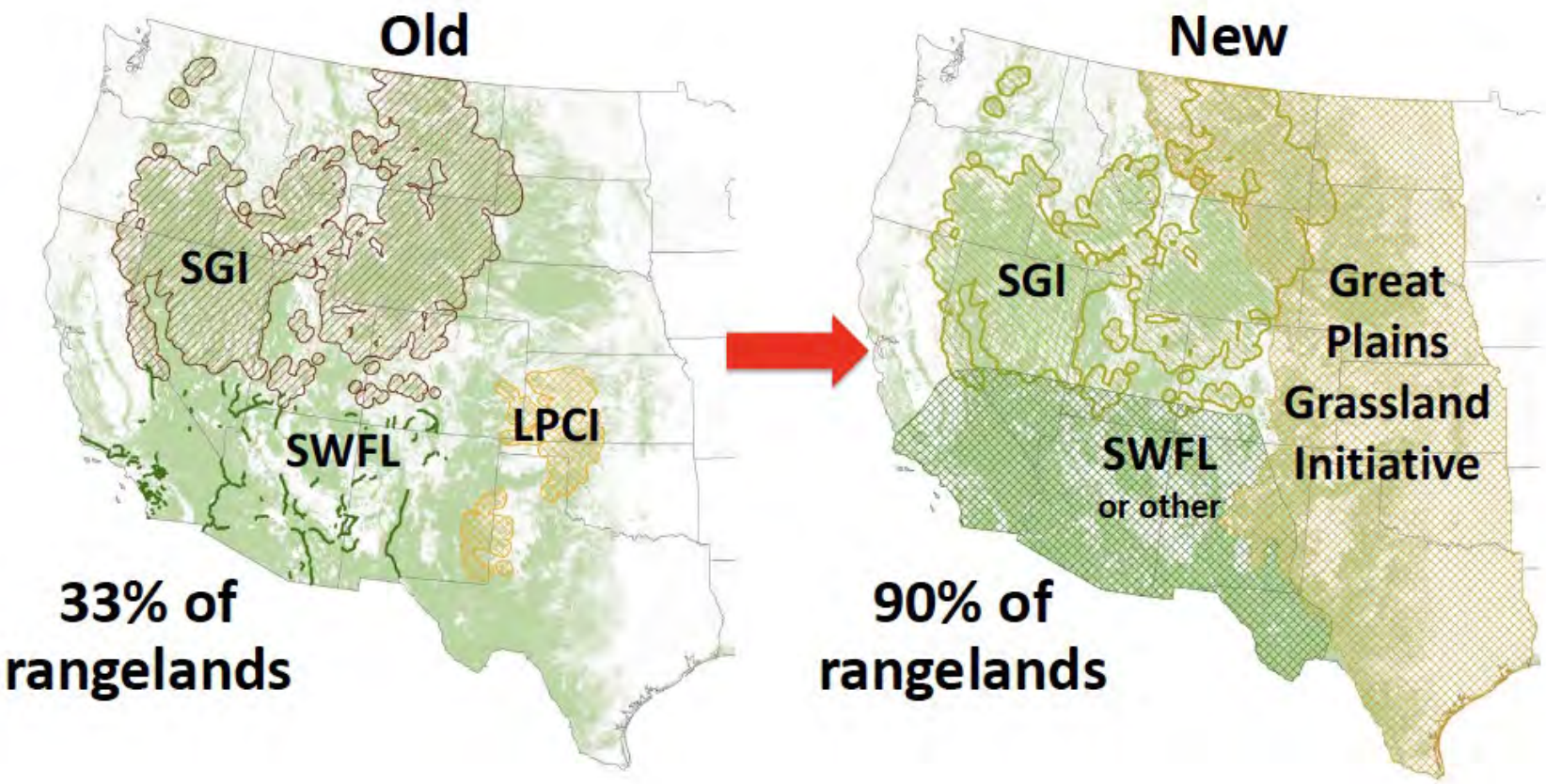
In Spring 2020, NRCS State Conservationists across a four-state region of the Great Plains including Nebraska, South Dakota, Kansas and Oklahoma, agreed to ramp up rangeland conservation by addressing woody expansion, particularly eastern redcedar. At risk: the sustainability of resources dependent on rangelands in the Great Plains; catastrophically impacted by the collapse of rangelands from woody encroachment are livestock production, ranch profitability, wildfire disaster avoidance, water security, wildlife habitat, and social and community programs.

A New Great Plains Grasslands Initiative:
USDA NRCS Working Lands for Wildlife Program



Wildlife Stronghold

Intact Landscape Core

Cultural Will

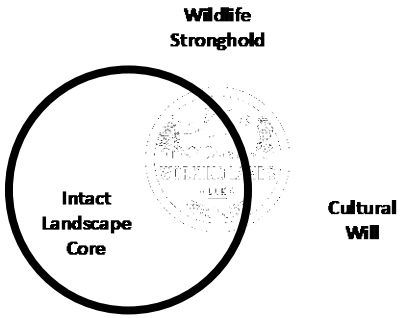
The Charge from NRCS Working Lands for Wildlife

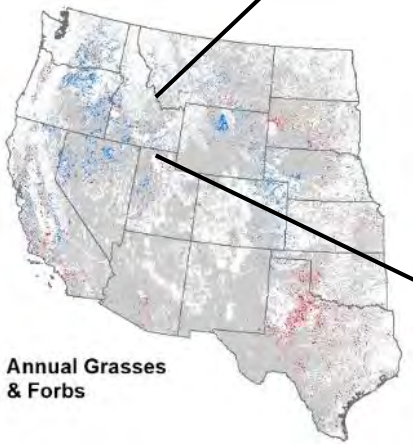
Wildlife Stronghold

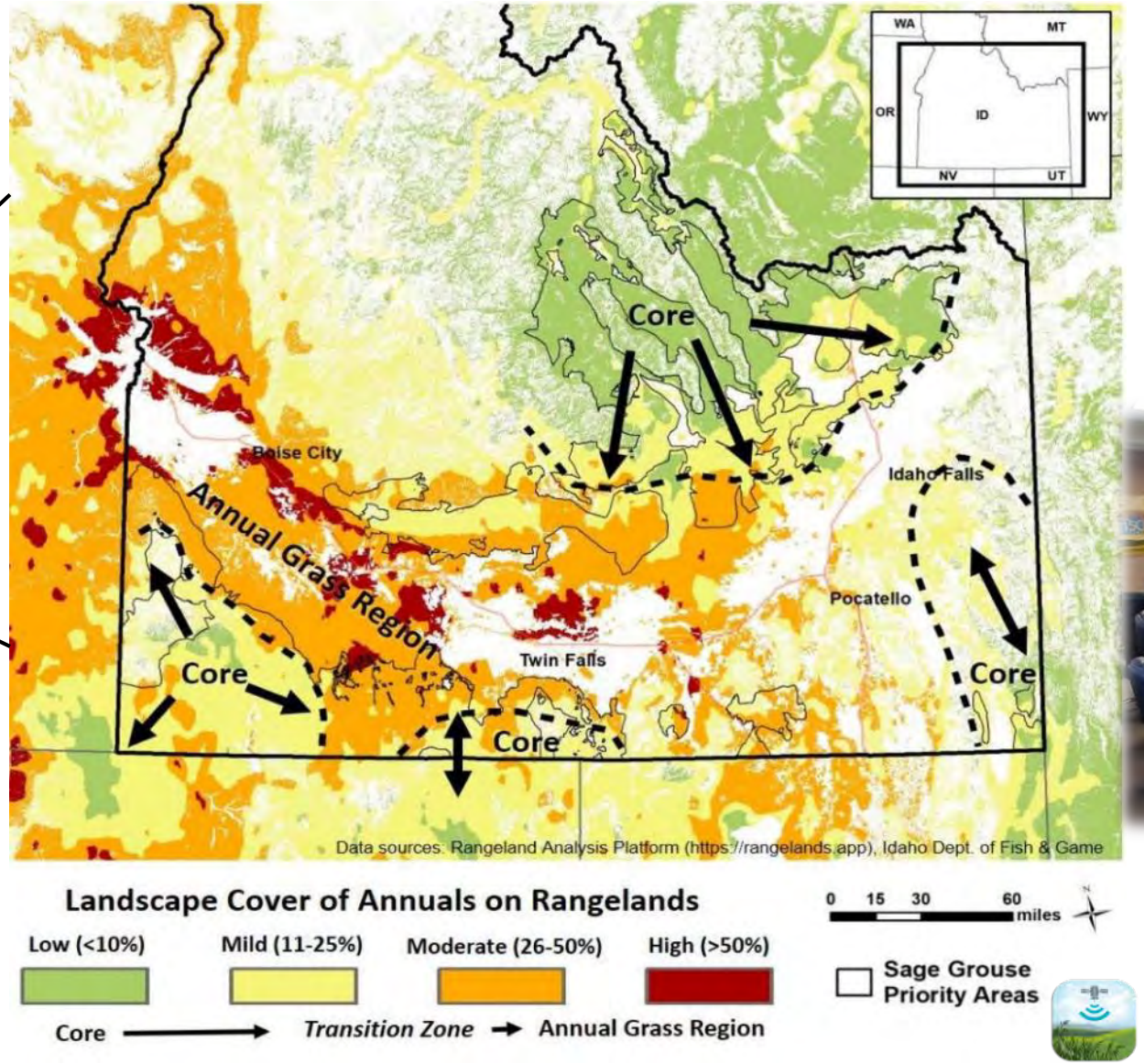
Intact Landscape Core

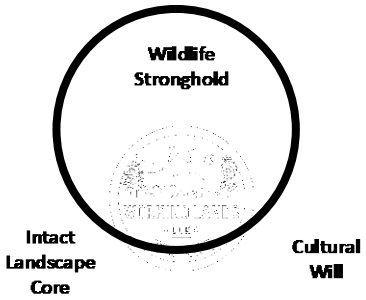
Cultural Will

Identifying Rangeland Cores: Idaho Cheatgrass Challenge

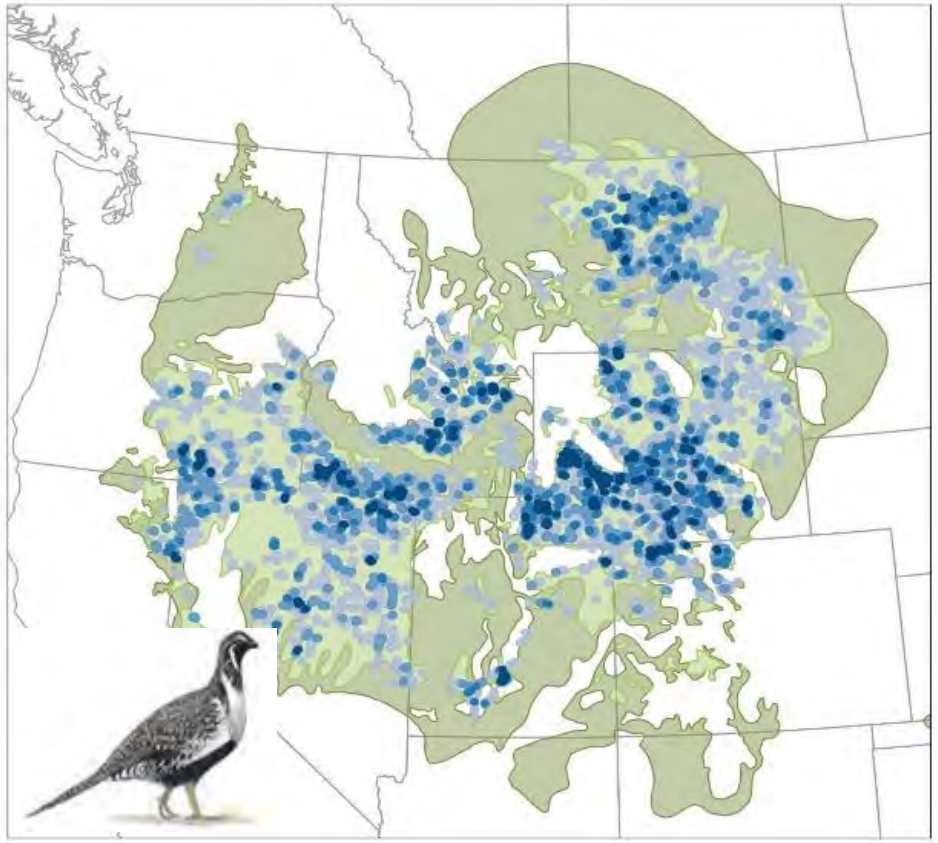








Using Wildlife Strongholds to Target Delivery



75% of birds, 25% of land area

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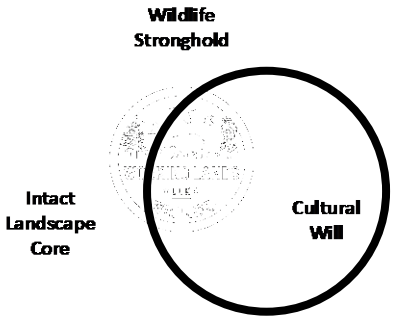
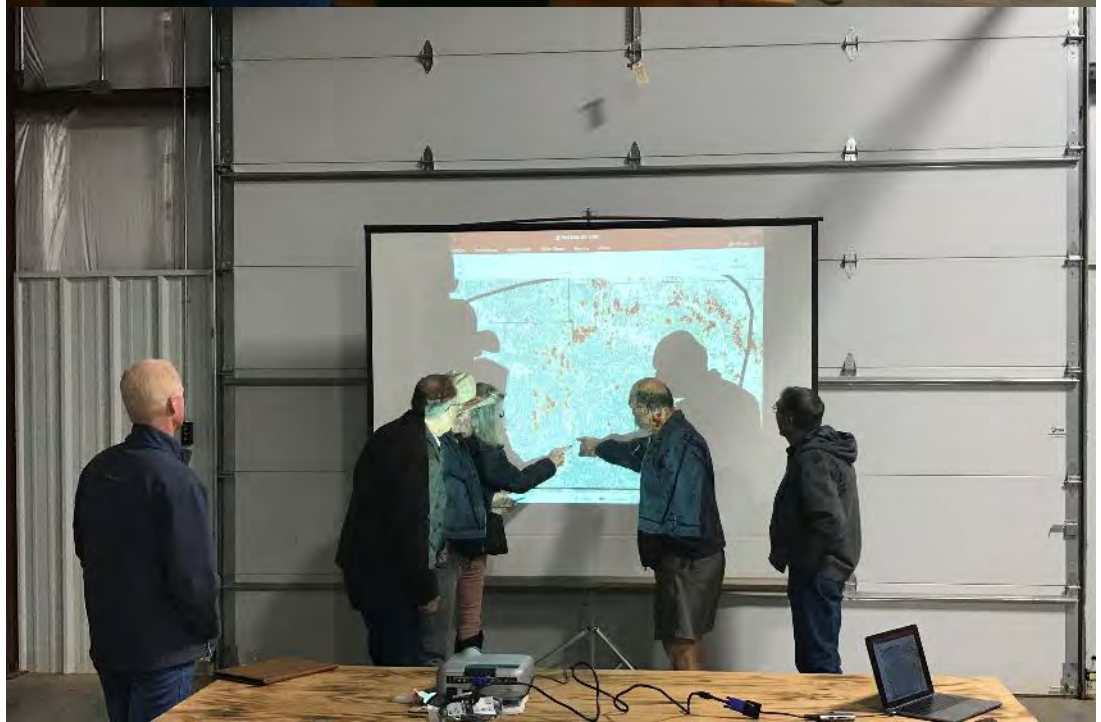


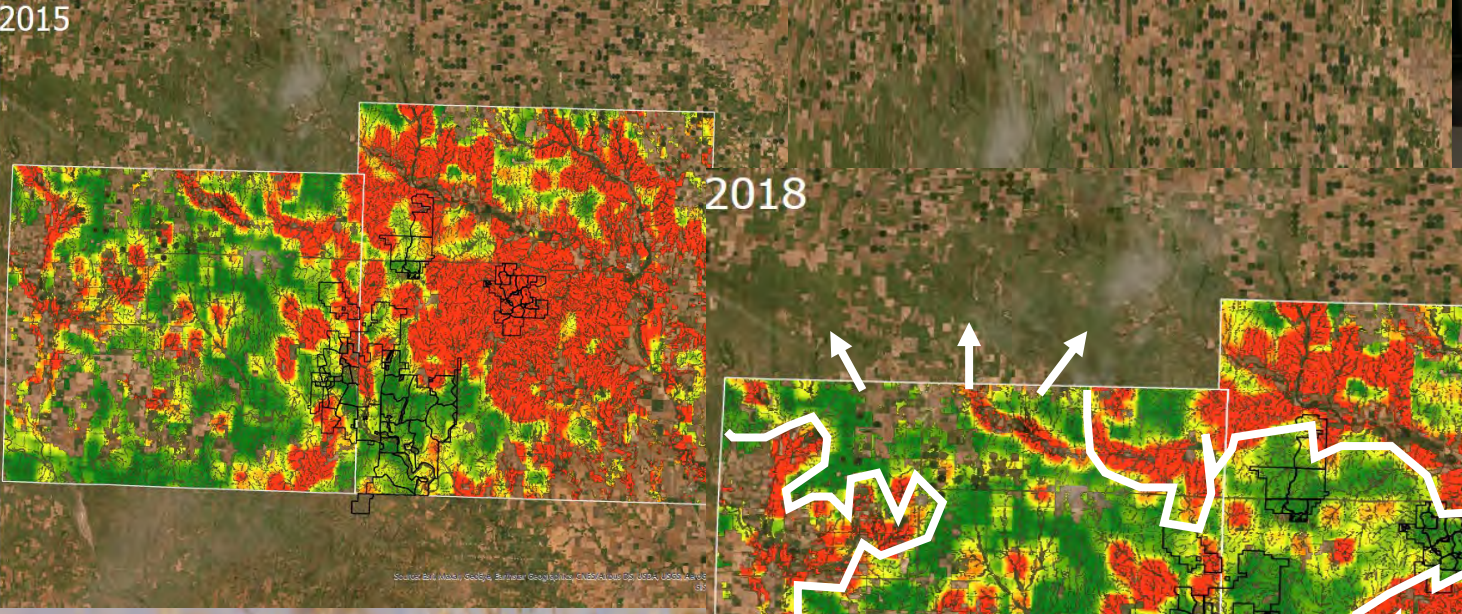
Leveraging Cultural Will: Red Hills (KS) Landscape

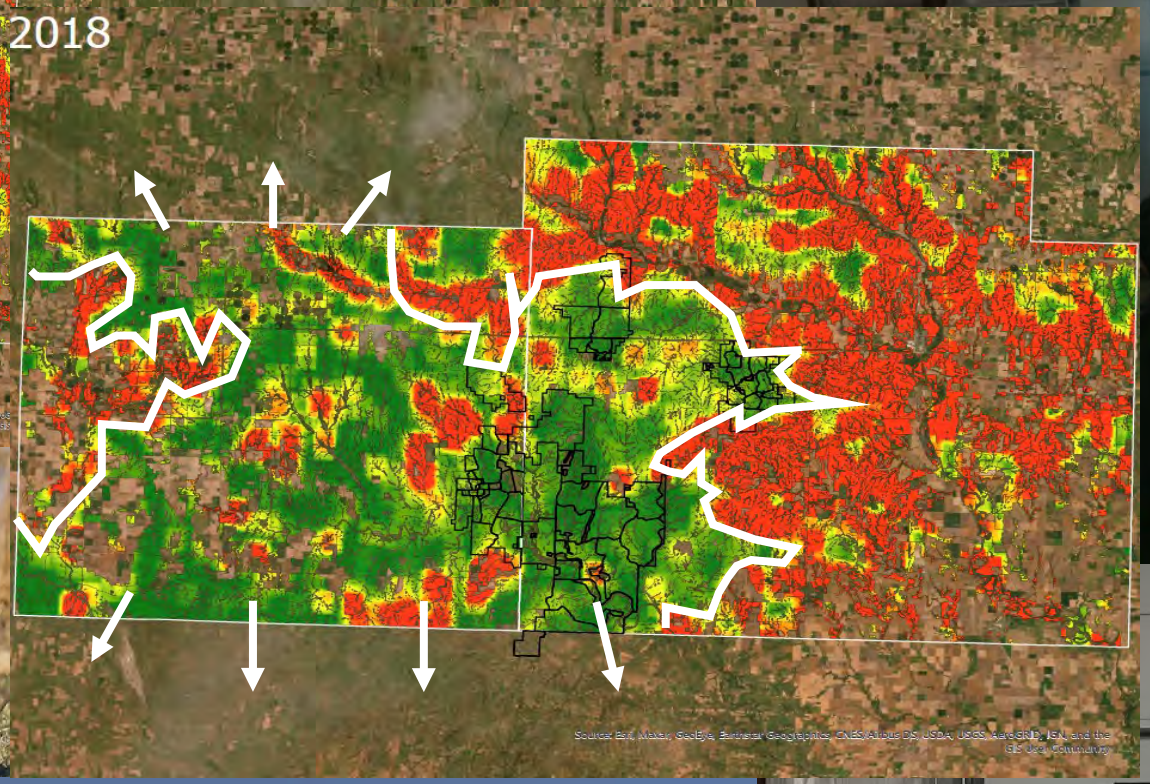


Next Steps in the Plains

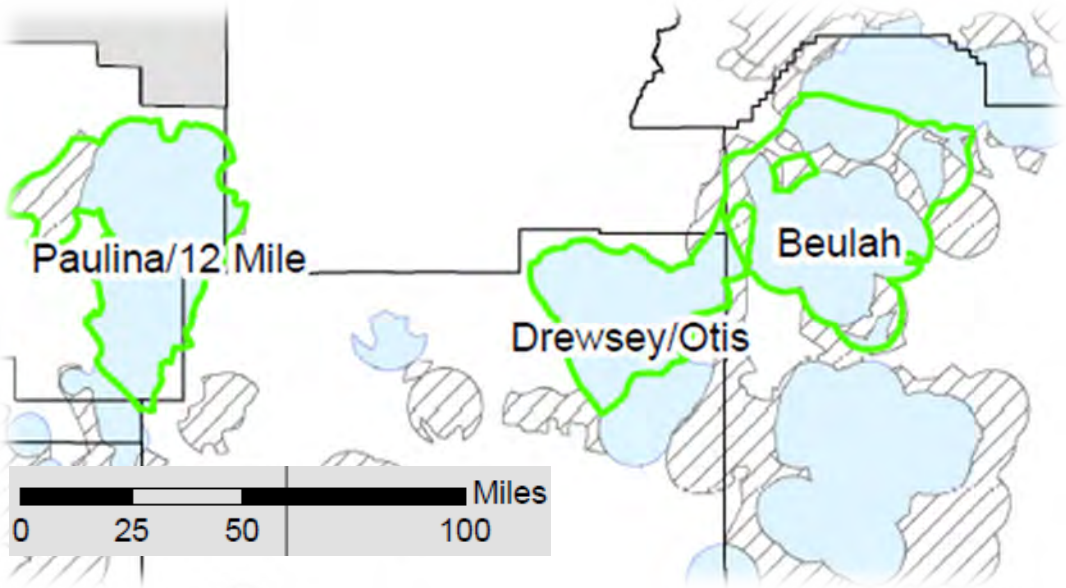
- Identify priority areas to anchor conservation
- Establish cores → Defend the cores → Grow the cores
- Right practice, Right place, Right scale
- Adapt practices to prevent resource concerns and improve project lifespans
- Technical guidance should match realities of restoration; requires rehab
- Dream Big
- Build Cultural Will

Gypsum Hills (KS) Landscape

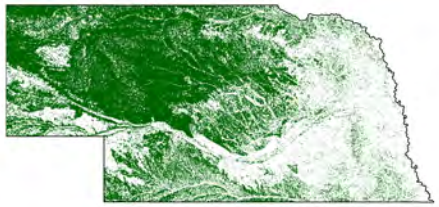




Identifying Priority Areas: due Oct. 15



Priority Areas for Grassland Conservation in Nebraska



Intact Grassland Landscapes

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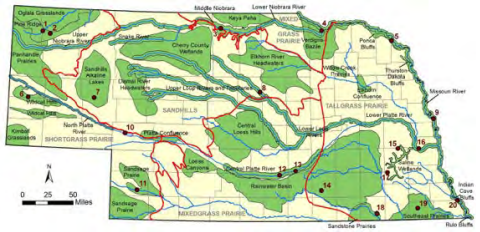
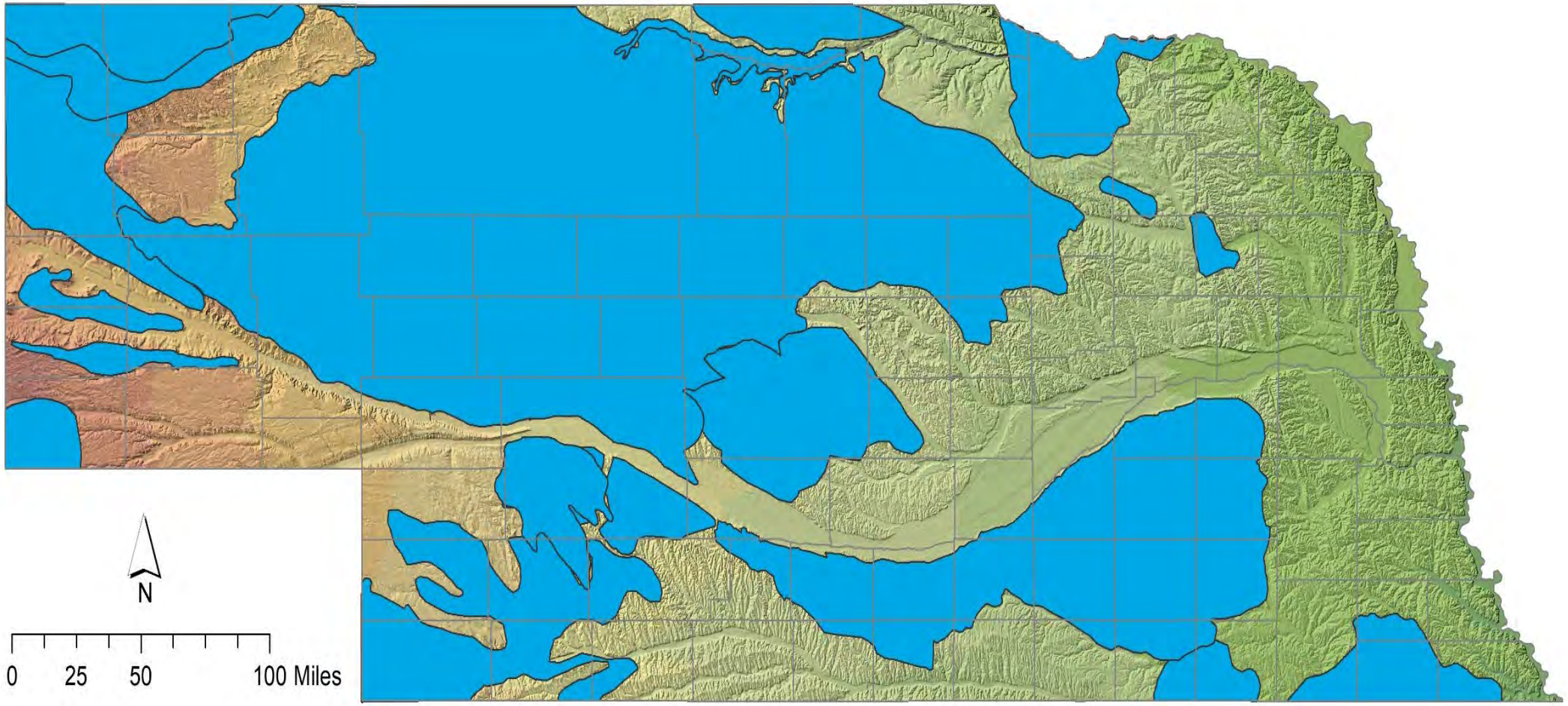
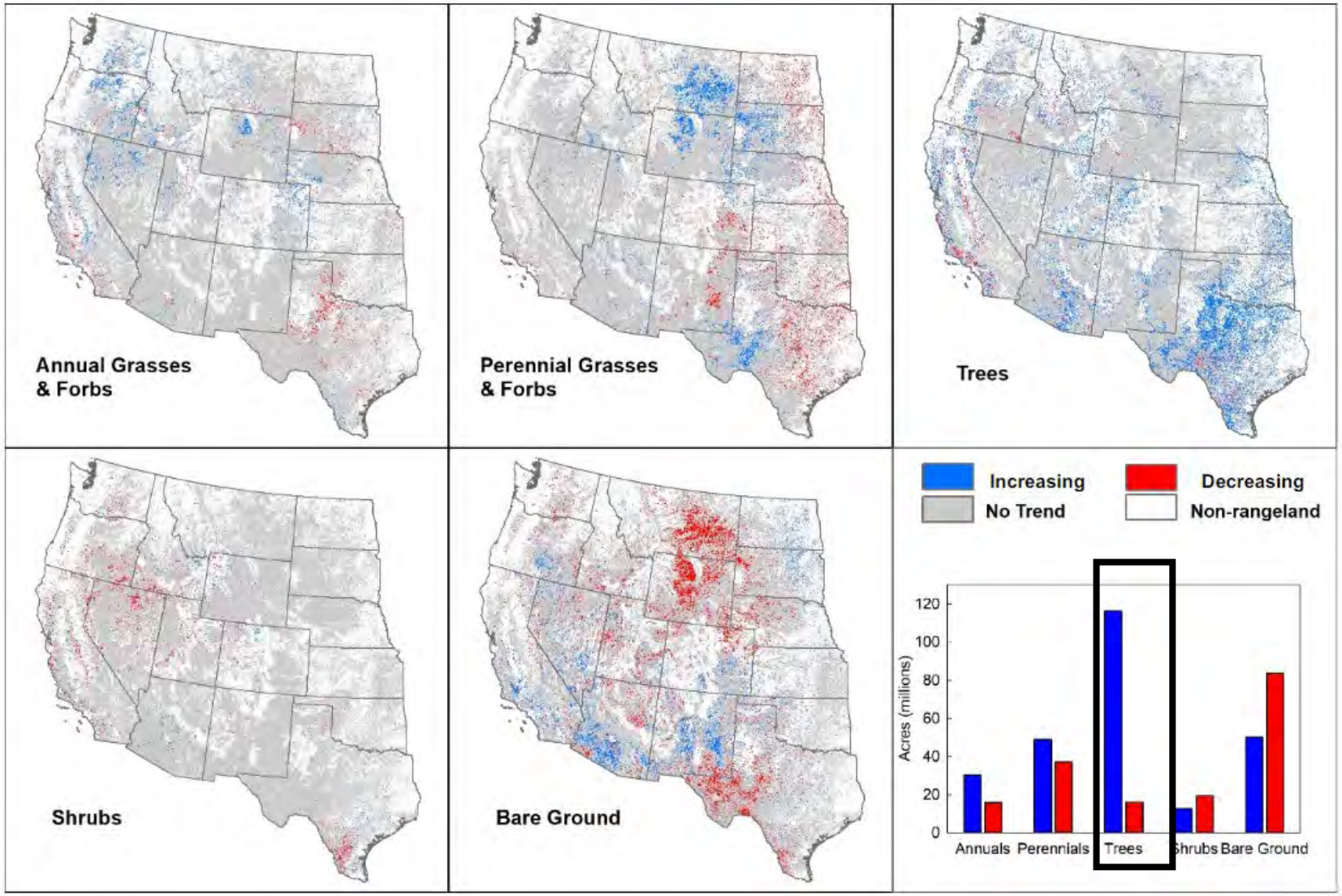


Nebraska Legacy Project



Part of a National Effort to Address the #1 driver of national rangeland loss in recent decades



1999-2018

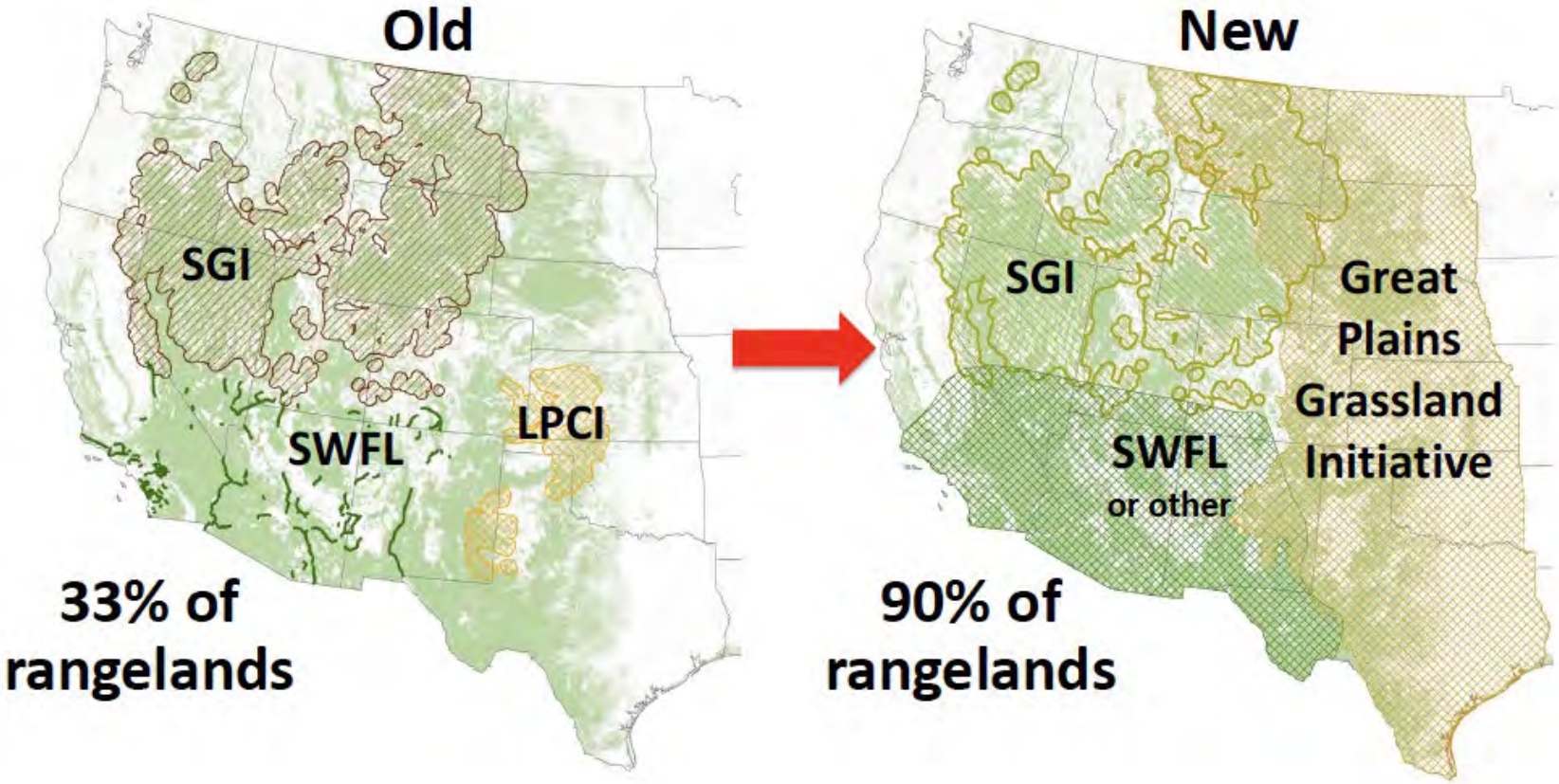
Rangeland Analysis Platform

Jones et al. 2020

A New Great Plains Grasslands Initiative:

USDA NRCS Working Lands for Wildlife Program

This is emerging as the largest grassland conservation initiative since the Conservation Reserve Program



Wildlife Stronghold

Intact Landscape Core

Cultural Will

Responsible for $750 Million of on-the-ground conservation last decade