



How Climate Change May Impact Maryland and Its Agriculture

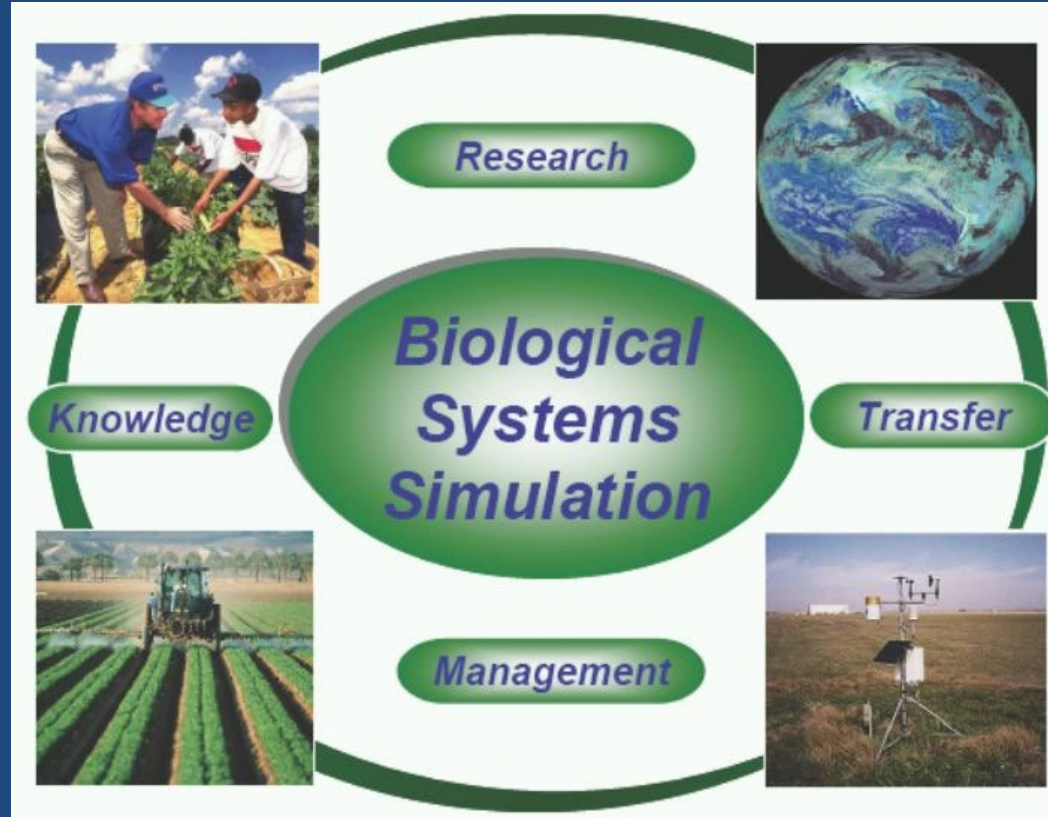
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**Agricultural
Research
Service**

Mission of the ACSL

Applying Systems Theory to Complex Agricultural Problems

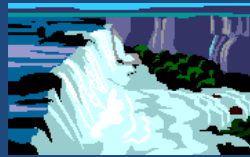


- Predicting Consequences of Environmental Change
 - Adapting Crops and Management Strategies
 - Improving Crop Management Decision Making

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



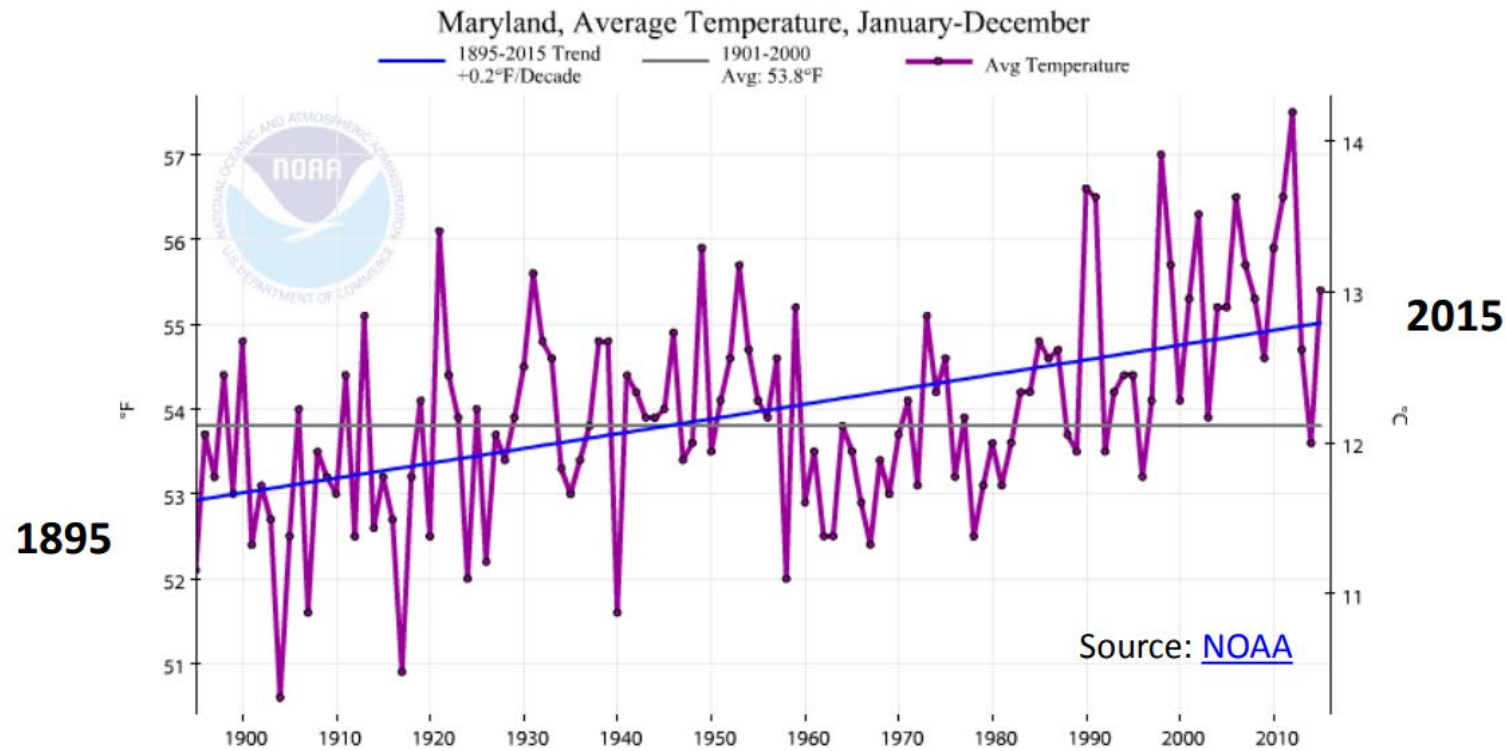
Warming in Maryland



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

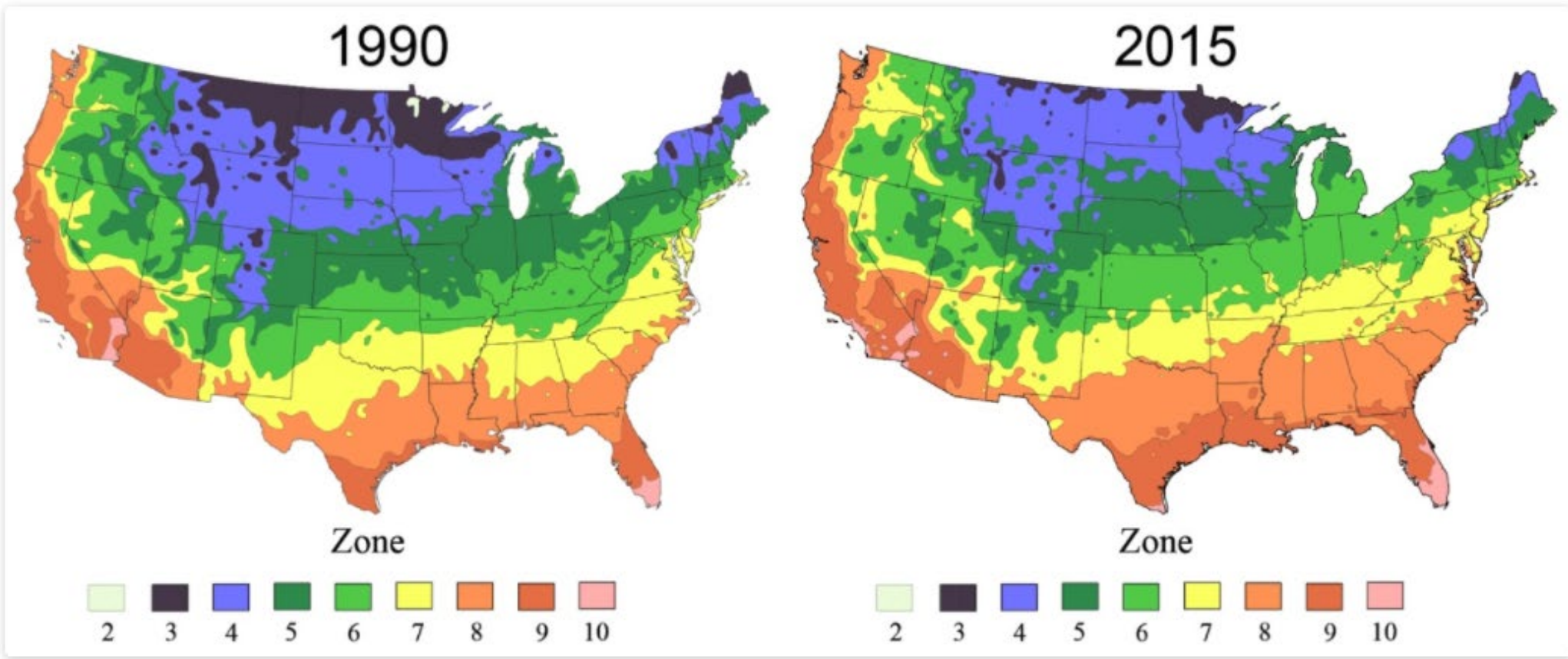
OBSERVATIONS

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.



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 – 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.

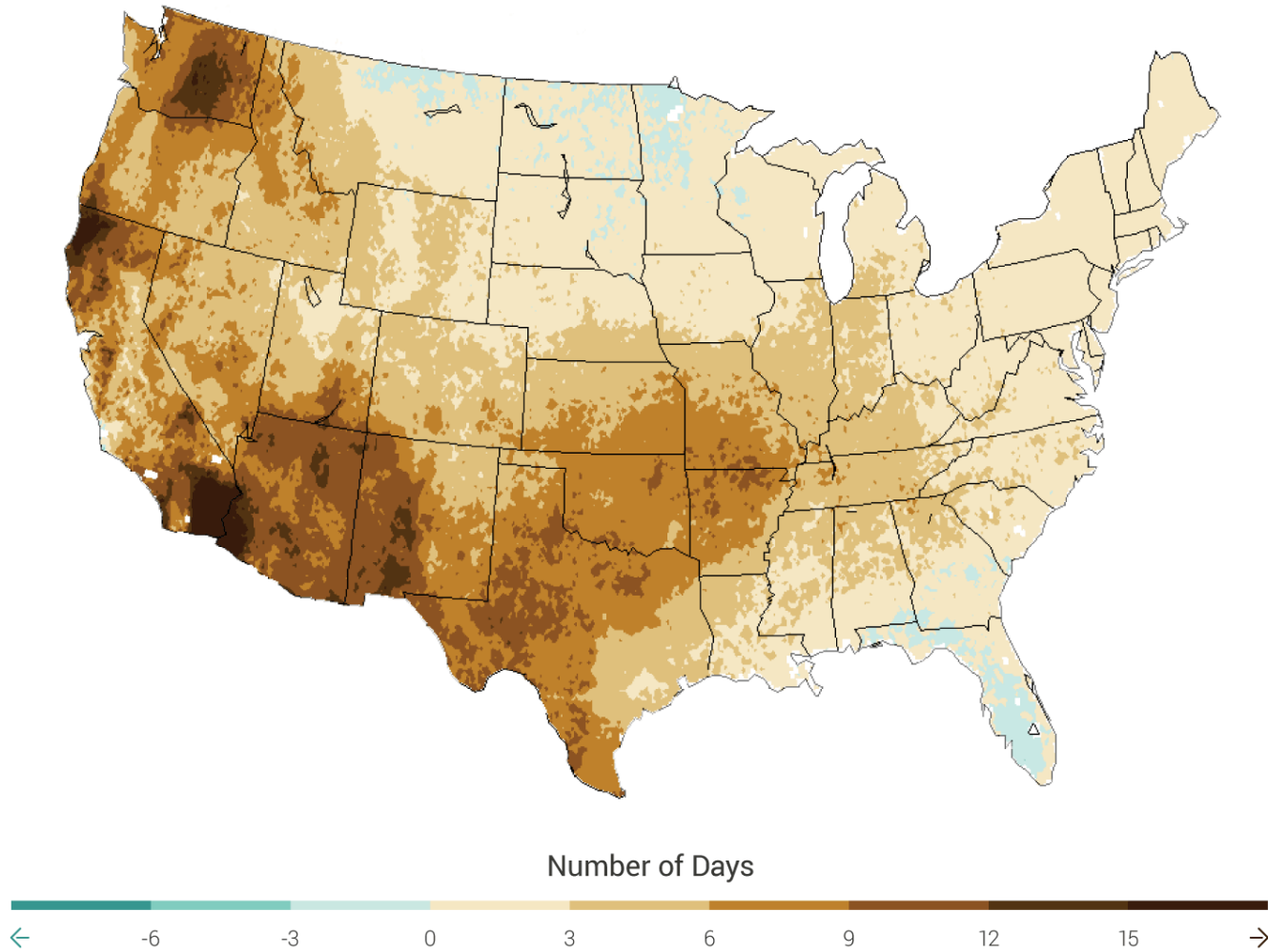
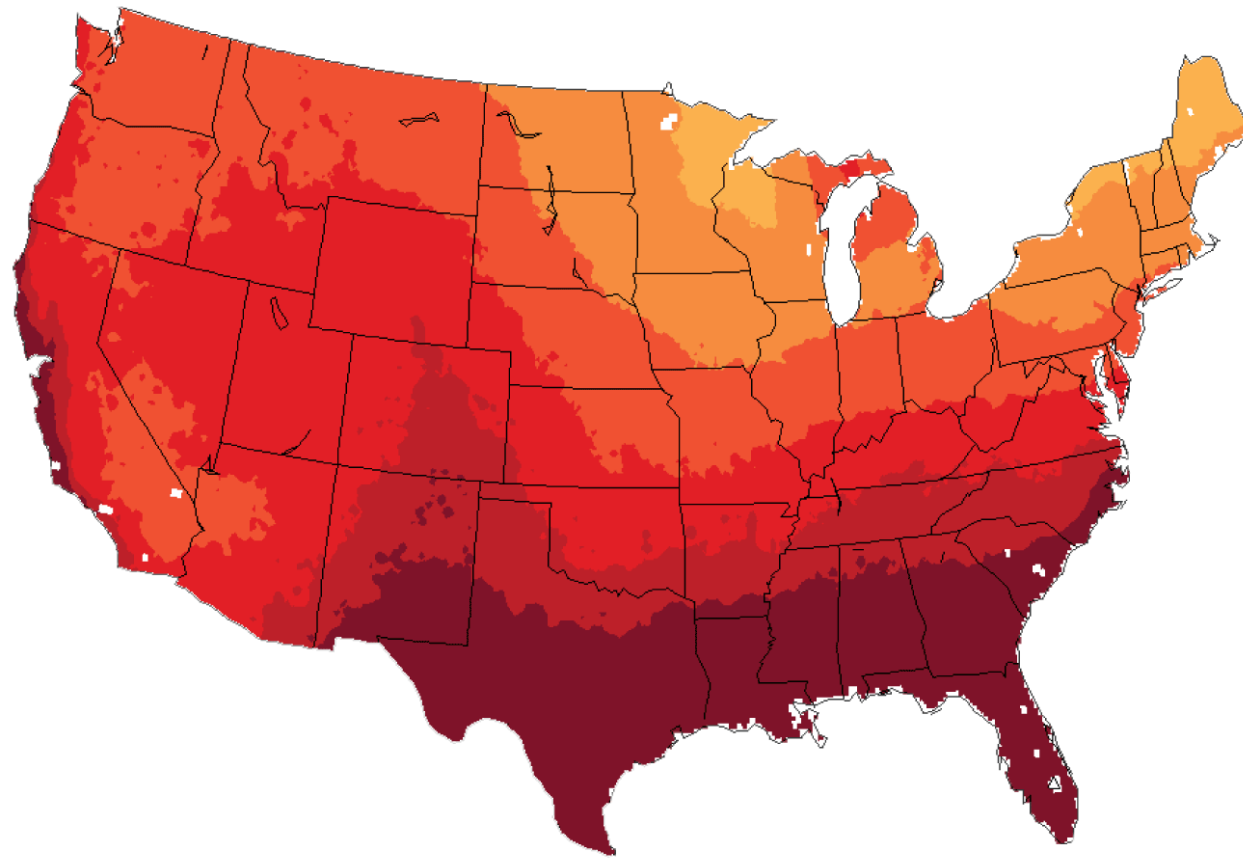


Image from the National Climate Assessment Center

Change in the Number of Hot Nights



Number of Nights



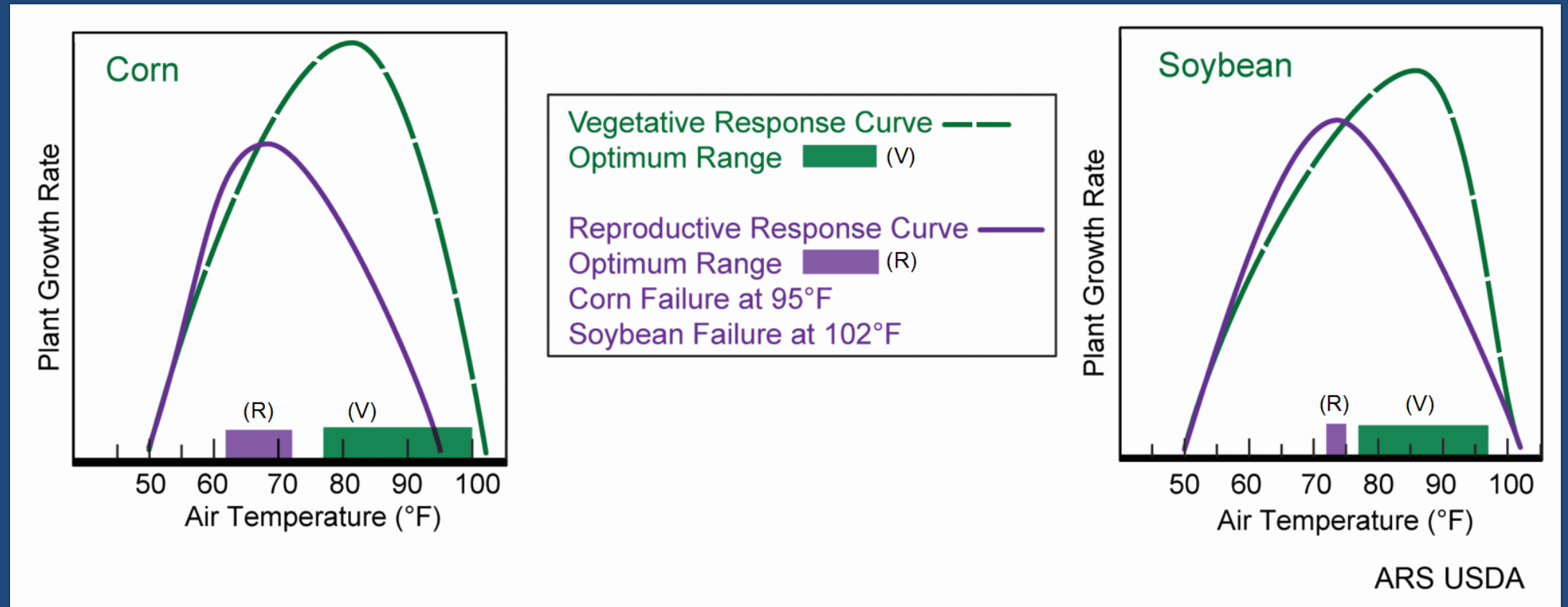
Hot nights are defined as nights with a minimum temperature higher than 98% of the minimum temperatures between 1971 and 2000. Such nights are projected to increase throughout the nation. High nighttime temperatures can reduce grain yields and increase stress on animals, resulting in reduced rates of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

Temperature drives plant growth



Wheat plants
grown at 6
temperatures

Corn and soybean temperature response



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

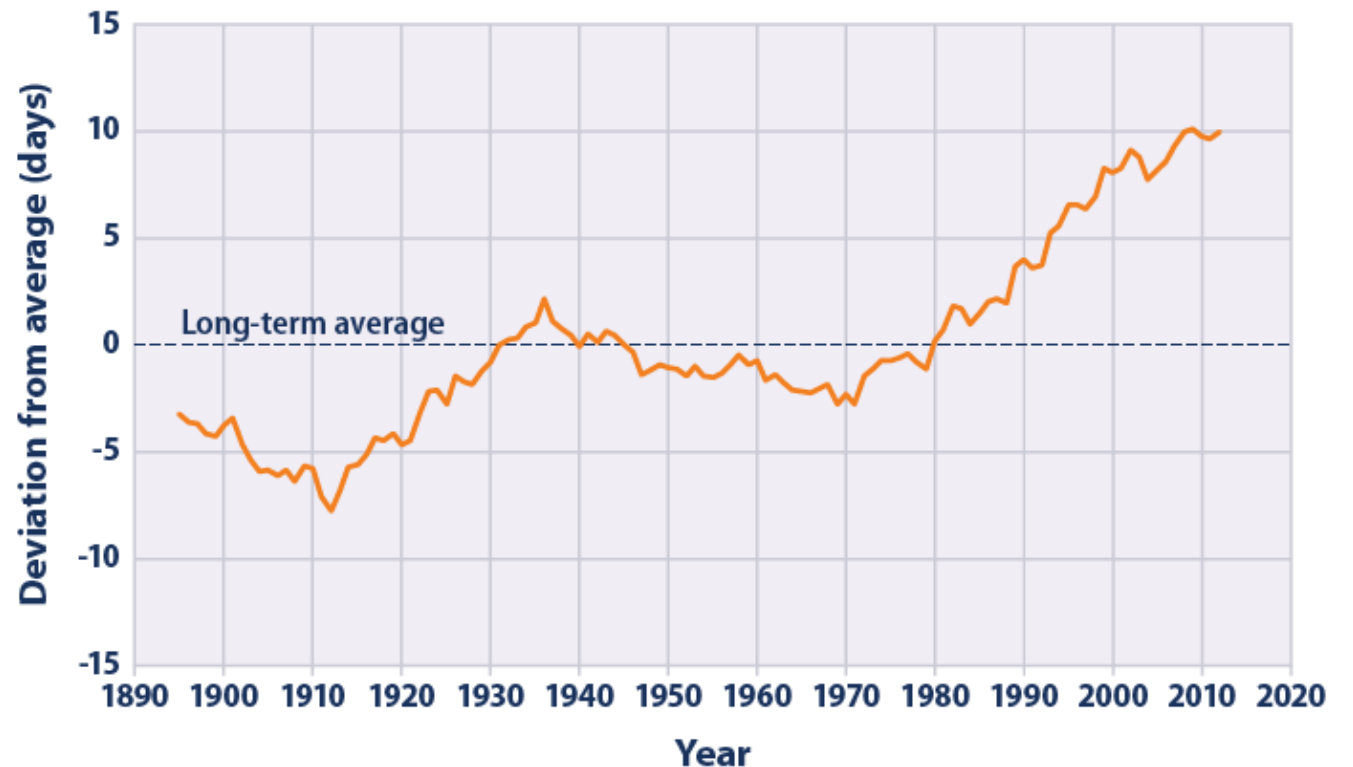
Frosts are also coming later.

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

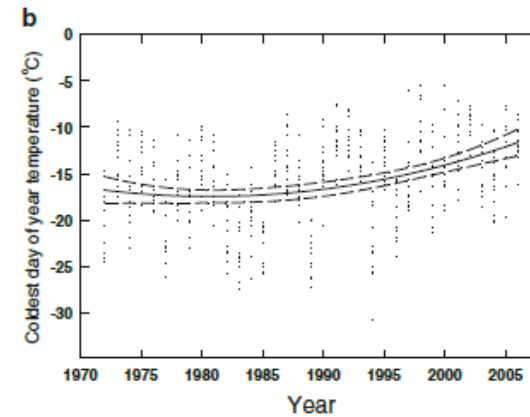
Length of Growing Season in the Contiguous 48 States, 1895–2012



Data source: Kunkel, K.E. 2013 update to data originally published in: Kunkel, K.E., D.R. Easterling, K. Hubbard, and K. Redmond. 2004. Temporal variations in frost-free season in the United States: 1895–2000. *Geophys. Res. Lett.* 31:L03201.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-change/indicators.

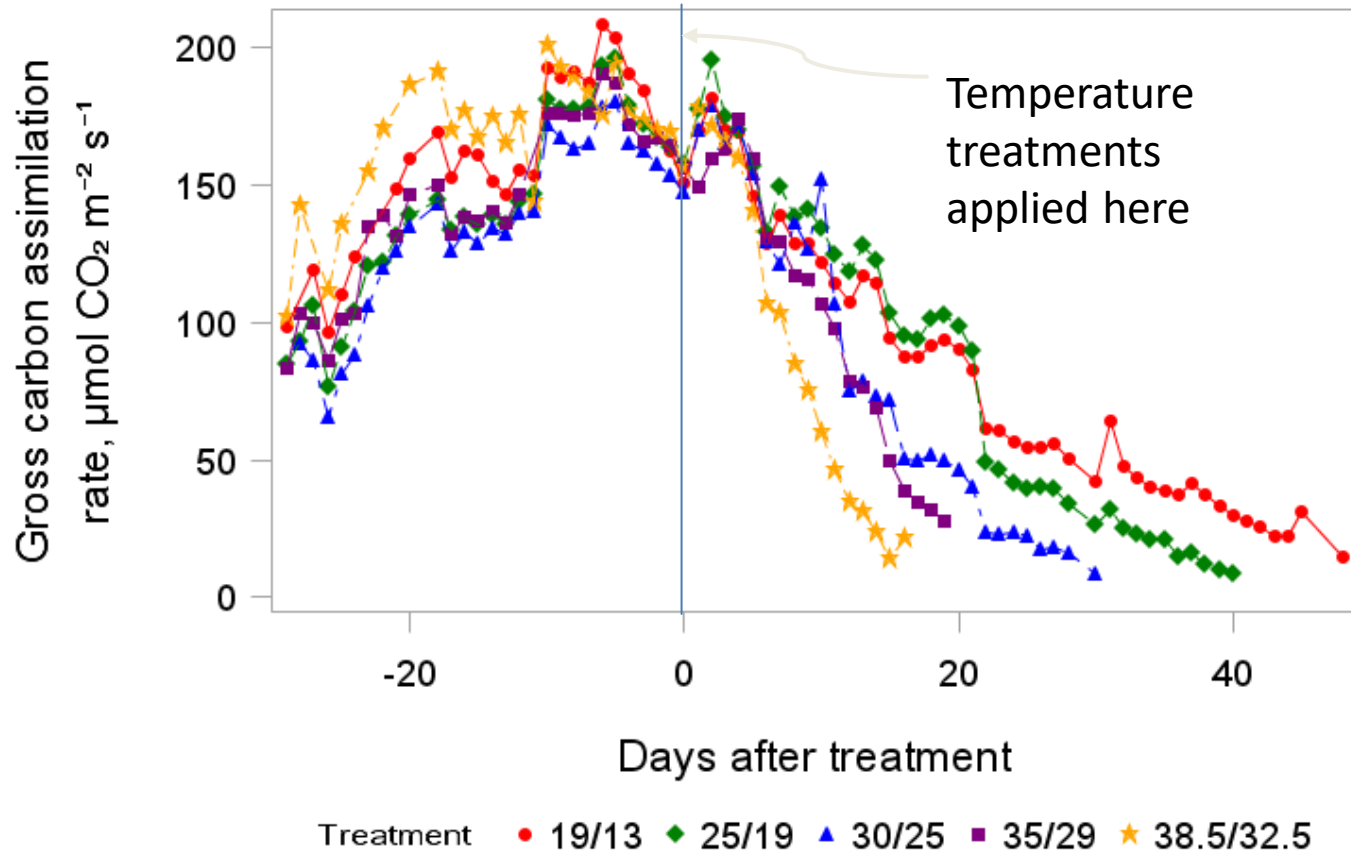
The Range of Kudzu has Shifted Further North



The common
milkweed is thriving
in Maryland,
especially in cities as
it thrives in the high
heat



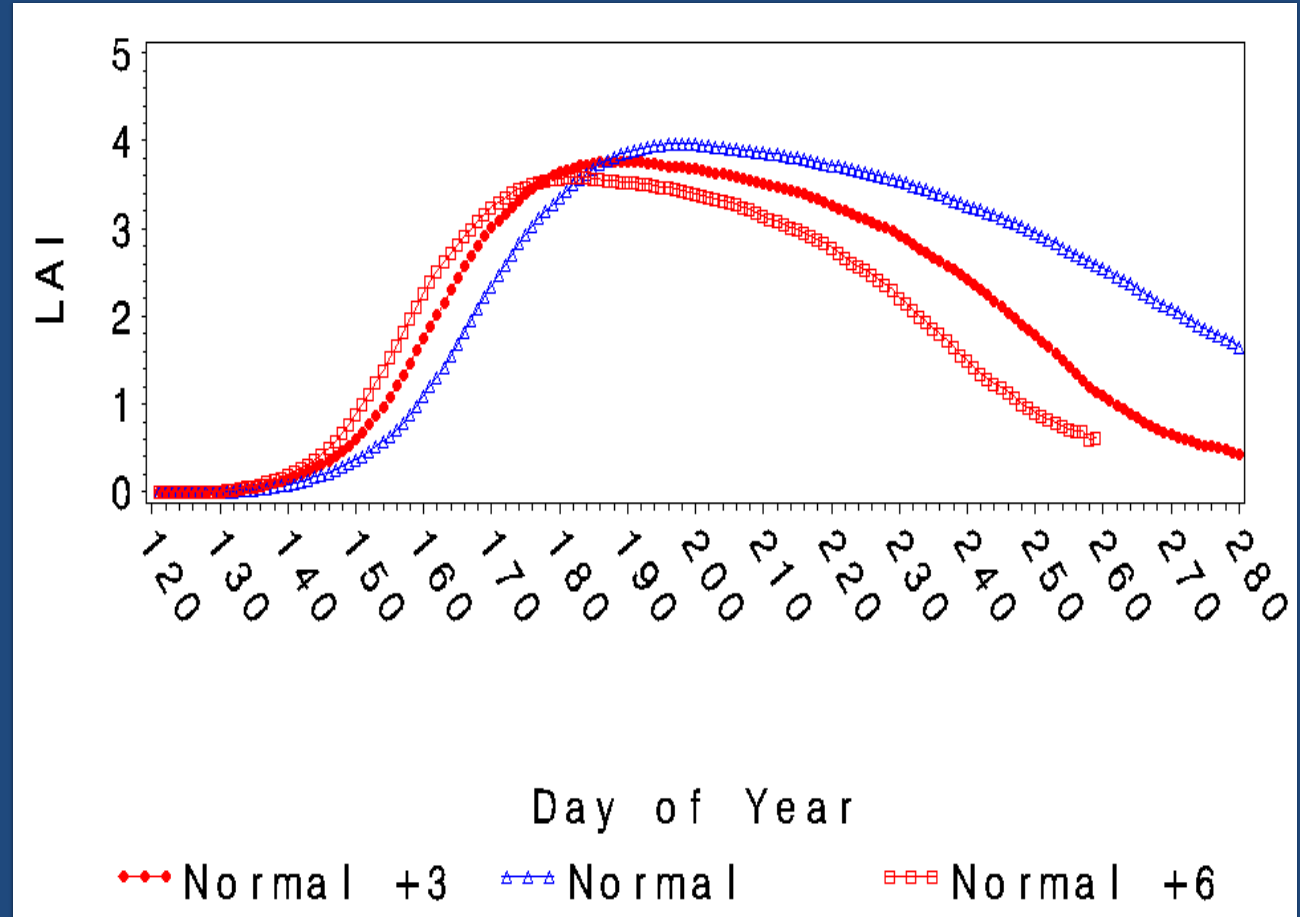
Rapid growth leads to early senescence



- ◇ High temperatures lead to faster senescence rates and then a decrease in canopy photosynthesis

Effect of increased temperature on development processes

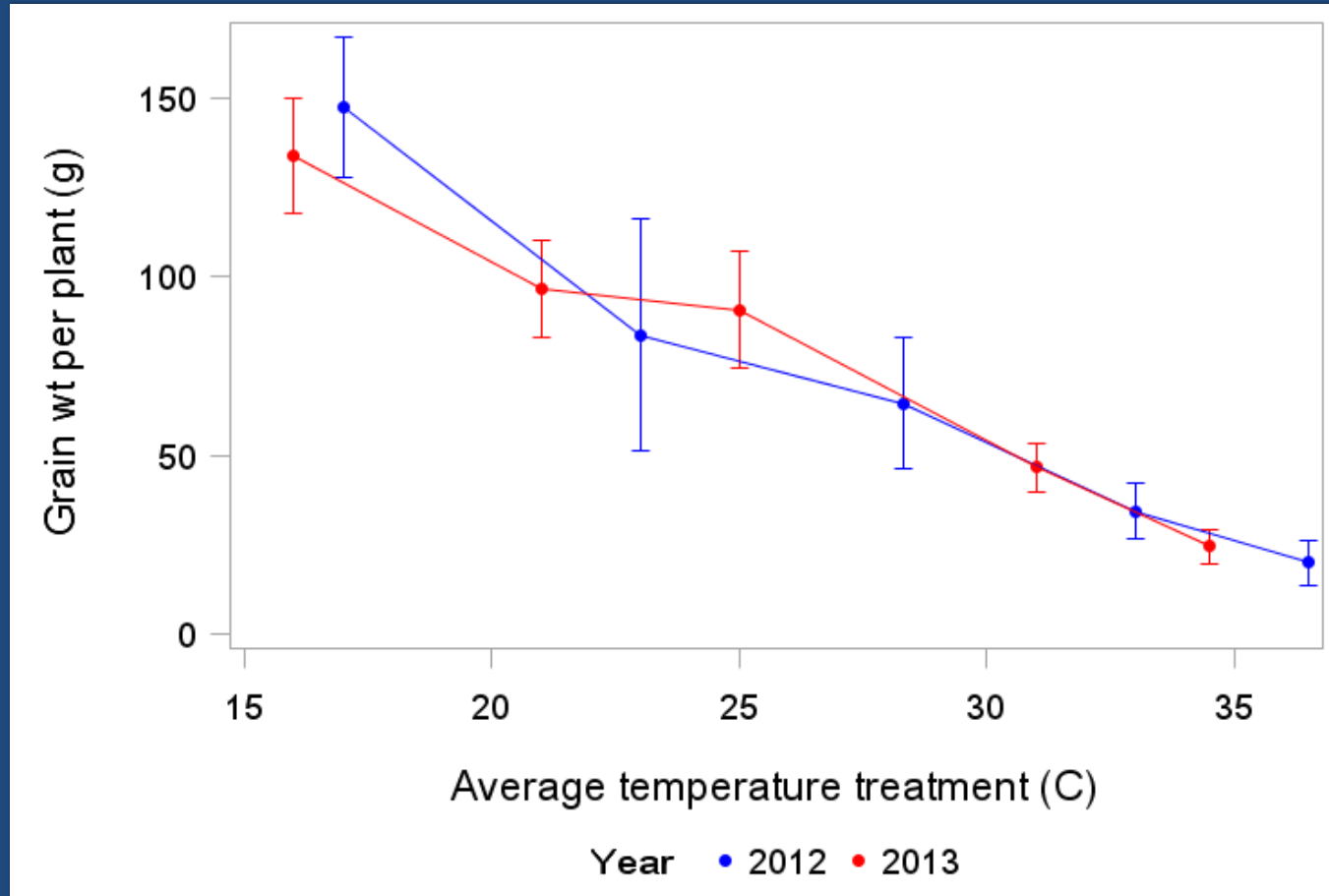
1. Exposure to higher temperatures will cause faster rate of development
2. This doesn't translate into maximum production because shorter life cycle creates smaller plants, shortened reproductive duration, and reduced yield potential because of reduced light interception during the growing season.
3.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

But, a shorter life cycle of one crop may allow
planting of a second crop

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 decline.

Weeds and Other Secondary Effects of Climate Change

Control of Invasive Plants and Weeds

Ambient CO₂

Future CO₂ (+300 ppm)

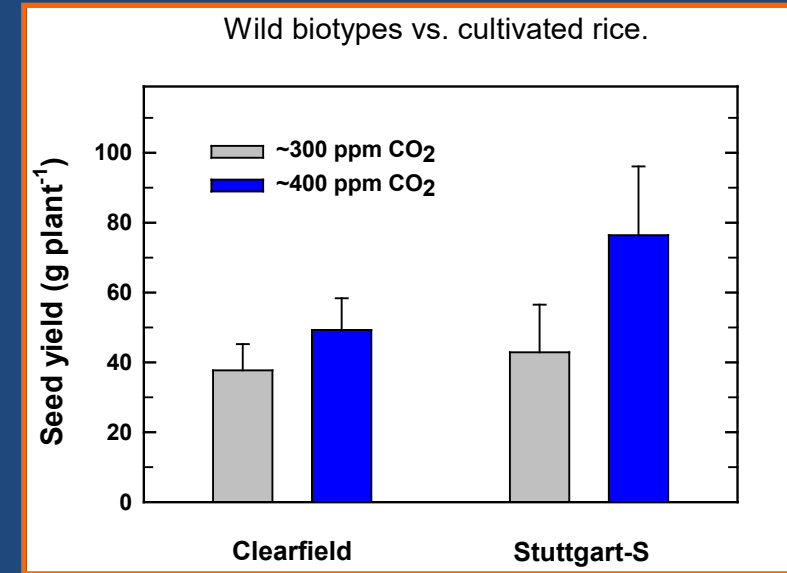
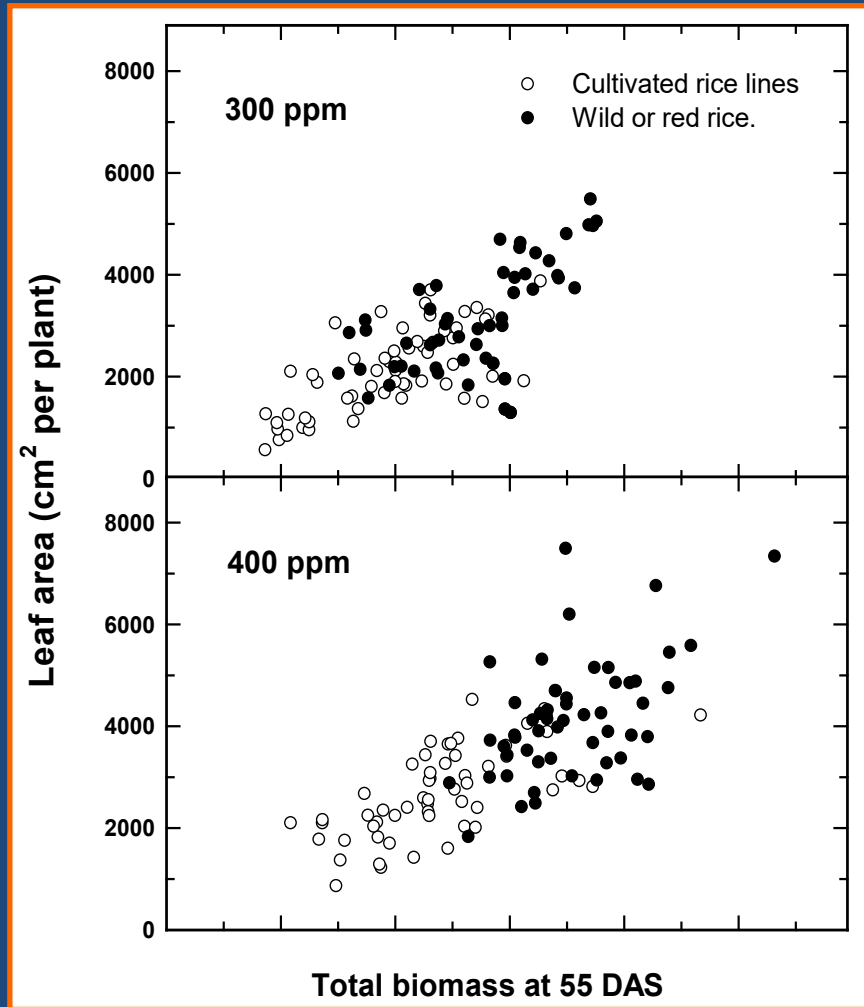


Question: By stimulating plant growth can rising CO₂ levels alter chemical efficacy of weed control?

Increasing CO₂ reduces herbicide efficacy.

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

Weeds and Rising CO₂.

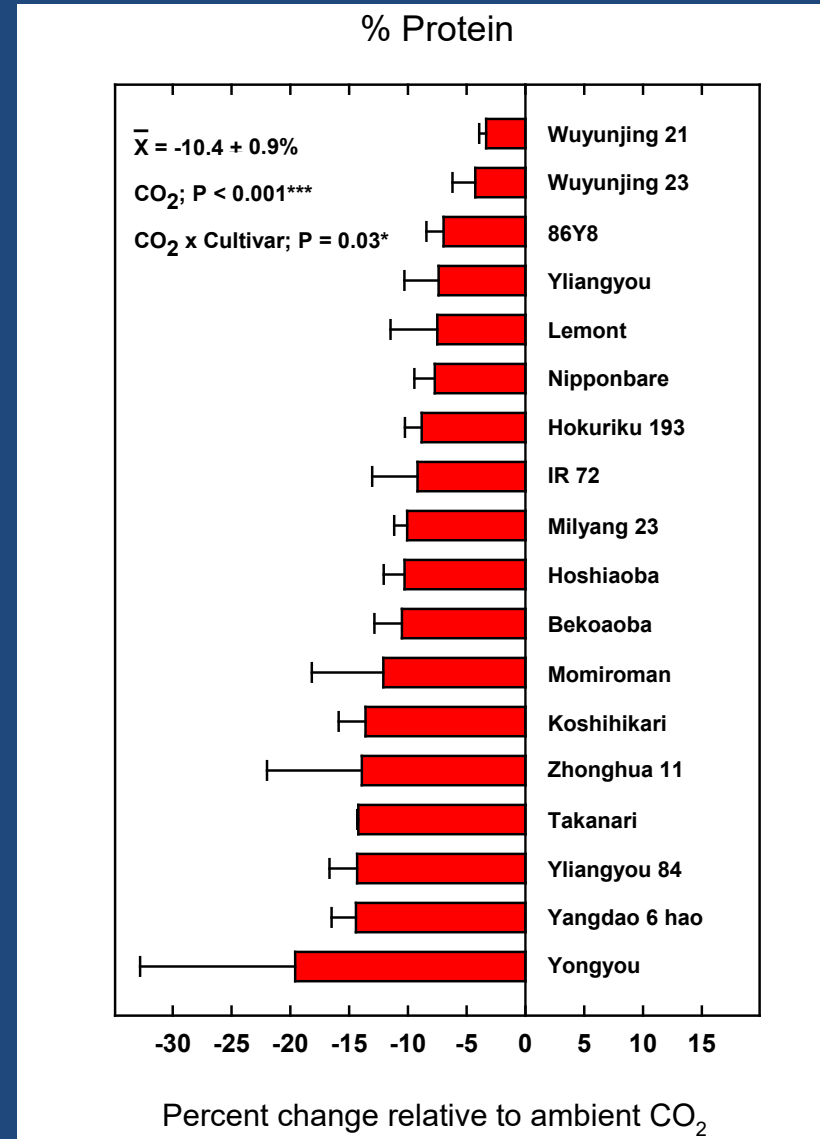
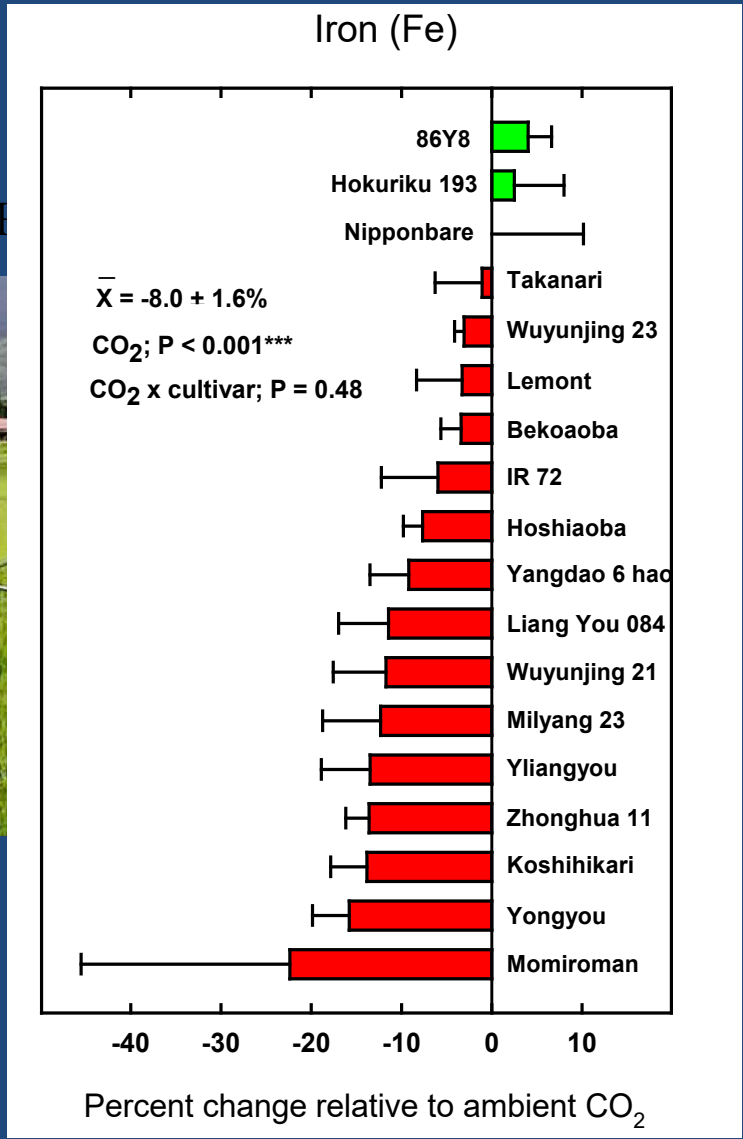


Are breeders and nature selecting for the same characteristics?

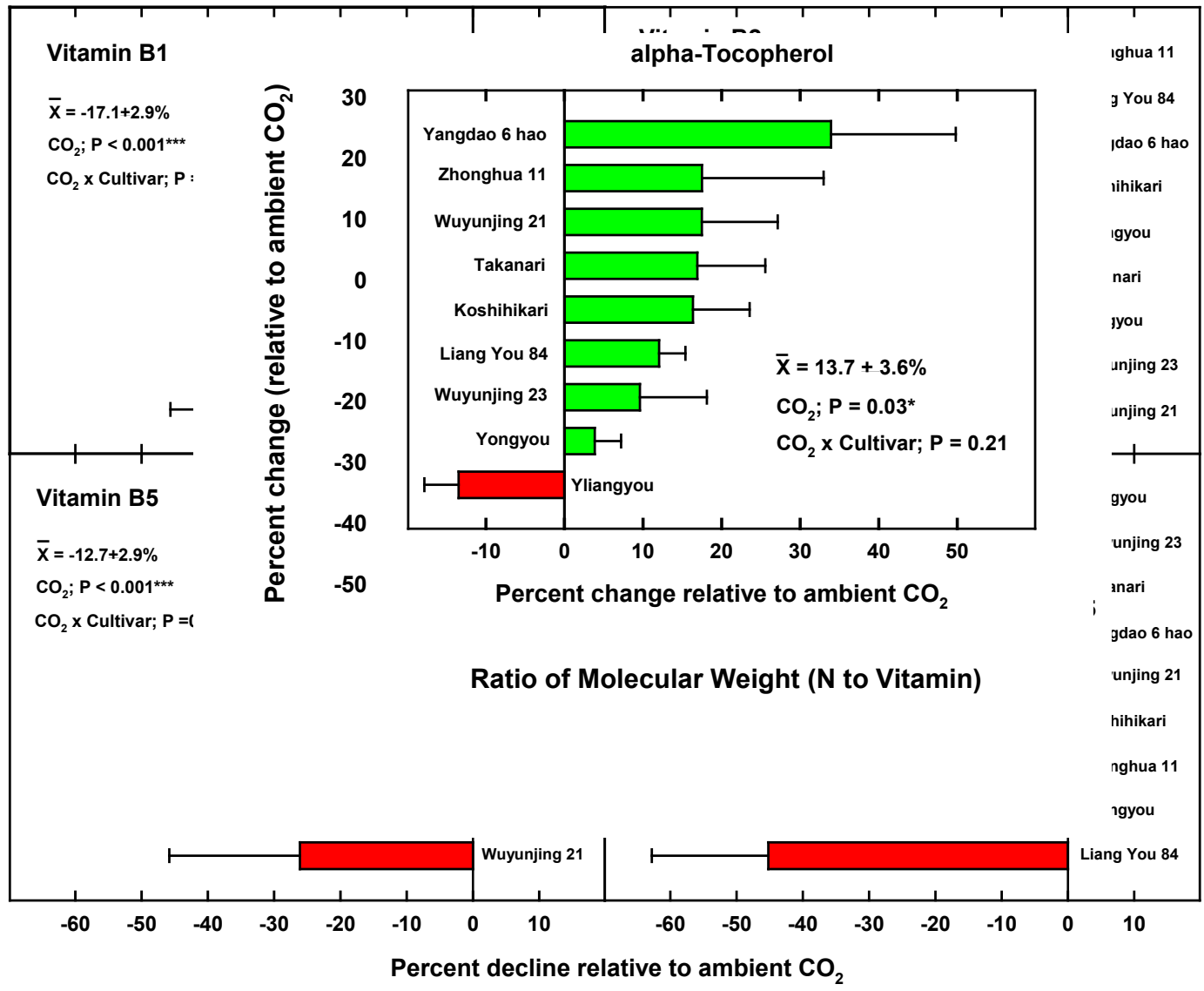
Can weedy, wild relatives of crops be a unique source of germplasm to adapt modern crop lines to an uncertain climate?



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

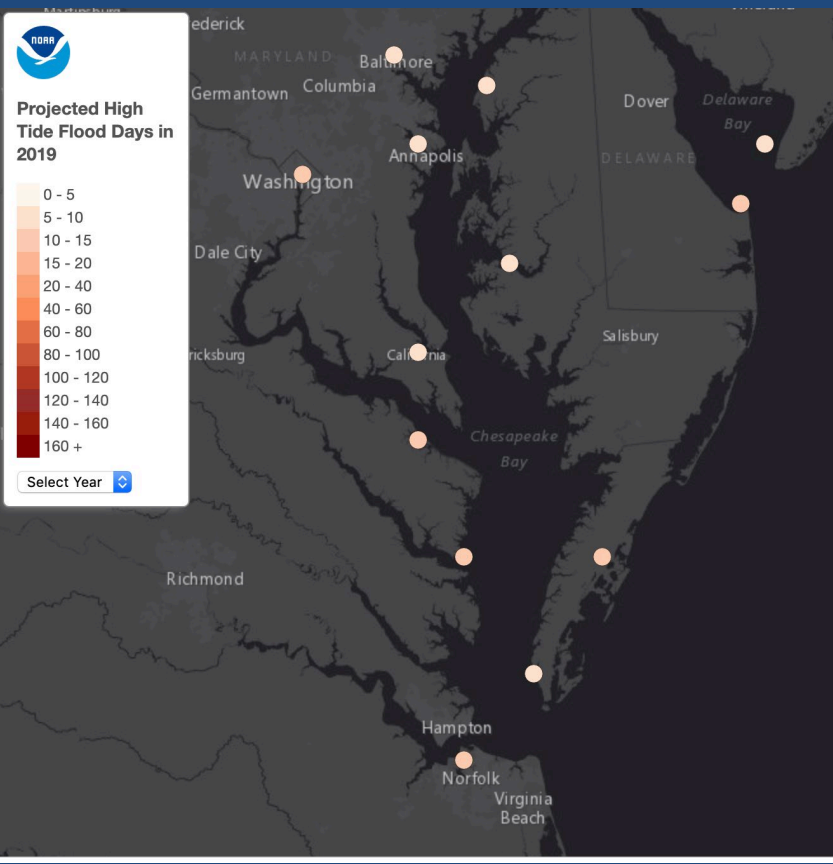


And the role of CO₂ on plant chemistry? Toxicology, Dermatitis, Allergens and Nutrition

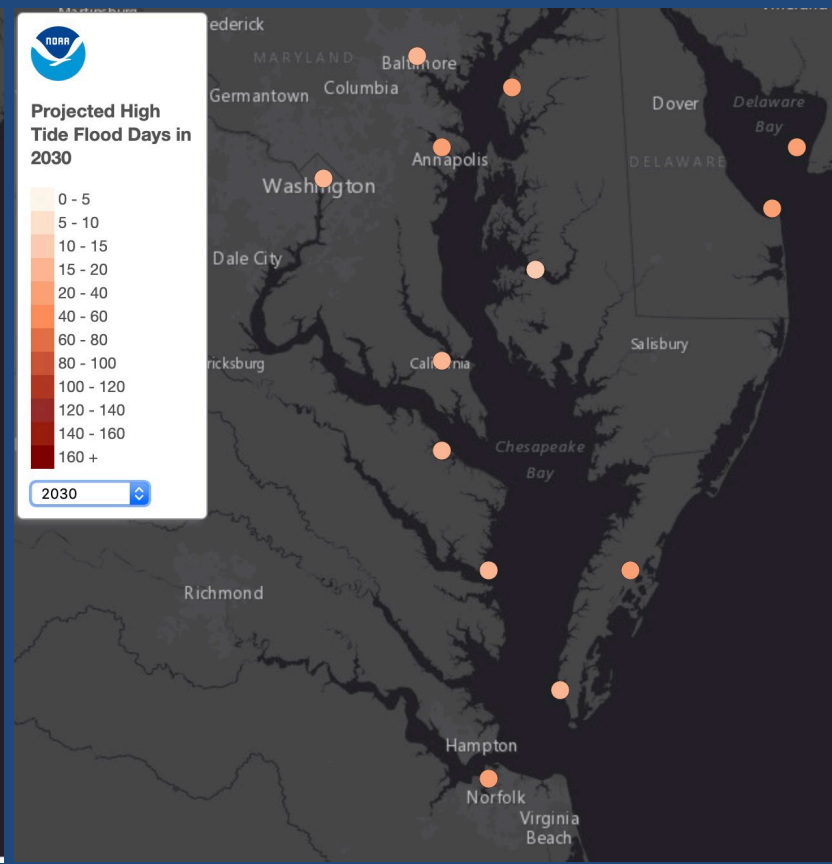


Causes of saltwater intrusion: sea level rise

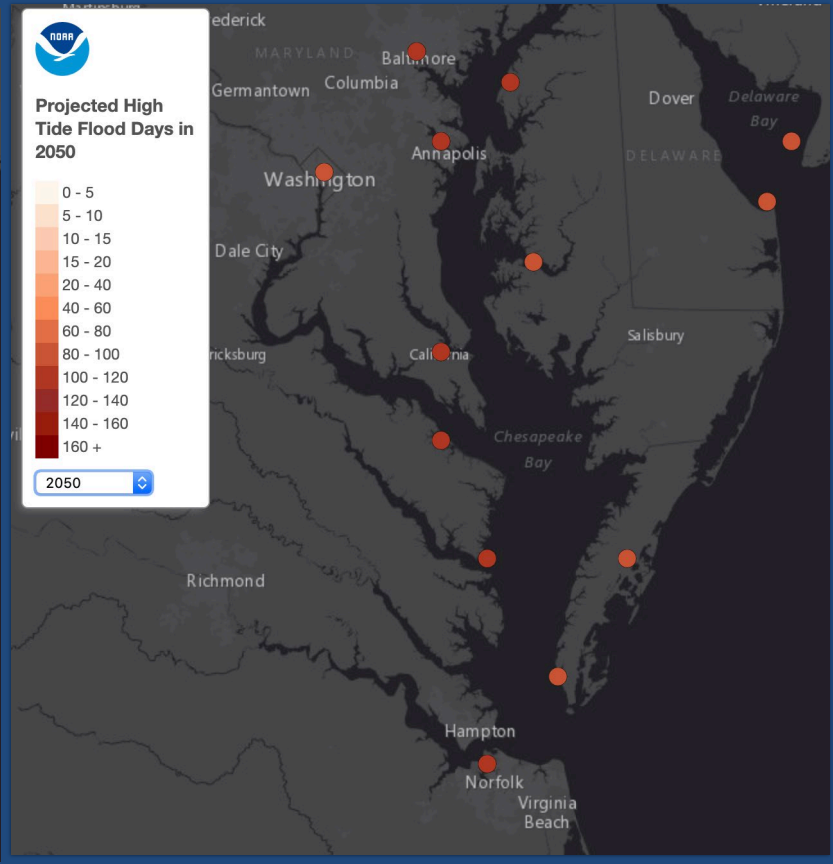
More red = more frequent “sunny day” flooding



In 2019, 10 flood days.

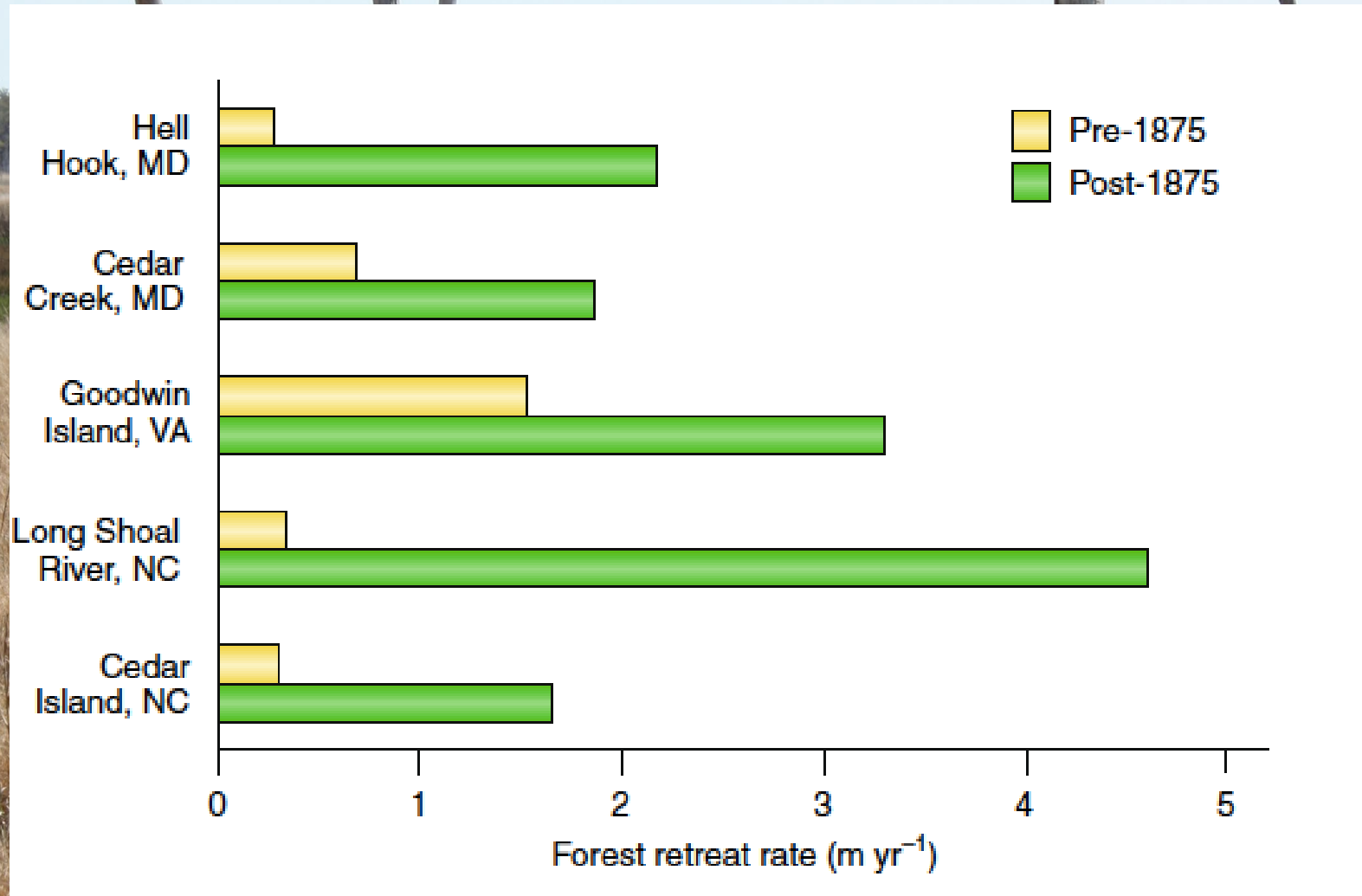


By 2030, 15-40 flood days.



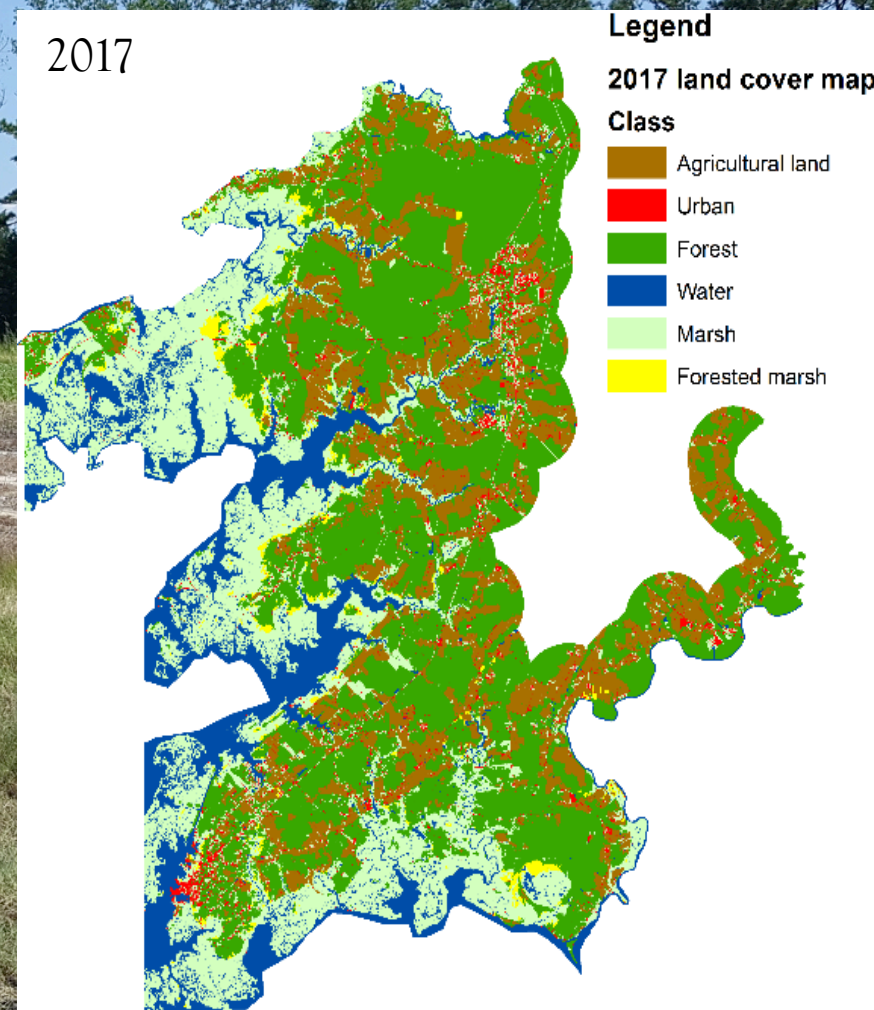
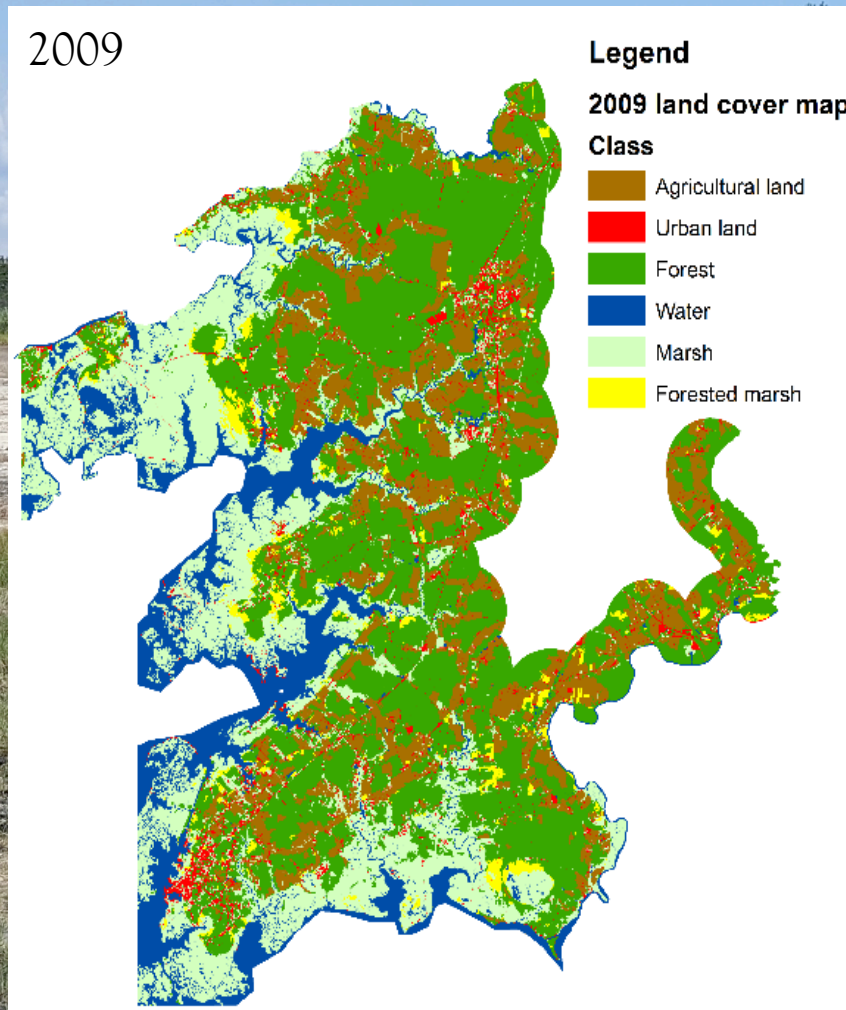
By 2050, 60-120 flood days.

Saltwater intrusion in uplands creates ghost forests



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

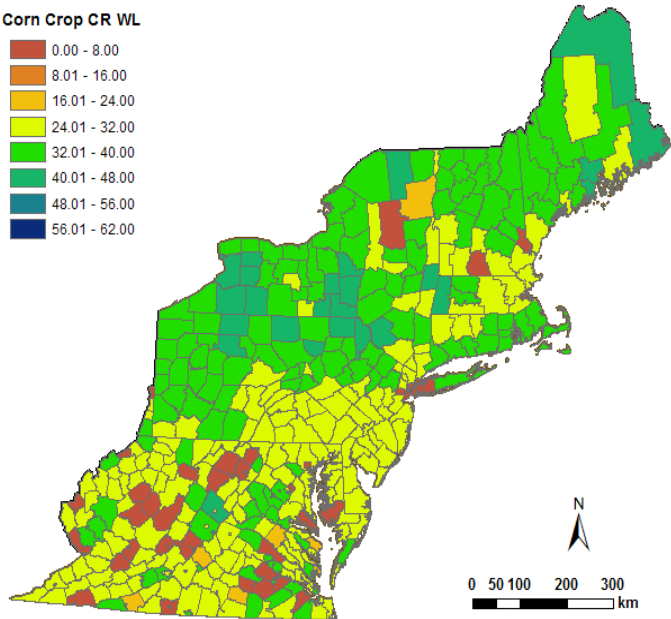
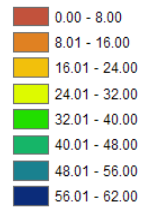
= 2% of the farmland lost in only 8 years!



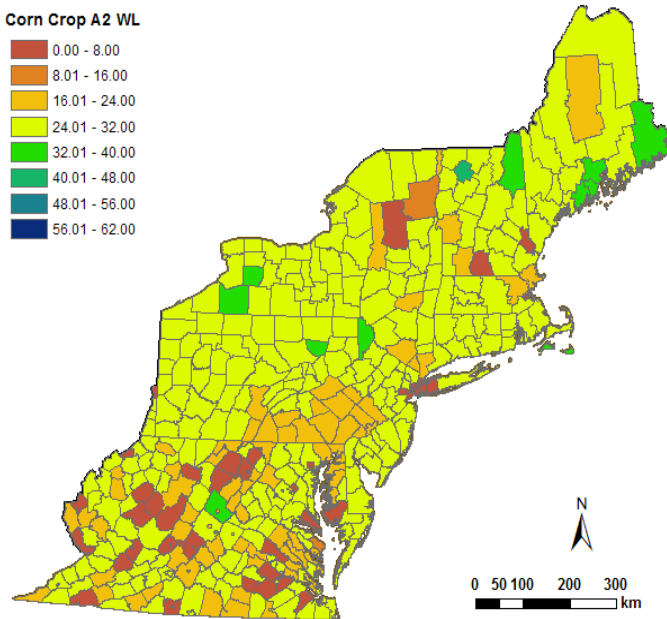
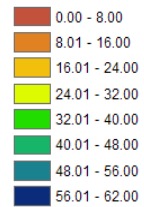
Projected Impacts Corn

◇ 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

CC & Agriculture - 1

- ◇ Local issues critical, but consider 'outside factors'
 - ◇ Even 2⁰C rise in mean temperature by 2100, in the IPCC low emission scenario, will destabilize current farming system!
- ◇ An opportunity / impact will be need to develop / ensure secure production system:
 - ◇ Government sponsored research on food systems including sensitivity to climate change:
 - ◇ Regional?
 - ◇ Local?
- ◇ Despite projected impacts, outside factors can be positive for agricultural community

CC & Agriculture - 2

- ◇ Concerns from the agricultural sector
 - ◇ Increased duration of frost-free season
 - ◇ earlier spring / summer start; later summer end
 - ◇ Heat stress
 - ◇ Availability of water
 - ◇ Availability / suitability of arable land
 - ◇ Biotic issues (pests, disease, weeds)
- ◇ Effect on:
 - ◇ crop yields – could be positive or negative
 - ◇ livestock – physiological stress, impacts on feed, energy, etc
 - ◇ fisheries – distribution, population size (sea temperature)



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

- ◆ 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



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Thanks!

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



For further information please contact
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