MID-CENTURY ANNUAL FORAGE PROJECTIONS

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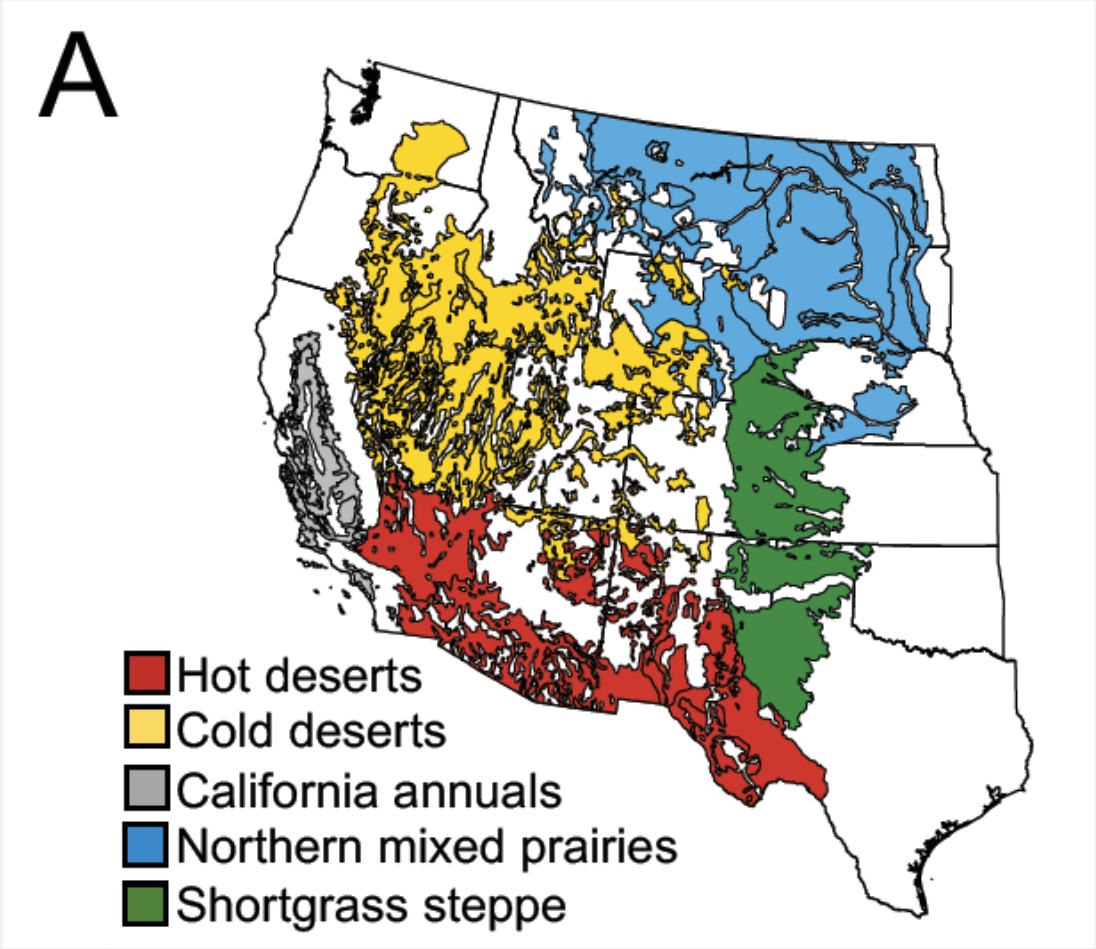
OUR APPROACH

- Used historical (1986-2015) satellite-based data of forage production and weather to build ecoregion specific statistical models of forage sensitivity to temperature and precipitation variability
- Fed projections from 11 different climate models through these statistical models to project mid-century changes to forage across western US rangeland sectors
- Focused on growing season weather



Limitations

- Models are based on *historical* relationships of forage and weather
- Potentially more 'pessimistic' because does not include other factors, such as CO2 fertilization

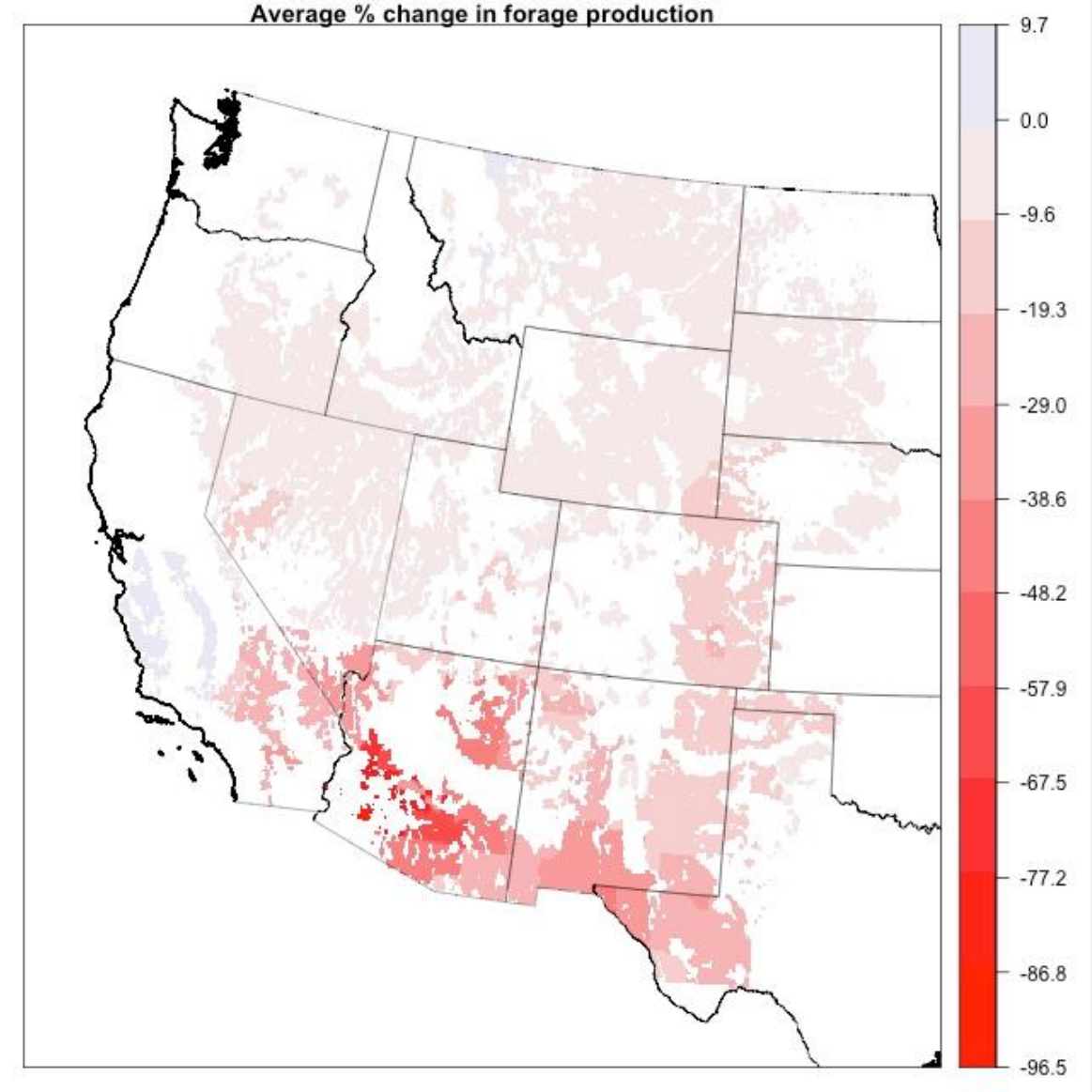
Forage data source
Robinson, Nathaniel P., et al. "Rangeland Productivity Partitioned to Sub-Pixel Plant Functional Types." *Remote Sensing* 11.12 (2019): 1427.

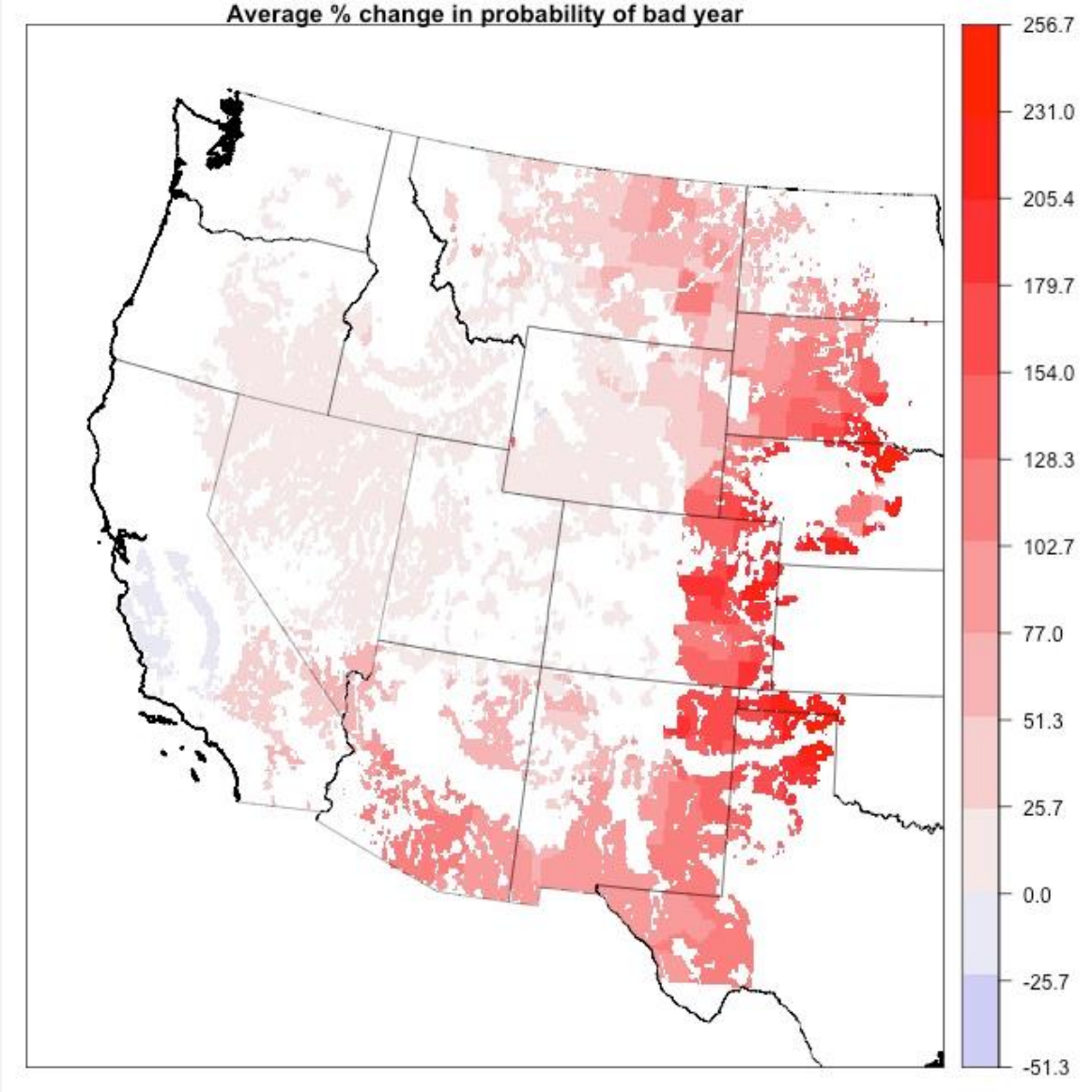
WHAT I WILL SHOW YOU

- Projections for mid-century % changes in average for production under a high emissions scenario (RCP 8.5)
- Projections of mid-century % changes in the probability of years of low forage production
  - Defined as a year with forage < 75% of historical mean*
- Maps show county-level aggregations of these projections

*Klemm, Toni, David D. Briske, and Matthew C. Reeves. "Vulnerability of Rangeland Beef Cattle Production to Climate-Induced NPP Fluctuations in the US Great Plains." *Global Change Biology* (2020).

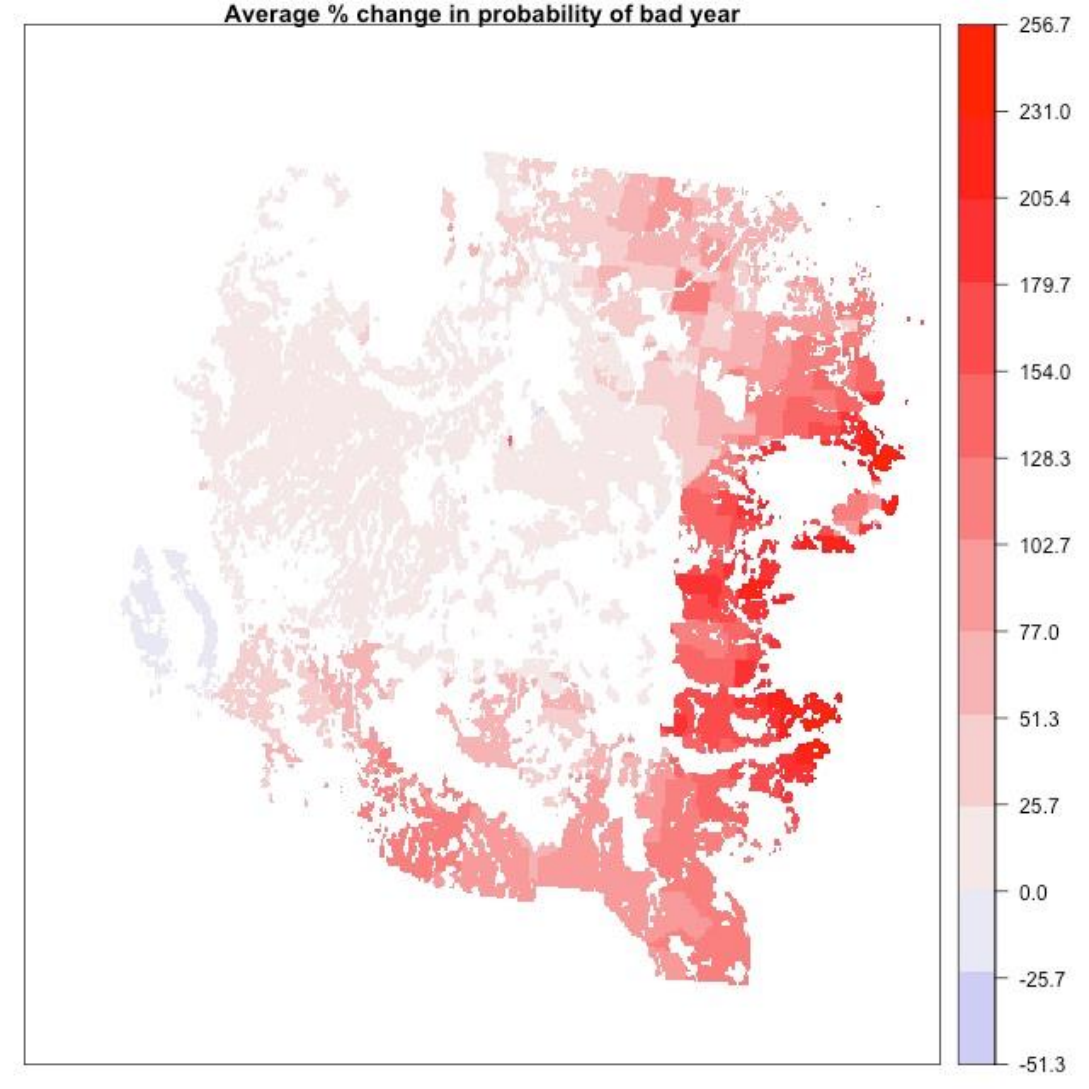
THE BIG PICTURE: MID-CENTURY PROJECTIONS WESTERN US RANGELANDS





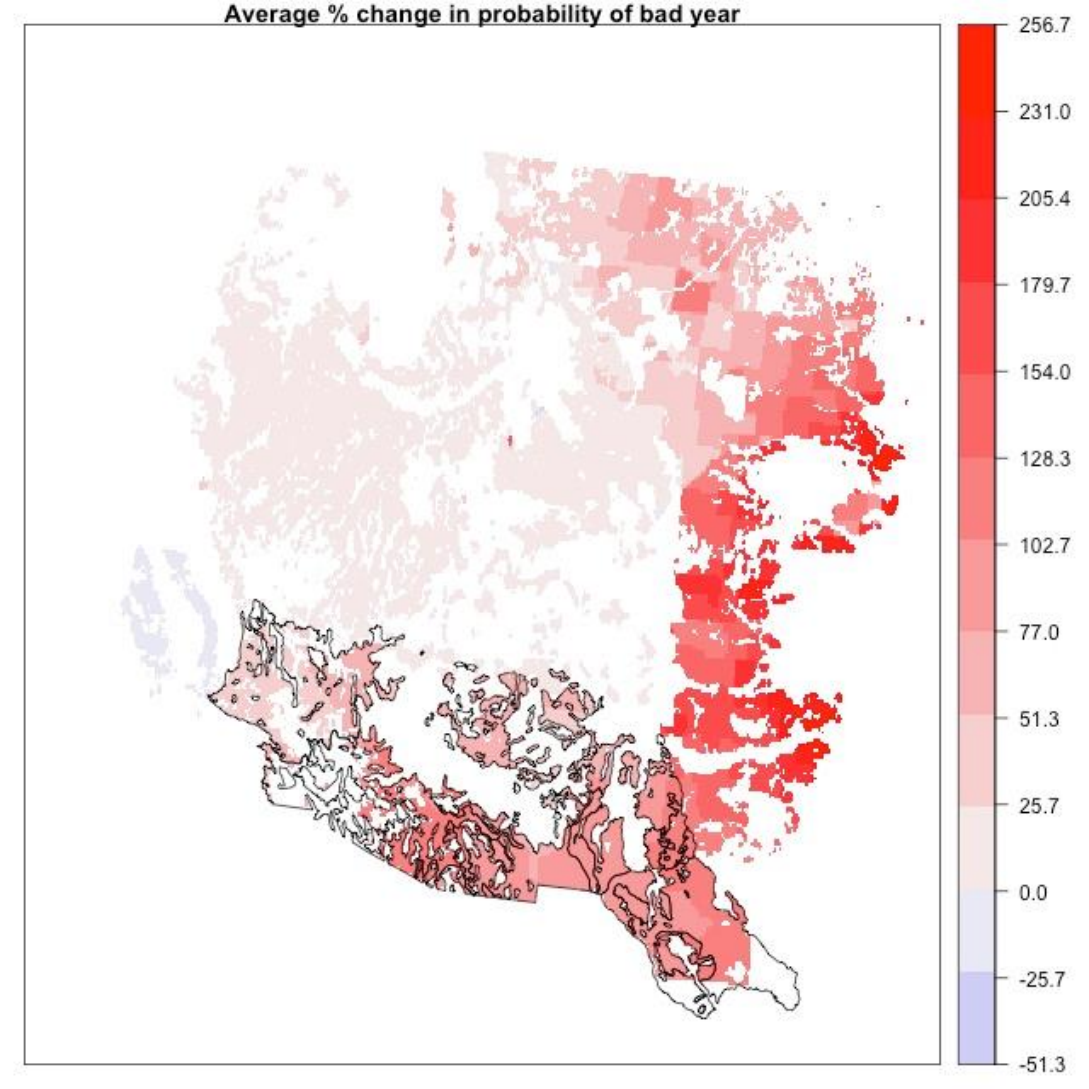
SOUTHERN PLAINS AND HOT DESERTS ARE ESPECIALLY VULNERABLE

Western US



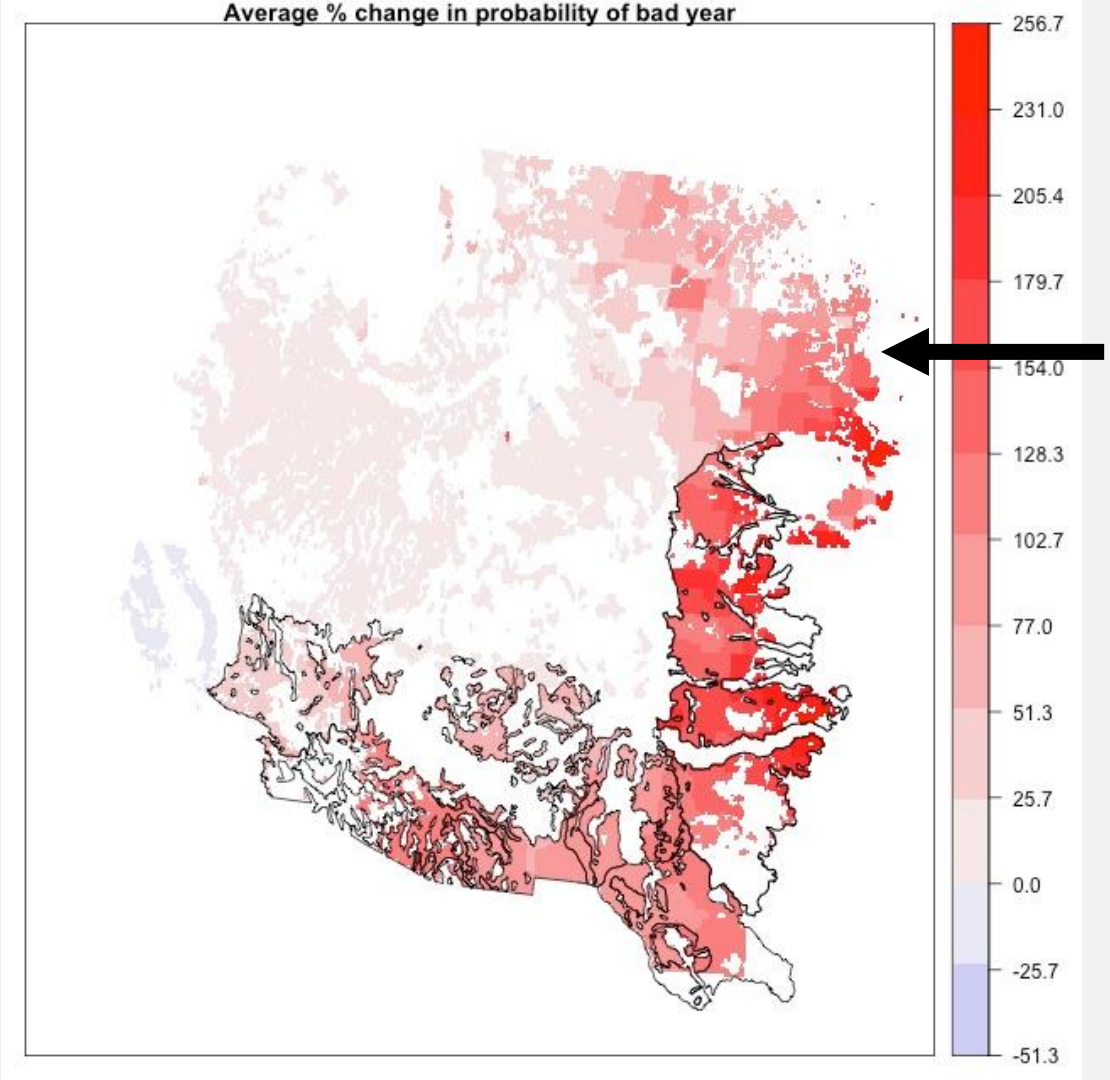
SOUTHERN PLAINS AND HOT DESERTS ARE ESPECIALLY VULNERABLE

Hot Deserts



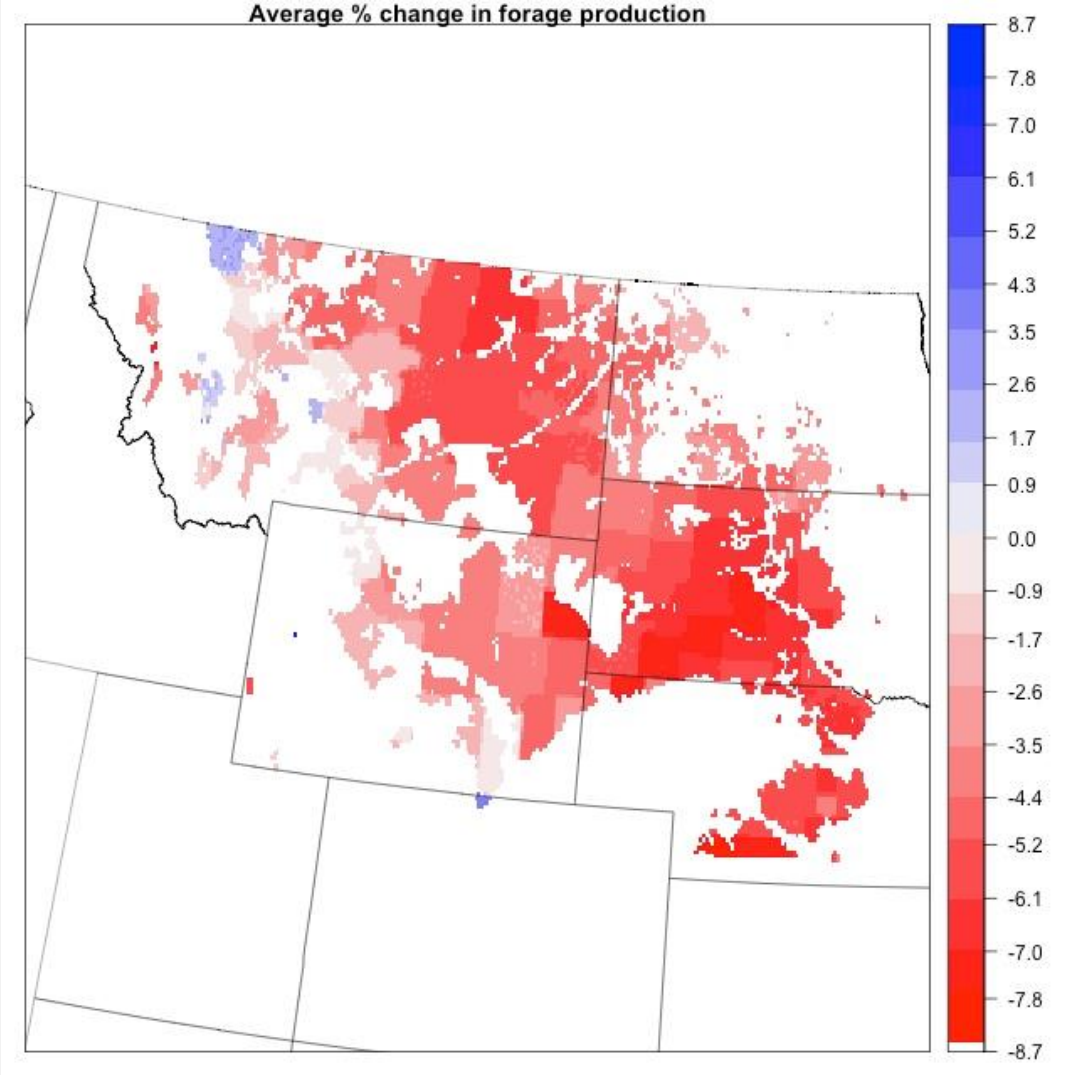
SOUTHERN PLAINS AND HOT DESERTS ARE ESPECIALLY VULNERABLE

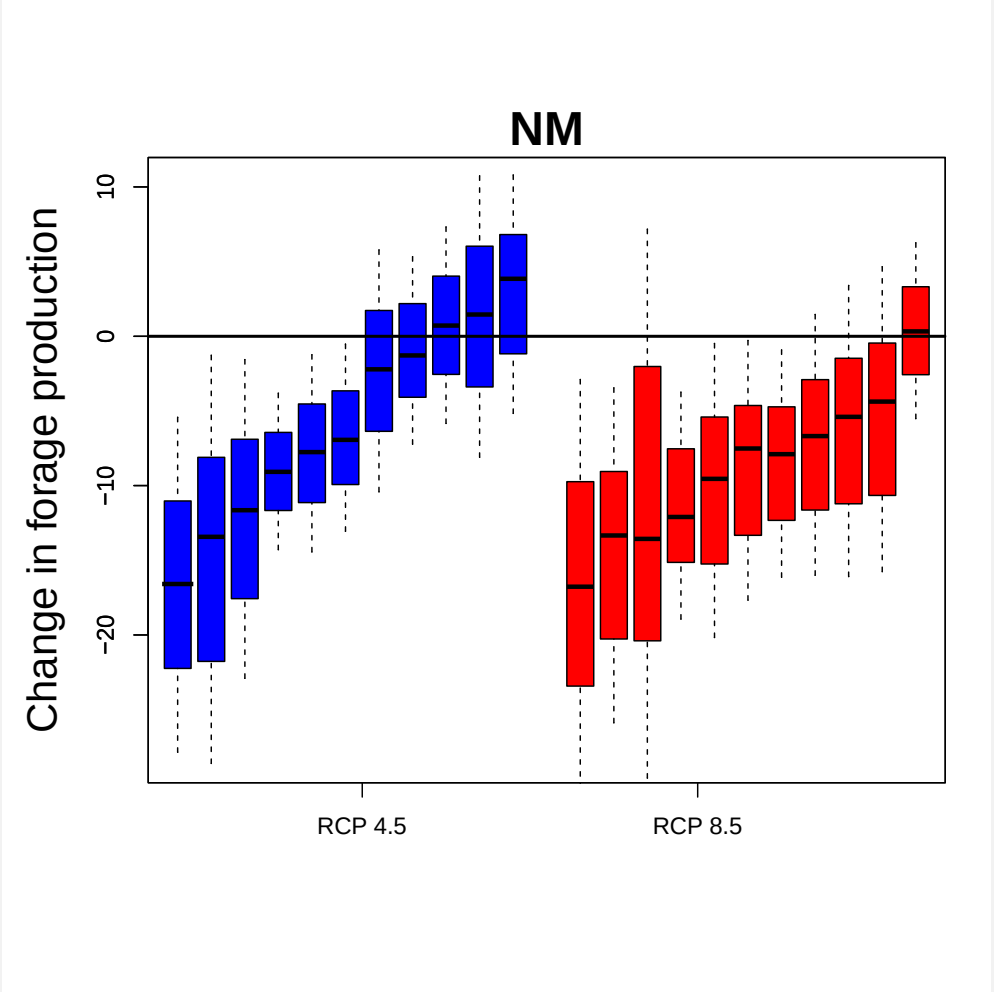
Hot Deserts and Shortgrass Steppe



Northern Mixed Prairies

LOOKING AT UNCERTAINTY IN OUR PROJECTIONS





HOW DO OUR FINDINGS COMPARE TO PREVIOUS FINDINGS?

Region	Source	Forage projection	Our work	Agree?	Prioritize climate change?
Great Basin	Zimmer et al. 2020	+ or 0	- or 0	Mostly	no
Great Basin	Hufkens et al.	+	- or 0	Not quite	no
Great Basin	Reeves et al. 2017	0	- or 0	Mostly	no
California annuals	Kramer & George 2013	+	+	Yes	no
California annuals	Hufkens et al.	+	+	Not quite	no
Northern Plains	Reeves et al. 2017	+	- or 0	Mostly	no*
Northern Plains	Hufkens et al.	+	- or 0	Not quite	no
Southwest	Reeves et al. 2017	-	-	Yes	Yes
Southern Plains	Reeves et al. 2017	-	-	Yes	Yes

GREAT BASIN

Region	Source	Forage projection	Our work	Agree?	Prioritize climate change?
Great Basin	Zimmer et al. 2020	+ or 0	- or 0	Mostly	no
Great Basin	Hufkens et al.	+	- or 0	Not quite	no
Great Basin	Reeves et al. 2017	0	- or 0	Mostly	no
California annuals	Kramer & George 2013	+	+	Yes	no
California annuals	Hufkens et al.	+	+	Yes	no
Northern Plains	Reeves et al. 2017	+	- or 0	Mostly	no*
Northern Plains	Hufkens et al.	+	- or 0	Not quite	no
Southwest	Reeves et al. 2017	-	-	Yes	Yes
Southern Plains	Reeves et al. 2017	-	-	Yes	Yes

CALIFORNIA ANNUALS

Region	Source	Forage projection	Our work	Agree?	Prioritize climate change?
Great Basin	Zimmer et al. 2020	+ or 0	- or 0	Mostly	no
Great Basin	Hufkens et al.	+	- or 0	Not quite	no
Great Basin	Reeves et al. 2017	0	- or 0	Mostly	no
California annuals	Kramer & George 2013	+	+	Yes	no
California annuals	Hufkens et al.	+	+	Not quite	no
Northern Plains	Reeves et al. 2017	+	- or 0	Mostly	no*
Northern Plains	Hufkens et al.	+	- or 0	Not quite	no
Southwest	Reeves et al. 2017	-	-	Yes	Yes
Southern Plains	Reeves et al. 2017	-	-	Yes	Yes

NORTHERN PRAIRIES

Region	Source	Forage projection	Our work	Agree?	Prioritize climate change?
Great Basin	Zimmer et al. 2020	+ or 0	- or 0	Mostly	no
Great Basin	Hufkens et al.	+	- or 0	Not quite	no
Great Basin	Reeves et al. 2017	0	- or 0	Mostly	no
California annuals	Kramer & George 2013	+	+	Yes	no
California annuals	Hufkens et al.	+	+	Not quite	no
Northern Plains	Reeves et al. 2017	+ or 0	- or 0	Mostly	no*
Northern Plains	Hufkens et al.	+	- or 0	Not quite	no
Southwest	Reeves et al. 2017	-	-	Yes	Yes
Southern Plains	Reeves et al. 2017	-	-	Yes	Yes

SOUTHERN PLAINS/SOUTHWEST

Region	Source	Forage projection	Our work	Agree?	Prioritize climate change?
Great Basin	Zimmer et al. 2020	+ or 0	- or 0	Mostly	no
Great Basin	Hufkens et al.	+	- or 0	Not quite	no
Great Basin	Reeves et al. 2017	0	- or 0	Mostly	no
California annuals	Kramer & George 2013	+	+	Yes	no
California annuals	Hufkens et al.	+	+	Not quite	no
Northern Plains	Reeves et al. 2017	+	- or 0	Mostly	no*
Northern Plains	Hufkens et al.	+	- or 0	Not quite	no
Southwest	Reeves et al. 2017	-	-	Yes	Yes
Southern Plains	Reeves et al. 2017	-	-	Yes	Yes

SUMMARY

- Smaller changes to forage production by midcentury for northern, great basin, and California annuals rangelands
- Larger changes to forage in southwestern US
- Southwestern and southern plains rangelands appear to be highly vulnerable regions

‘Multiple indicators point toward increasing vulnerability of cattle production in southwestern regions
providing strong support for the need for adaptation measures and suggest significant change to the industry.’
– Reeves et al. 2017

Reeves, Matthew Clark, Karen E. Bagne, and John Tanaka. "Potential climate change impacts on four biophysical indicators of cattle production from western US Rangelands." *Rangeland ecology & management* 70.5 (2017): 529-539.