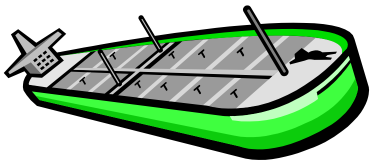
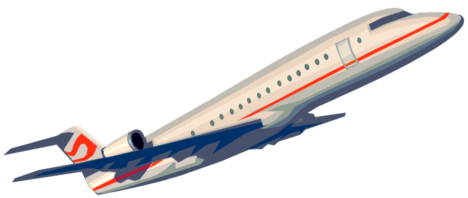
Climate Change and Production Location: A Challenge for Agribusiness



Energy



Mitigation

Climate Change Effects

Adaptation

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Presidential Impact Fellow

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Presented at IAMA Meeting, Miami FL, June 2017

Theme and Topics

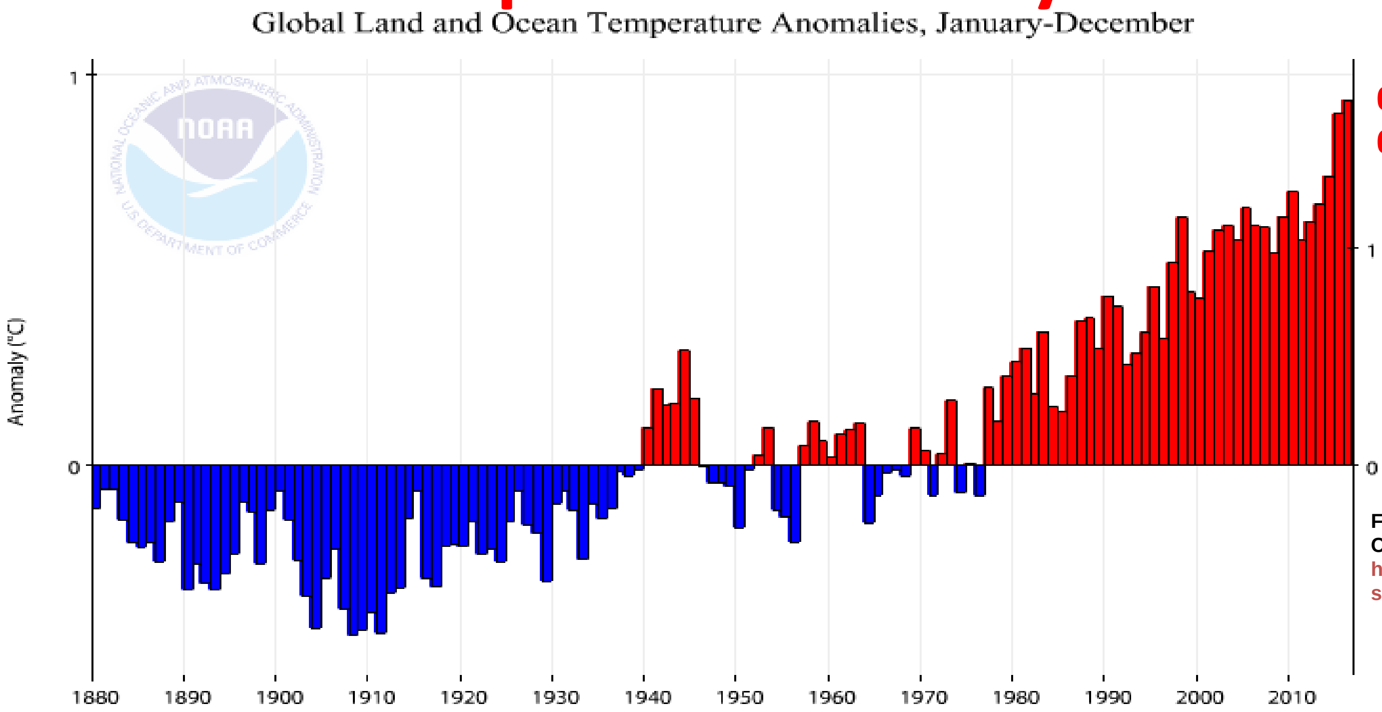
Climate change can and has influenced locations of agricultural production

Will discuss

- Drivers
- Observed/Predicted shifts

Drivers

Temperature history

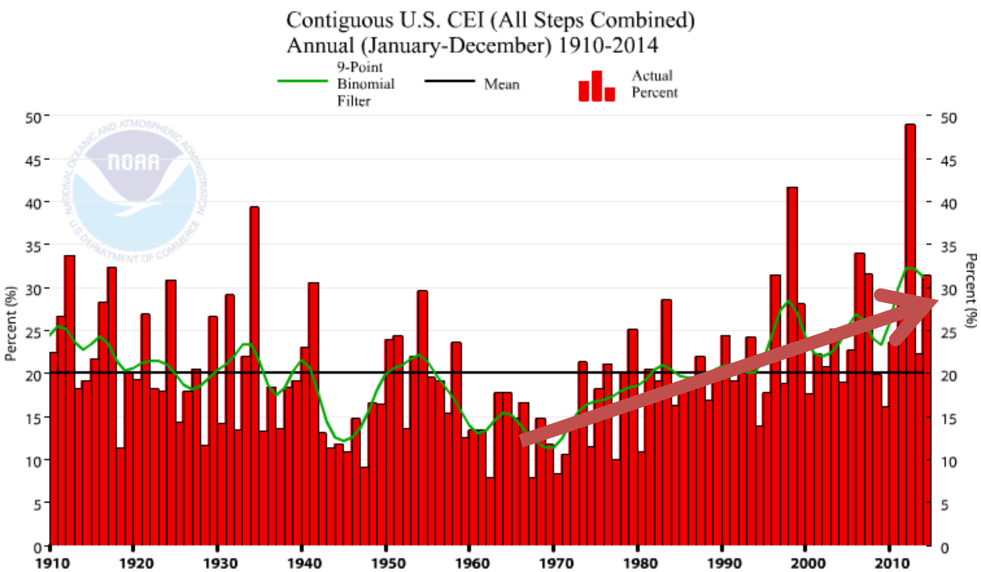


0.94 2016
0.90 2015

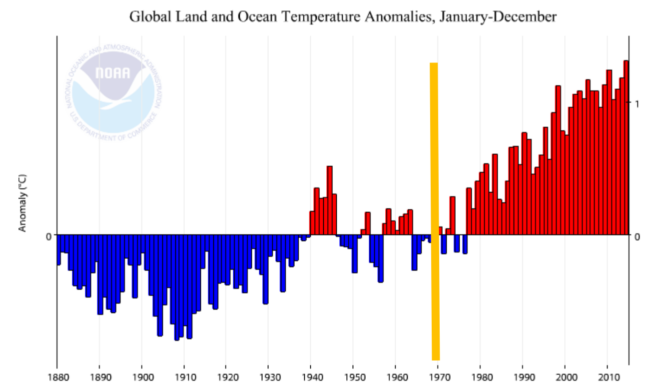
From NOAA State of the Climate
https://www.ncdc.noaa.gov/sotc/global/201613

- **2016 was the warmest year in NOAA's 137-year series.**
- **Third consecutive year with new high in global temperature.**
- **40th in row with (since 1977) temperature above 20th century avg.**
- **All 16 years since 2000 among 17 warmest on record (1998 is 8th)**
- **Five warmest years have all occurred since 2010.**
- **Temperatures in 2016 majorly influenced by strong El Niño**
- **Δ .07°C (.13°F) per decade since 1880 & .17°C (.31°F) since 1970**

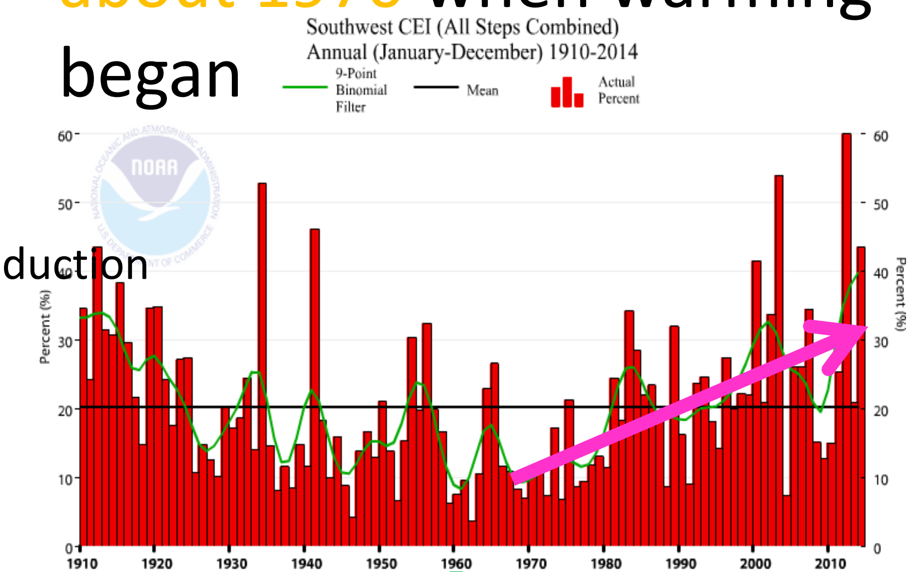
Incidence of Extremes



US



We see an increase in events and variability since about 1970 when warming began



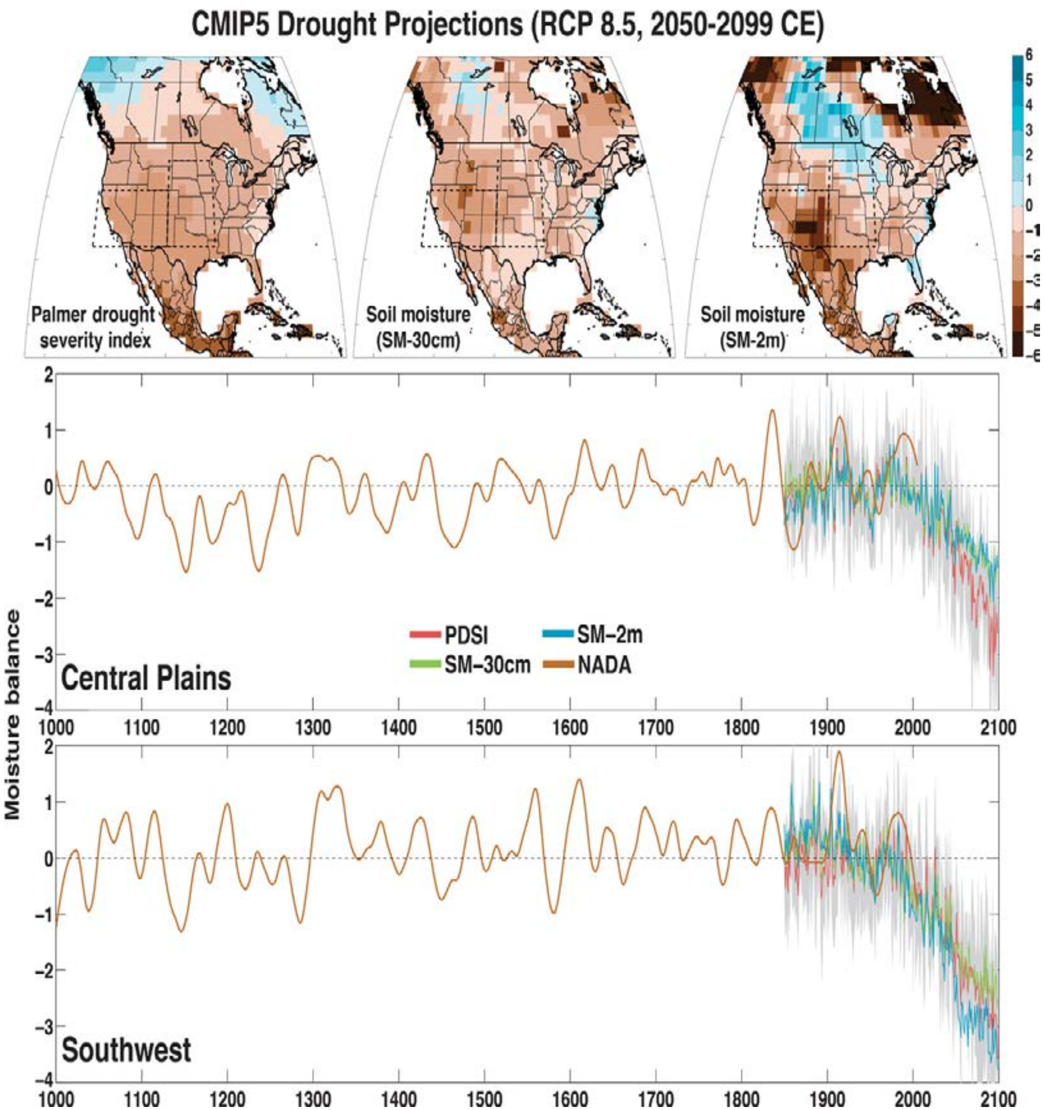
Southwest

From noaa climate extremes index
http://www.ncdc.noaa.gov/extremes/cei/introduction

average of percentage of conterminous U.S. area:

- with maximum temperatures much below or above normal
- with minimum temperatures much above or below normal.
- under severe drought
- with severe moisture surplus
- with a much greater than normal precipitation from extremes
- with a much greater than normal number of days with precipitation
- with much greater than normal days without precipitation.

Precipitation and Soil Moisture



Much less water in some regions

Mean summer (JJA) PDSI (drought index) and standardized soil moisture (SM-30cm and SM-2m) for 2050–2099 from 17 CMIP5 projections using RCP 8.5.

Summer moisture in Central Plains and Southwest. Brown line represents the variation in dryness since year 1000;

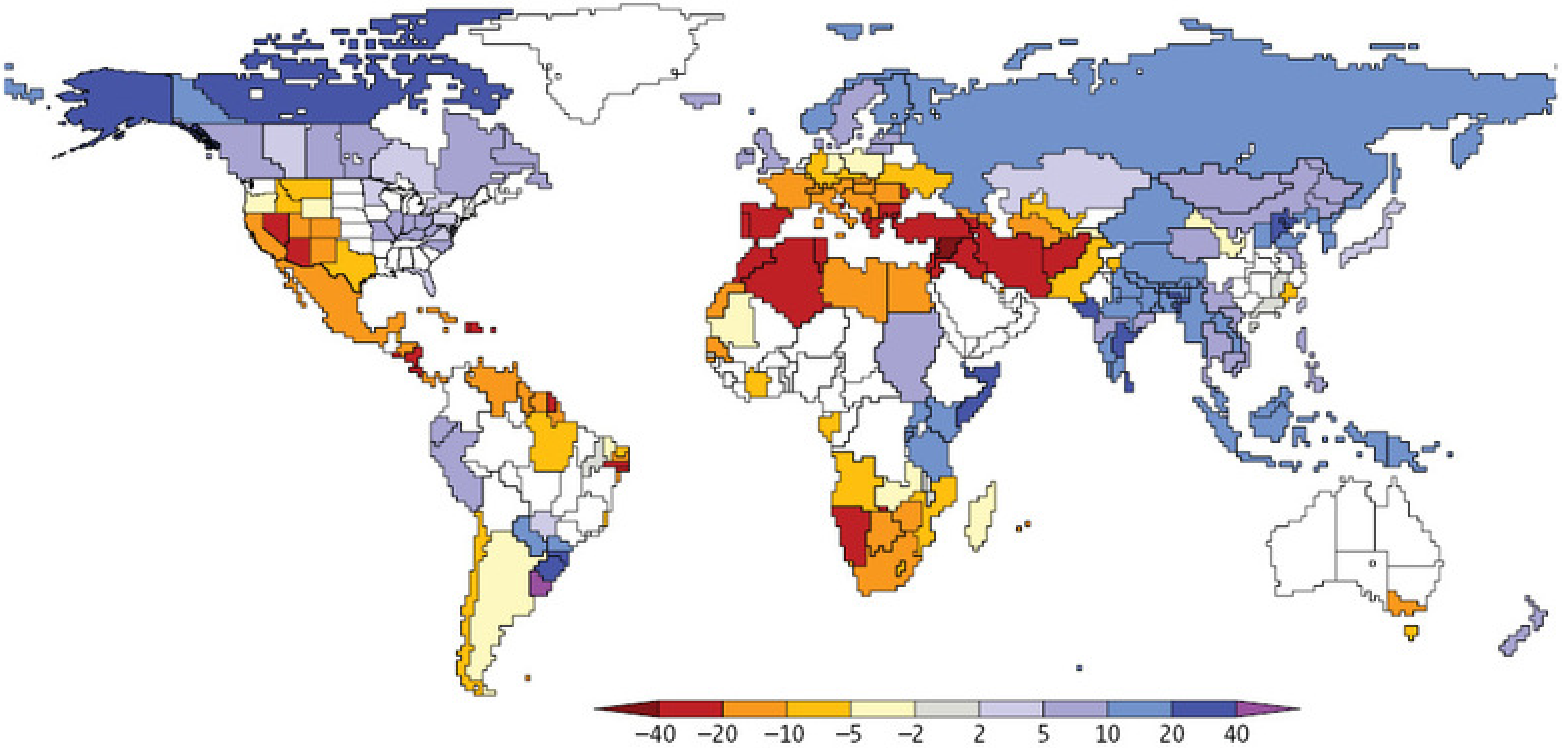
The lower the line, the drier. Colored lines represent what climate models see ahead:

Trend toward dryness not seen in the previous millennium.

Cook, B.I. , T.R. Ault, J.E. Smerdon, Unprecedented 21st century drought risk in the American Southwest and Central Plains. Science Advances, 12 Feb 2015

http://www.earthinstitute.columbia.edu/articles/view/3232

Projections are for altered river flow



Human influences. Dramatic changes in runoff volume from ice-free land are projected in many parts of the world by the middle of the 21st century (relative to historical conditions from the 1900 to 1970 period). Color denotes percentage change (median value from 12 climate models). Where a country or smaller political unit is colored, 8 or more of 12 models agreed on the direction (increase versus decrease) of runoff change under the Intergovernmental Panel on Climate Change's "SRES A1B" emissions scenario.

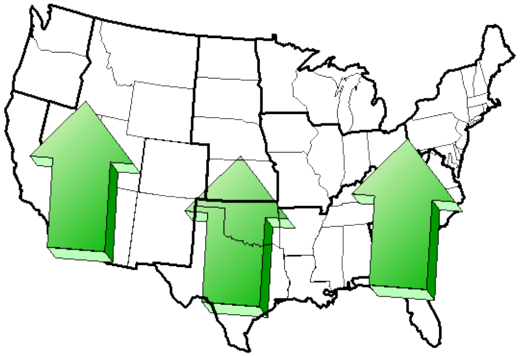
What you see is nonstationarity: the future is not like the past

Less water in rivers in sub tropical regions

Milly P.C.D., Betancourt J., Falkenmark M., Hirsch R.M., Kudzewicz Z.W., Lettenmaier D.P., and Stouffer R.J. Climate Change: Stationarity is Dead: Whither Water Management? Science 2008;319:573-74

2030 Regional Effects

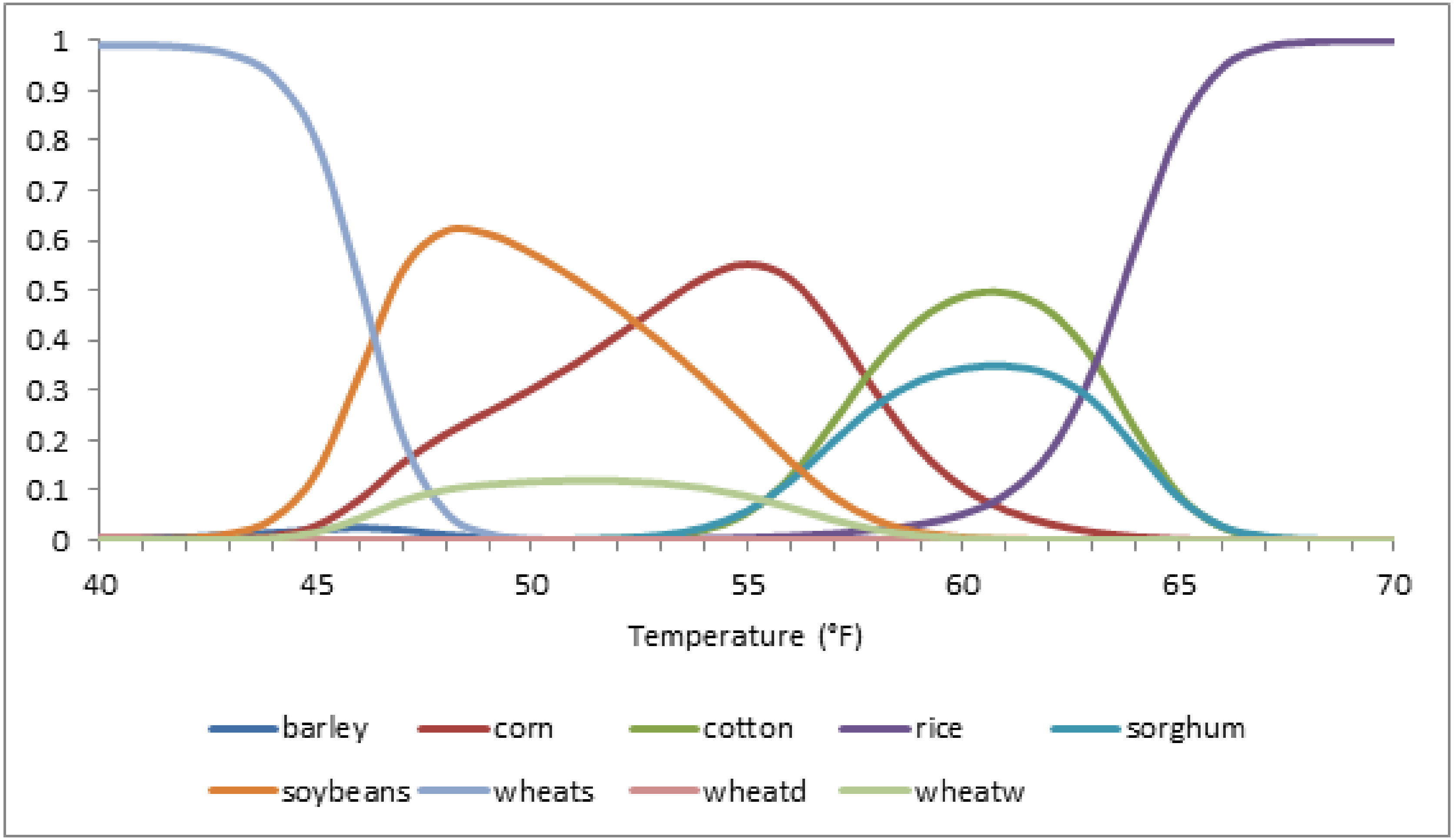
	Canadian	Hadley
Northeast	+ 3	+ 4
Lakestates	+63	+43
Cornbelt	+16	+14
Northplains	- 2	+18
Applachia	-24	-25
Southeast	-60	-15
Delta	- 6	+25
South Plains	-24	- 7
Mountain	+30	+39
Pacific	+26	+47



McCarl, B.A., "Vulnerability of Texas Agriculture to Climate Change", Impact of Global Warming on Texas, Chapter 6, Second Edition, edited by Jurgen Schmandt, Judith Clarkson and Gerald R. North, University of Texas Press, ISBN: 978-0-292-72330-6,

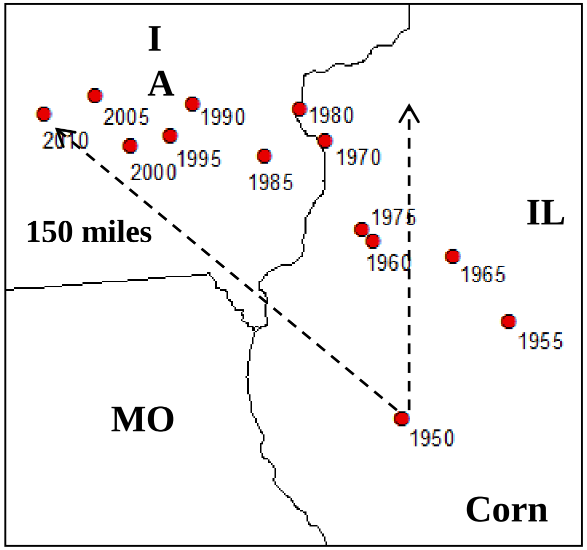
Producer Adaptation

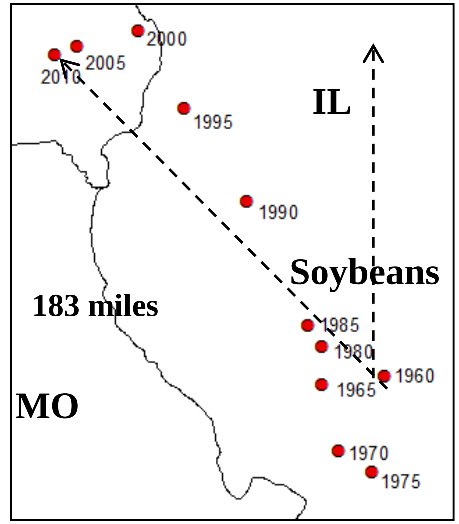
Observed Adaptation – Crop Choice

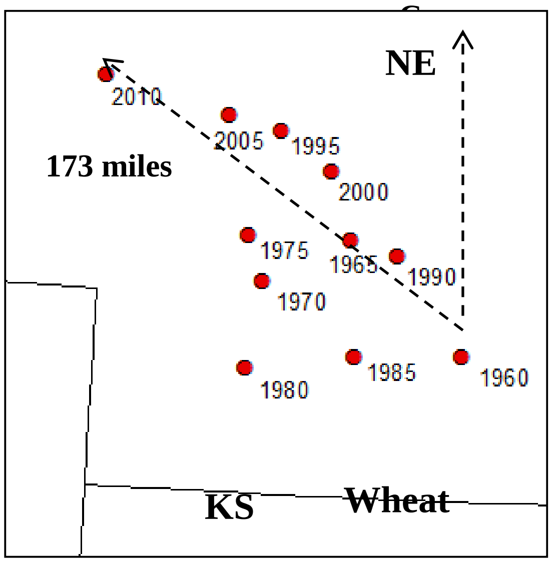


Park, J.Y., B.A. McCarl, and X.M. Wu, "The Effects of Climate on Crop Mix and Climate Change Adaptation", 2013.

Observed Adaptation – Crop mix shift





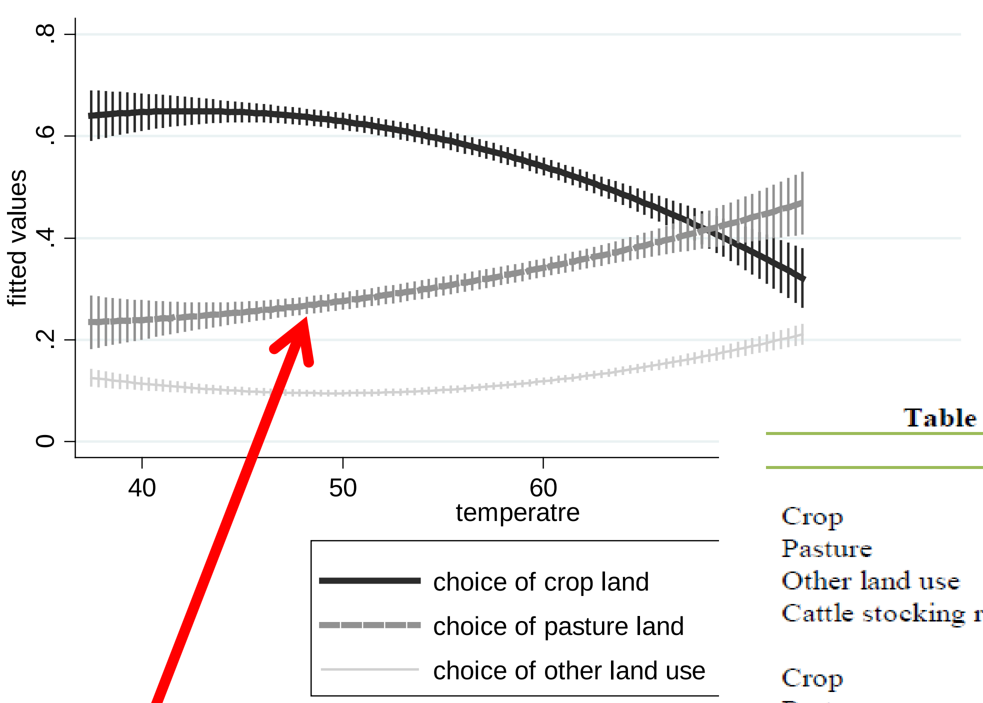


- Shifts have already happened
- Greater yield has transport implications
  - wheat yields 44 bu/acre
  - corn yields 165 bu/acre
- More demands for transport and grain movement in the north

Witsanu Attavanich PhD Thesis

Attavanich, W., B.A. McCarl, Z. Ahmedov, S.W. Fuller, and D.V. Vedenov, "Climate Change and Infrastructure: Effects of Climate Change on U.S. Grain Transport", Nature Climate Change, on line at doi:10. 1038/nclimate1892, VOL 3 JULY 2013, 638-643, 2013.

Observed Adaptation –
Land use and stocking rate



Cropland to pasture/range

Mu, J.E., B.A. McCarl, and A.M. Wein, "Adaptation to climate change: changes in farmland use and stocking rate in the U. S", Mitigation and Adaptation Strategies for Global Change, doi:10. 1007/s11027-012-9384-4, 2012.

Table 5 Changes of Land Use Allocation and Cattle Stocking Rate

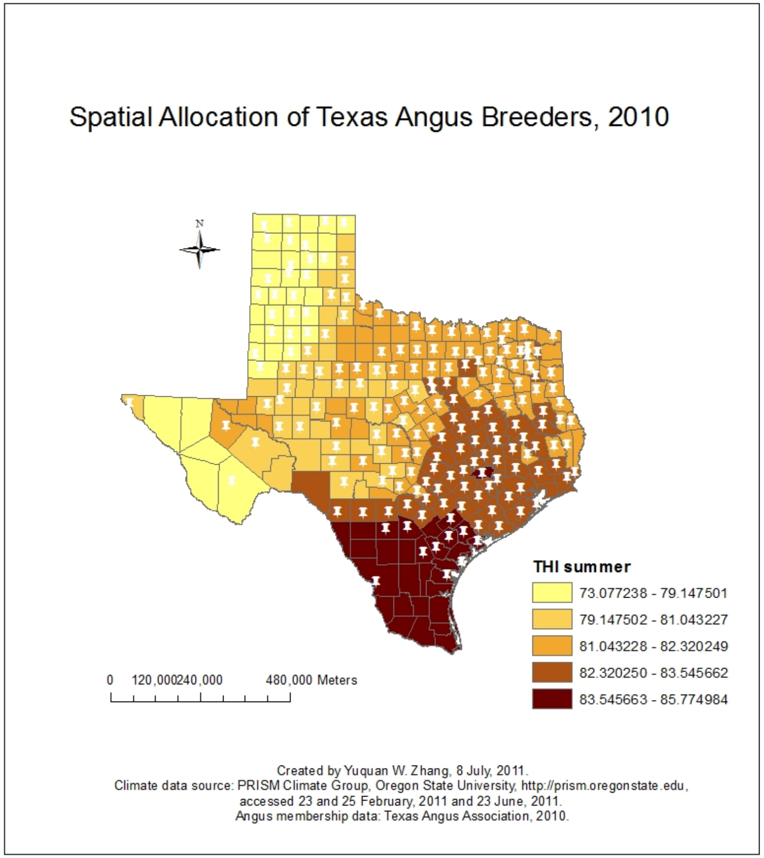
	Base	2010-2039	2040-2069	2070-2099
		HadCM3-B1 emission scenario		
Crop	0.60	-0.22	-0.28	-0.33
Pasture	0.29	0.28	0.35	0.41
Other land use	0.11	-0.06	-0.07	-0.08
Cattle stocking rate*(animal/acre)	0.25	-35.48	-41.86	-48.87
		HadCM3-A1B emission scenario		
Crop	0.60	-0.31	-0.38	-0.43
Pasture	0.29	0.39	0.46	0.52
Other land use	0.11	[illegible]	[illegible]	[illegible]
Cattle stocking rate*(animal/acre)	0.25	-49.89	-58.01	-66.34
		HadCM3-A2 emission scenario		
Crop	0.60	-0.28	-0.35	-0.44
Pasture	0.29	0.35	0.43	0.53
Other land use	0.11	0.07	0.08	0.09
Cattle stocking rate *(animal/acre)	0.25	-47.72	-54.63	-70.27

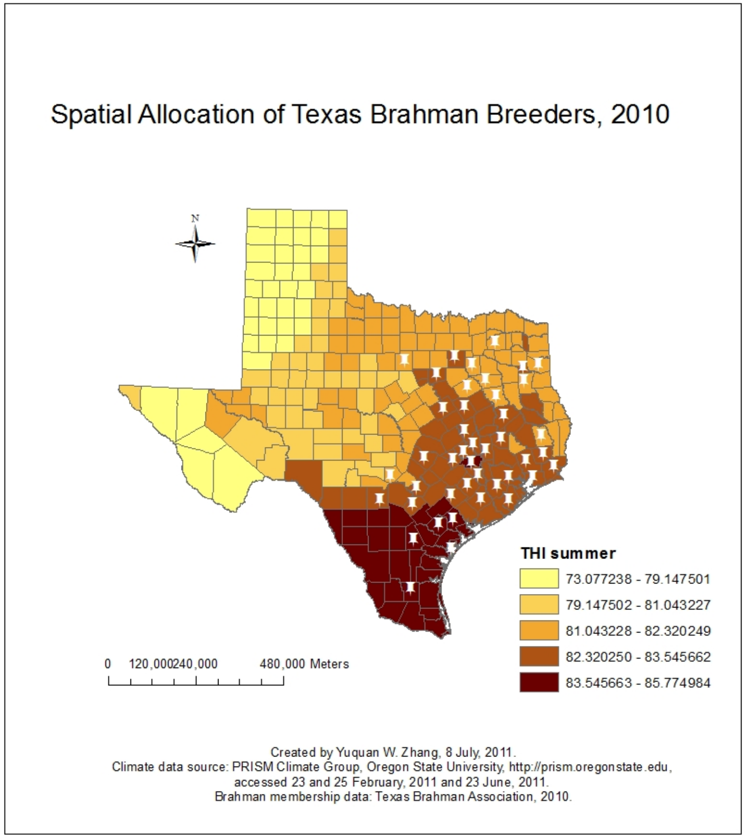
Note: For land use allocation, this table shows the changes of predicted probabilities that are calculated from the FMNL model with pooled sample and sub-regional dummies;

For cattle stocking rate, this table shows the predicted changes of cattle stocking rate that are derived from the OLS model with pooled sample.

Decreased stocking rate

Observed Adaptation – Cattle breed location





Angus breeders spread across Texas.

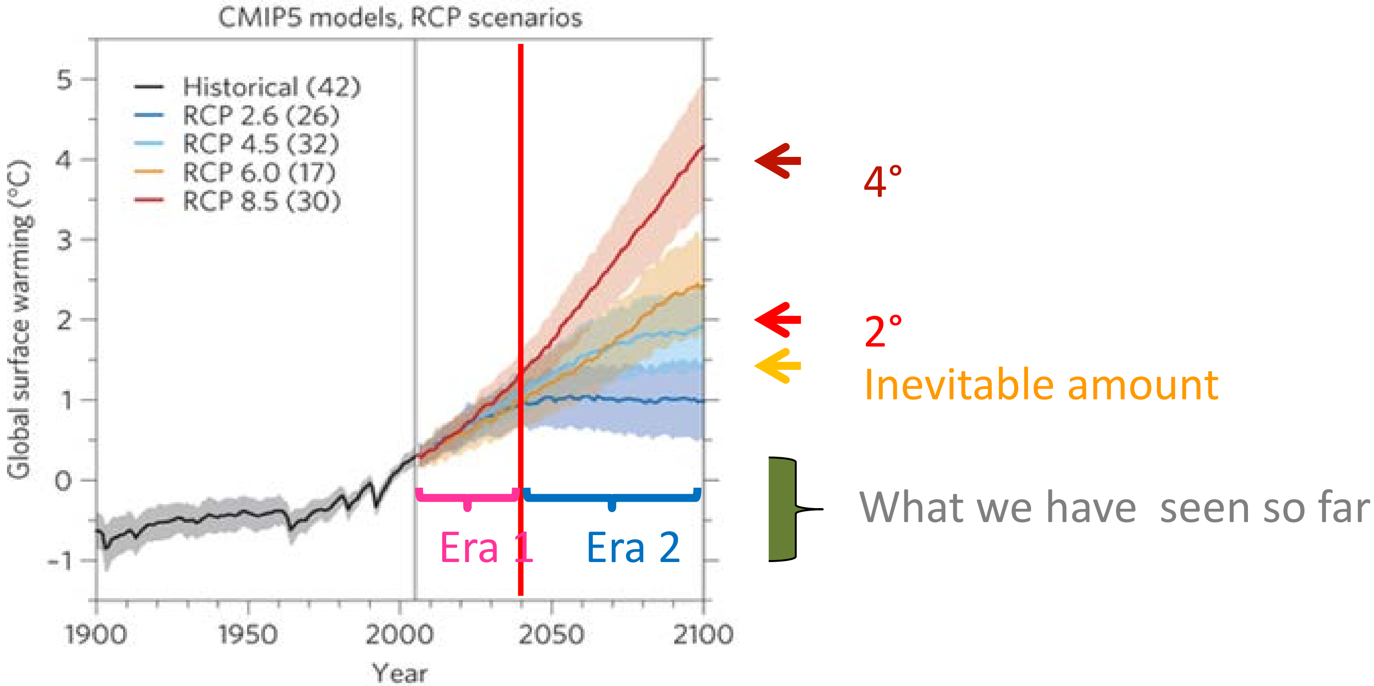
Brahman breeders are located in Southeast Texas, where the temperature-humidity index (THI) values for summer are high.

Animal choices shift with climate

Zhang, Y.W., A.D. Hagerman, and B.A. McCarl, "How climate factors influence the spatial distribution of Texas cattle breeds", Climatic Change, Volume 118, Issue 2, 183-195, 2013.

More Producer Adaptation
Yet to Come

Adaptation – Inevitability



Era 1 For now until 2040-2050 there is not much contribution from limiting emissions with an inevitable amount of climate change of about 1 degree C. Need adaptation plus mitigation

Era 2 – In this time period (2050-2100) mitigation has effects and the climate is warming the question is how much

McCarl, B.A., "Elaborations on Climate Adaptation in U.S. Agriculture", Choices, 2nd Quarter 30(2) http://www.choicesmagazine.org/magazine/pdf/cmsarticle_432.pdf , 2015.
McCarl, B.A., A. Thayer, and J.P.H. Jones, "The Challenge of Climate Change Adaptation: An Economically Oriented Review", Journal of Agricultural and Applied Economics, forthcoming, 2015.

Ag Adaptation and the treadmill

Climate change and its progression raises new demand on agriculture research and extension

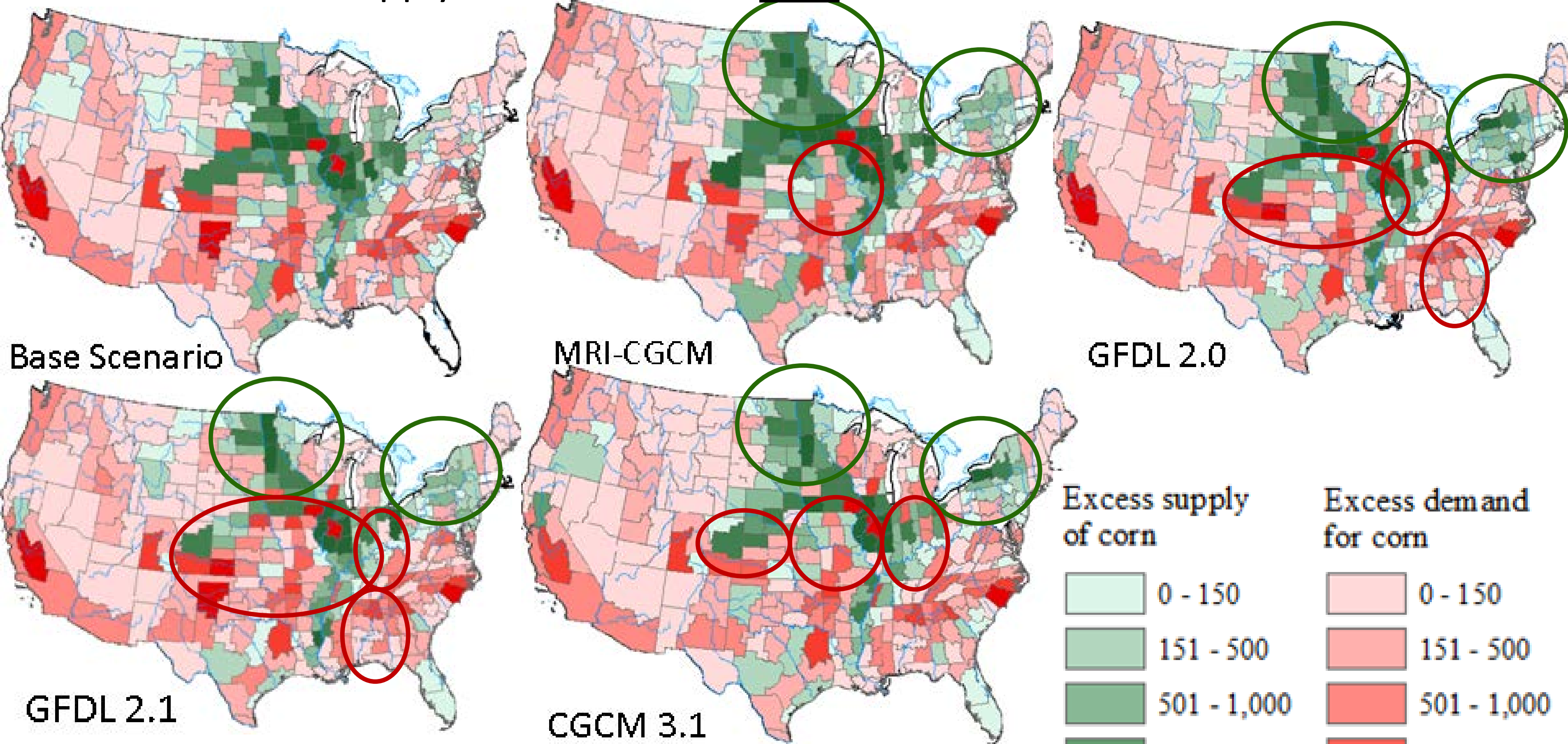
Traditionally we researched yield improvement and some maintenance for say pest resistance

We could count on weather being stationary but now this is likely not so.

So we must devote resources to technological adaptation in maintaining productivity at a spot

Model Results: Spatial Mapping (CRD level)

Excess supply and demand for corn under base and climate scenarios

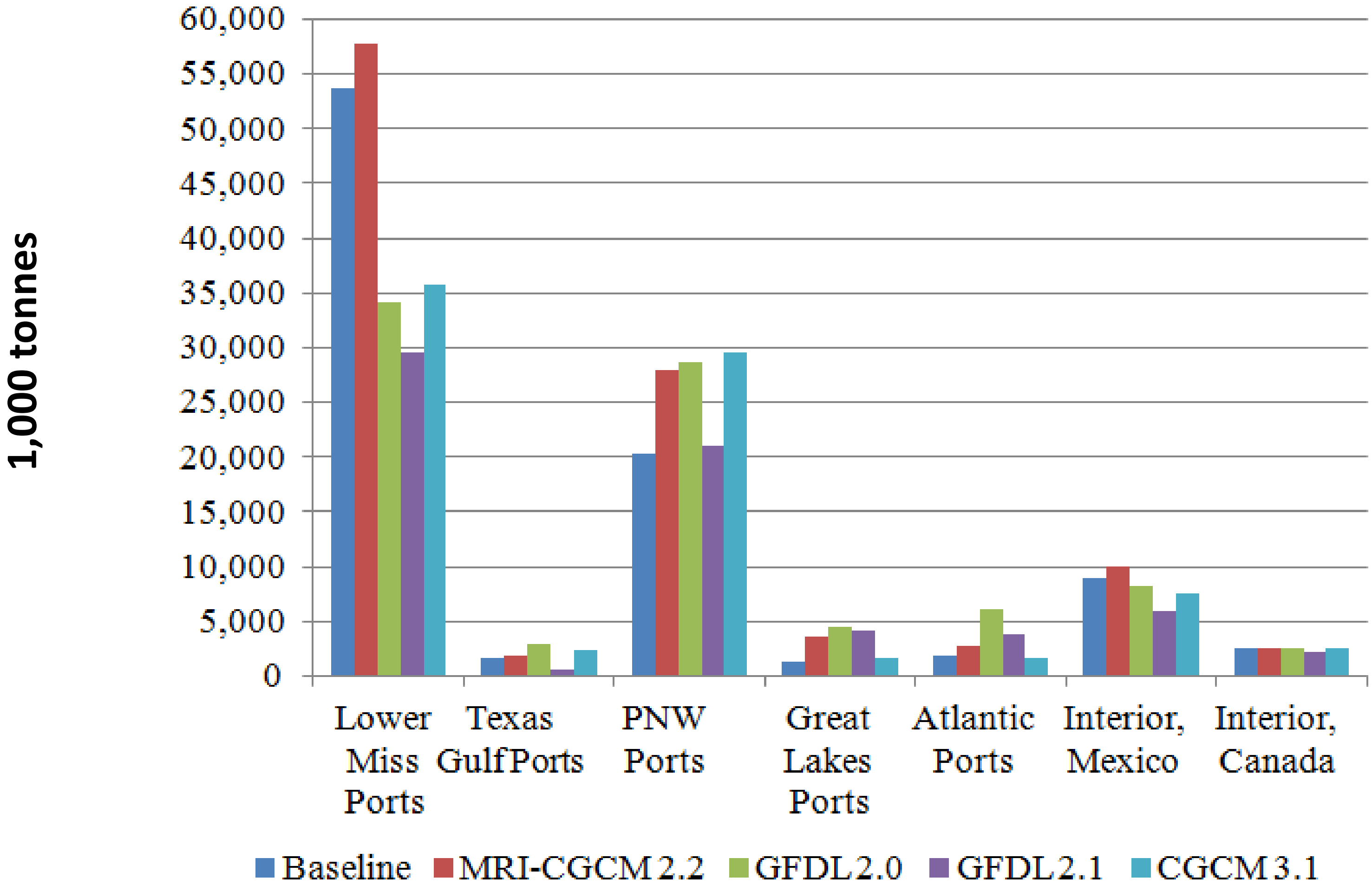


Note northward shifts in excess supply
plus southern/central shifts in excess demand

Attavanich, W., B.A. McCarl, Z. Ahmedov, S.W. Fuller, and D.V. Vedenov, "Climate Change and Infrastructure: Effects of Climate Change on U.S. Grain Transport", Nature Climate Change, on line at doi:10. 1038/nclimate1892, VOL 3 JULY 2013, 638-643, 2013.

Transport effects of Crop mix shifts

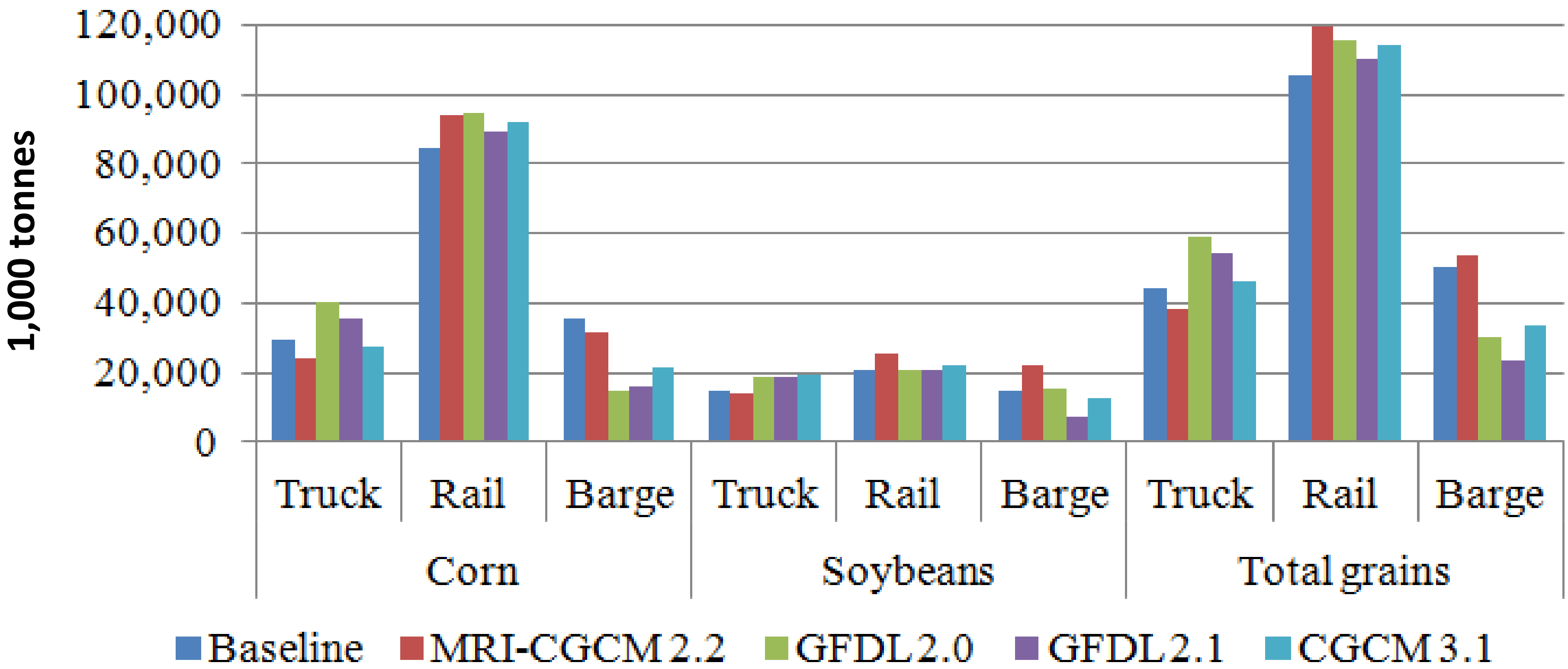
Total grain shipments to port areas for export



- In most cases less to Gulf
- More to PNW, Lakes and Atlantic

Transport effects of Crop mix shifts

Demand for modes of transportation

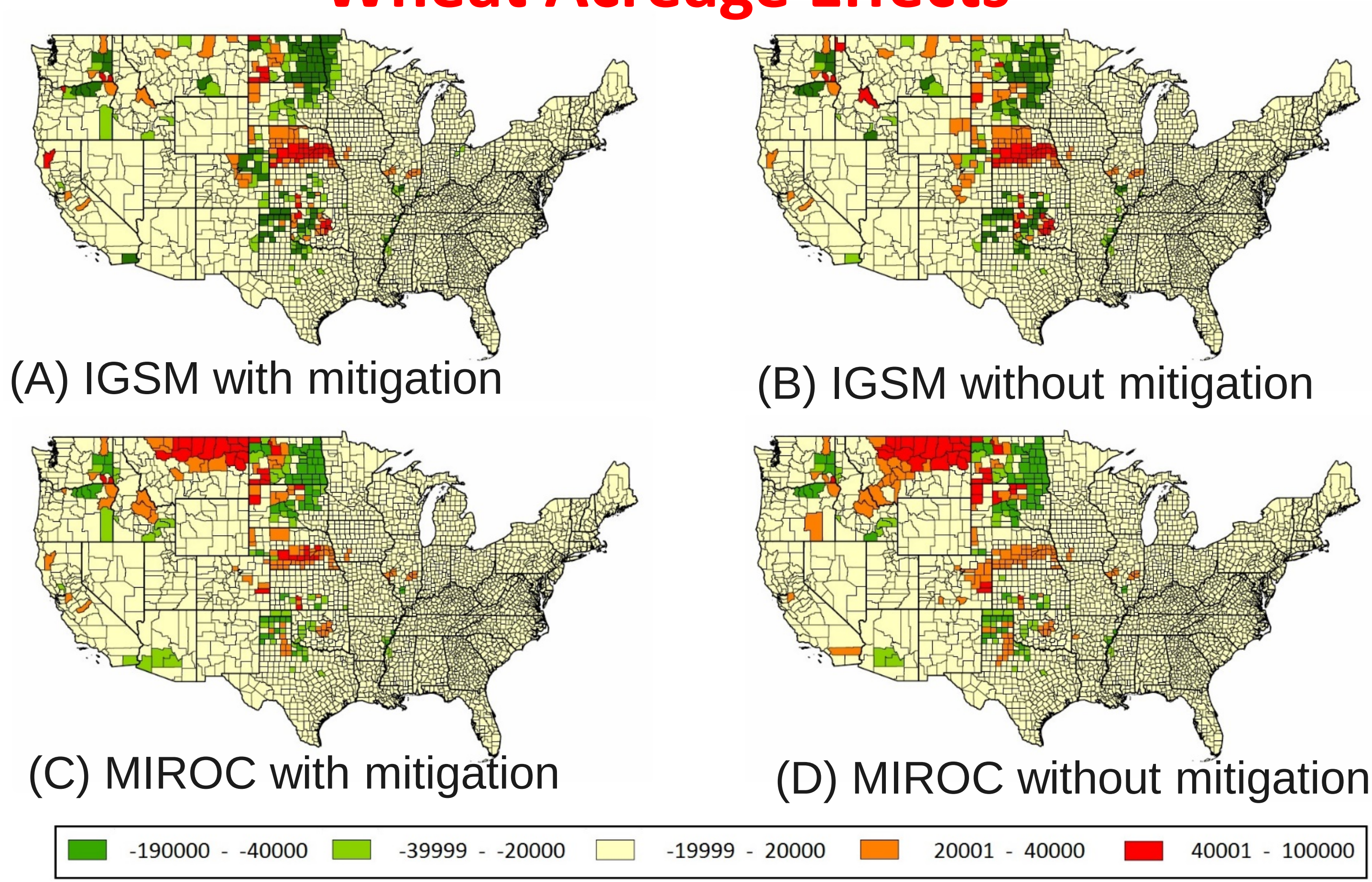


- Less by barge
- More rail
- Generally more truck

Other Transport effects

- Reduced ice cover
- Altered great lakes levels
- Heavier volume
- Trade effects of changed production in global grain exporting countries

Wheat Acreage Effects



Difference in wheat harvested acres by US county relative to the no climate change scenario under 4 scenarios. Wheat acres are sum of hard red winter, hard red spring, soft red winter, white and durum

North and Up movements.

Source: Fei, C.C., B.A. McCarl, and A. Thayer, "Estimating the impacts of climate change and potential adaptation strategies for the production, transportation, and trade of cereal production in the United States", Frontiers in Ecology and Evolution, forthcoming, 2017.

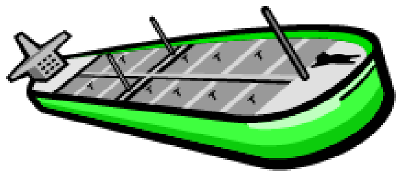
Concluding comments

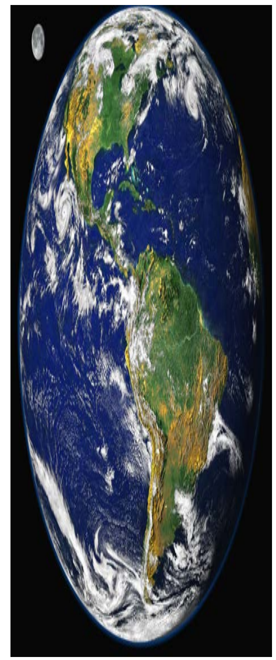
- Production is shifting and will shift more
- Will be a continuous process for sometime
- Agribusiness will face locational issues
- Road infrastructure also affected

The onset and exact effects of climate change are uncertain

Mitigation

Energy





Adaptation

Effects

Food Supply is Vulnerable
Some Regions will be Squeezed

For More information

- Attavanich, W. Essays On The Effect Of Climate Change On Agriculture And Agricultural Transportation Ph.D. Dissertation, Texas A&M University, Oct 2011
- Attavanich, W., B.A. McCarl, S.W. Fuller, D.V. Vedenov, and Z. Ahmedov, "The Effect of Climate Change on Transportation Flows and Inland Waterways Due to Climate-Induced Shifts in Crop Production Patterns", Draft Manuscript, 2012.
- Attavanich, W., B.A. McCarl, Z. Ahmedov, S.W. Fuller, and D.V. Vedenov, "Climate Change and Infrastructure: Effects of Climate Change on U.S. Grain Transport", Draft Manuscript, 2012.
- Vedenov, D.V., S.W. Fuller, B.A. McCarl, W. Attavanich, and Z. Ahmedov, "Effect of Climate Change on Crop Production Patterns with Implications to Transport Flows and Inland Waterways", Final report to UTCM 10-54-51, 2011.