Climate Change & Invasive Species

National Wilderness Stewardship Alliance

USDA-Agricultural Research Service

USDA-Forest Service

Panel Member Introductions
Scientists

Linda Joyce

Supervisory Research Rangeland Scientist

Rocky Mountain Research Station, Fort Collins, CO.

Panel Member Introductions
Scientists

Dana Blumenthal

Research Ecologist

USDA-Agricultural Research Service, Rangeland Resources Research Unit, Fort Collins, CO.

Panel Member Introductions
Scientists

Jack Morgan

Research Plant Physiologist

USDA-Agricultural Research Service (retired), Rangeland Resources Research Unit, Fort Collins, CO.

Panel Member Introductions
Volunteers

Robert Drage

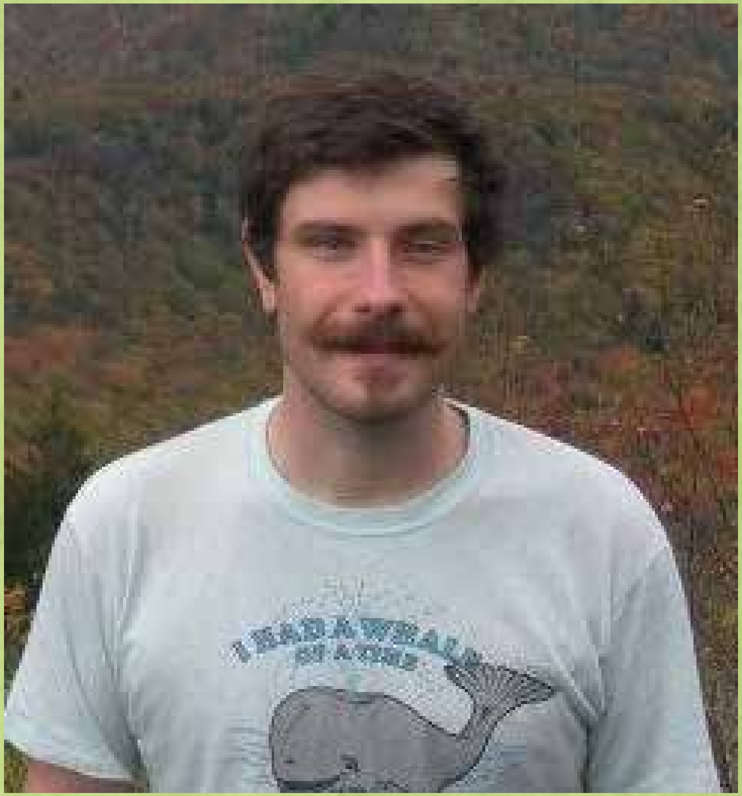
Poudre Wilderness Volunteers

Canyon-Lakes Ranger District, USDA Forest Service, Colorado.

Panel Member Introductions
Volunteers

David Greene

Southern Appalachian
Wilderness Stewards

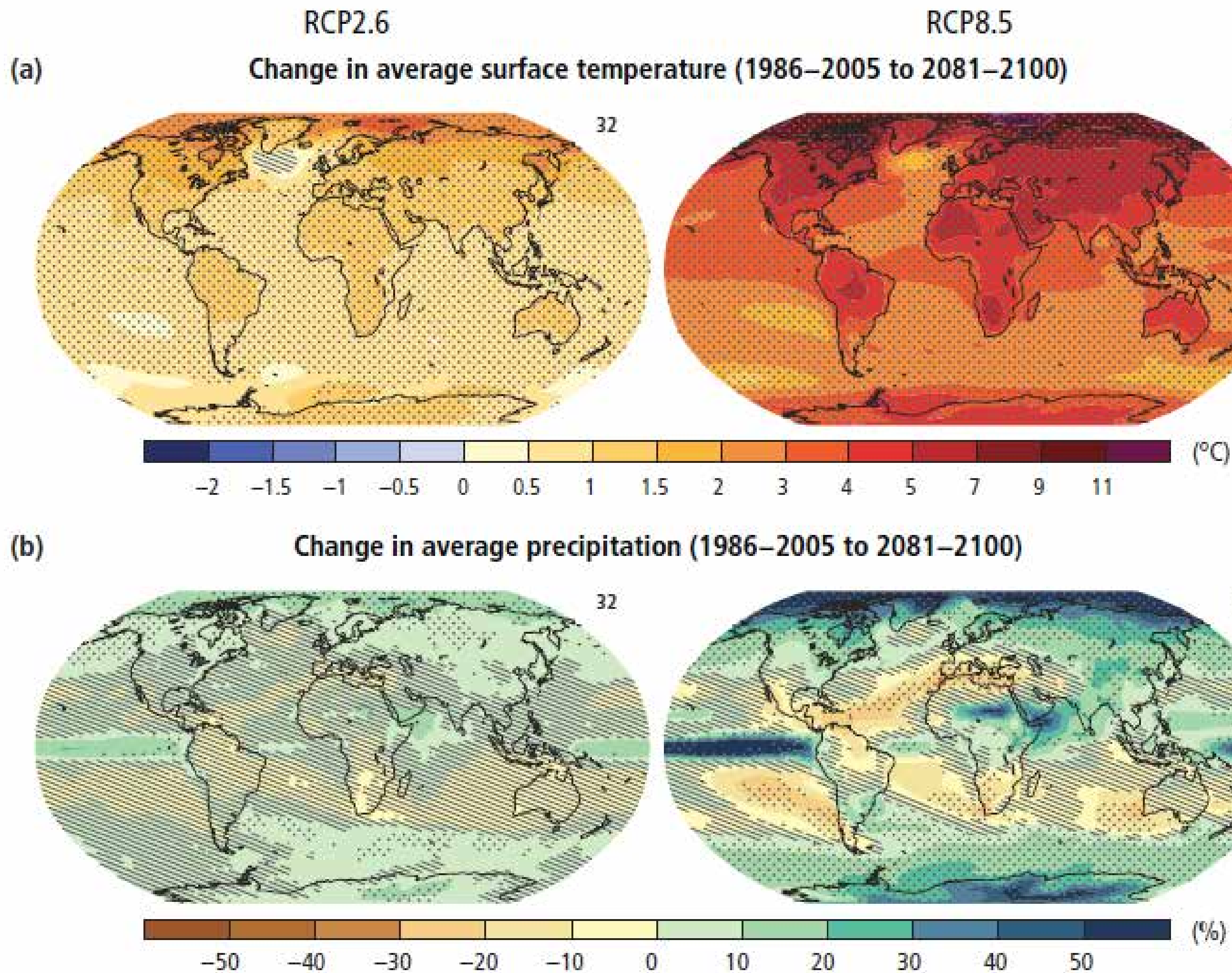


Panel Member Introductions
Volunteers

Nora Kaufmann

Volunteer Stewardship Coordinator

Friends of Nevada Wilderness


RCP2.6
RCP8.5
(a)
Change in average surface temperature (1986–2005 to 2081–2100)
32
39
−2 −1.5 −1 −0.5 0 0.5 1 1.5 2 3 4 5 7 9 11
(°C)
(b)
Change in average precipitation (1986–2005 to 2081–2100)
32
39
−50 −40 −30 −20 −10 0 10 20 30 40 50
(%)

Boots-on-the-ground folks know these systems.

Climate Change & Invasive Species

- Linda Joyce
  - Climate & weather
  - What will the future look like?
  - How will this effect wilderness areas & invasion?
- Dana Blumenthal
  - Overview of climate and invasion
  - How do we study these things?
- Panel Member responses
- Audience questions & participation

Climate change, wilderness, invasives

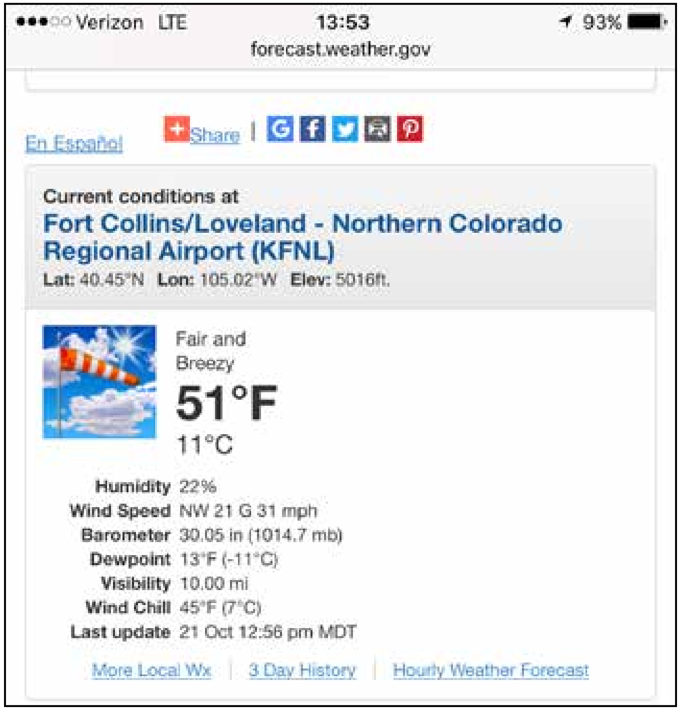
Linda A Joyce
USDA FS Rocky Mountain Research Station

November 1, 2017

Key Points – Past, Current and Future Climates

What has changed and will change?	Implication
Increasing atmospheric carbon dioxide	**Plant growth nutrient**
Increasing atmospheric nitrogen (N)	**Plant growth nutrient**
Warmer temperatures	**Plant community shifts, increased disturbances**
Longer growing season	**Plant community shifts**
Changing patterns of disturbances	**Natives lost, opens habitat**
Increasing frequency of storms	**Natives lost, invasive dispersal**

Weather versus Climate

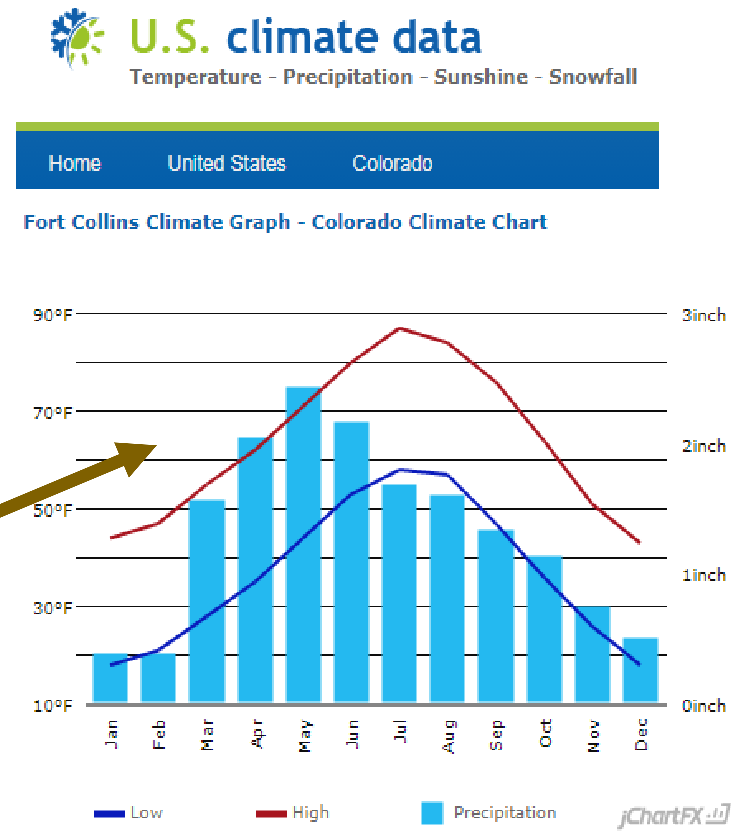


Weather –
the specific conditions of the atmosphere at a particular place and time, measured in terms of variables that include temperature, precipitation, cloudiness, humidity, air pressure, and wind.

Weather versus Climate

CURRENT

30 year average

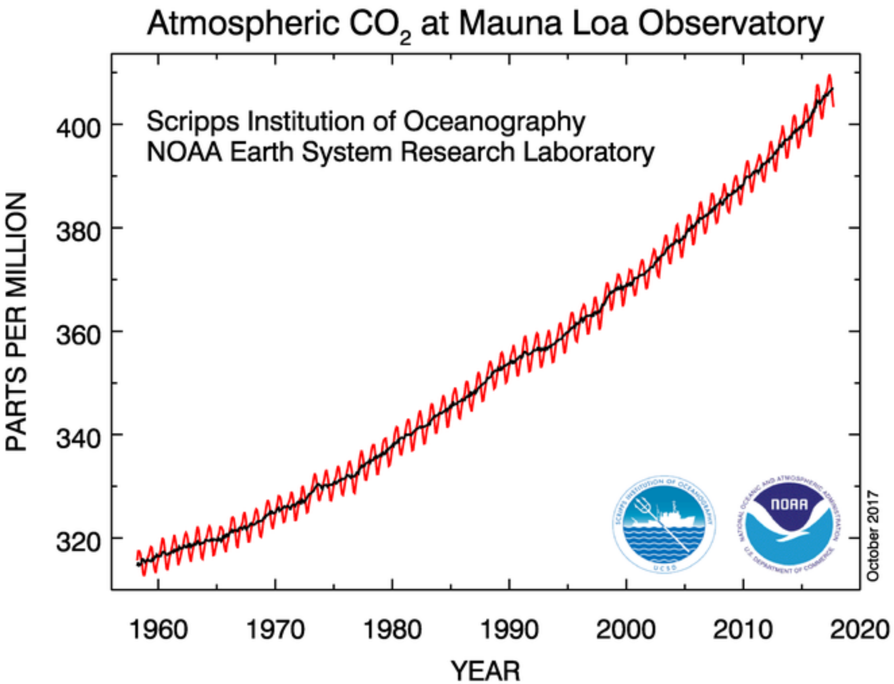


Weather

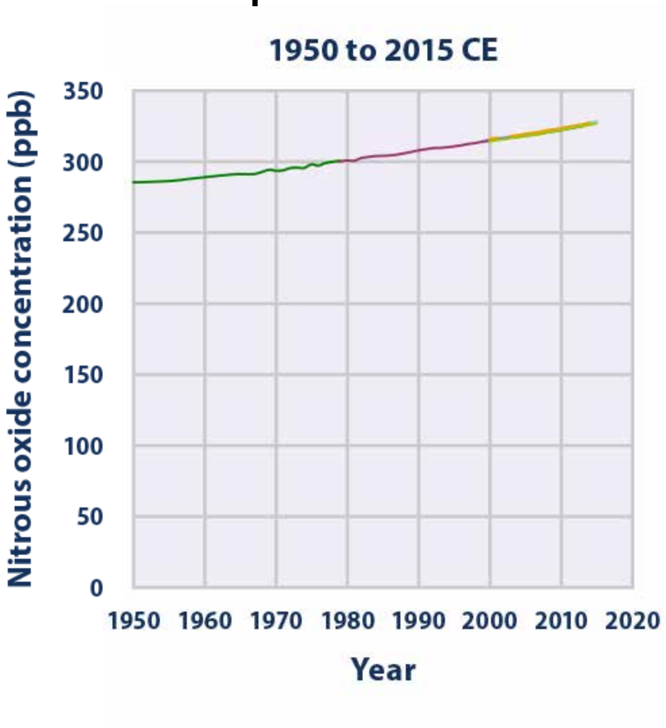
Climate

https://www.usclimatedata.com/climate/fort-collins/colorado/united-states/usco0140

What is changing? **Atmospheric chemistry**



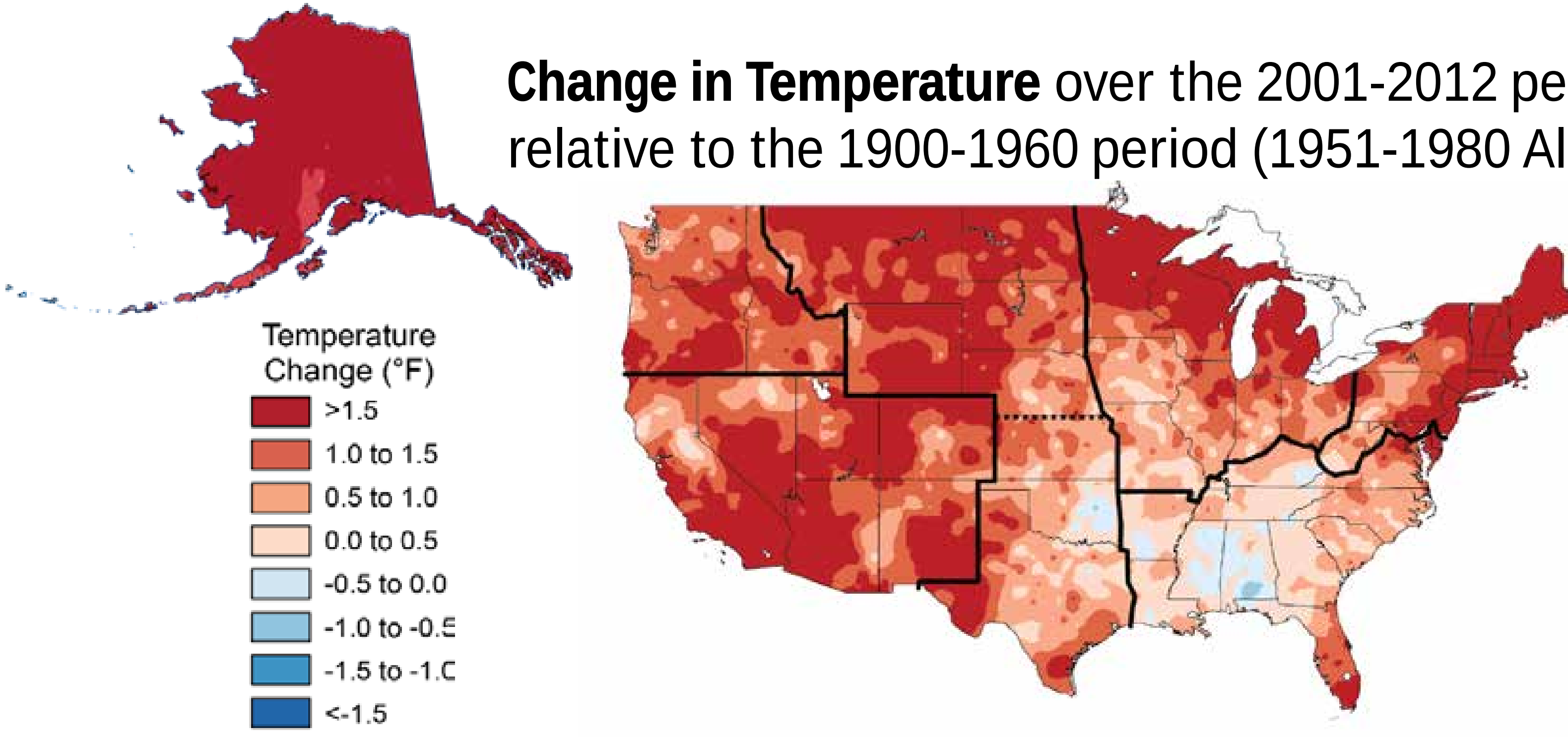
Atmospheric nitrous oxide



https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases

What is changing? **Average Temperatures**

Change in Temperature over the 2001-2012 period, relative to the 1900-1960 period (1951-1980 Alaska)

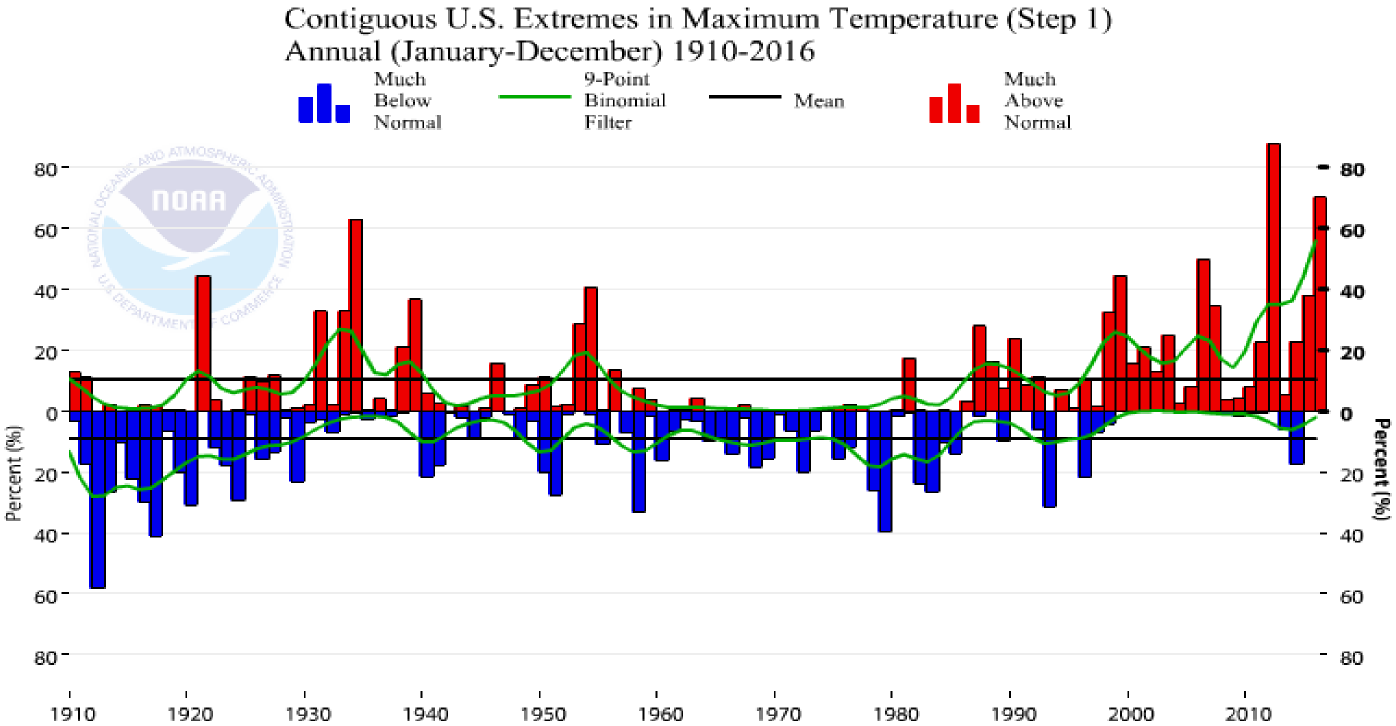


Comparing 1991-2012 with 1901-1960 for the conterminous US and 1951-1980 for Alaska

http://nca2014.globalchange.gov/report/our-changing-climate/recent-us-temperature-trends

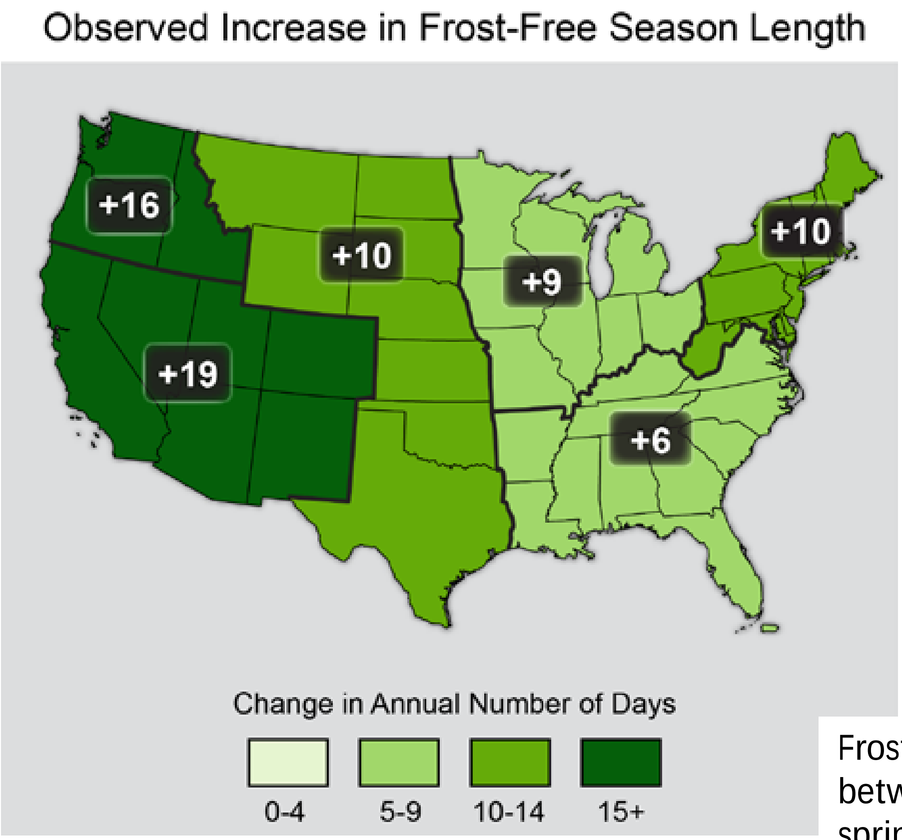
What is changing?

Much above normal maximum temperatures



https://www.ncdc.noaa.gov/extremes/cei/graph

What is changing? **Longer frost-free seasons**

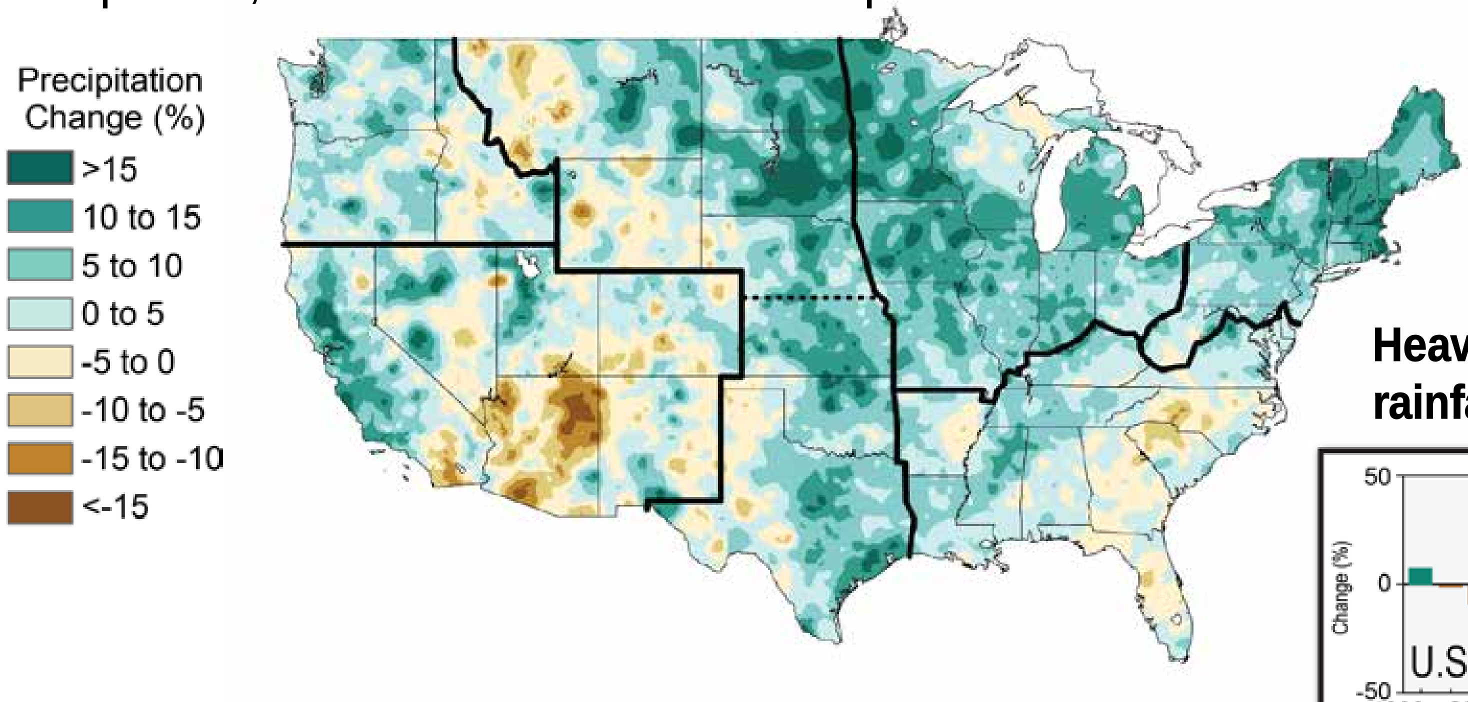


Frost-free season length has increased in each U.S. region during 1991-2012 relative to 1901-1960.

Frost-free season is defined as the period between the last occurrence of 32°F in the spring and the first occurrence of 32°F in the fall.

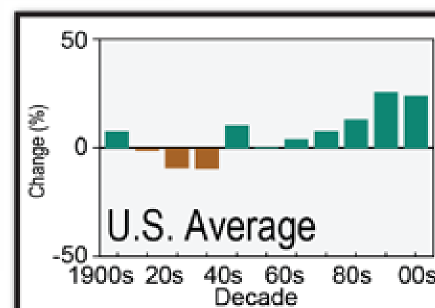
What has been changing? **Annual Precipitation**

Change in Precipitation (percent) over the 2001-2012 period, relative to the 1900-1960 period



Comparing the 1991-2012 with 1901-1960 for the conterminous US

Heavy daily rainfall events



What has been changing - Disturbances

Wildfire

- Increasing trends in the number of large fire per year
- Coincided with trends in increasing drought severity
- Legacy of land use and management

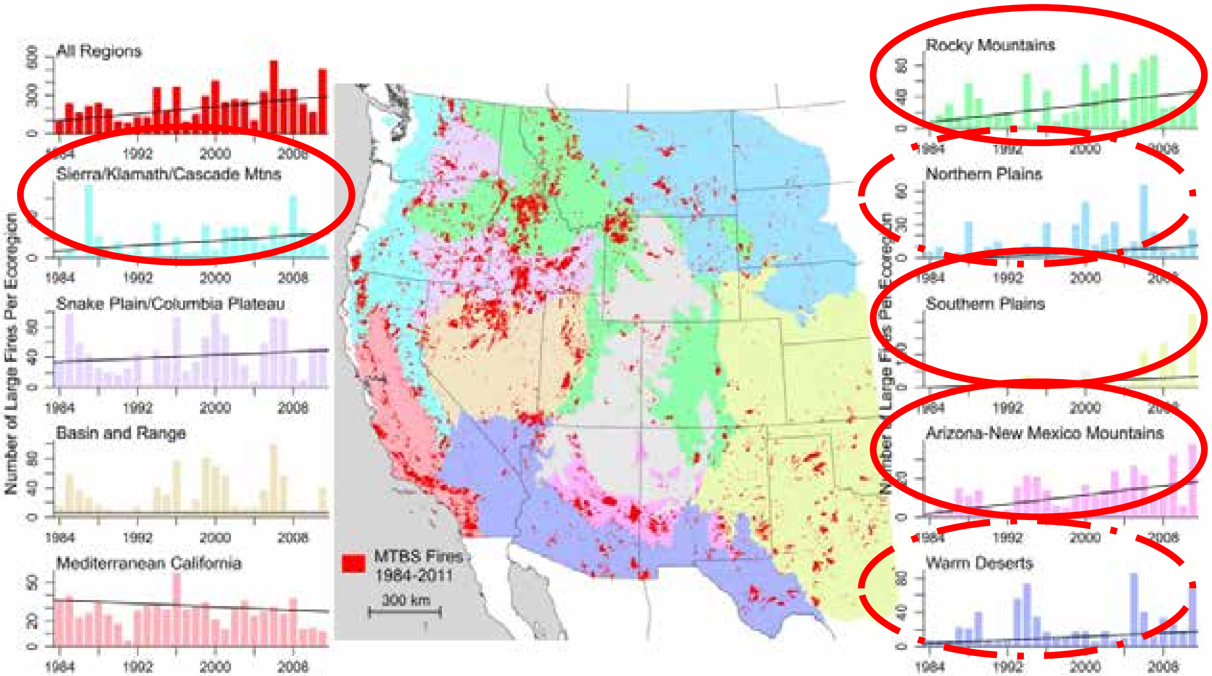


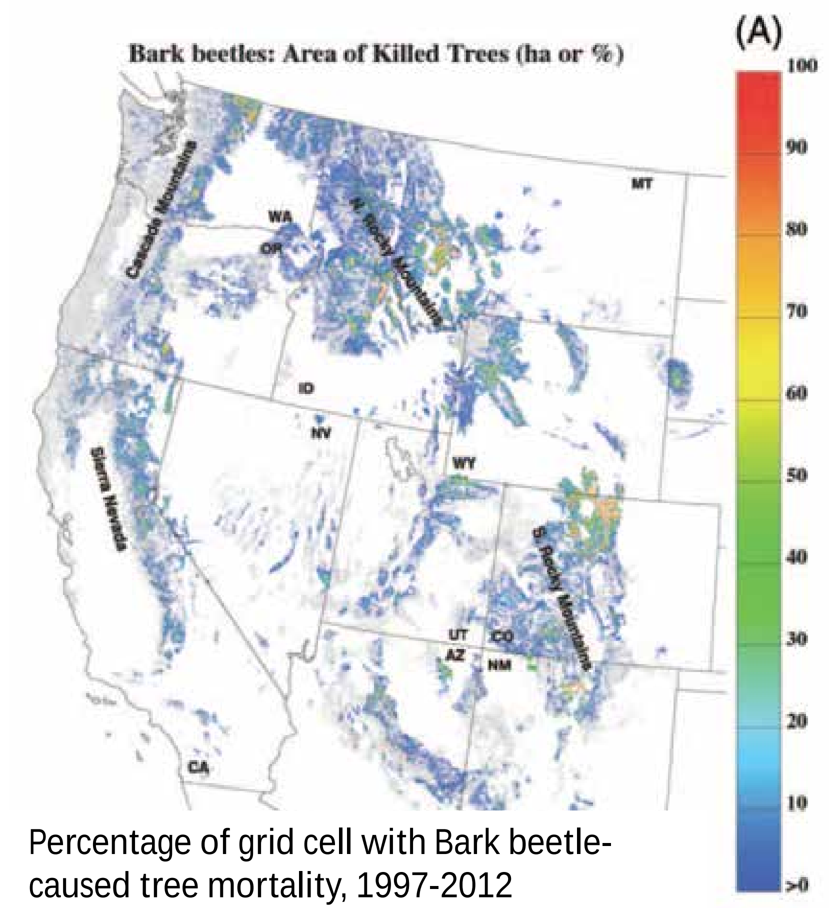
Figure 1. Western U.S. trends for number of large fires in each ecoregion per year. The center map illustrates ecoregions based on Levels II and III of the Omernik ecoregion system. The Wyoming Basin and Colorado Plateau ecoregions had too few large fires for trend analysis at the ecoregion level, and are shown in gray. MTBS-mapped fires are shown in red. The surrounding bar plots display the number of large fires in each ecoregion over the 1984–2011 study period. The black line on each plot indicates the Theil-Sen estimated slope for each ecoregion, with slope values and significance shown in Figure 2a.

Dennison et al. 2014

What has been changing - Disturbances

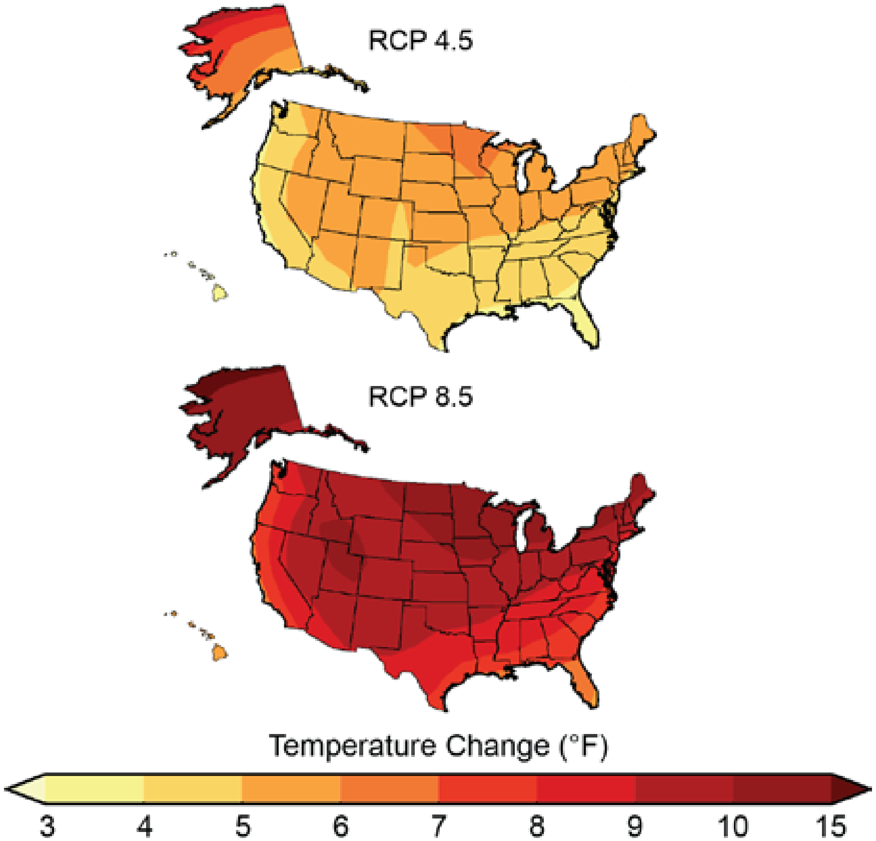
Bark Beetles

- Widespread bark-beetle-caused mortality
- Mountain pine beetle outbreak -- related to warming temperatures enhancing reproduction and reducing winter mortality
- Legacy of land management



Percentage of grid cell with Bark beetle-caused tree mortality, 1997-2012

Future climate – **Temperature increases by 2099**



Change in average temperature by 2071-2099 relative to 1970-1999

Average temperatures are projected to increase.

Extreme temperatures are projected to increase more than average temperatures.

Number of days about 90 ^{o}F will increase.

Future climate change – **Precipitation**

Frequency and intensity of heavy precipitation events are projected to increase.

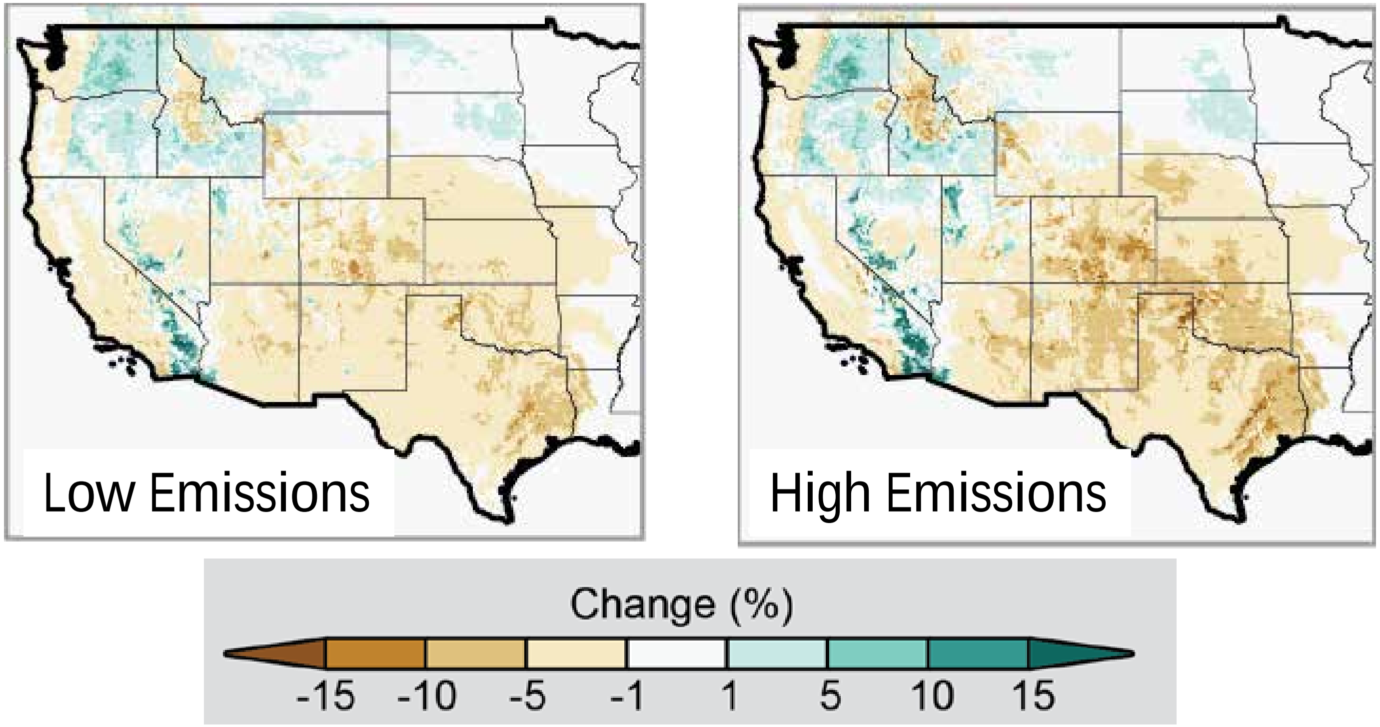
Precipitation projections:

Northern US - increase in precipitation;
Southwest - decrease in precipitation.

Large declines in snowpack for western U.S.

Future climate change – **Soil Moisture**

Projected Changes in Soil Moisture – mid 21st Century



http://nca2014.globalchange.gov/report/our-changing-climate/extreme-weather#tab2-images

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Global change and invasion – examples from semi-arid prairie

Dana Blumenthal

USDA-ARS Fort Collins, CO

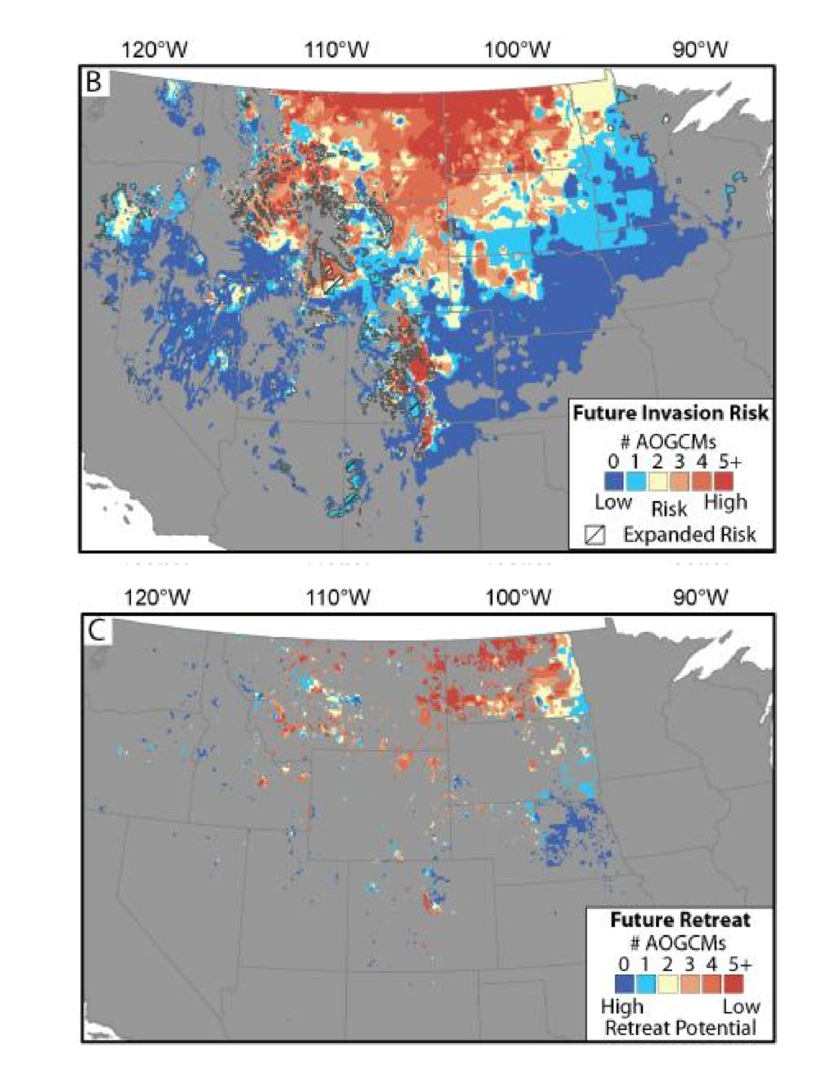
Global change & plant invasion

- As with natives
  - Winners and losers

Photo by Stephen Asmus

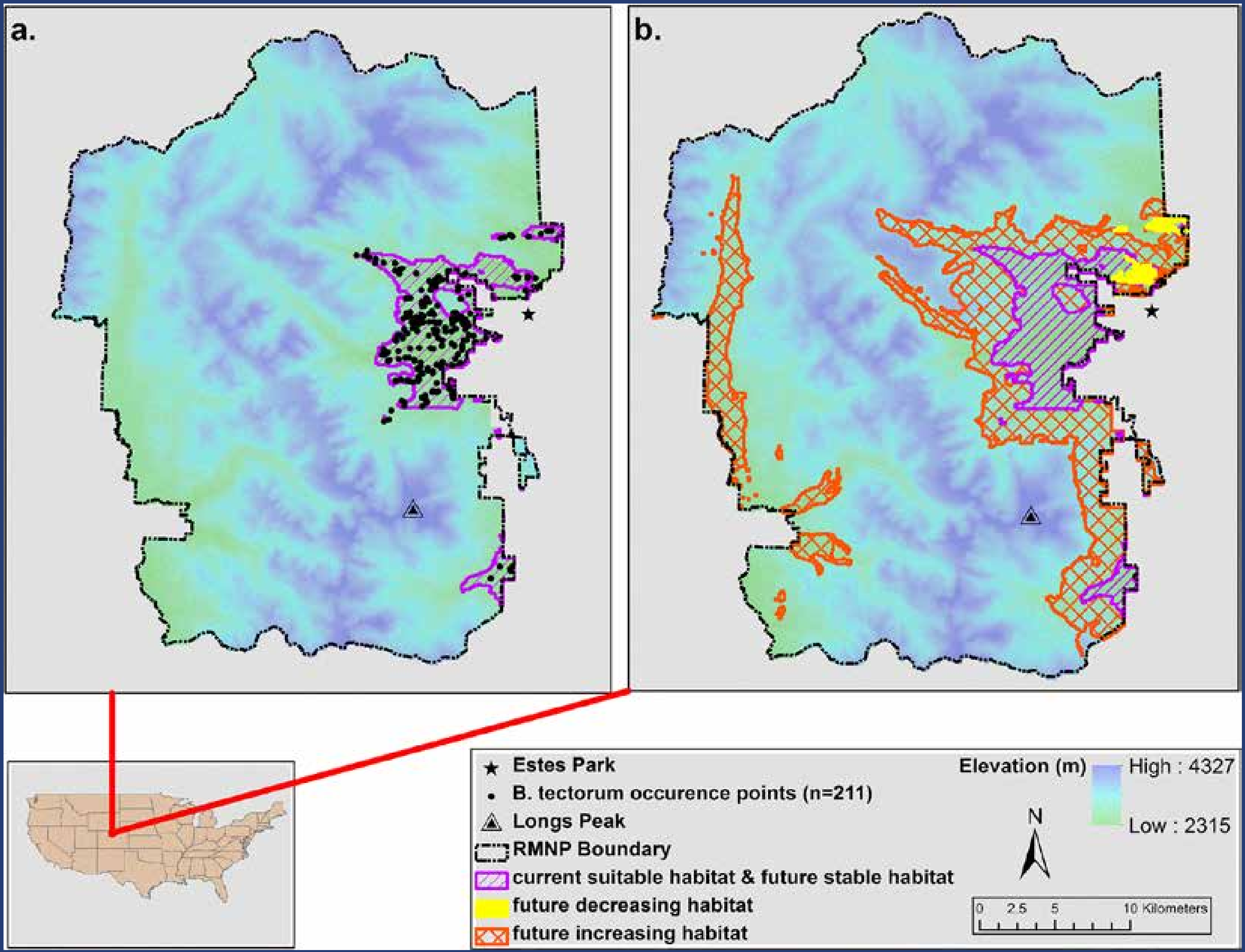
Global change & plant invasion

- As with natives
  - Winners and losers
  - Range shifts



Bradley et al. 2009
Global Change Biology 15:1511

Cheatgrass in Rocky Mtn. Natl. Park



West et al. 2015, PLoS One

Global change & plant invasion

- As with natives
  - Winners and losers
  - Range shifts
- Invasives may be favored over natives
  - Invasive species are good at dealing with novel environments

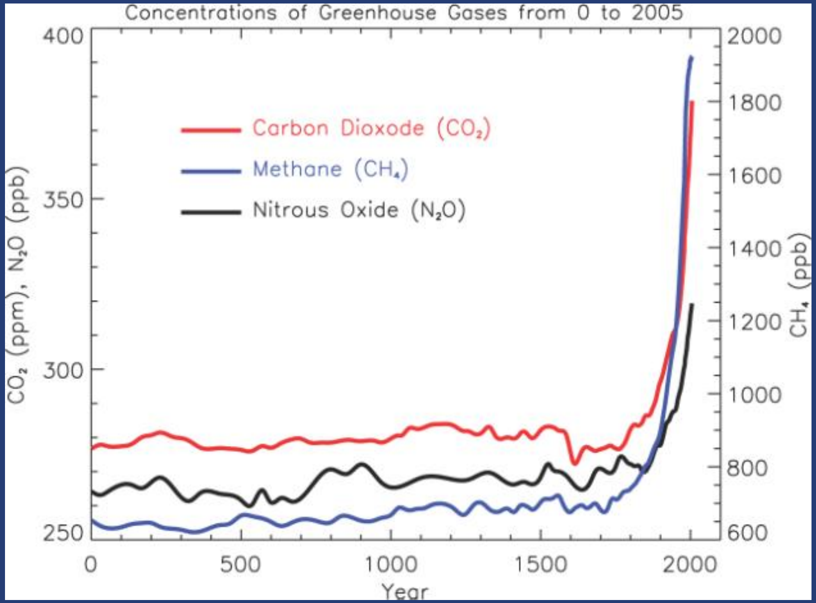
Dukes and Mooney 1999, TREE, 14:135

Bradley et al. 2010, TREE, 25:310-318

Photo by Dan Cariveau

Global change & plant invasion

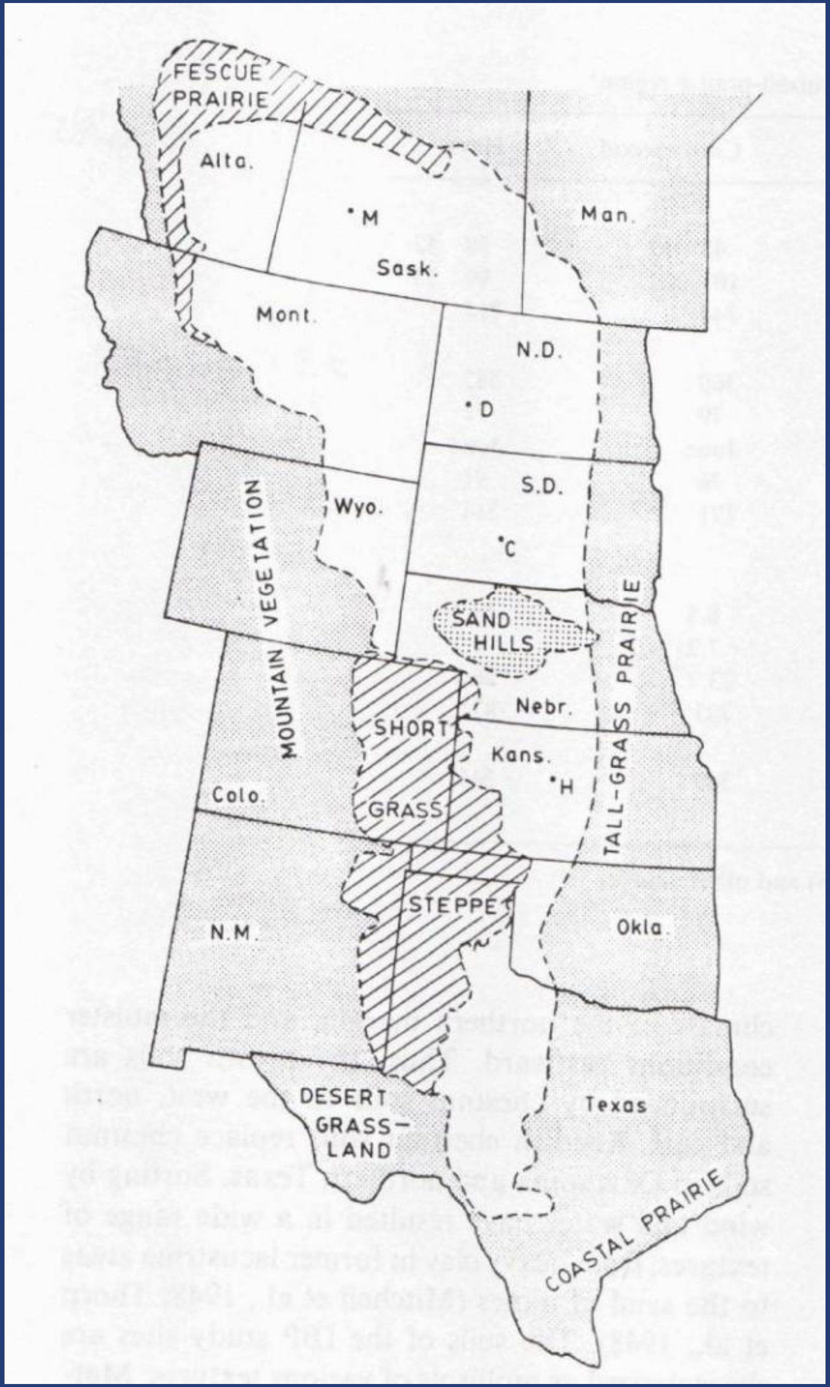
- As with natives
  - Winners and losers
  - Range shifts
- Invasives may be favored over natives
  - Invasive species are good at dealing with novel environments
  - Increases in resource availability: CO_2, N, Land use change, Fire



IPCC Working Group I Report, Chapter 2, 2007

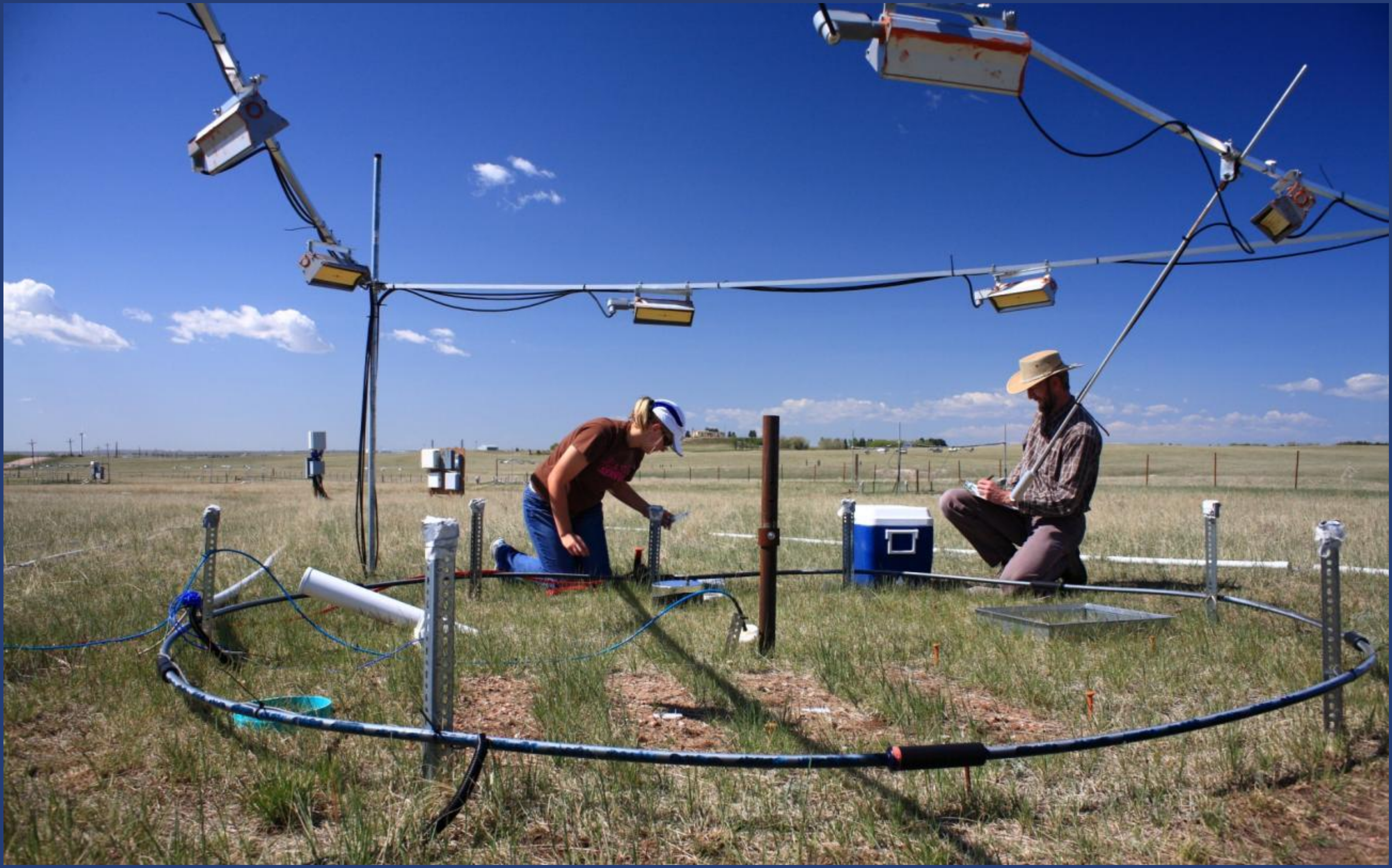
Davis et al. 2000, J. Ecol. 88:528

Mixed-grass prairie



Coupland 1992

Elevated CO_2 and Warming

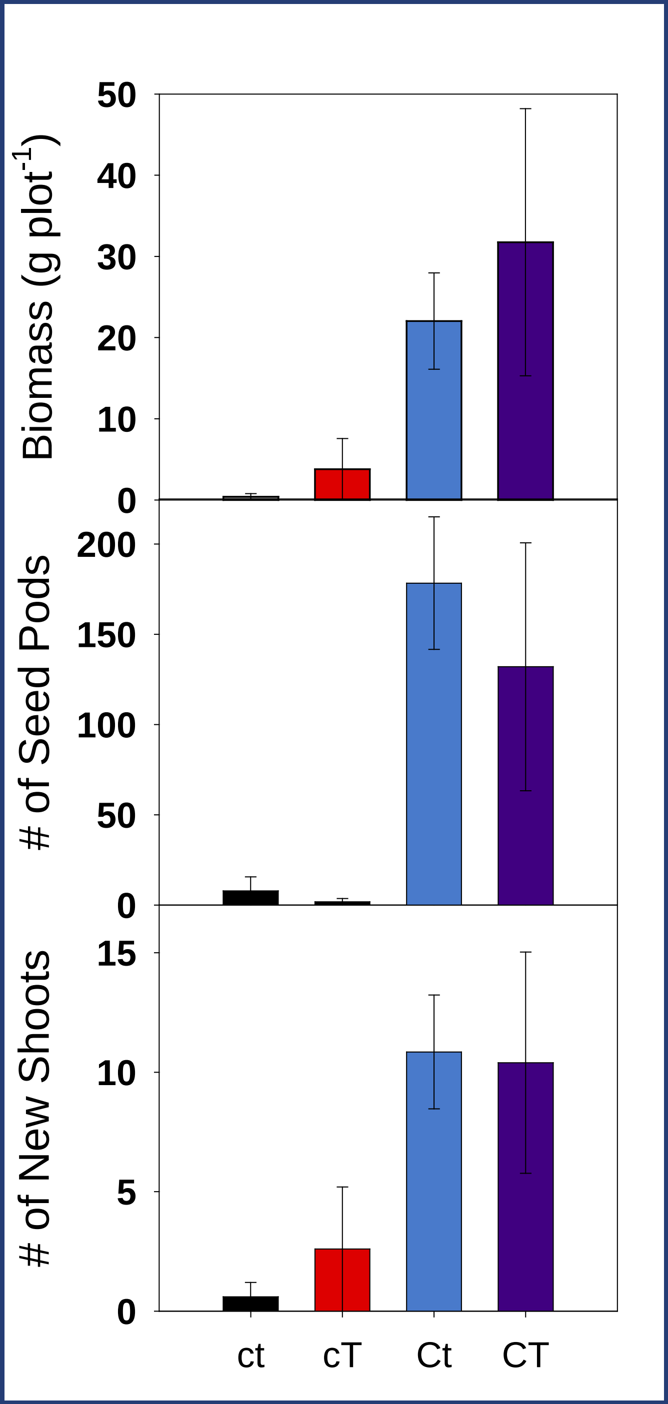


Morgan et al. 2011, Nature 476:202-205

Prairie Heating and CO_2 Enrichment - PHACE

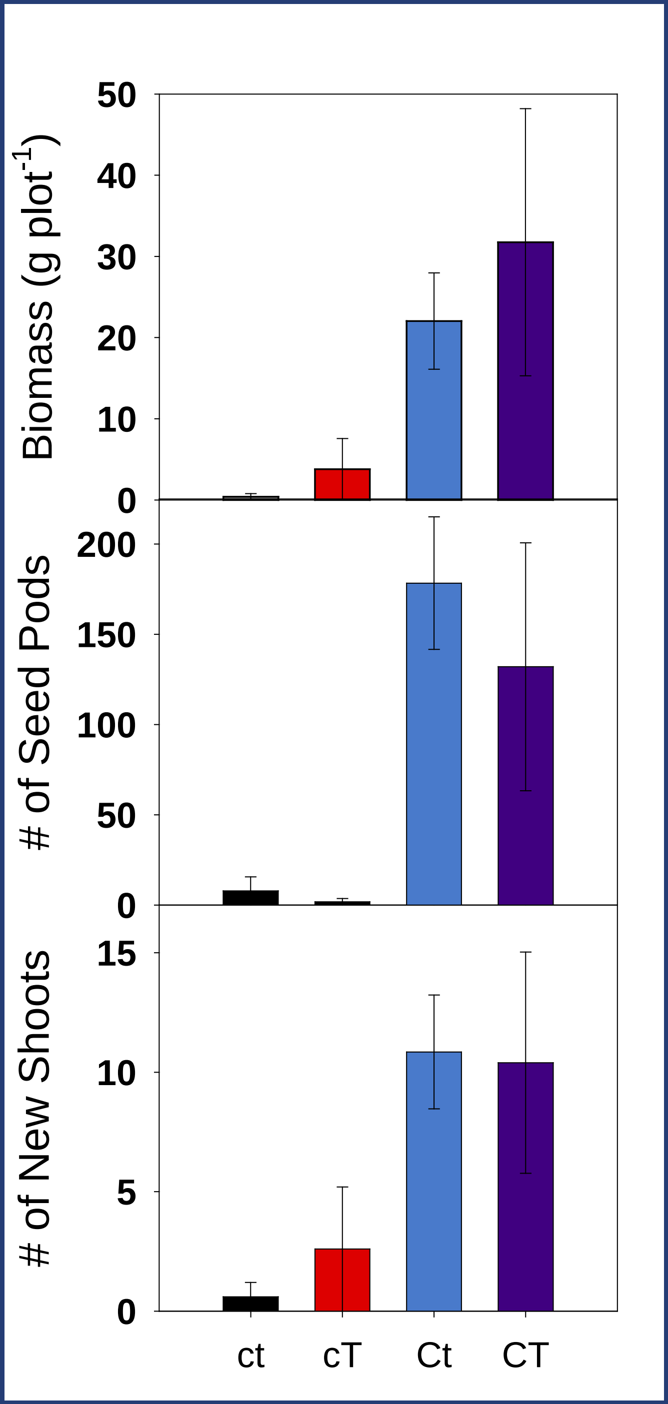
5 Reps: Control, +CO_2, +T, +CO_2 & +T

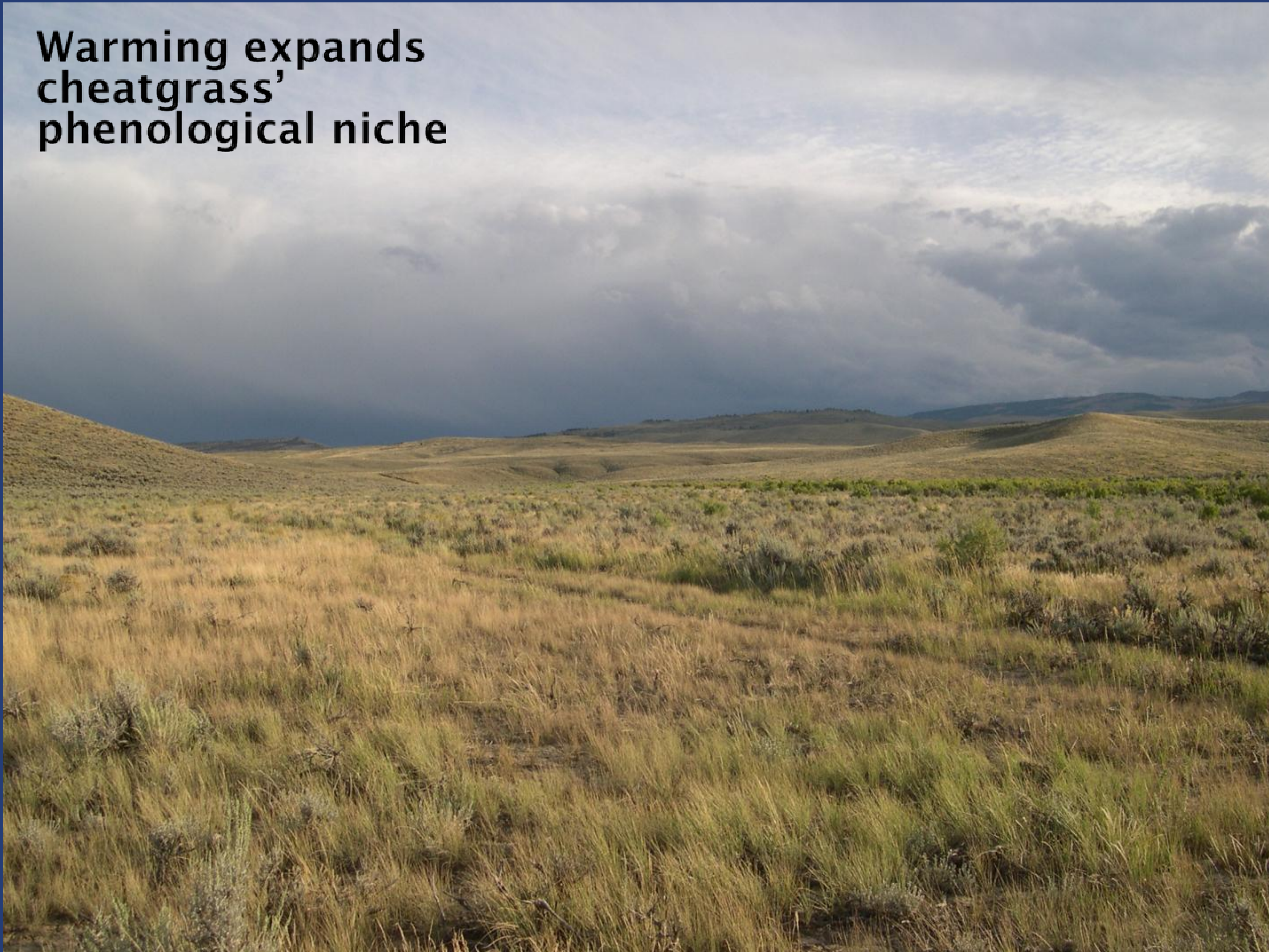
CO_2 increases toadflax biomass 13-fold



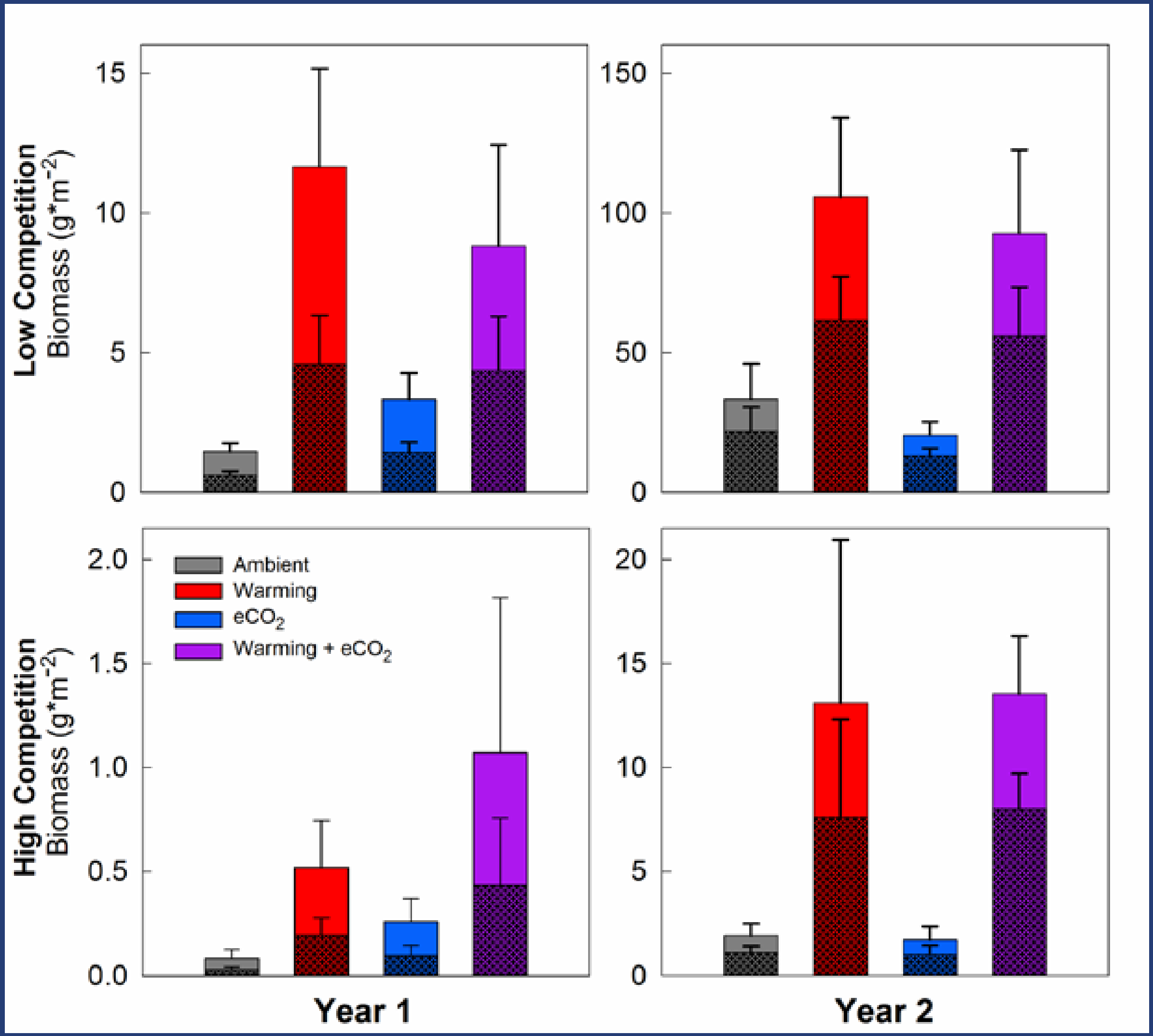
Conclusion

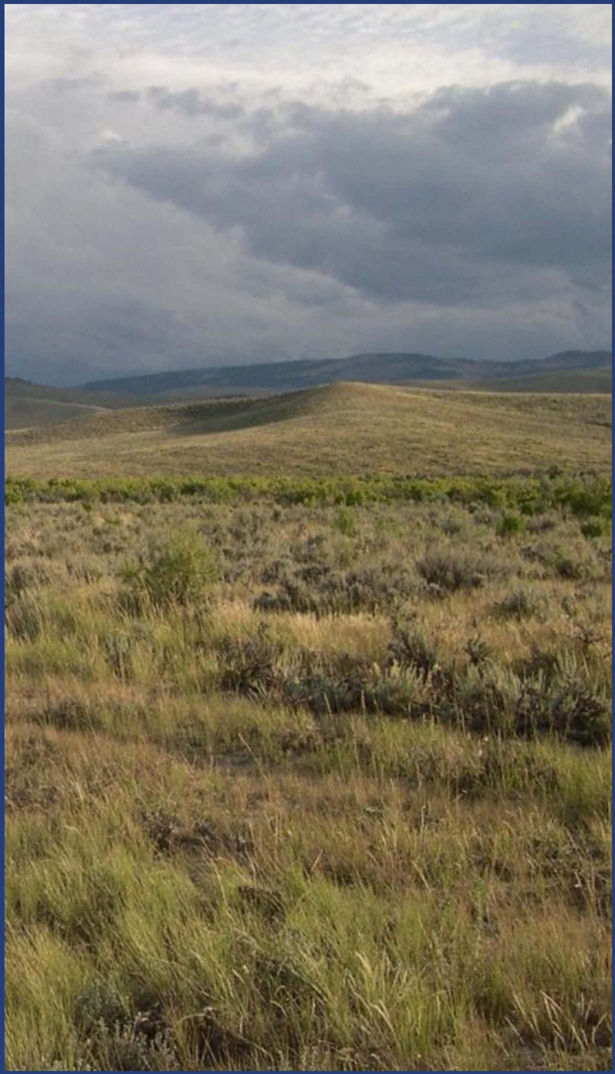
CO_2 increases two resources, C and water, and may often increase invasion in semi-arid ecosystems



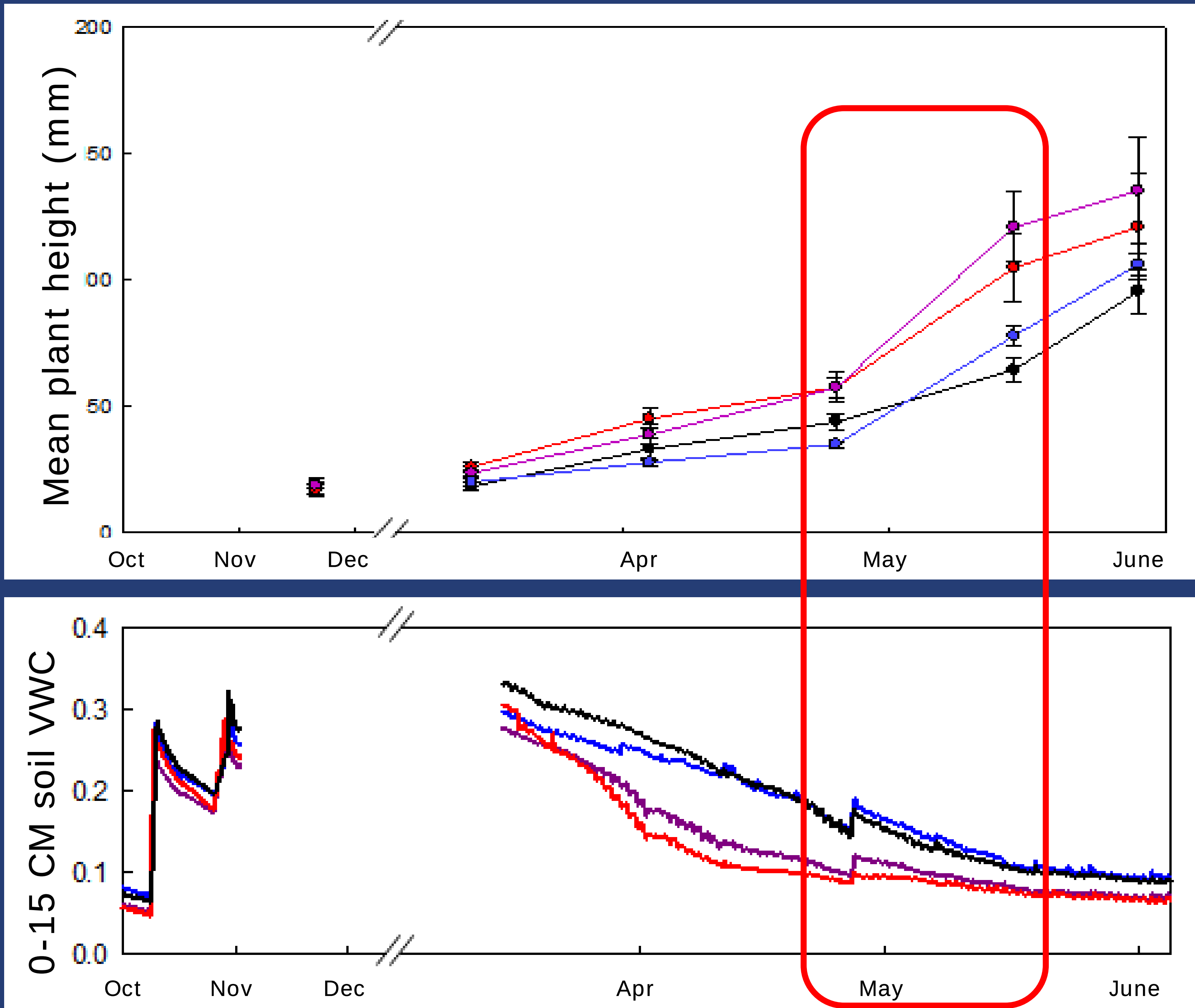

Warming expands
cheatgrass'
phenological niche

Warming increases cheatgrass biomass and seed set 4-fold

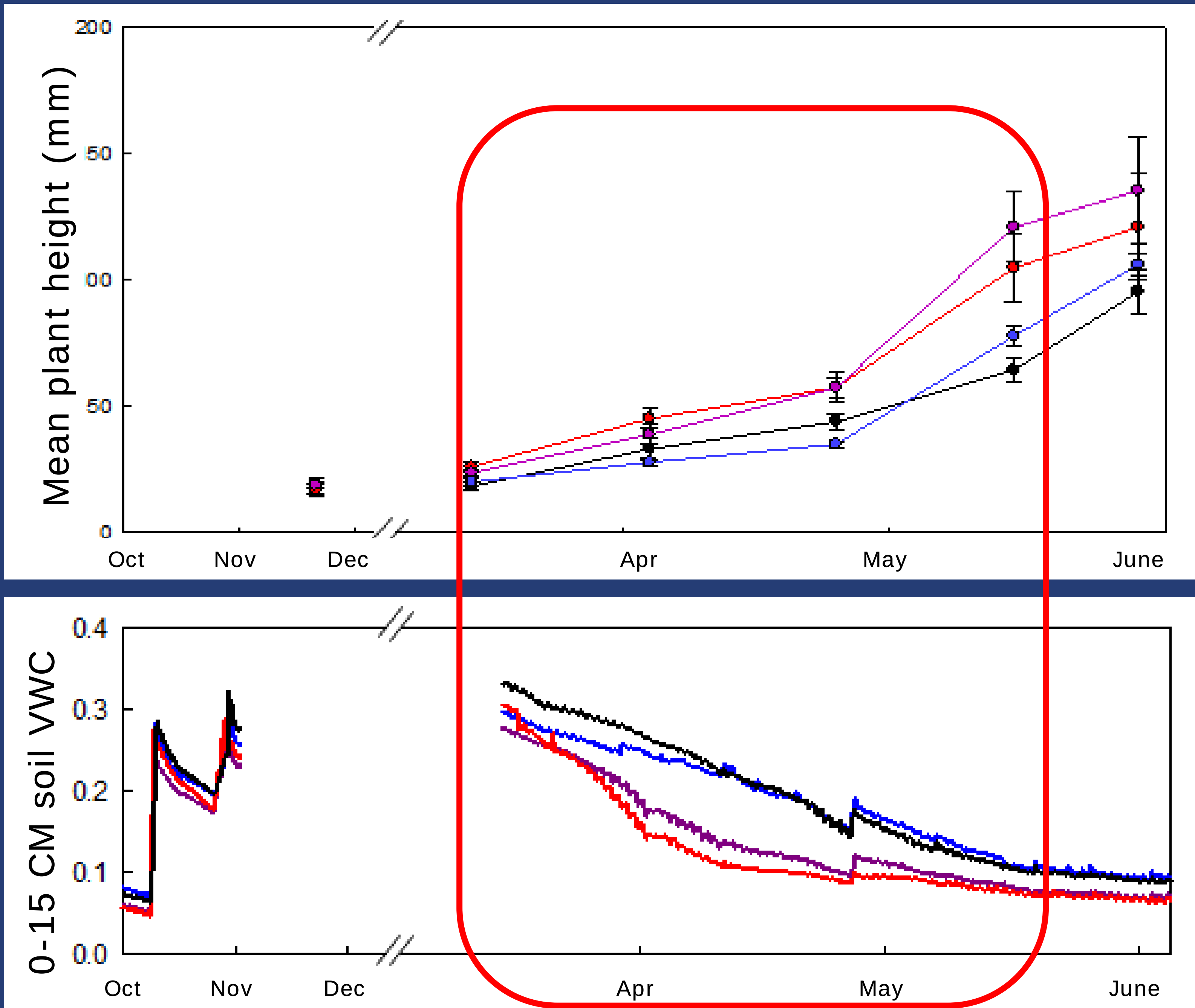




Blumenthal et al. 2016, GCB 22:3026



Mean plant height (mm)
200
50
00
50
0
Oct
Nov
Dec
Apr
May
June
0-15 CM soil VWC
0.4
0.3
0.2
0.1
0.0
Oct
Nov
Dec
Apr
May
June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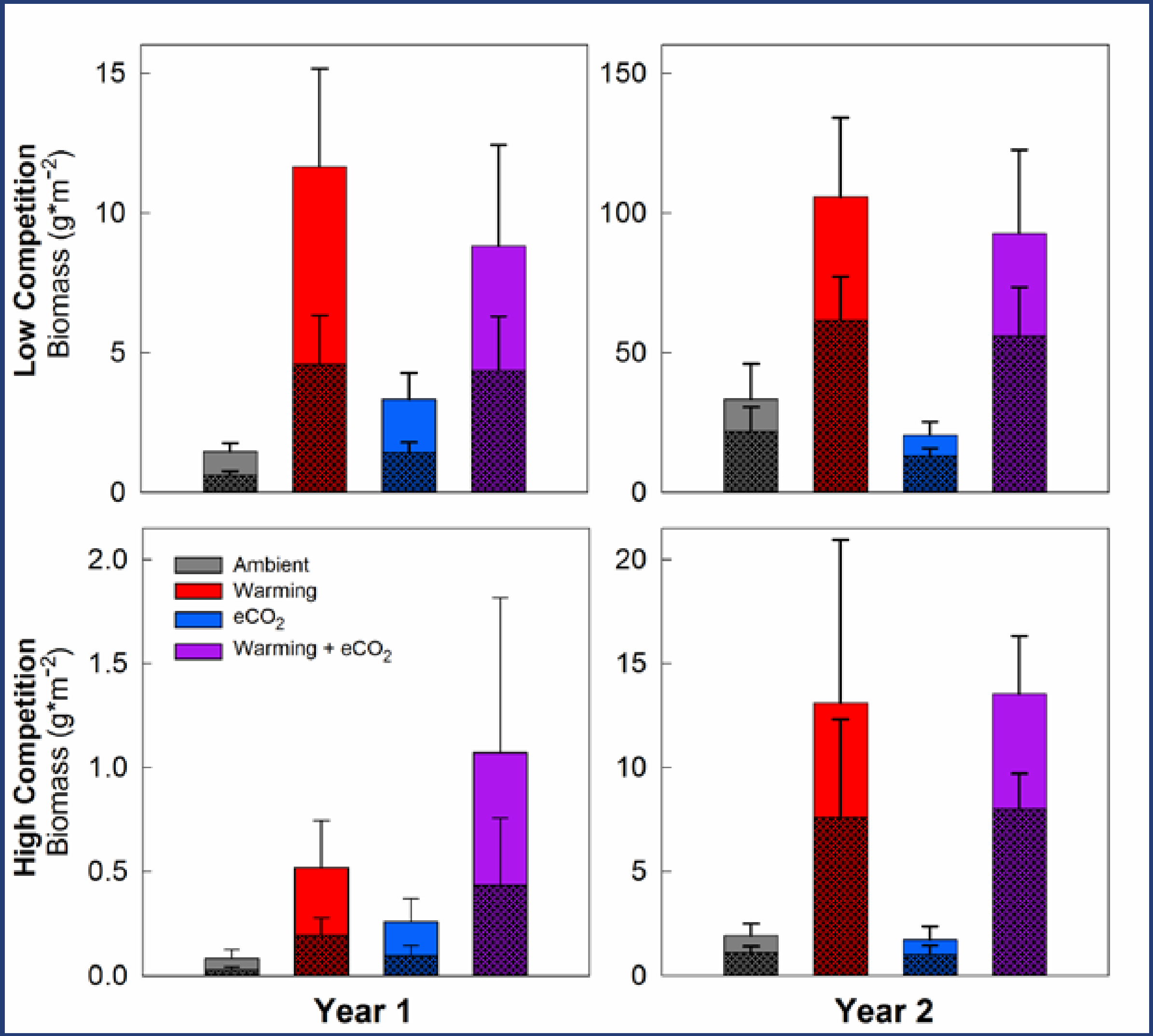

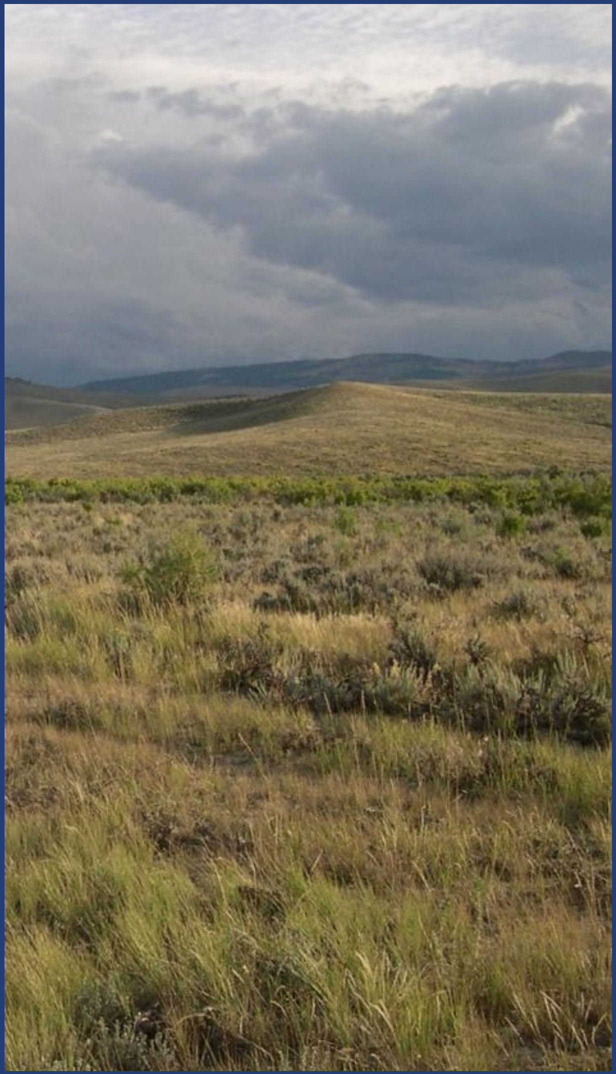

Blumenthal et al. 2016, GCB 22:3026

Solutions

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  - Healthy native communities = biotic resistance. Focus on species that thrive under future climatic conditions.

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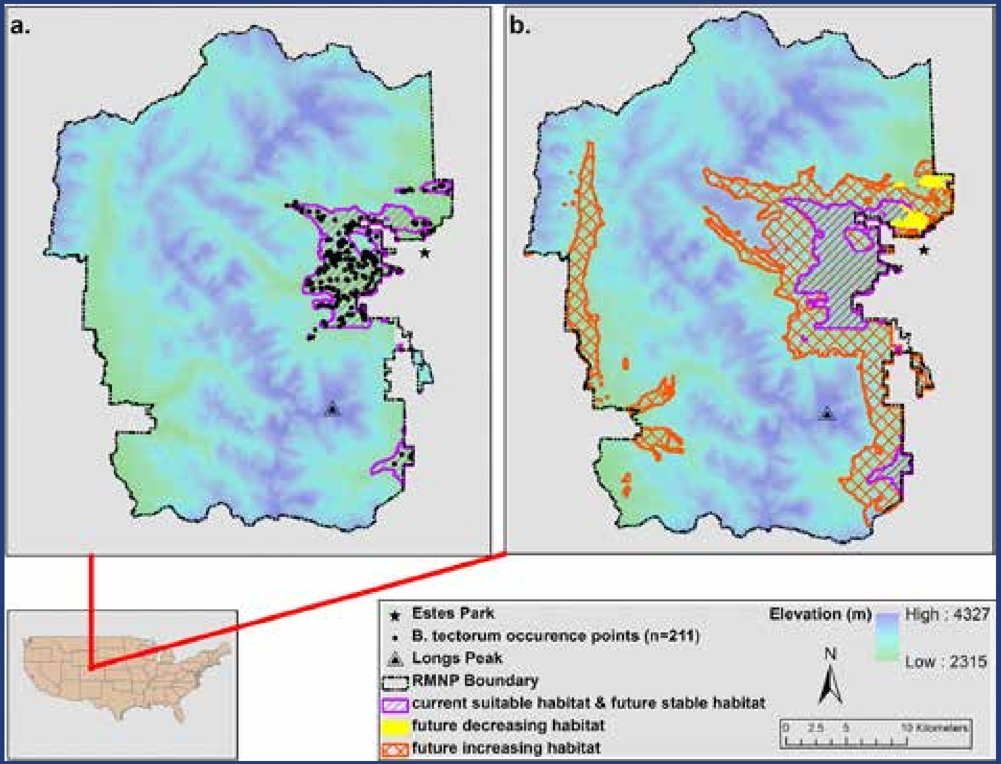

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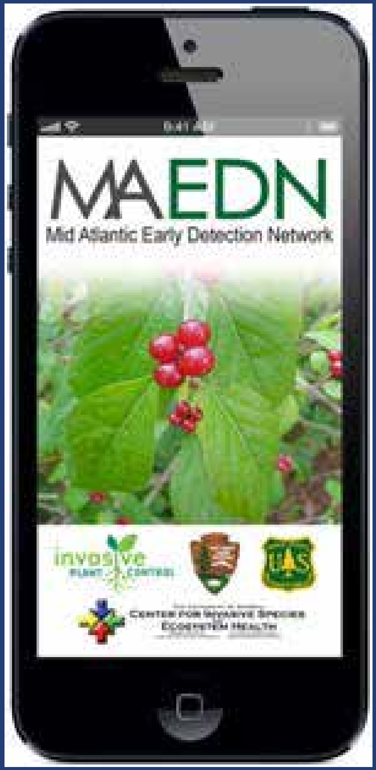
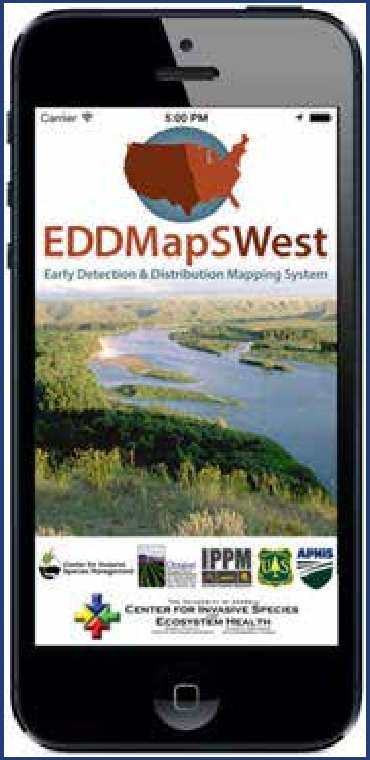




Solutions

- Slow Climate Change.
- Work with the new climates:
  - Healthy native communities = biotic resistance. Focus on species that thrive under future climatic conditions.
- Early detection: Watch for species moving north and up.
- Rapid response: Control invaders before they spread.

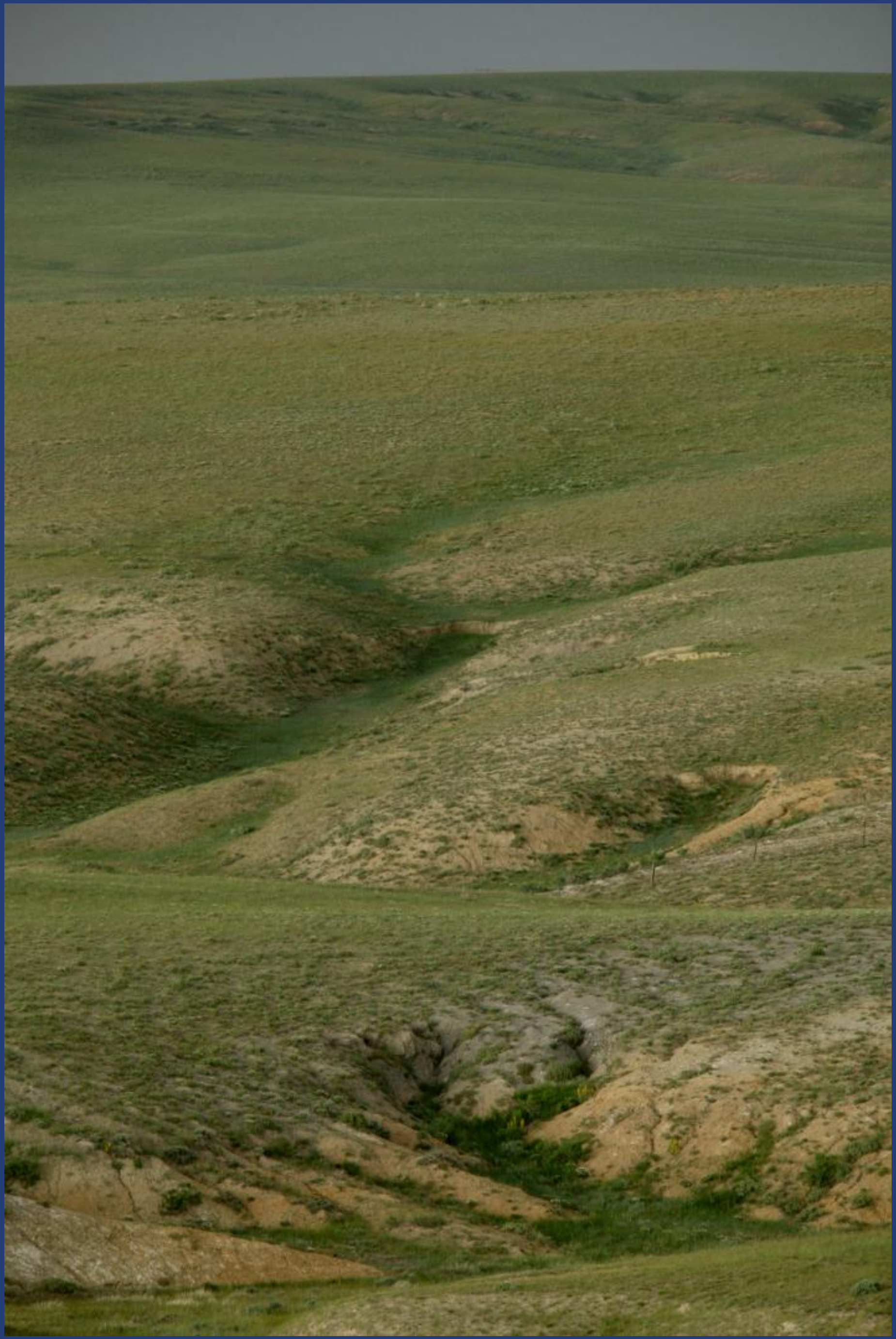
http://treebaltimore.org/weed-of-the-season-kudzu/#.We9vH2hSzqY

Many thanks to

Collaborators: David Augustine, Emma Bladyka, Rod Chimner, Justin Derner, Erik Hardy, Julie Kray, Dan LeCain, Jack Morgan, Elise Pendall, Lauren Porensky, Victor Resco, Benjamin Schiltz, David Smith, Mitch Stephenson, Jeff Welker, David Williams.

Photographers: Steve Asmus, Dan Cariveau, Sam Cox.

Field Assistants: Caitlin Brooks, Julie Bushey, Megan Busick, Brenda Castlemain, Laura Dev, Megan Dudley, Ally Eden, Joe Henderer, Sarah Hylander, Caitlin May, Kristen Oles, Jennifer Regier, Seth Romero, Steve Tekell, Stacy Wetherelt.



Conclusions

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- Very little good news – Across global changes, species and years, invasive plants were generally more successful in competition with natives.
- Water often mediates global change effects on invasion.
  - Snow addition increases invasion (also summer irrigation)
  - Increases in atmospheric CO_2 increase invasion.
    - Less conservative water use may make invasive plants well suited for wetter environments.
    - CO_2 may have particularly strong effects by increasing C and water.
  - Warming can inhibit invasion under dry conditions.

Conclusions

- Very little good news – Across global changes, species and years, invasive plants were generally more successful in competition with natives.
- Water often mediates global change effects on invasion.
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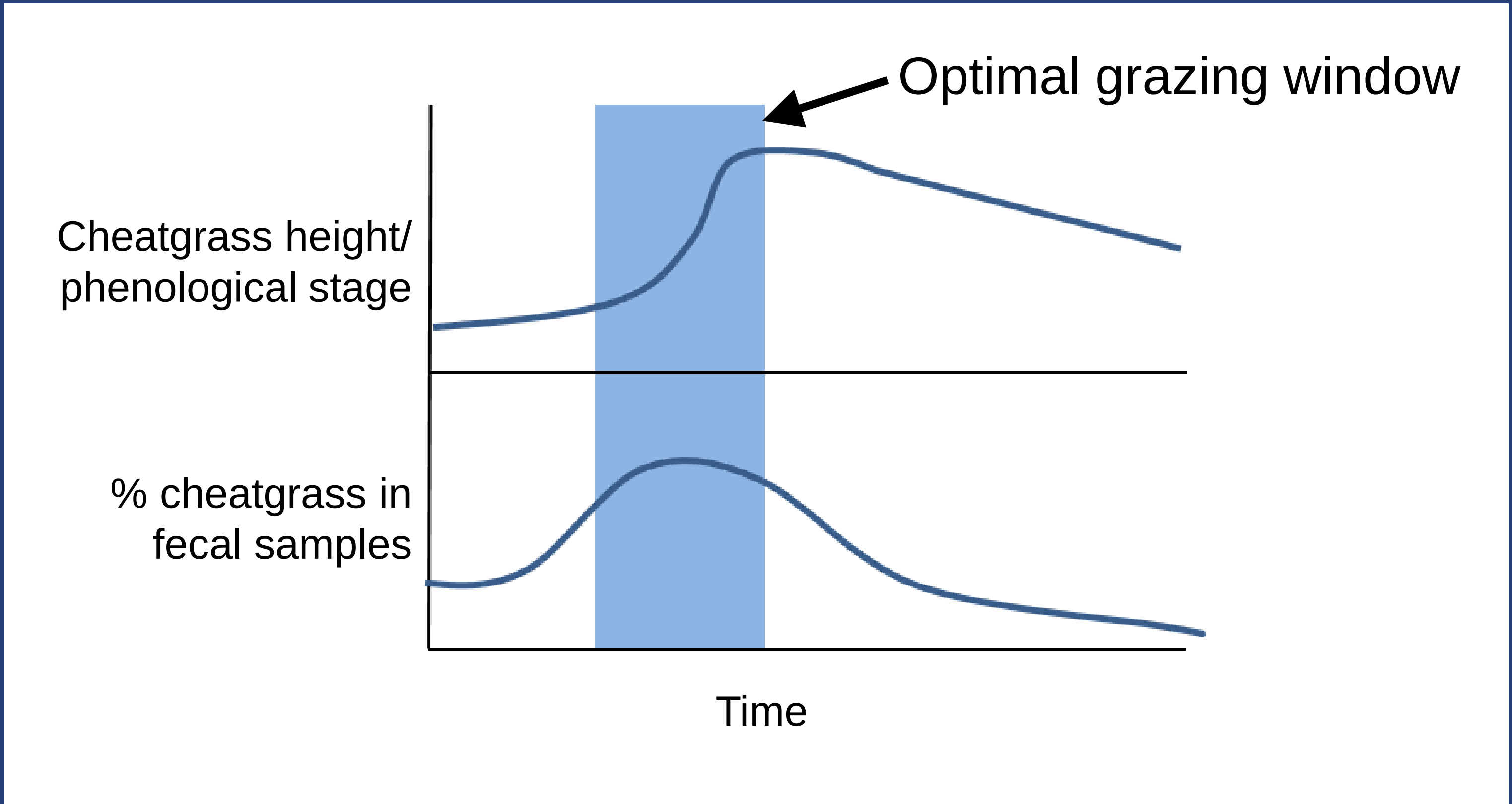
    - Less conservative water use may make invasive plants well suited for wetter environments.
    - CO_2 may have particularly strong effects by increasing C and water.
  - Warming can sometimes inhibit invasion under dry conditions.
- But it's not ALL about water:
  - Warming favors cheatgrass by expanding its phenological niche.
  - N deposition facilitates invasion; N limitation precludes CO_2 effect on cheatgrass

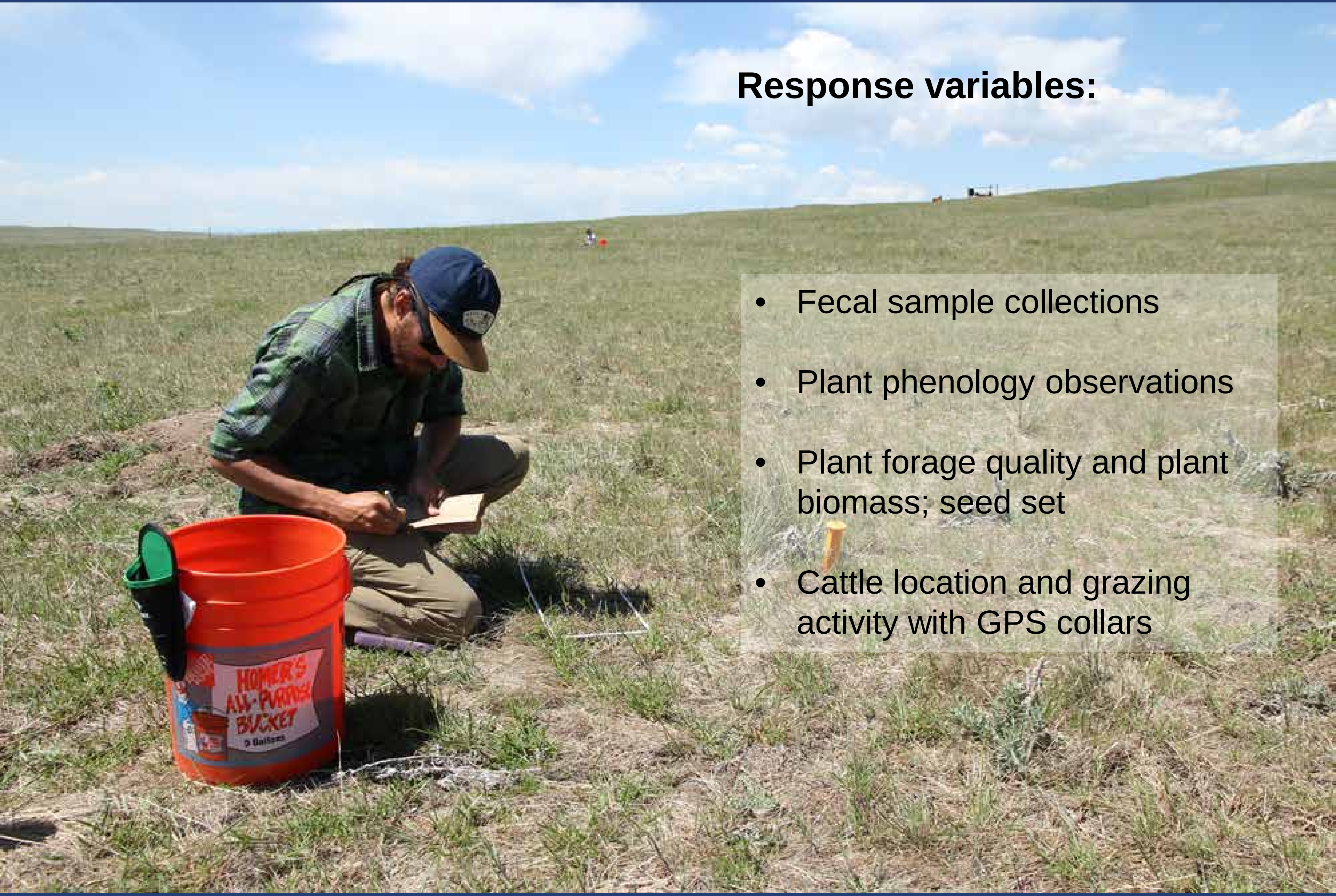
Making use of warmer springs - Targeted grazing

When will cows select cheatgrass?



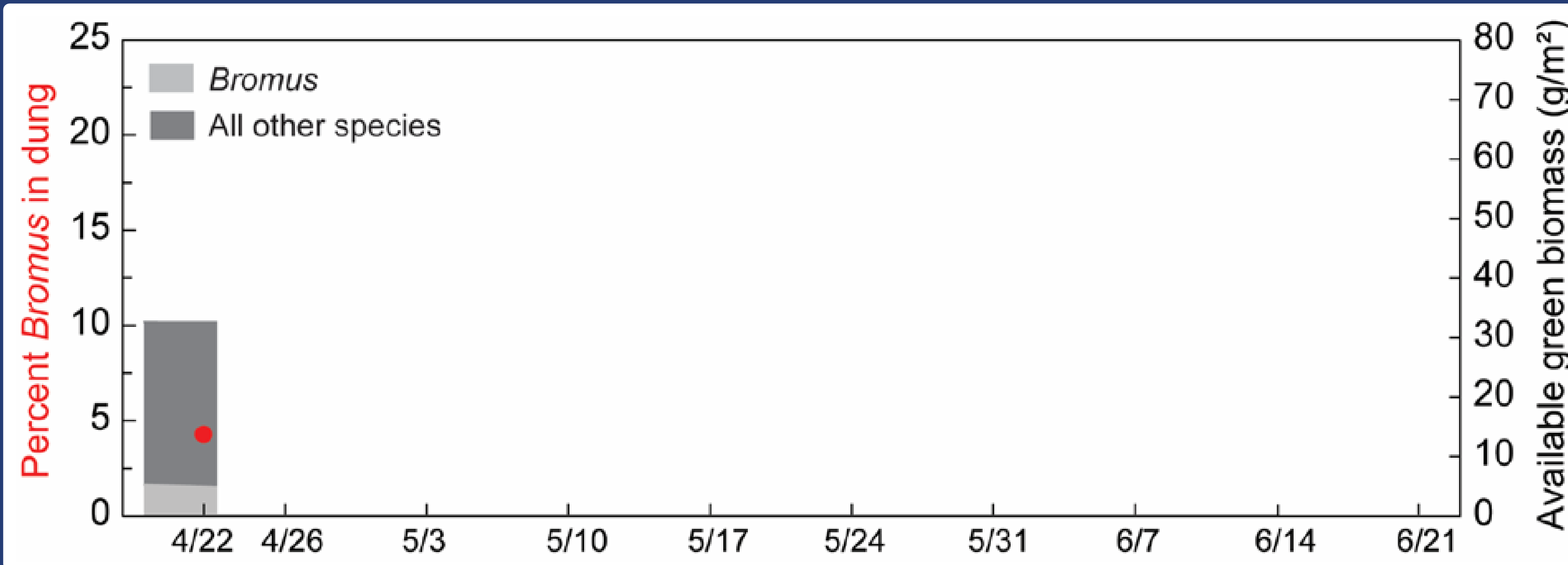

6/2014
858 ft
Tour Guide
1994
Imagery Date: 6/19/2014
41°12'55.21" N 104°51'29.53" W elev 6347 ft
eye alt 9237 ft
Google earth


154 m
Tour Guide
1994
Imagery Date: 6/19/2014 13 T 512090.64 m E 4562372.96 m N elev 1932 m eye alt 2.59 km
Google earth
N



Response variables:

- Fecal sample collections
- Plant phenology observations
- Plant forage quality and plant biomass; seed set
- Cattle location and grazing activity with GPS collars


Percent *Bromus* in dung
Available green biomass (g/m²)
Bromus
All other species
25
20
15
10
5
0
80
70
60
50
40
30
20
10
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4/22
4/26
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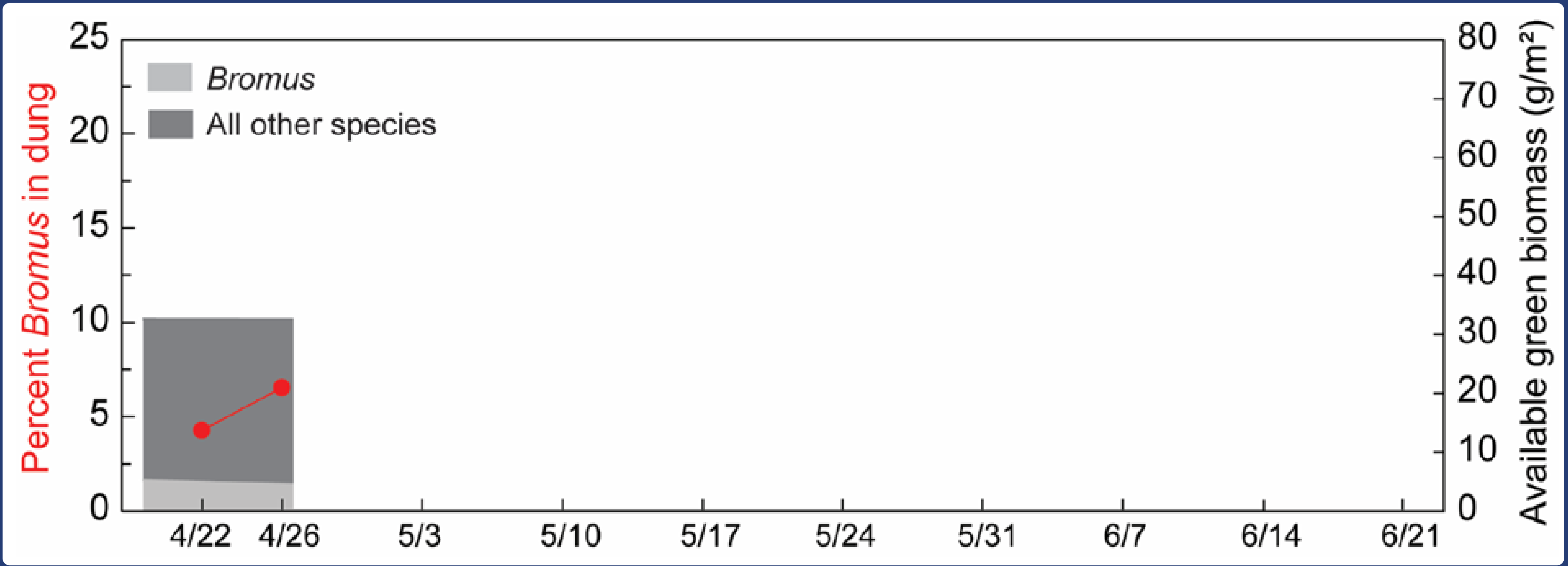
6/7
6/14
6/21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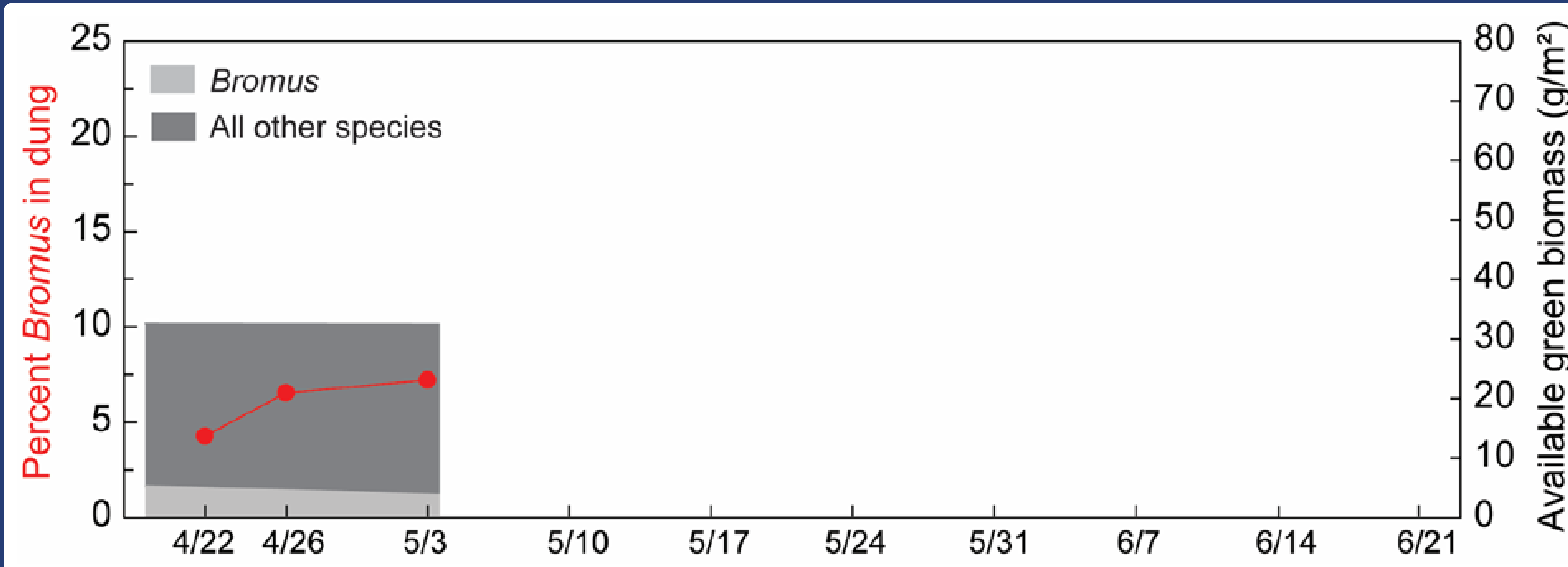
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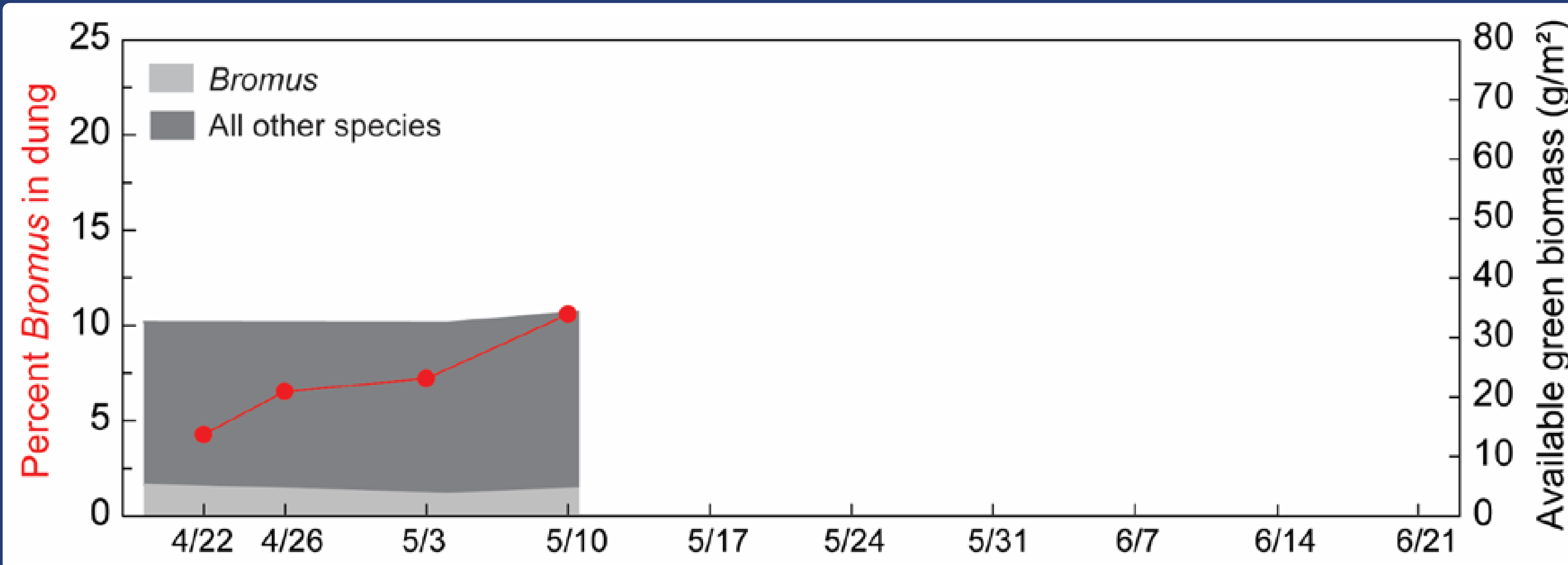
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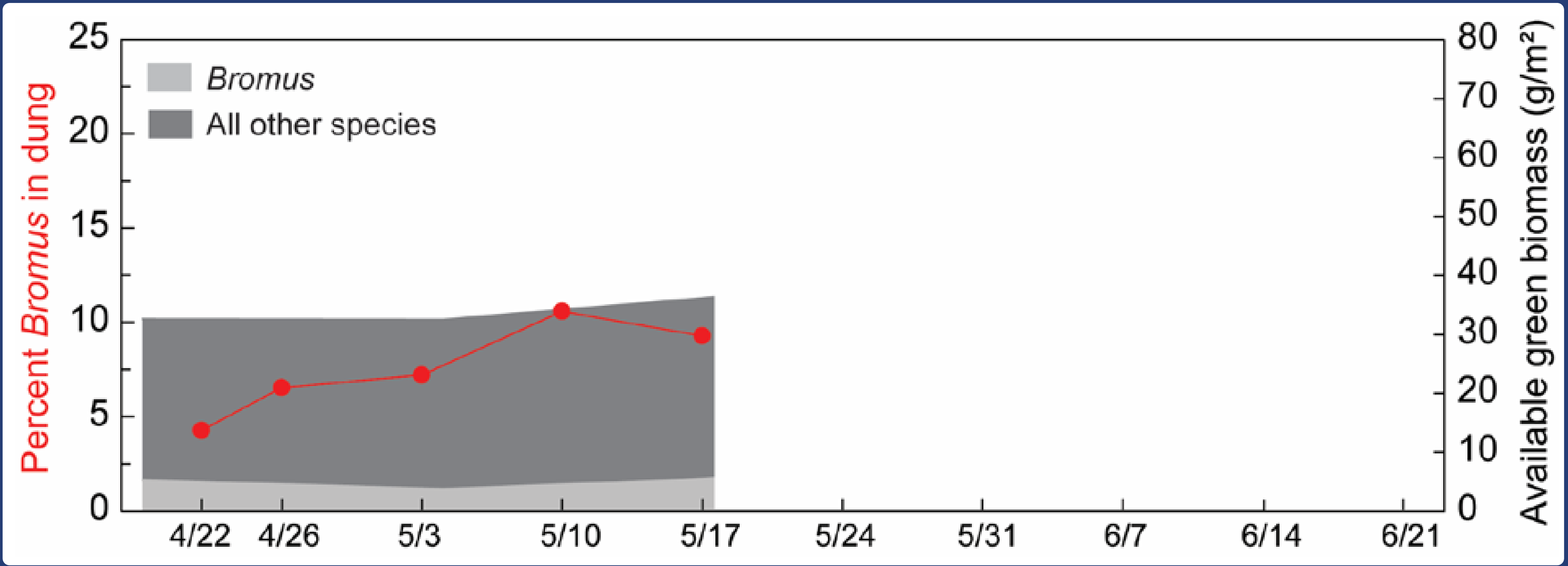
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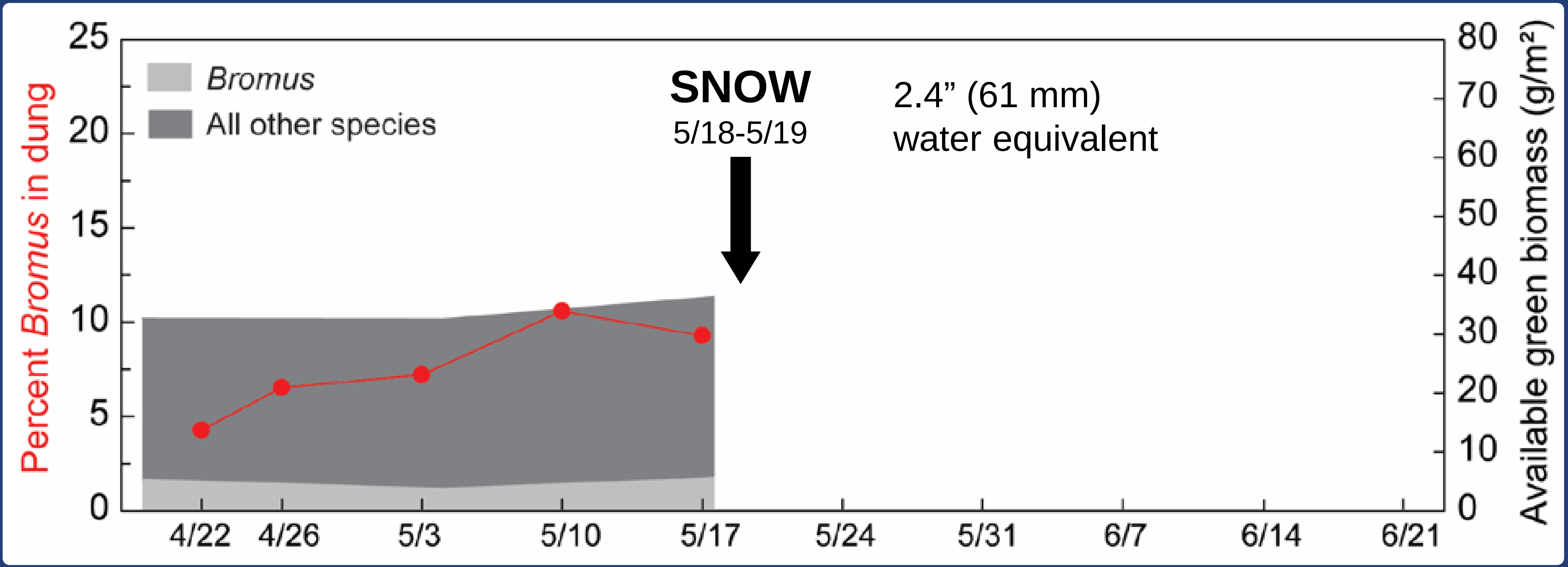
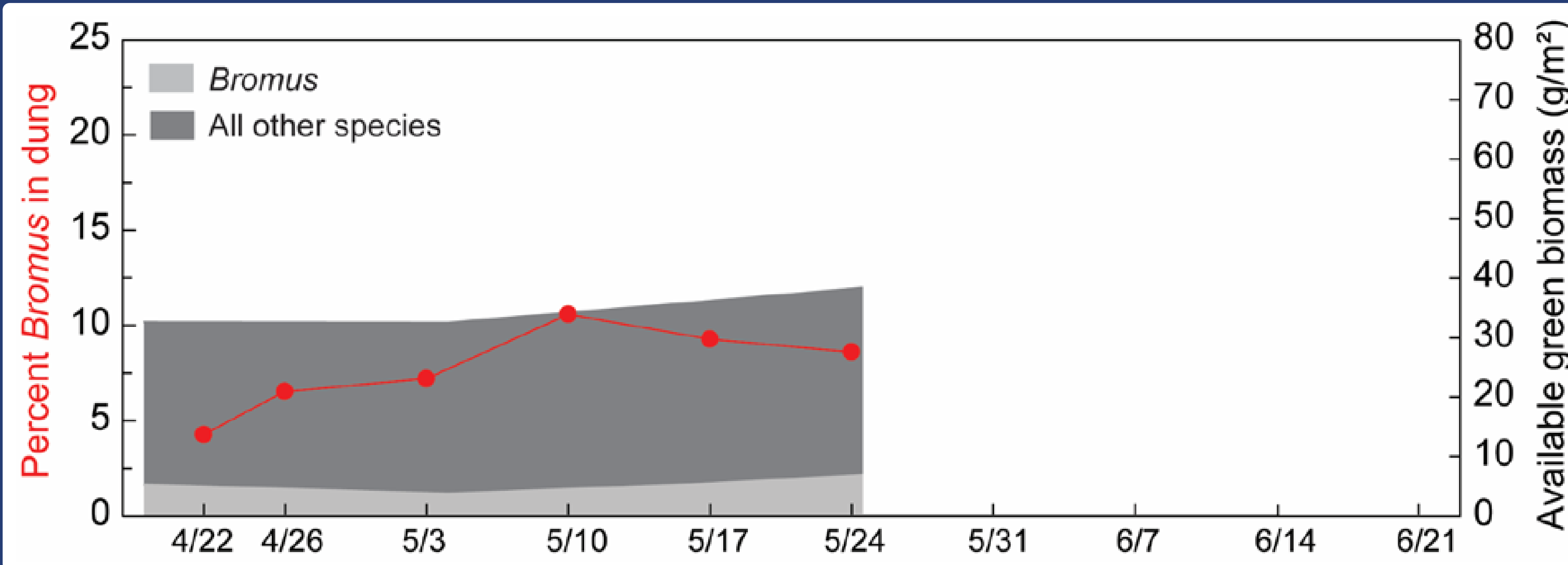
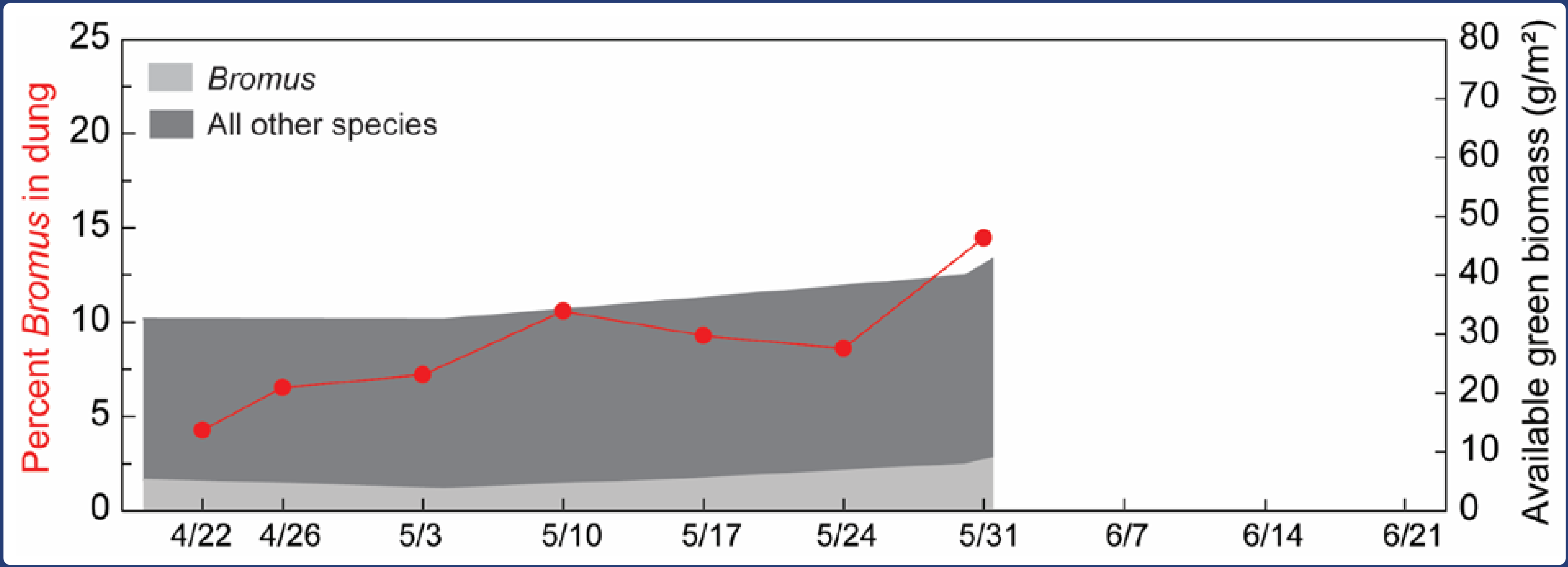
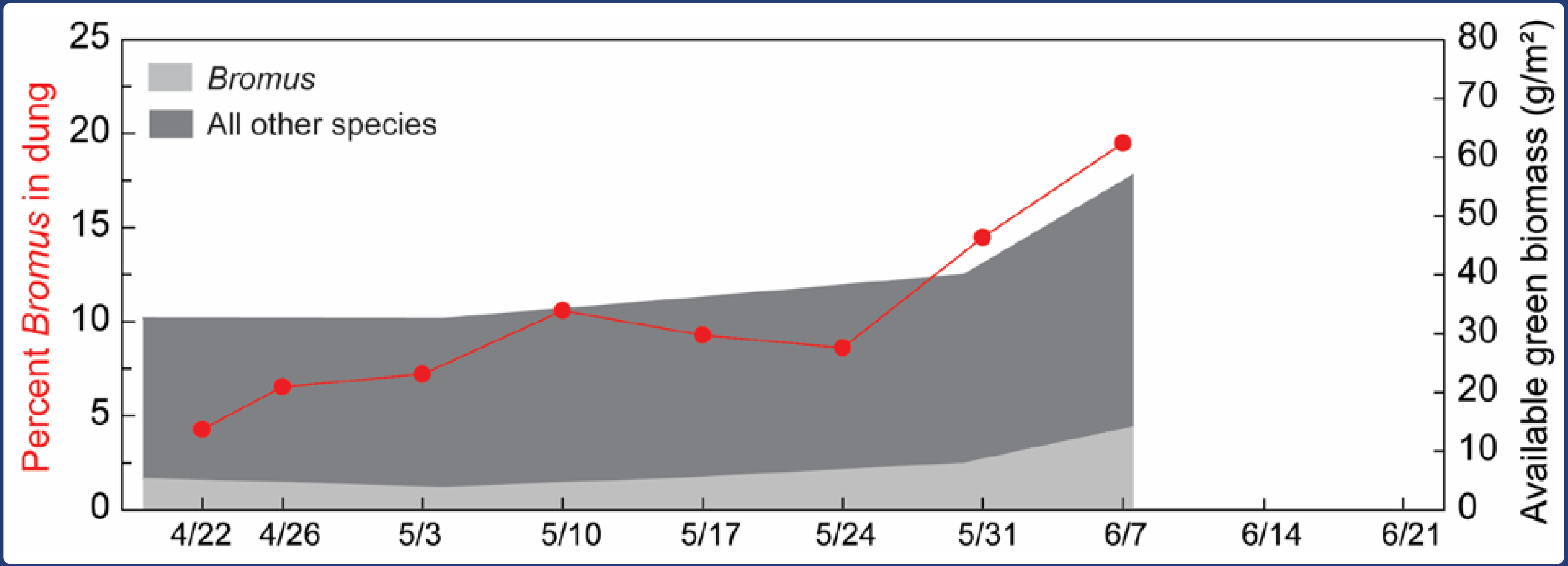
6/14
6/21



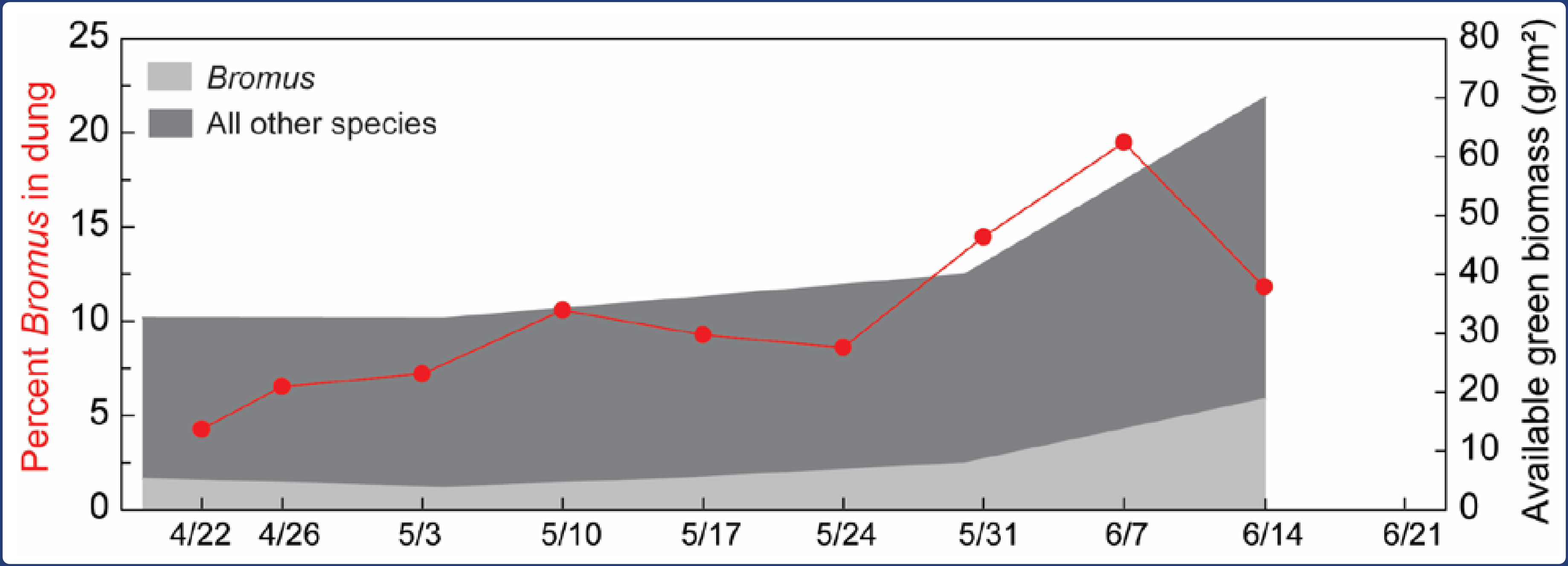
Bromus
All other species
SNOW
5/18-5/19
2.4” (61 mm)
water equivalent
Percent Bromus in dung
Available green biomass (g/m²)
25
20
15
10
5
0
80
70
60
50
40
30
20
10
0
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21

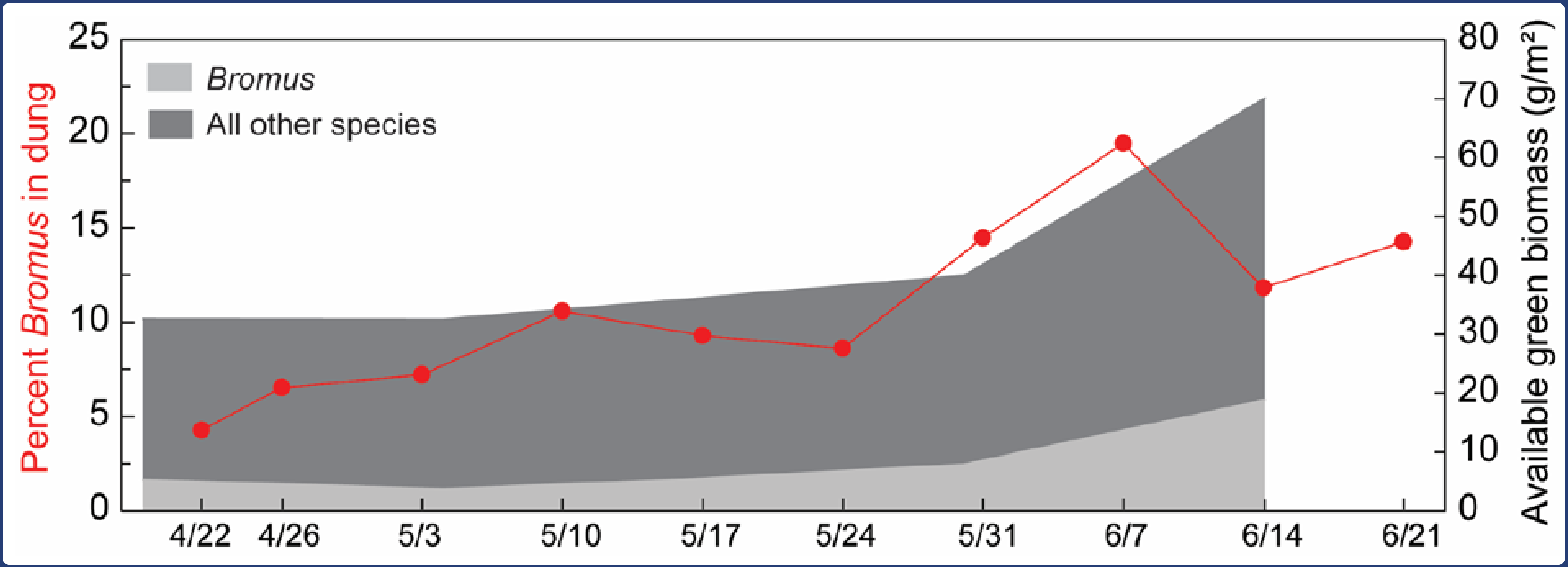

Bromus
All other species
Percent Bromus in dung
Available green biomass (g/m²)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21


25
20
15
10
5
0
Percent Bromus in dung
Bromus
All other species
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21
80
70
60
50
40
30
20
10
0
Available green biomass (g/m²)

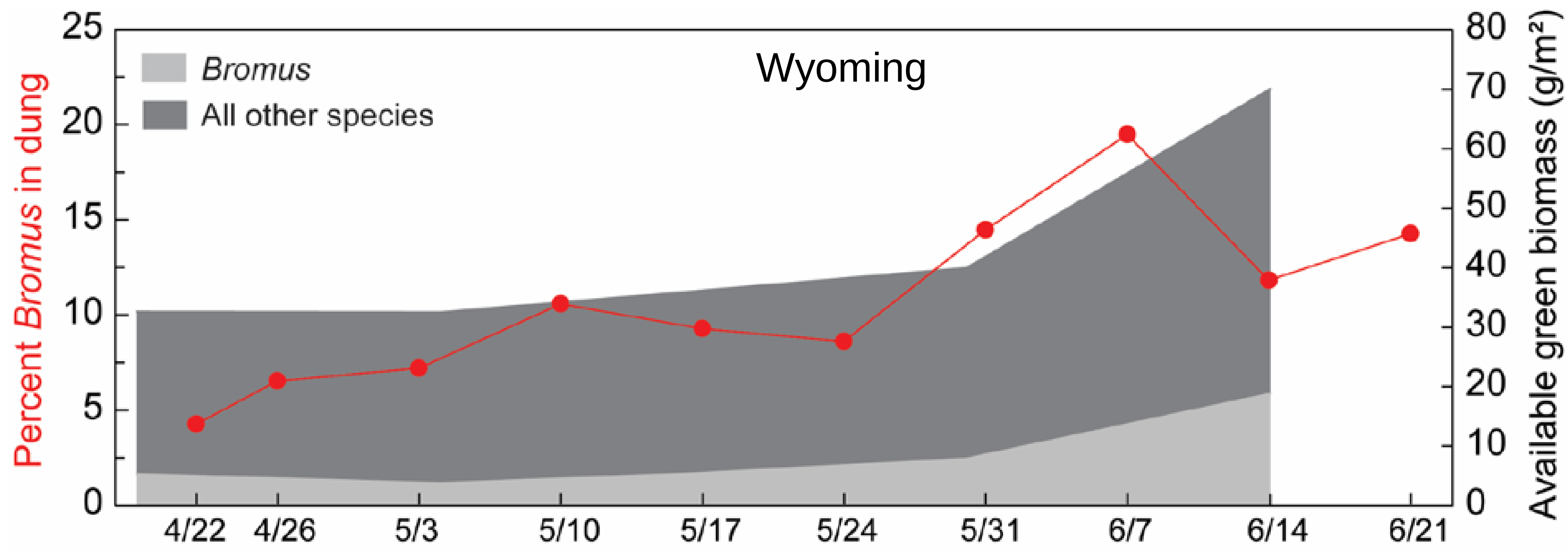


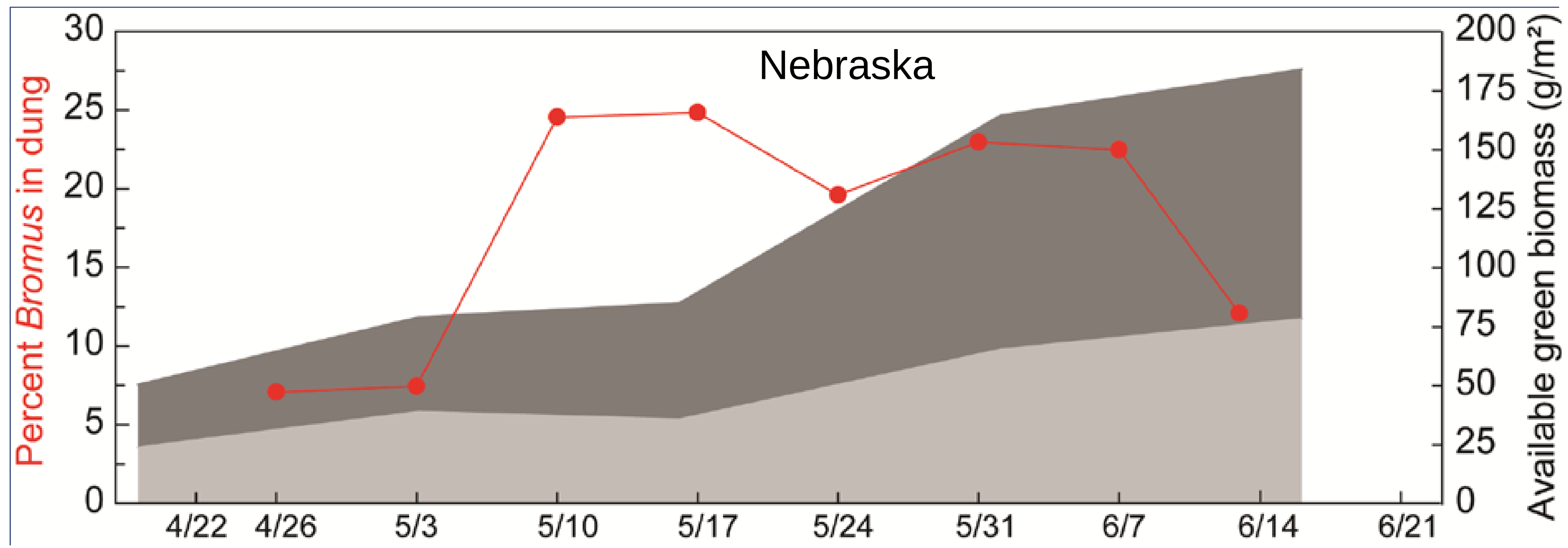
Bromus
All other species
Percent Bromus in dung
Available green biomass (g/m²)
25
20
15
10
5
0
80
70
60
50
40
30
20
10
0
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21

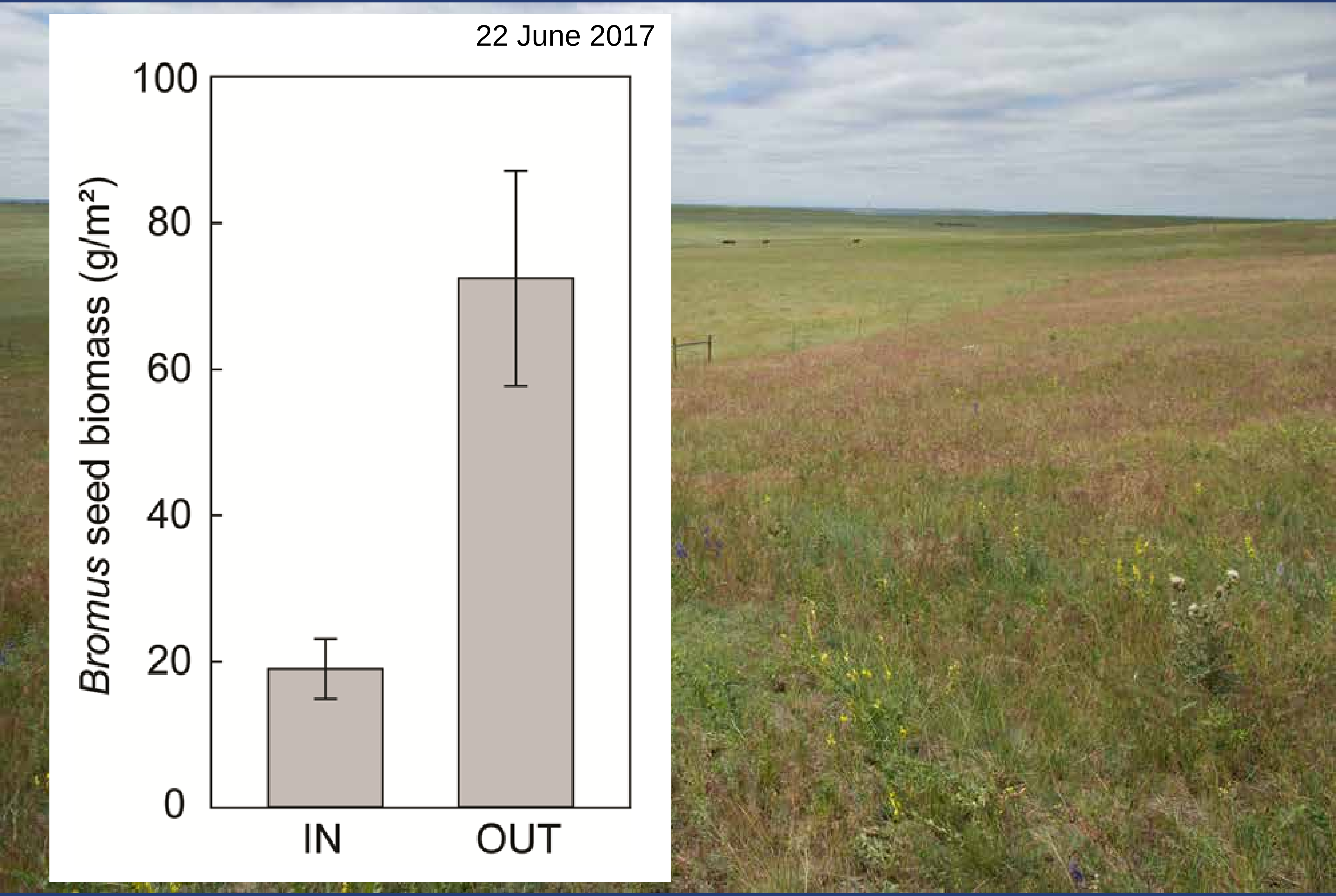

Bromus
All other species
Percent Bromus in dung
Available green biomass (g/m²)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21


Bromus
All other species
Percent Bromus in dung
Available green biomass (g/m²)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21

Nebraska site in 2016
with collaborators Mitchell Stephenson & Benjamin Schiltz (U Nebraska-Lincoln)


Wyoming
Bromus
All other species
Percent Bromus in dung
Available green biomass (g/m²)
25
20
15
10
5
0
80
70
60
50
40
30
20
10
0
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21


Nebraska
Percent Bromus in dung
Available green biomass (g/m²)
30
25
20
15
10
5
0
200
175
150
125
100
75
50
25
0
4/22
4/26
5/3
5/10
5/17
5/24
5/31
6/7
6/14
6/21


22 June 2017
Bromus seed biomass (g/m²)
100
80
60
40
20
0
IN
OUT

Many thanks to

Collaborators: David Augustine, Emma Bladyka, Rod Chimner, Justin Derner, Erik Hardy, Julie Kray, Lauren Porensky, Victor Resco, Benjamin Schiltz, David Smith, Mitch Stephenson, Jeff Welker, David Williams.

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