

How Climate Change May Impact The Chesapeake Bay Region and Its Agriculture

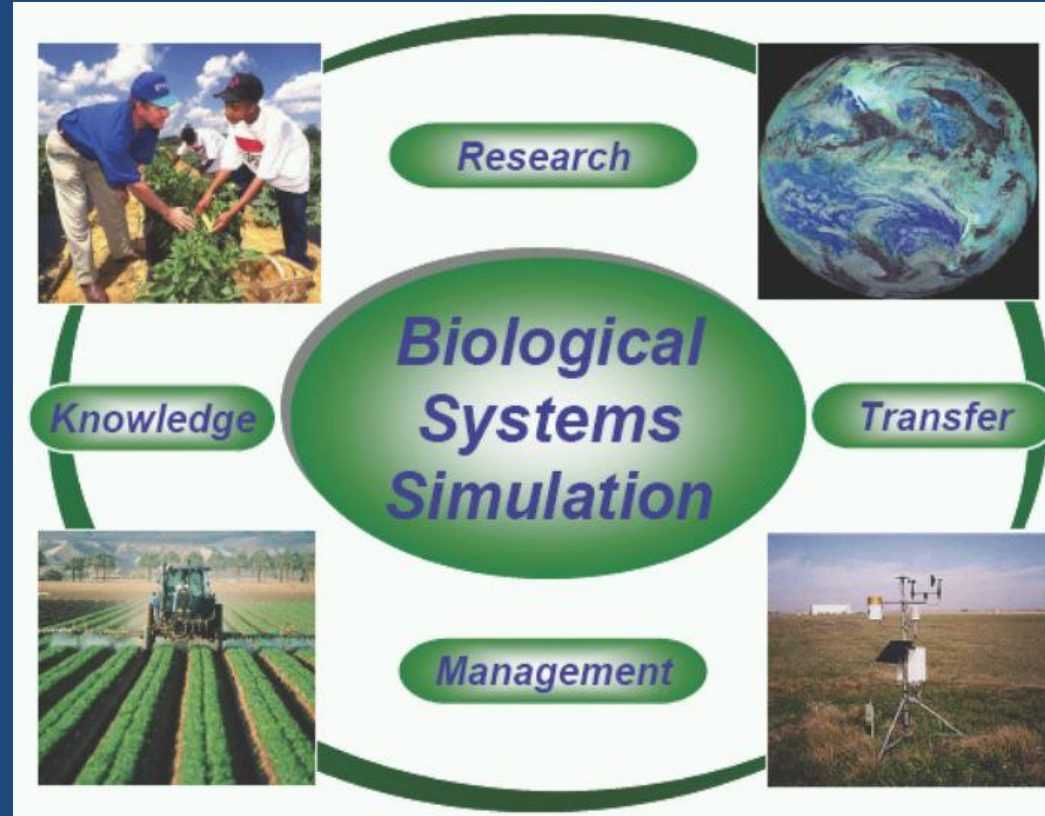
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**Agricultural
Research
Service**

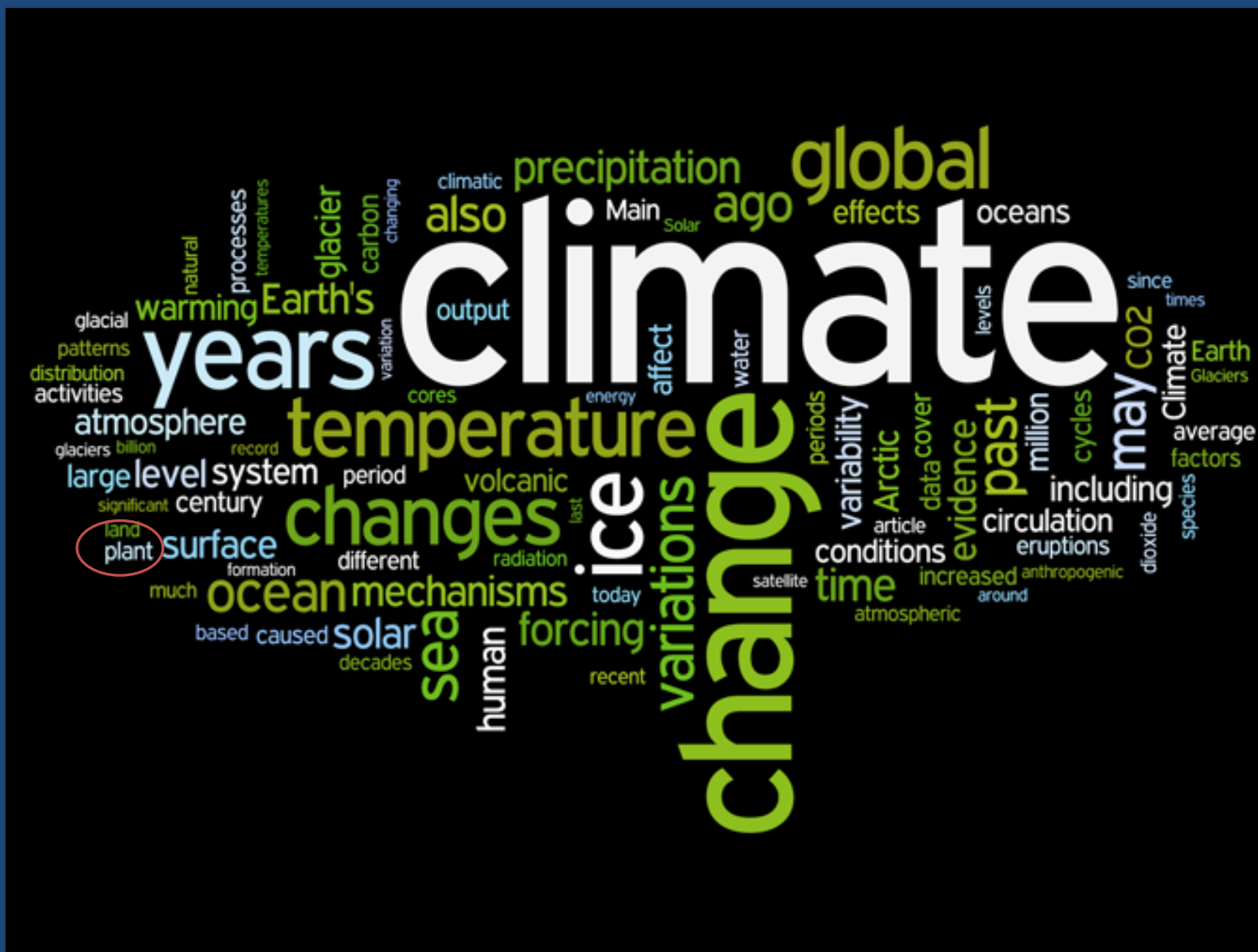
Mission of the ACSL USDA Agricultural Research Service

Applying Systems Theory to Complex Agricultural Problems



- Predicting Consequences of Environmental Change
 - Adapting Crops and Management Strategies
 - Improving Crop Management Decision Making

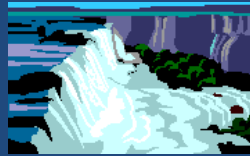
What is Climate Change All About?



How Will Climate Change Alter Our Ability to Achieve Food Security?

Direct effects:

Water



Temperature



Energy



Weather Extremes



Indirect:

Insects, weeds, diseases.



Food quality.



Amount

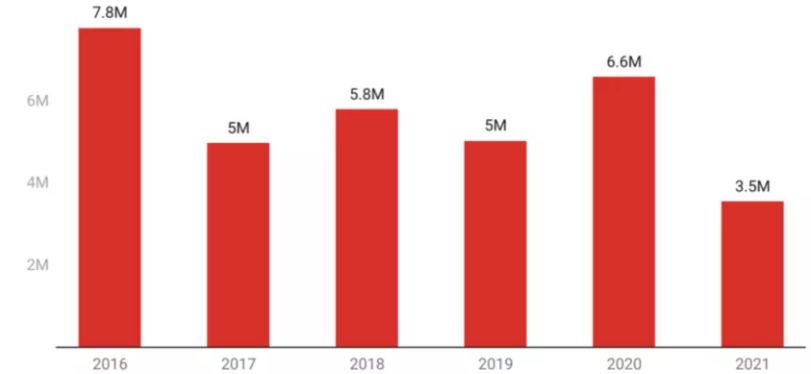


Costs



Bad News for Pasta Lovers

Durum wheat production in Canada by year in metric tonnes



Source: Statistics Canada • Created with Datawrapper

Image: World Economic Forum

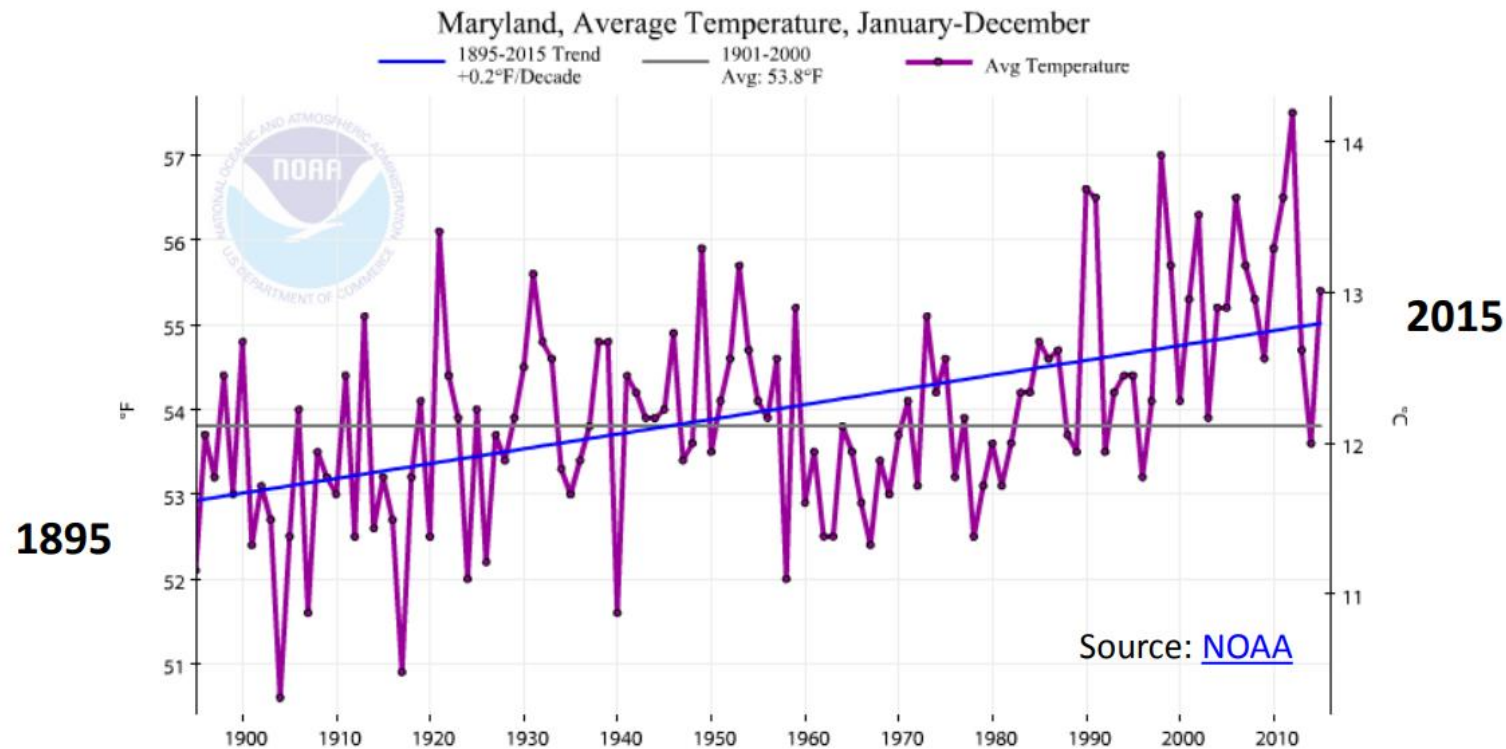
Warming in Maryland



OBSERVATIONS

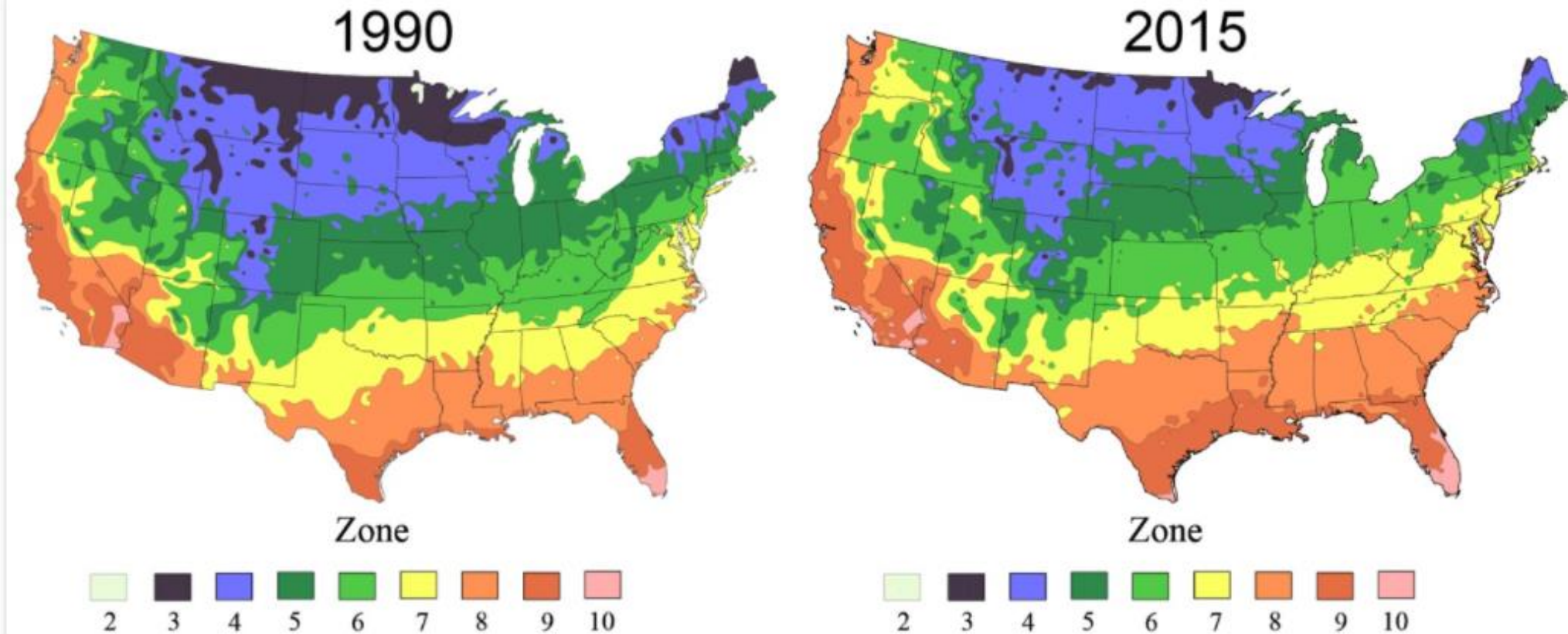
The annual mean temperature in MD has already increased by about 2.1°F (1.1°C) since 1895 – faster than the rise in global mean temperature.

<https://www.geo.umass.edu/stateClimateReports>



The annual mean temperature in MD exceeded the 20th-century average almost every year since 1997 (the last 18 years).





Plant Hardiness Zones, 1990 and 2015. Images from USDA and Arbor Day Foundation.

Will we be able to plant peanuts and cotton in Maryland soon?

Changing Climate in the Northeastern US

- ◆ Increased temperatures— 3.6 degrees Fahrenheit average and summer temperatures 9 degrees by the time 2035 rolls around.
- ◆ The highest rates of sea-level rise in the U.S. and the highest rate of ocean warming. Urban centers are particularly at risk (remember Superstorm Sandy?). Winters are projected to warm in our region three times faster than summers.
- ◆ Increased rainfall (and rates) – but not all during the growing season
- ◆ Temperature and drought frequency will be less here than in the interior of the country.

Change in Consecutive Number of Dry Days

Longer periods of drought are expected in the western part of the U.S.

The eastern part is expected to suffer less from long periods without rainfall. In fact, rainfall is expected to increase in the north eastern part of the U.S.

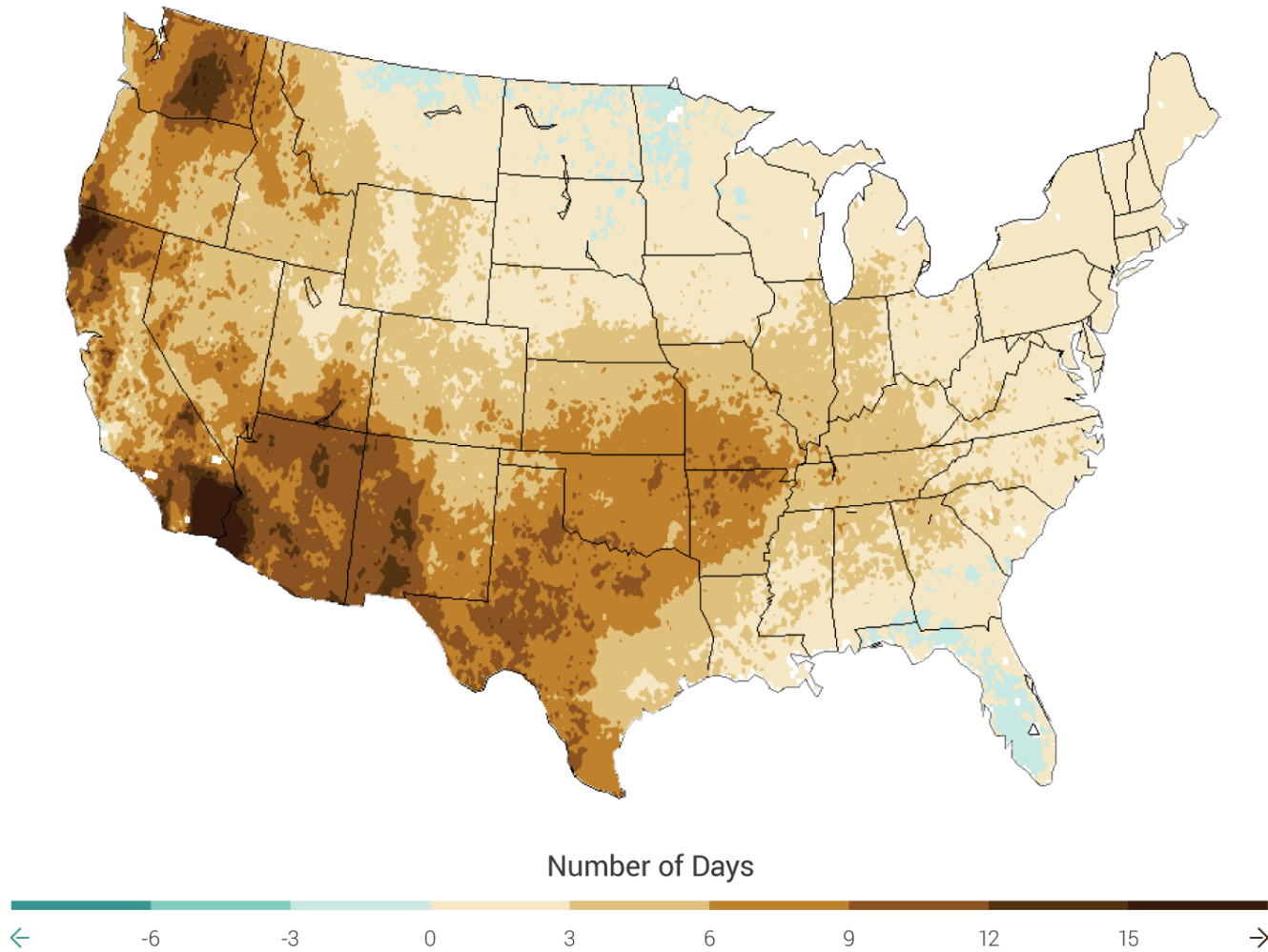
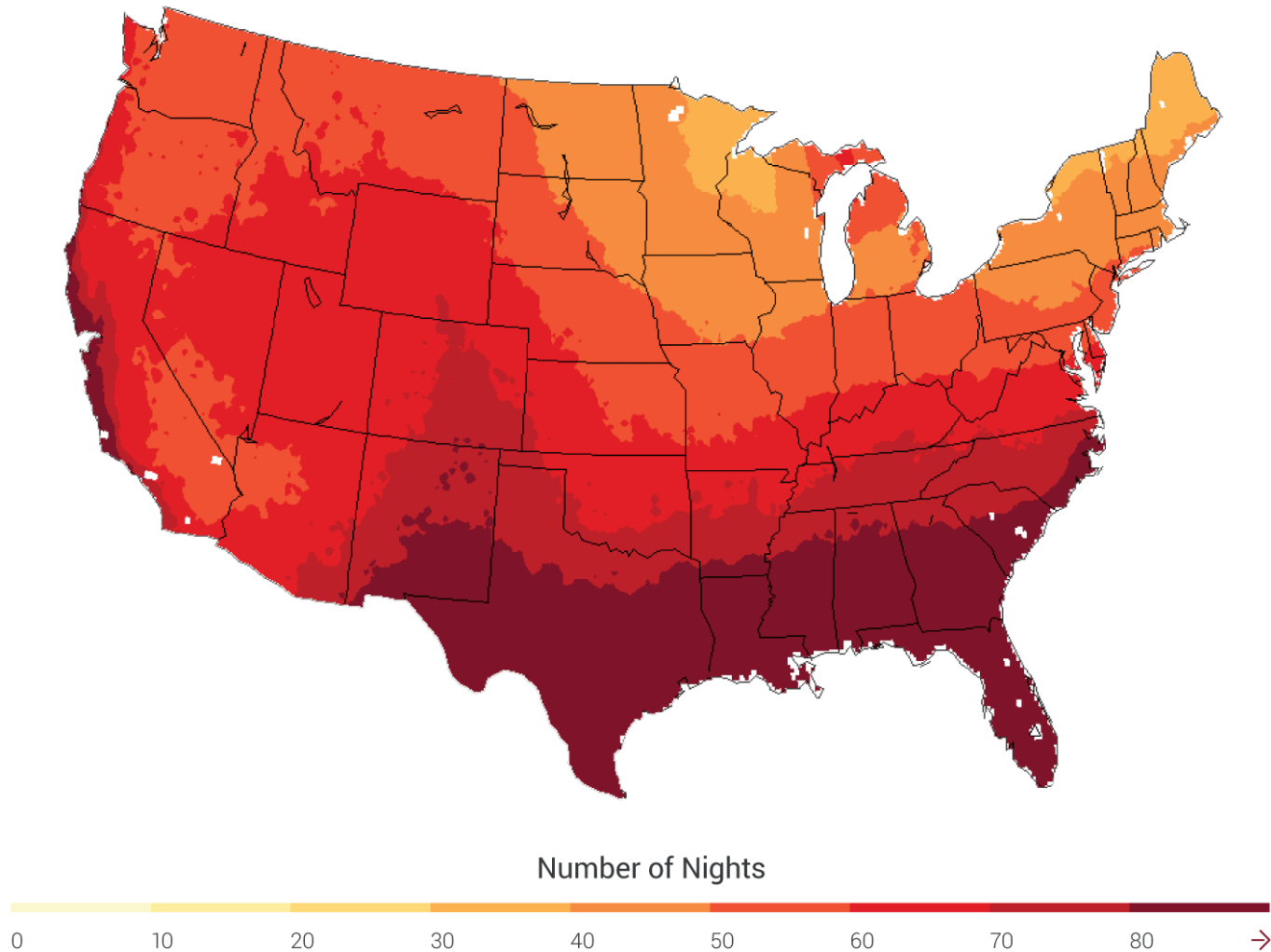


Image from the National Climate Assessment Center

Change in the Number of Hot Nights



Hot nights are defined as nights with a minimum temperature higher than 98% of the minimum temperatures between 1971 and 2000. Such nights are projected to increase throughout the nation. High nighttime temperatures can reduce grain yields and increase stress on animals, resulting in reduced rates of meat, milk, and egg production.

Spring is arriving 2 to 8 days earlier in the N.E. U.S.

Frosts are also coming later.

But these trends are not consistent over all latitudes.

In Iowa, sales of larger sized equipment have been increasing. This allows for a more narrow window between field preparation and planting. Sometimes there is not enough time between the end of spring rains and optimal planting date.

The Length of the Growing Season is Increasing

MORE MOSQUITO DAYS BALTIMORE

1980s

150
DAYS PER YEAR

2010s

159
DAYS PER YEAR

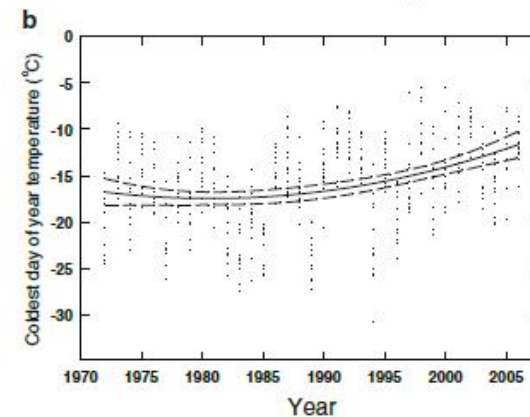


Mosquito days: 50-95°F, relative humidity >42%
Source: Yamana and Eltahir (2013)

CLIMATE  CENTRAL

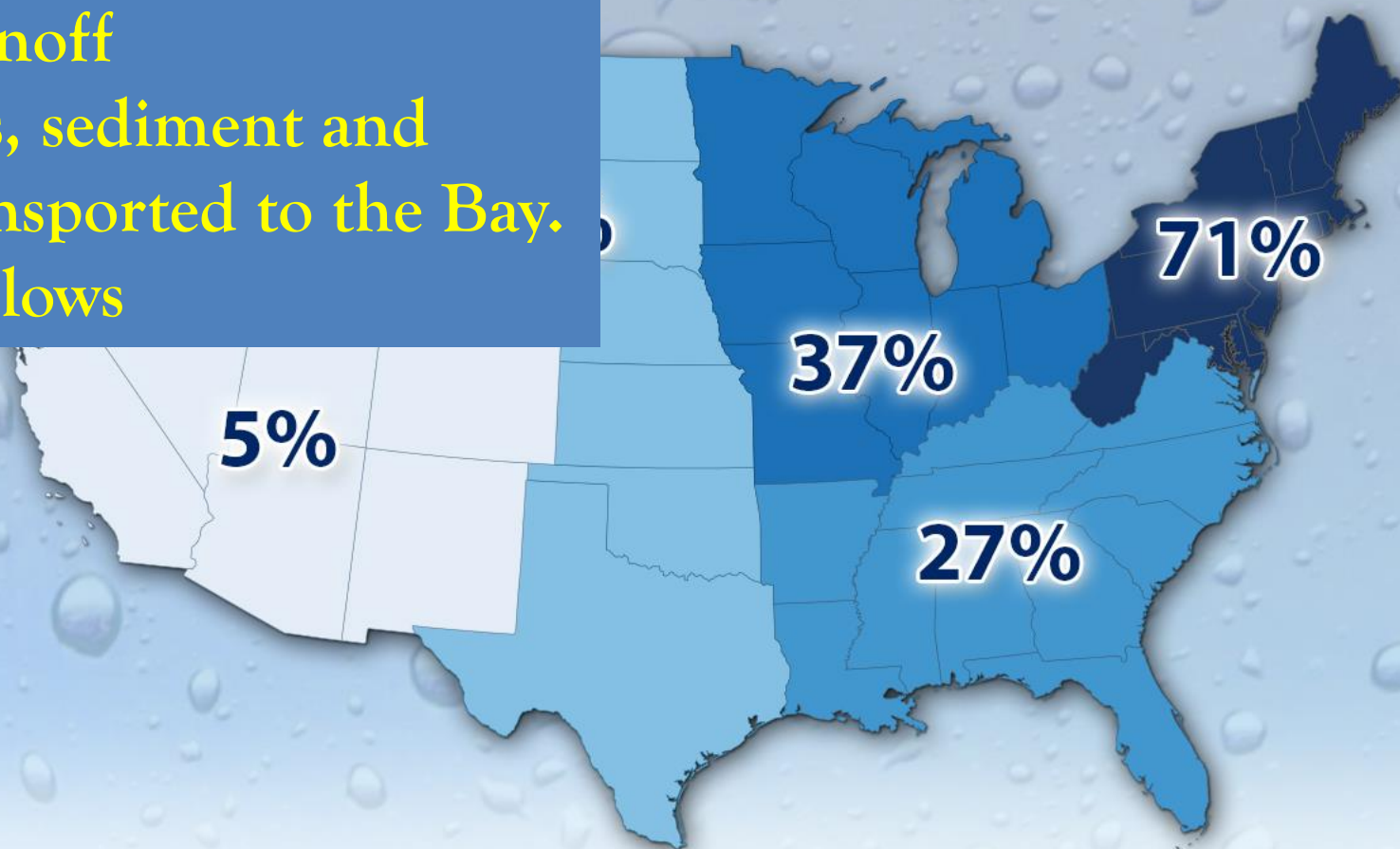
The Range of Kudzu has Shifted Further North

From: Ziska et al., 2010



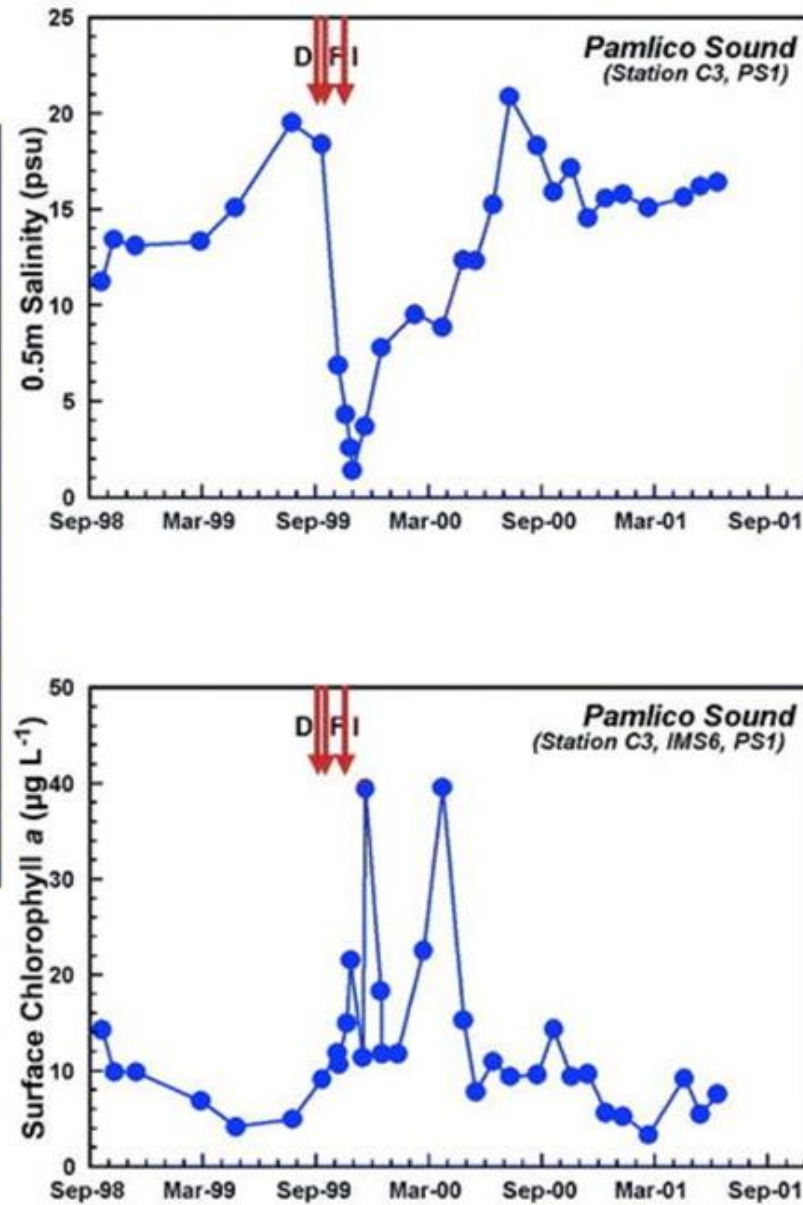
Heavy Downpours Increasing

- Increased runoff
 - Nutrients, sediment and water transported to the Bay.
- Sewage overflows



Percent increase from 1958 to 2012 in the amount of precipitation falling in very heavy events.

Very Heavy Precipitation is defined as the heaviest 1% of all daily events from 1958-2012.



Effects of three successive hurricanes (1999) on water salinity and subsequent growth of plankton in the Pamlico Sound

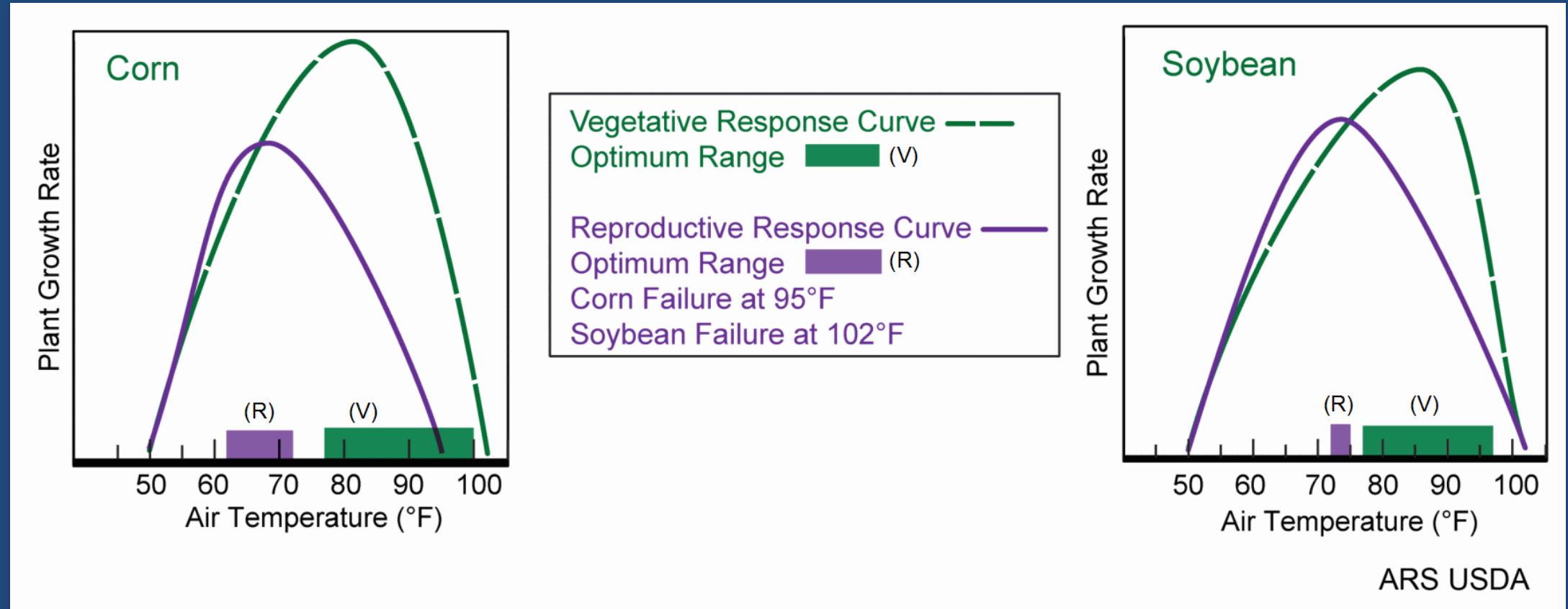
Paerl et al., 2003, *BioScience*, Volume 53, Issue 10, October 2003, Pages 953–964, [https://doi.org/10.1641/0006-3568\(2003\)053\[0953:PPAIOE\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2003)053[0953:PPAIOE]2.0.CO;2)

Temperature drives plant growth



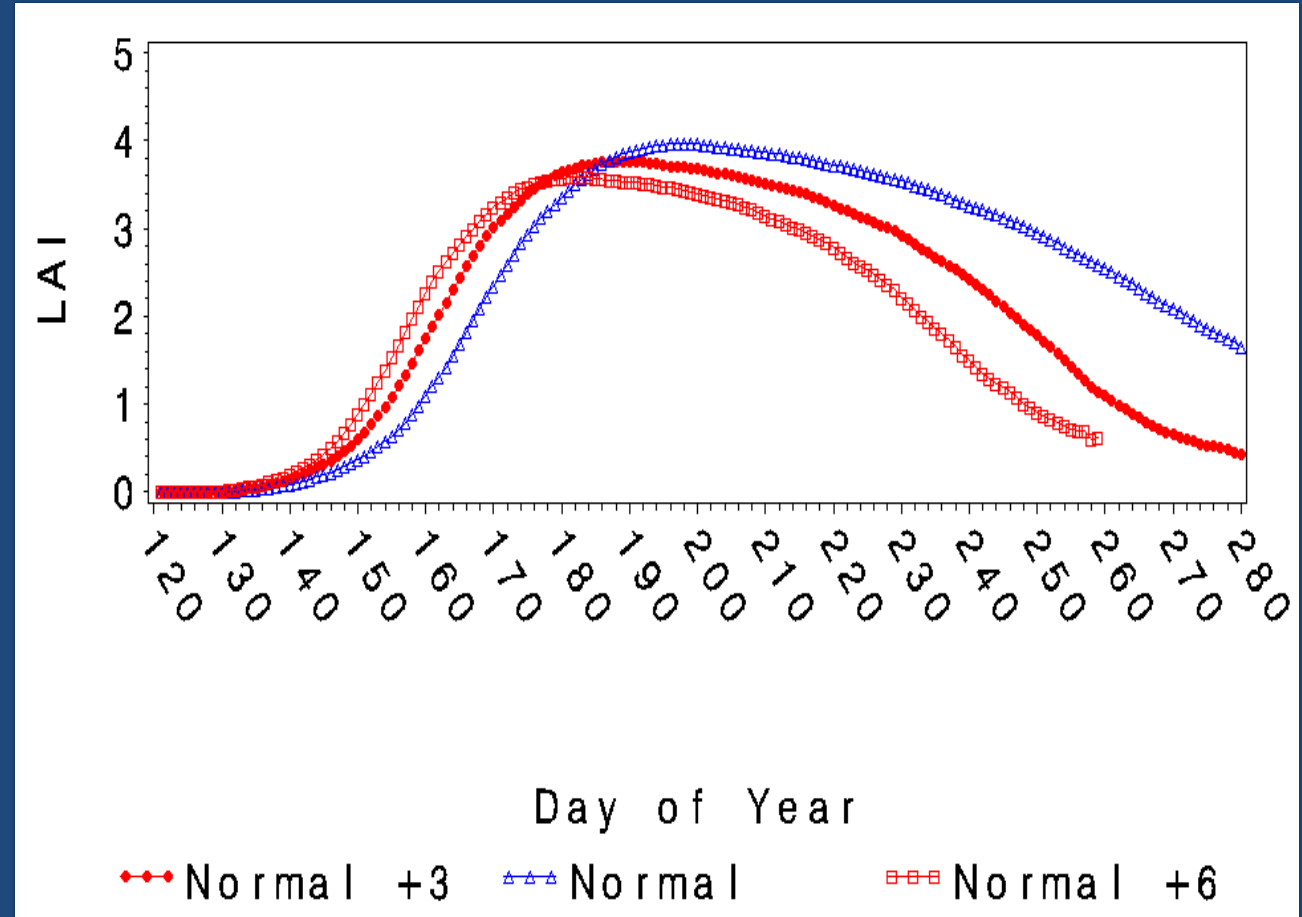
Wheat plants
grown at 6
temperatures
36C is about
96F

Corn and soybean temperature response



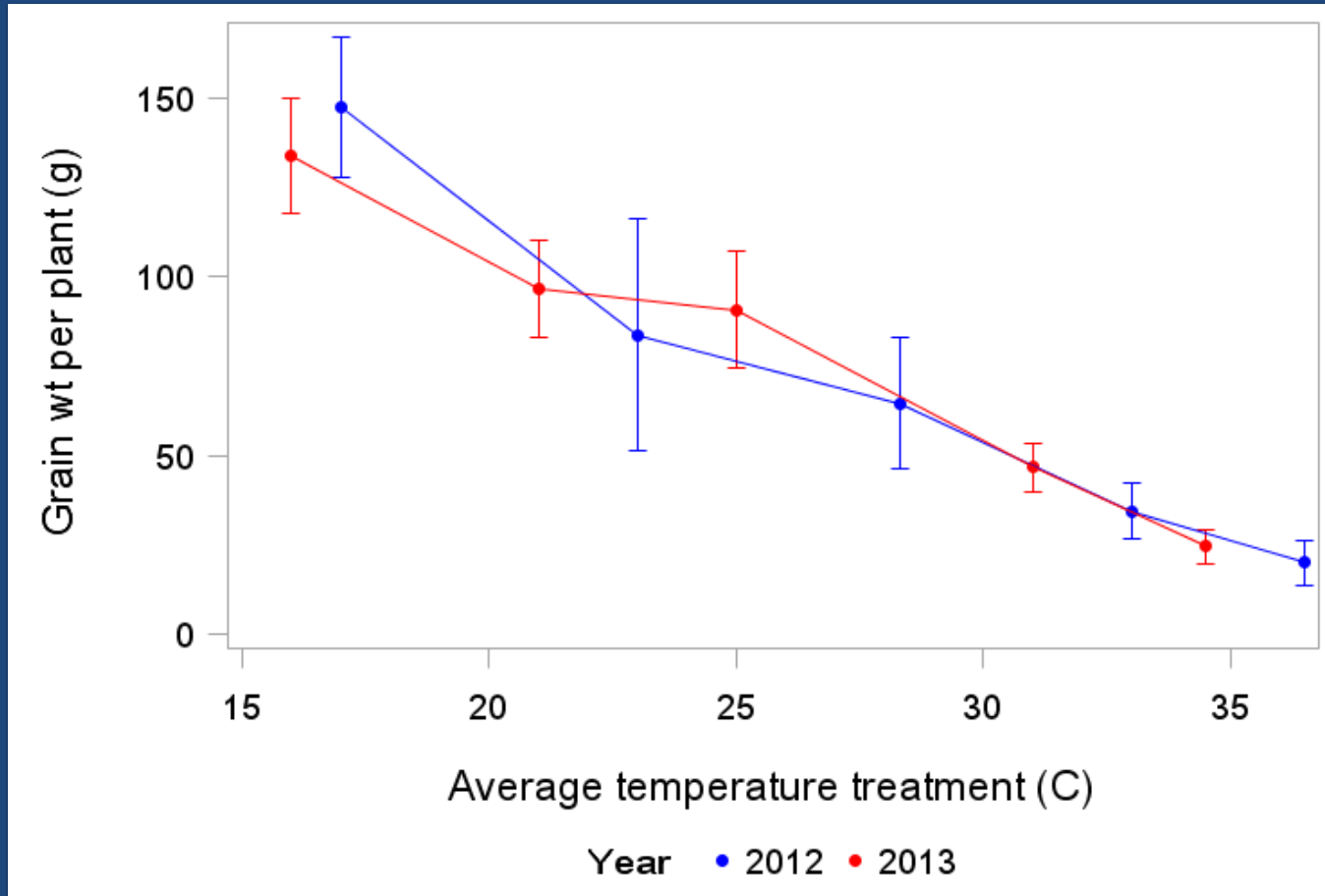
Effect of increased temperature on development processes

1. Exposure to higher temperatures will cause faster rate of development
2. This doesn't translate into maximum production because shorter life cycle creates smaller plants, shortened reproductive duration, and reduced yield potential because of reduced light interception during the growing season.
3. At higher temperatures plant leaves grow and age faster.



This figure shows the decrease in the lifetime of a corn crop as temperature increases. LAI is Leaf Area Index, leaf area per unit ground area.

Relationship Between Temperature and Grain Weight.



Note the decline is similar for both years
Consistently decreases with temperature. The decrease is about 6 g per plant per degree of temperature. With a plant population of about 6 plants per sq meter, this is near 360 kg/ha per 1 degree of temperature increase.

Weeds and Other Secondary Effects of Climate Change

Control of Invasive Plants and Weeds

Ambient CO₂

Future CO₂ (+300 ppm)

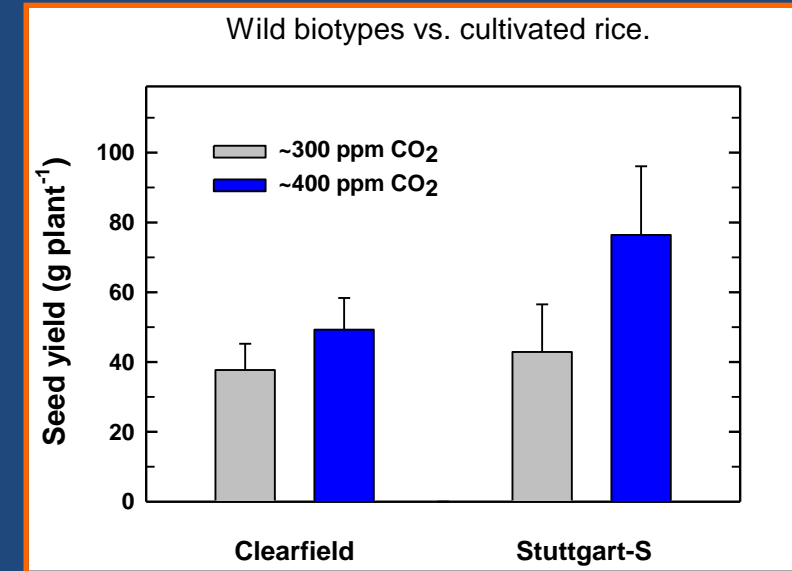
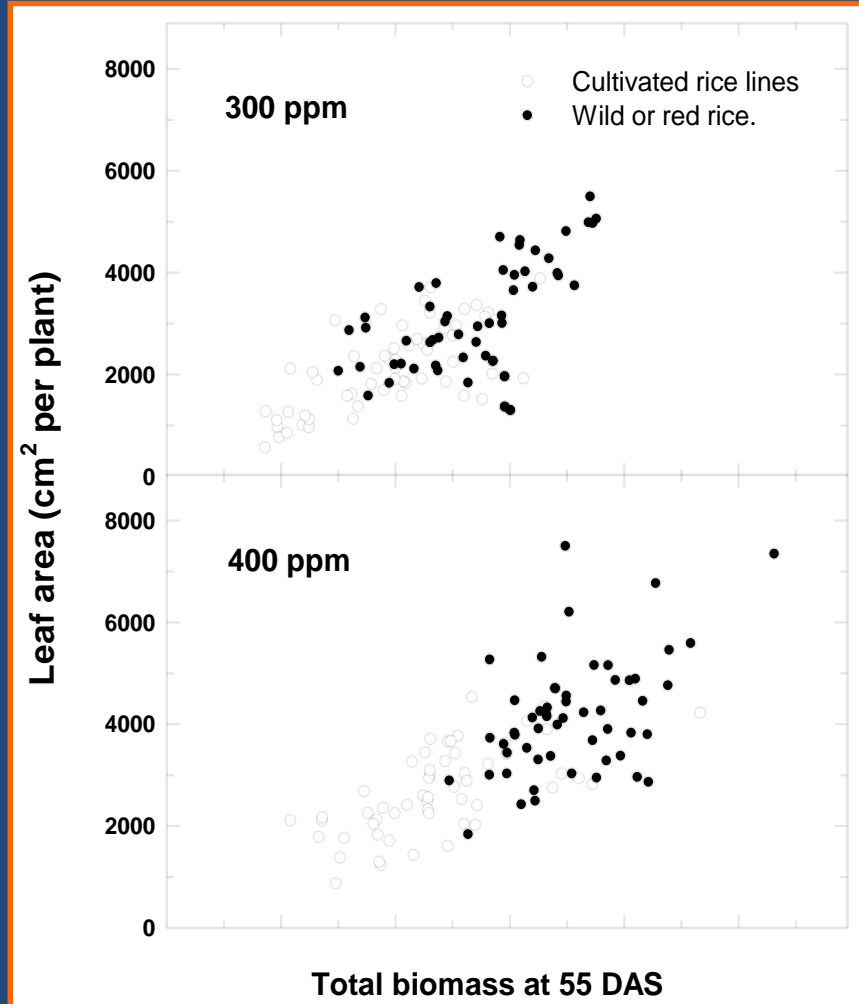


Increasing CO₂ reduces herbicide efficacy.

e.g. Ziska et al. *Weed Science* 2004

Question: By stimulating plant growth can rising CO₂ levels alter chemical efficacy of weed control?

Weeds and Rising CO₂.



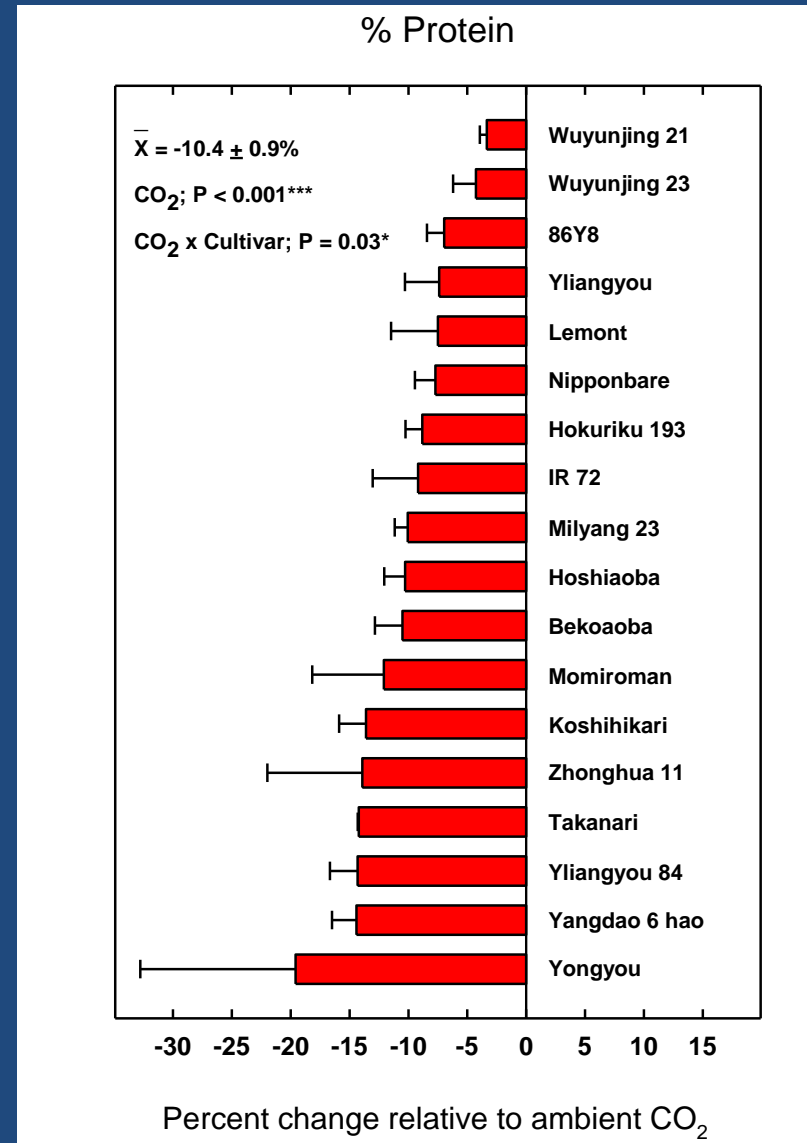
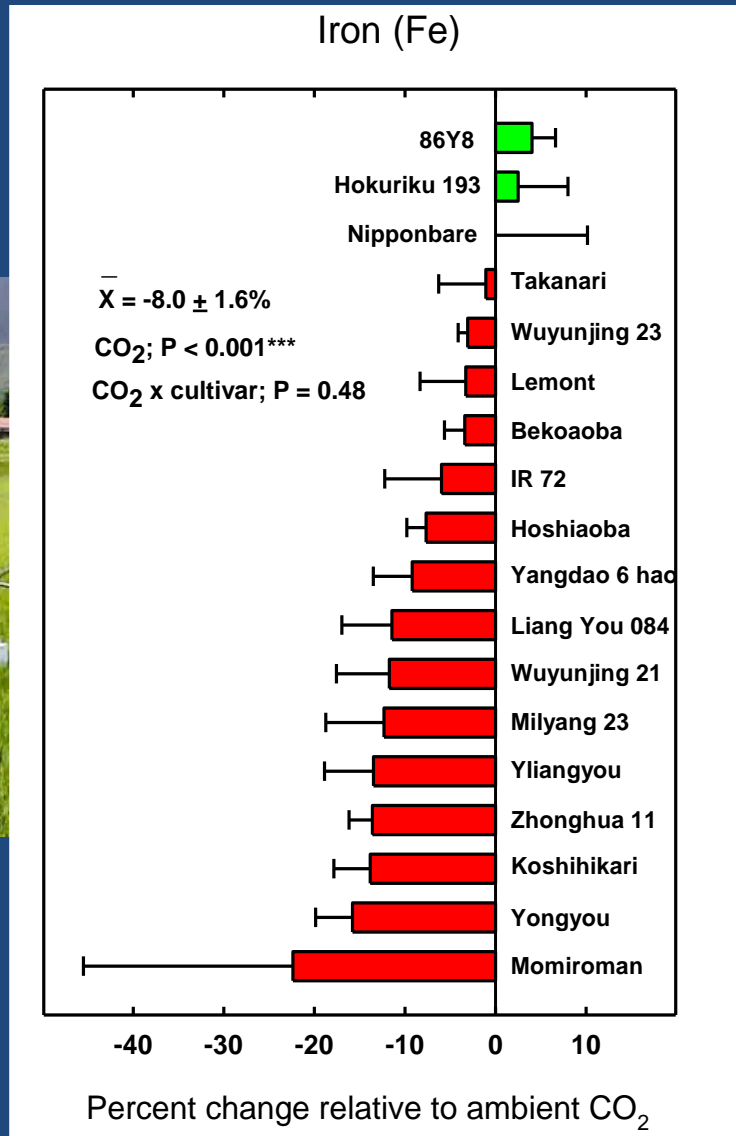
Are breeders and nature selecting for the same characteristics?

Can weedy, wild relatives of crops be a unique source of germplasm to adapt modern crop lines to an uncertain climate?



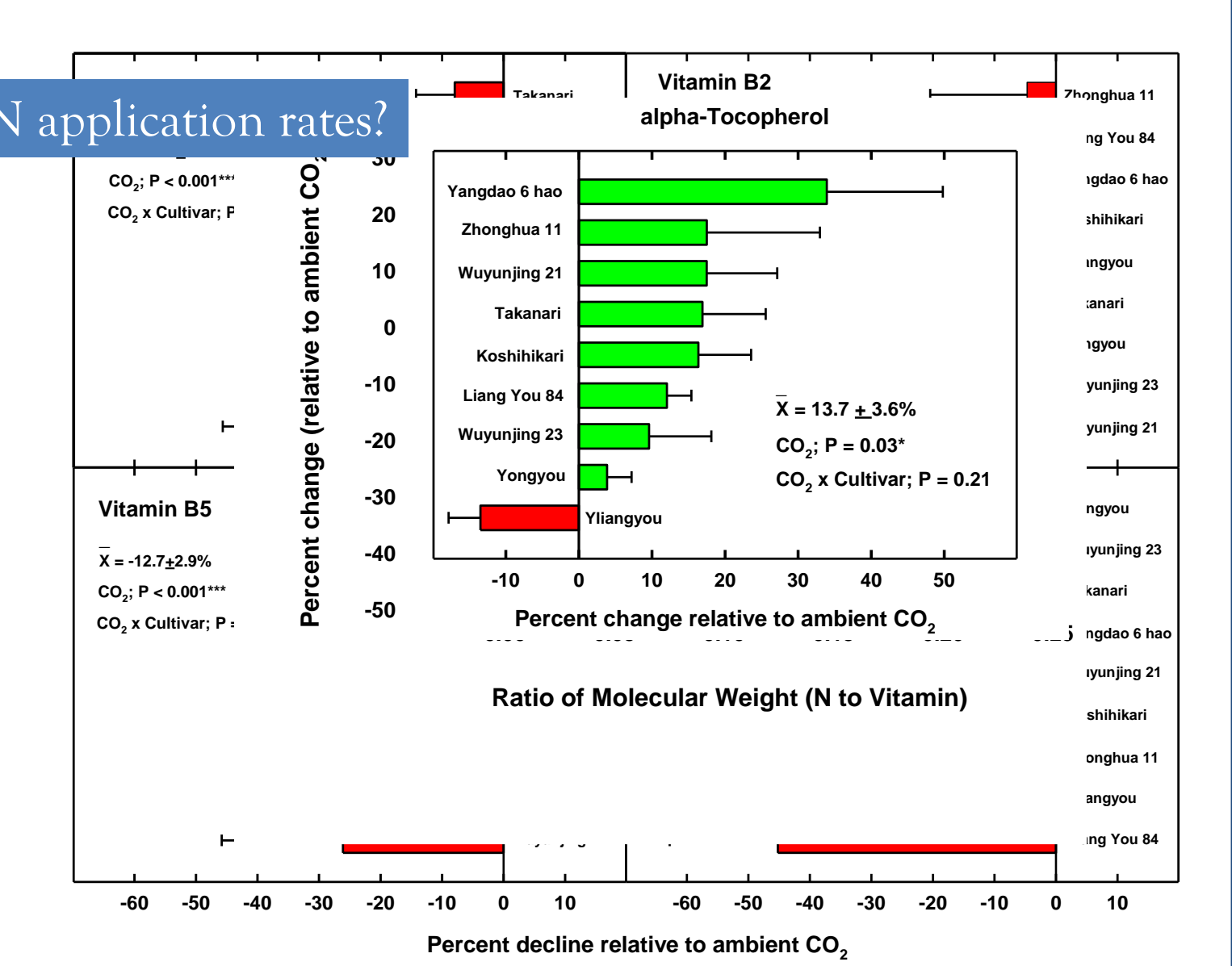
Nutrient Content of
our food decreases
under elevated CO₂
due to faster growth
rates and changes in
biochemistry and
nutrient uptake

Nitrogen uptake decreases at elevated CO₂



And the role of CO₂ on plant chemistry? Toxicology, Dermatitis, Allergens and Nutrition

Adjust N application rates?

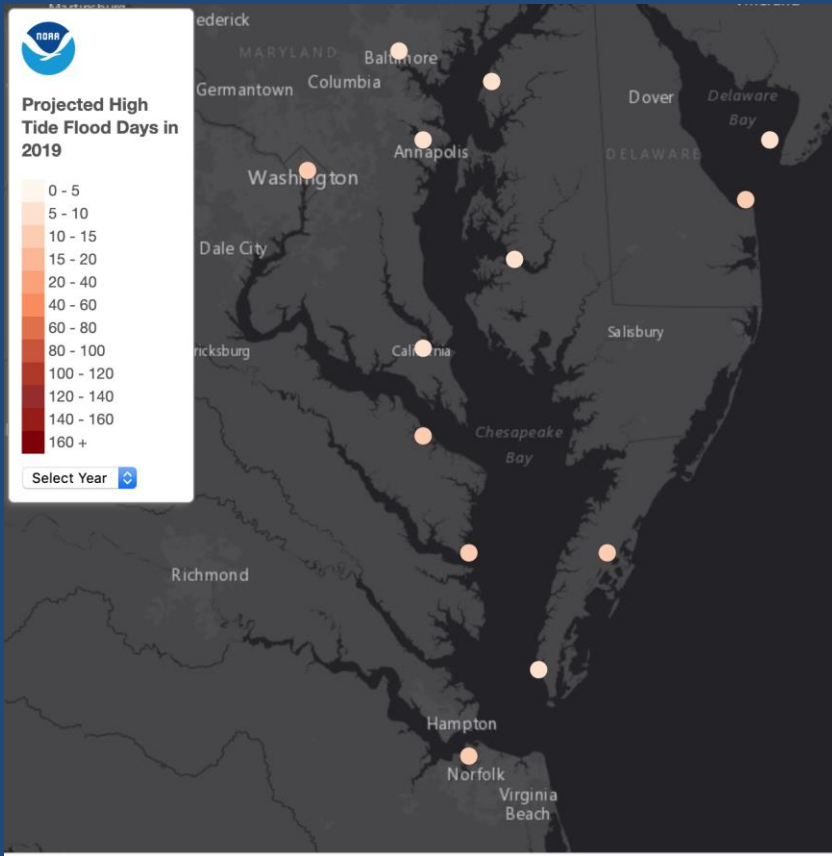


As plant N decreases the B vitamins decrease as well

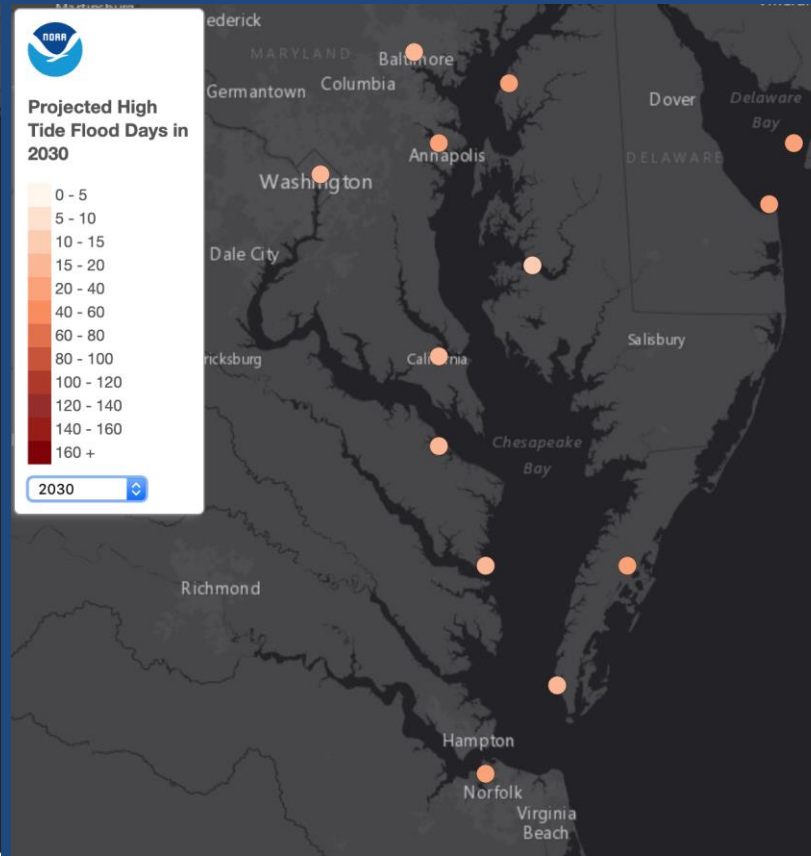
Lower N uptake due to lower transpiration at elevated CO₂ and dilution by higher carbon assimilation

Causes of saltwater intrusion: sea level rise

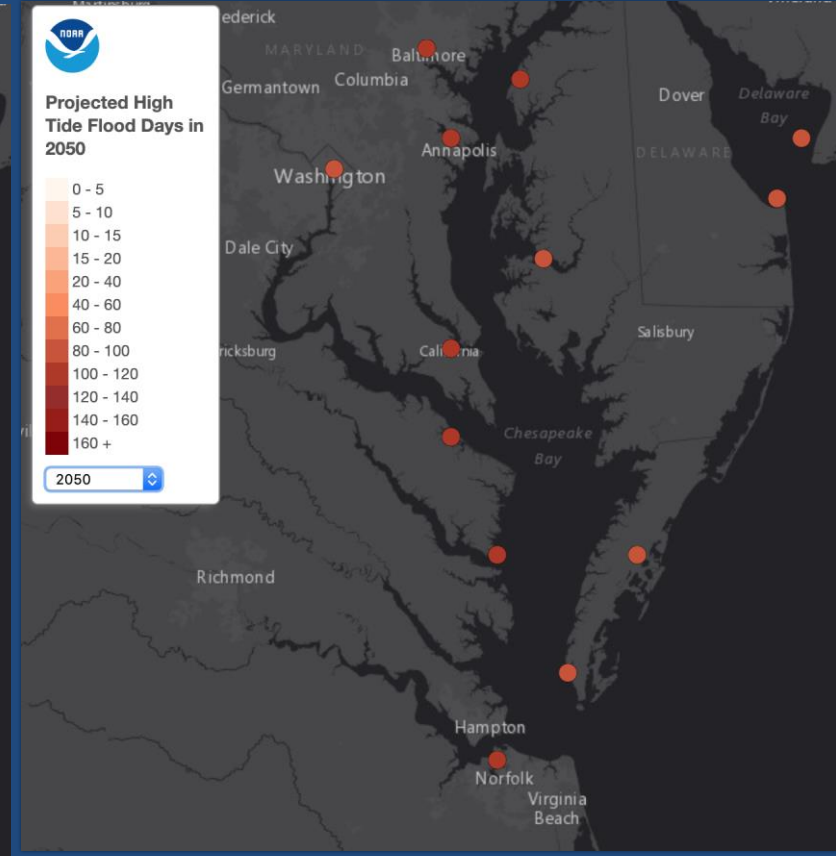
More red = more frequent “sunny day” flooding



In 2019, 10 flood days.



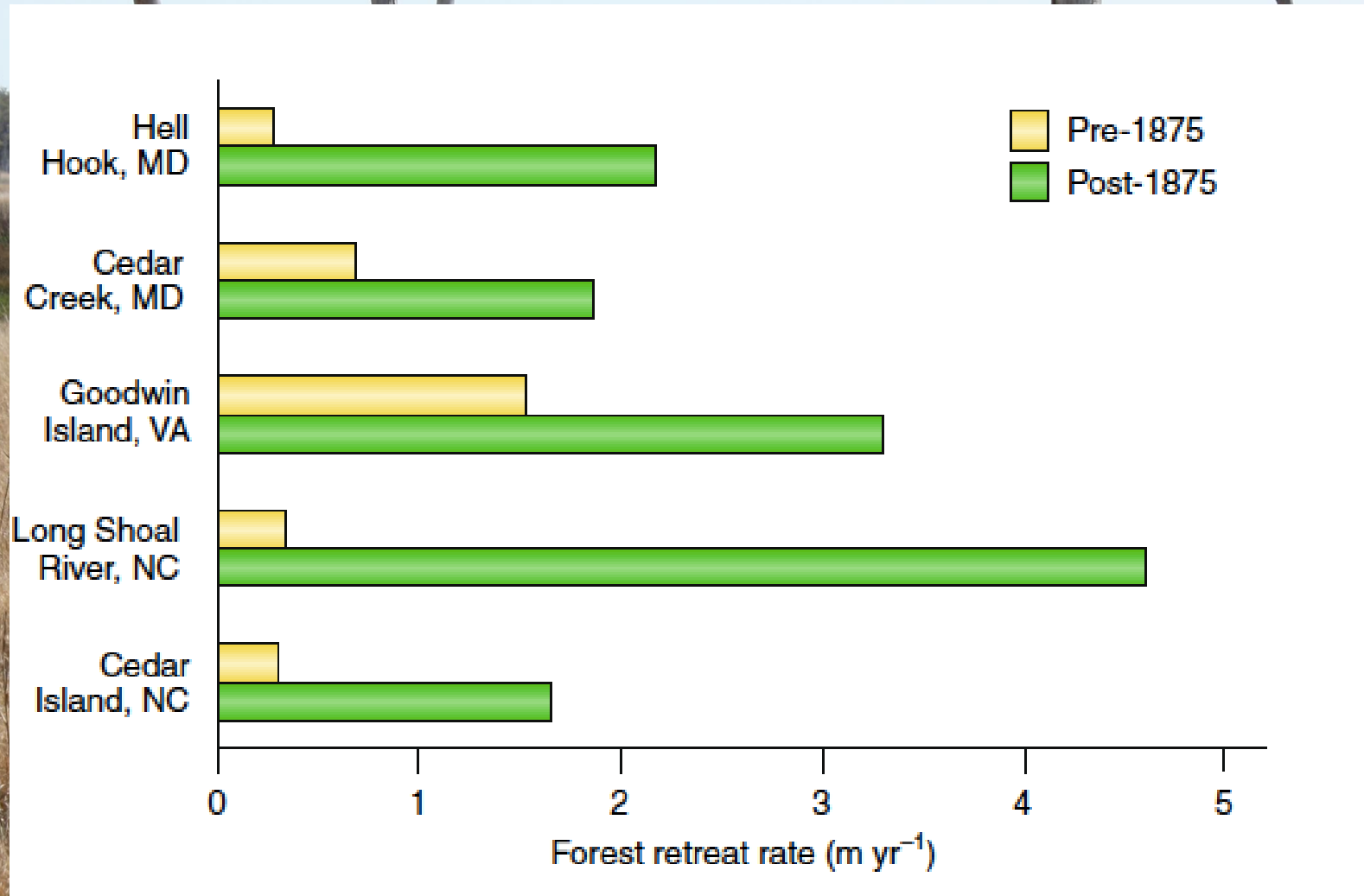
By 2030, 15-40 flood days.



By 2050, 60-120 flood days.

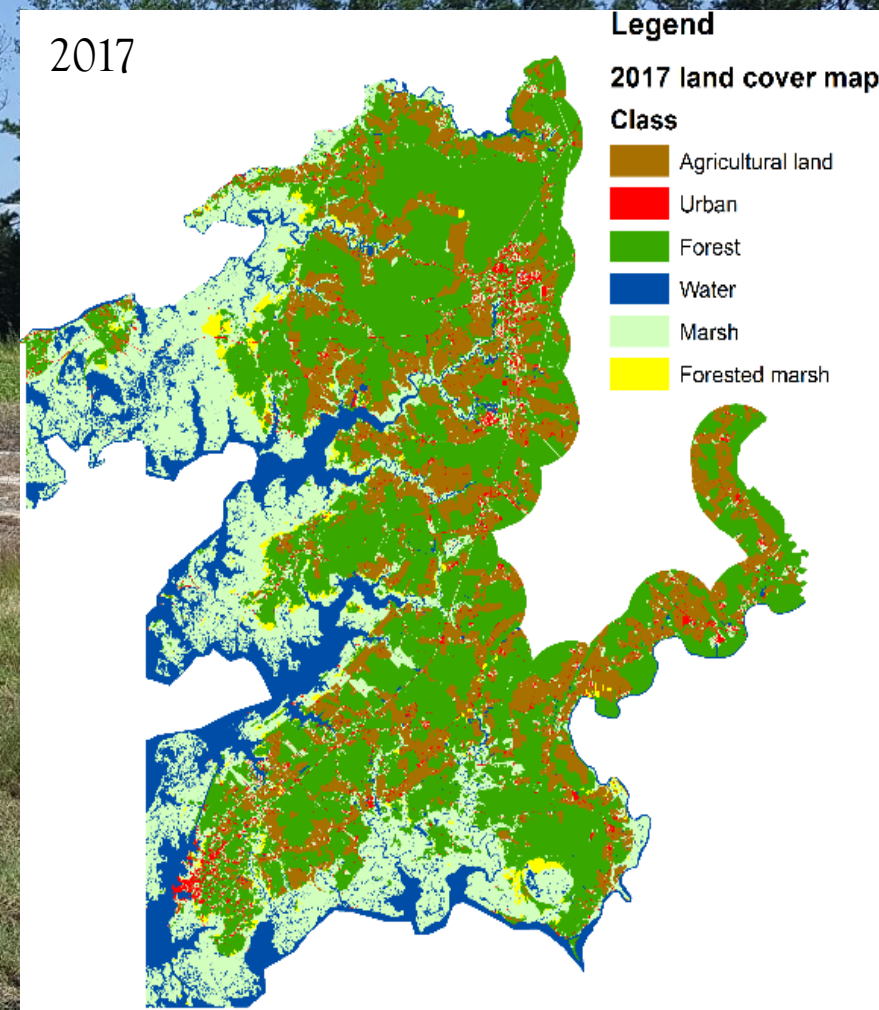
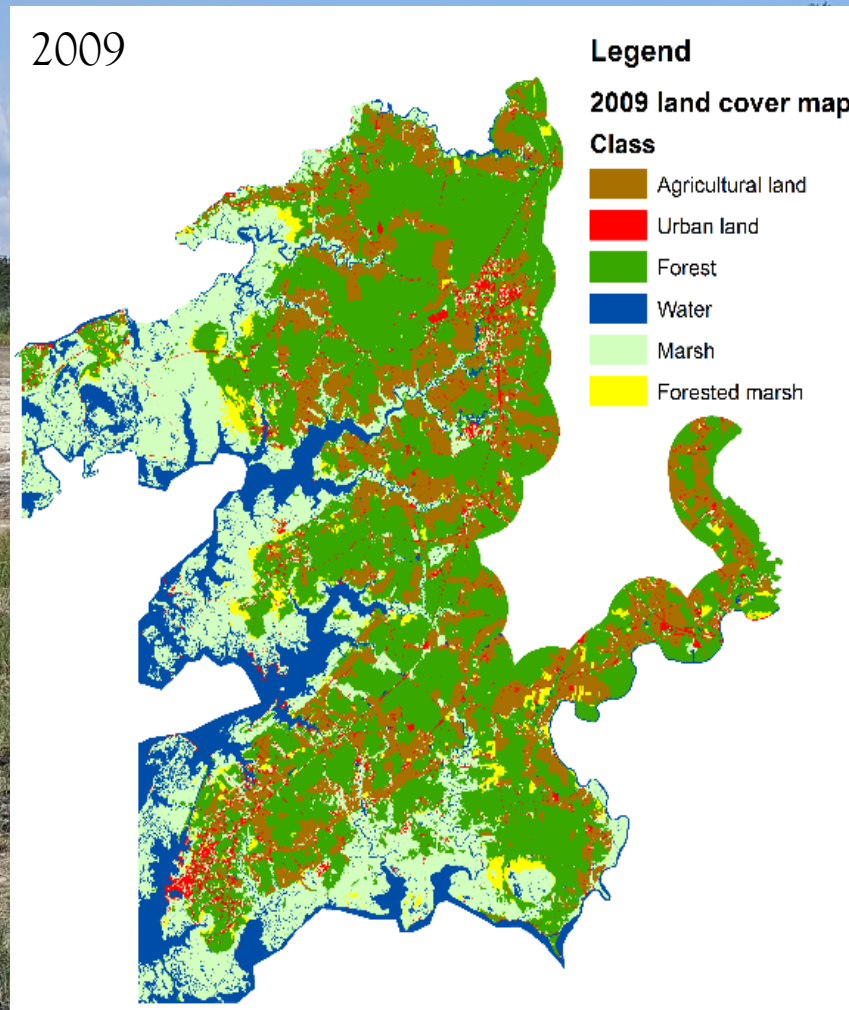
These following slides on salt water intrusion are from Dr. Katherine Tully of the Univ. of MD NOAA CO-OPS Tides and Currents

Saltwater intrusion in uplands creates ghost forests



In Somerset county, 1400 acres of farmland converted to tidal marsh from 2009-2017

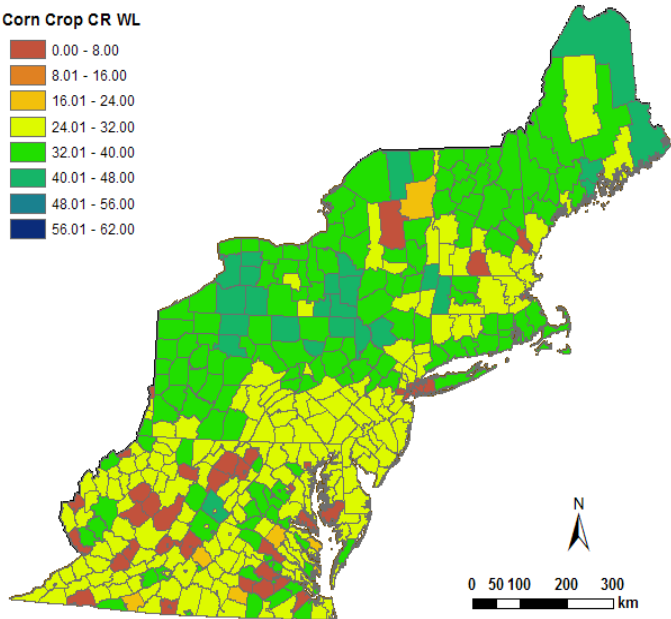
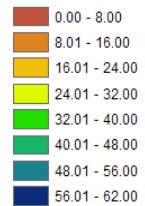
= 2% of the farmland lost in only 8 years!



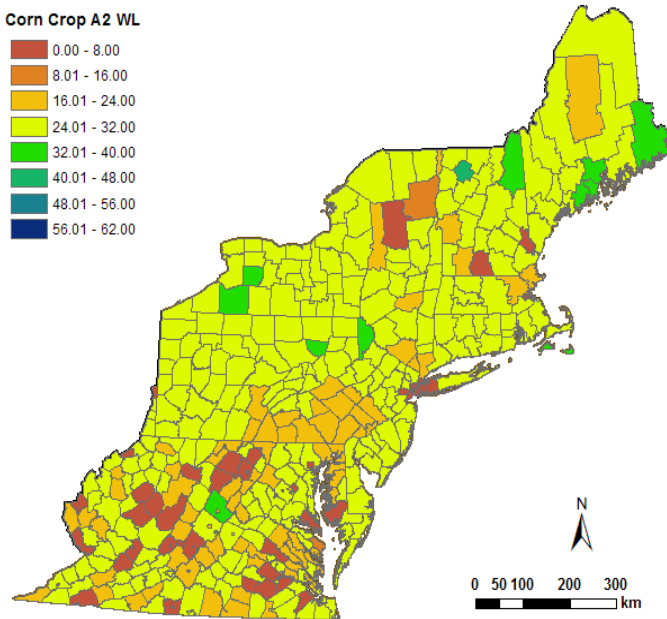
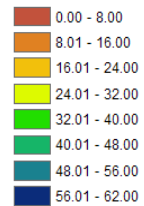
Projected Impacts Corn

◇ Corn crop-land: Current vs A2

Corn Crop CR WL



Corn Crop A2 WL



Percent Yield Declines

Corn

State	WL→A2
ME	-23
VT	-24
RI	-20
NH	-19
MA	-20
CT	-19
NY	-21
PA	-20
NJ	-18
MD	-17
DE	-14
WV	-22
VA	-17
MEAN	-20

Projections

- ◆ General concerns (Mid-Atlantic, mid-century 2040-2069)
 - ◆ Warmer, more frequent hot days and nights
 - ◆ summers (0.8 to 4.5 C) on average above baseline
 - ◆ Increased annual rainfall not necessarily during growing season
 - ◆ flooding; drought (not so much)
 - ◆ Heat wave frequency and duration
 - ◆ Even 2°C rise in mean temperature by 2100, in the IPCC low emission scenario, could destabilize current farming system!
- ◆ May lead to environmental Impacts:
 - ◆ Salt-intrusion
 - ◆ Land-loss
 - ◆ Extreme Events
 - ◆ Seasonal shifts in climate
 - ◆ Ecological issues



Remarks

- ◇ Agriculture will be significantly impacted if we don't adapt
 - ◇ Example: 18 to 92% reduction for MES counties
- ◇ Simple adaptation measures (shifting planting dates) help:
 - ◇ Example: 6 to 23% reduction for MES counties
- ◇ Other approaches (e.g. increasing irrigation) may help:
 - ◇ Example: 14 to 15% reduction
- ◇ Many ag - components that are being evaluated:
 - ◇ Additional commodities
 - ◇ Breeding with 'heritage' or wild varieties
 - ◇ Region specific adaptation studies can be conducted (e.g. fertilizer, varieties)
 - ◇ Land-configuration
 - ◇ Other things: distribution networks, transportation, biotic issues, sustainable agriculture



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Thanks!

A useful resource:
<https://www.climatehubs.usda.gov/>



For further information please contact
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