Managing Risk in a Changing Climate

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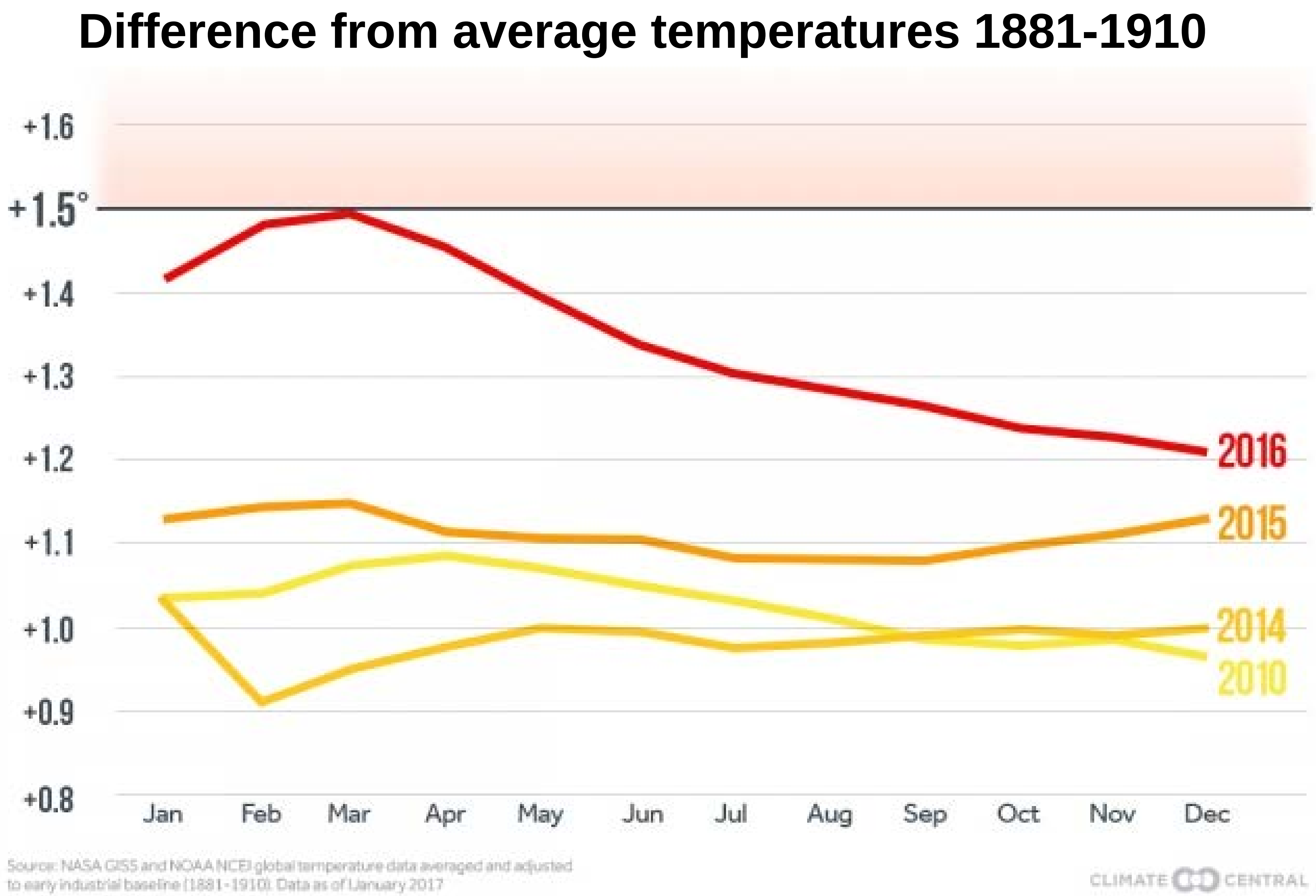
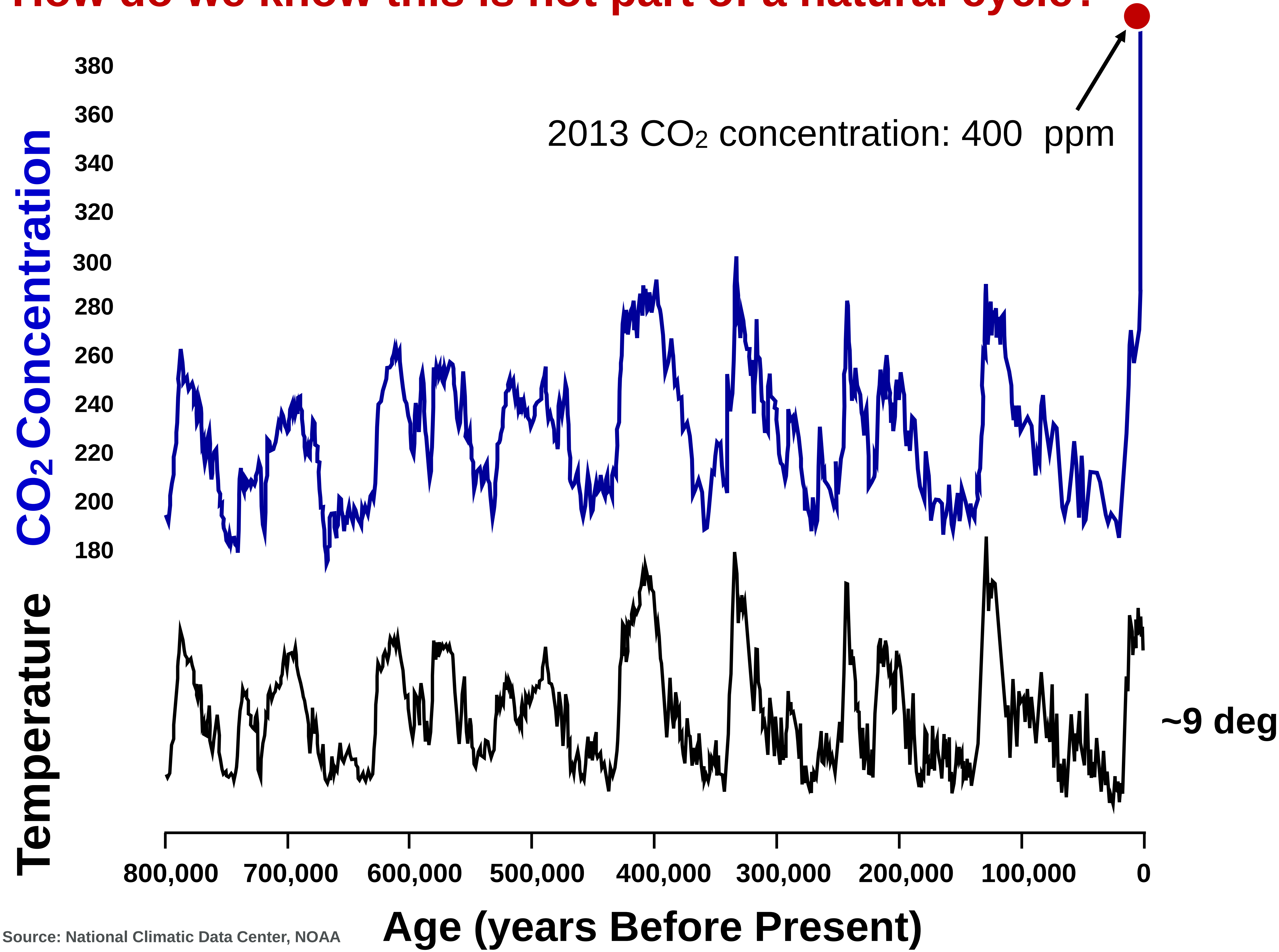
2016 the hottest year ever



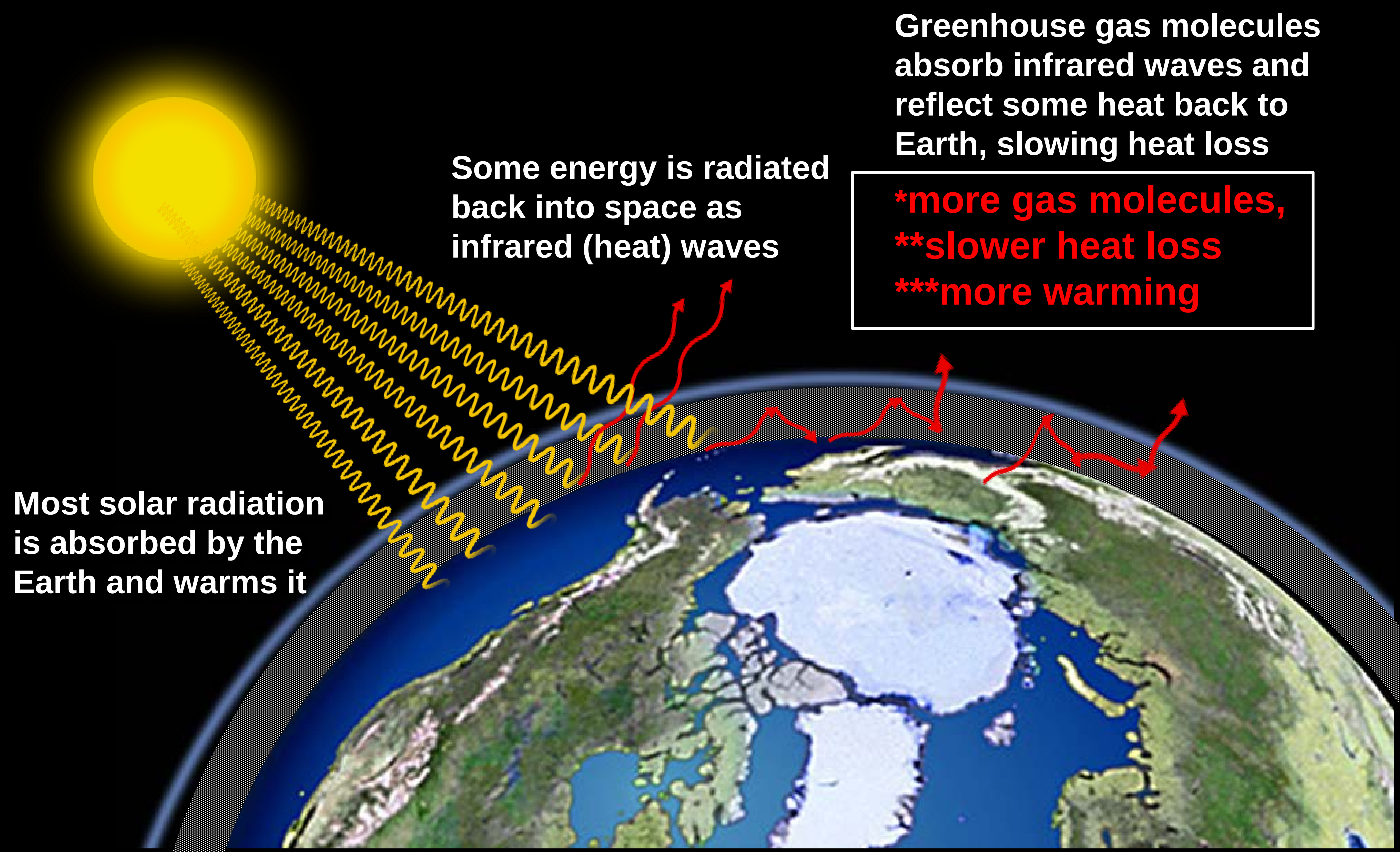
Source: NASA, Climate Central

How do we know this is not part of a natural cycle?



Source: National Climatic Data Center, NOAA

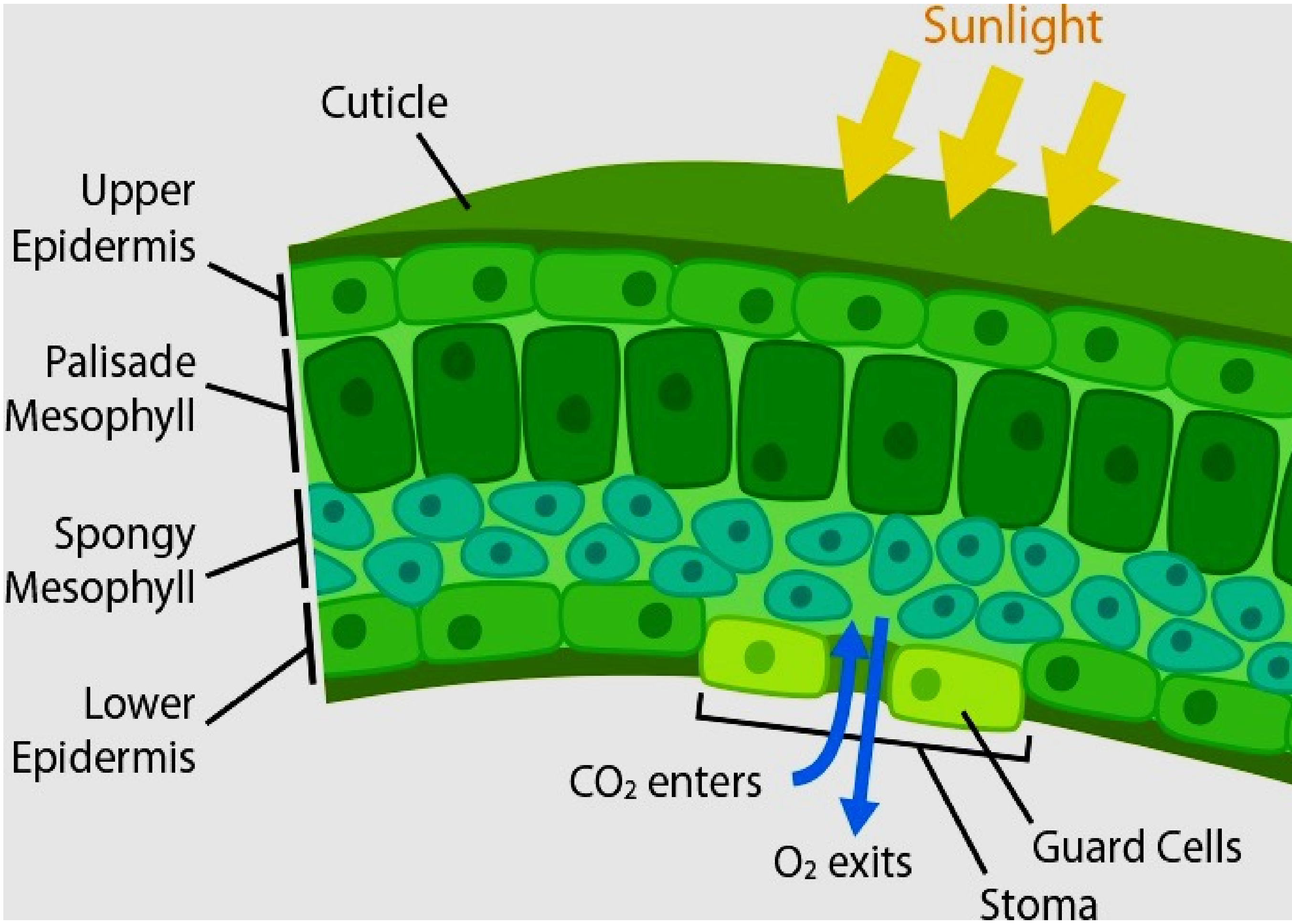
More CO_2 in the atmosphere slows heat loss



Isn't more CO_2 good for plants?

Yes: Plants use CO_2 in photosynthesis, so more should be good, but

No: As CO_2 rises in the atmosphere,
- temperature rises, soil moisture decreases
- summer droughts more likely
- photosynthesis drops b/c stomates close to prevent water loss



Net effect of increased CO_2 is negative for plants

The “New Normal”

-Warmer air
-Warmer ocean
-More water vapor in air
-Higher sea level

These cause

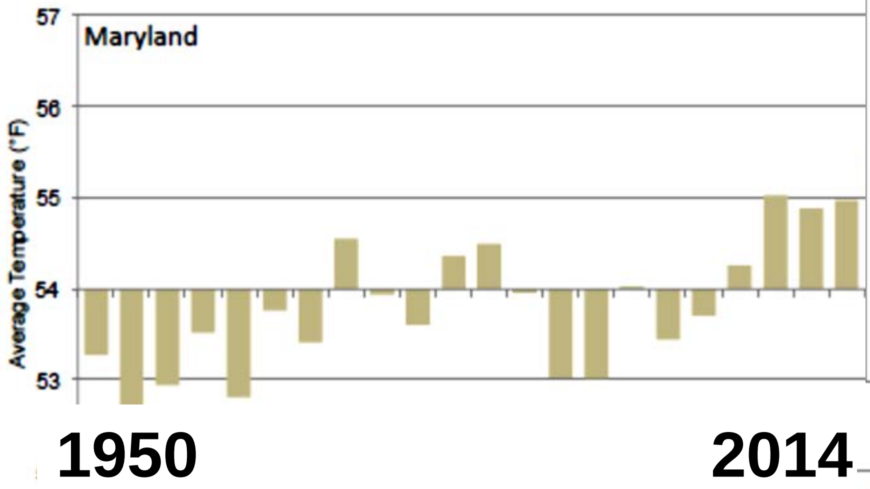
- Severe weather; more extreme extremes
- More variable weather
- Warmer winters, earlier springs, hotter summers

- More rainfall comes as downpours; flash flooding
- Rainy springs & falls (MD)
- Dryer summers
- More tidal flooding and storm surge

What does this look like for Maryland?

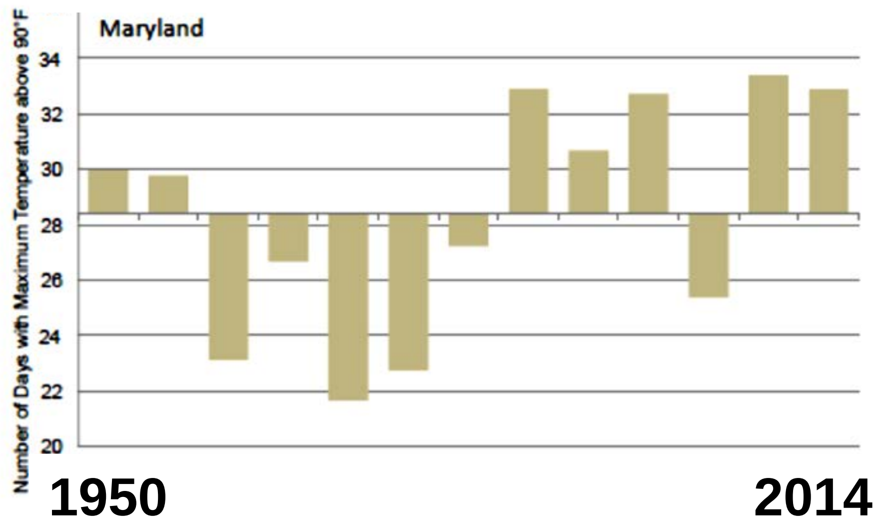
Temperature

Annual Temperature

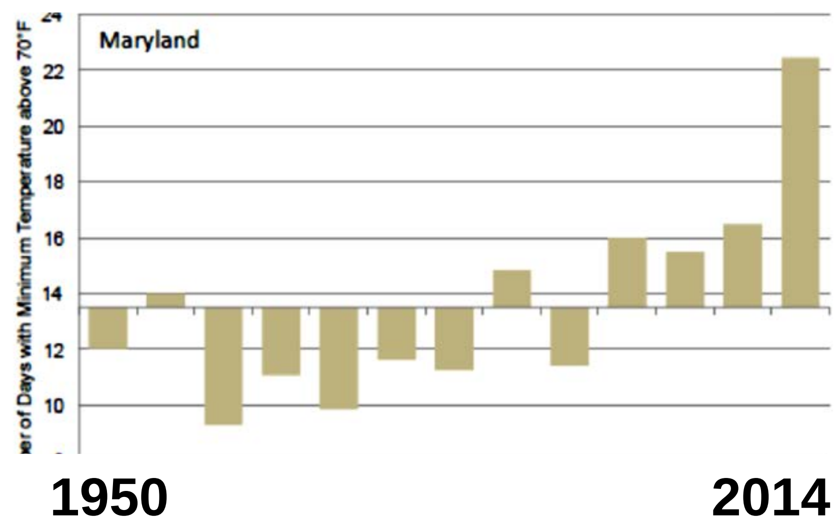


5-year intervals

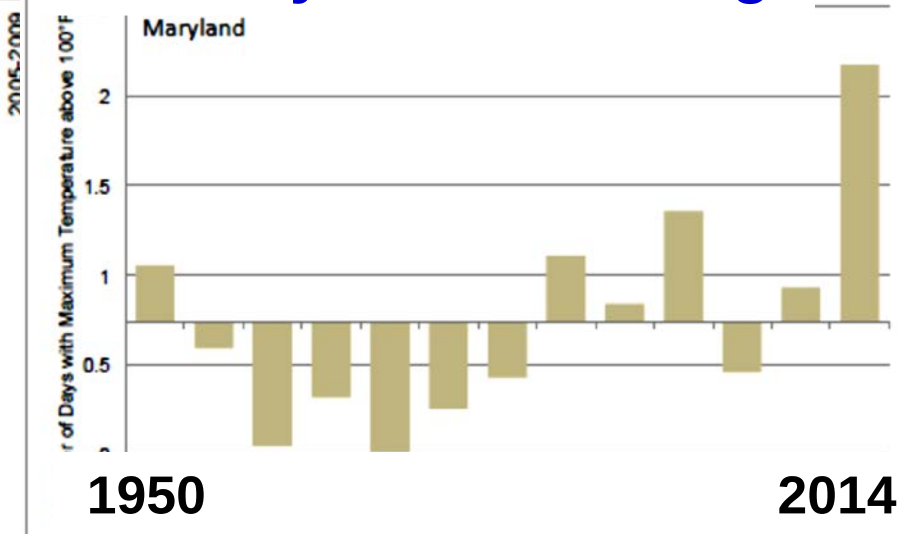
Days over 80 deg



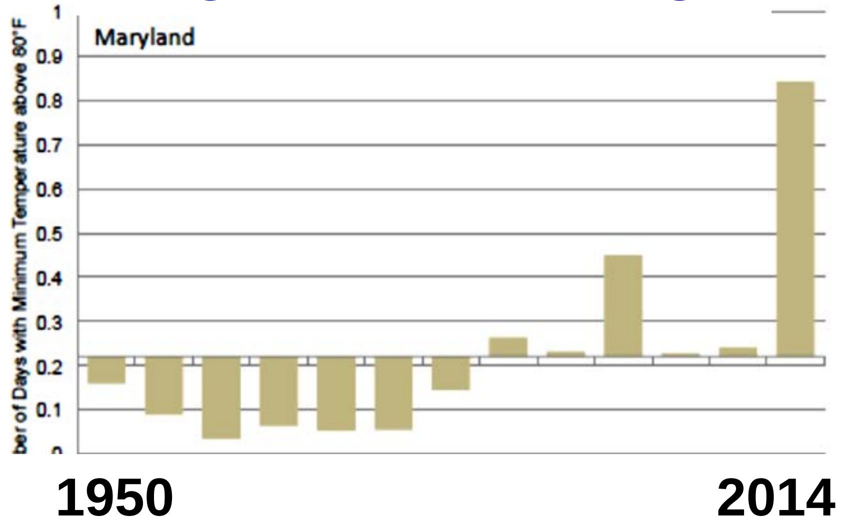
Nights over 70 deg



Days over 100 deg



Nights over 80 deg

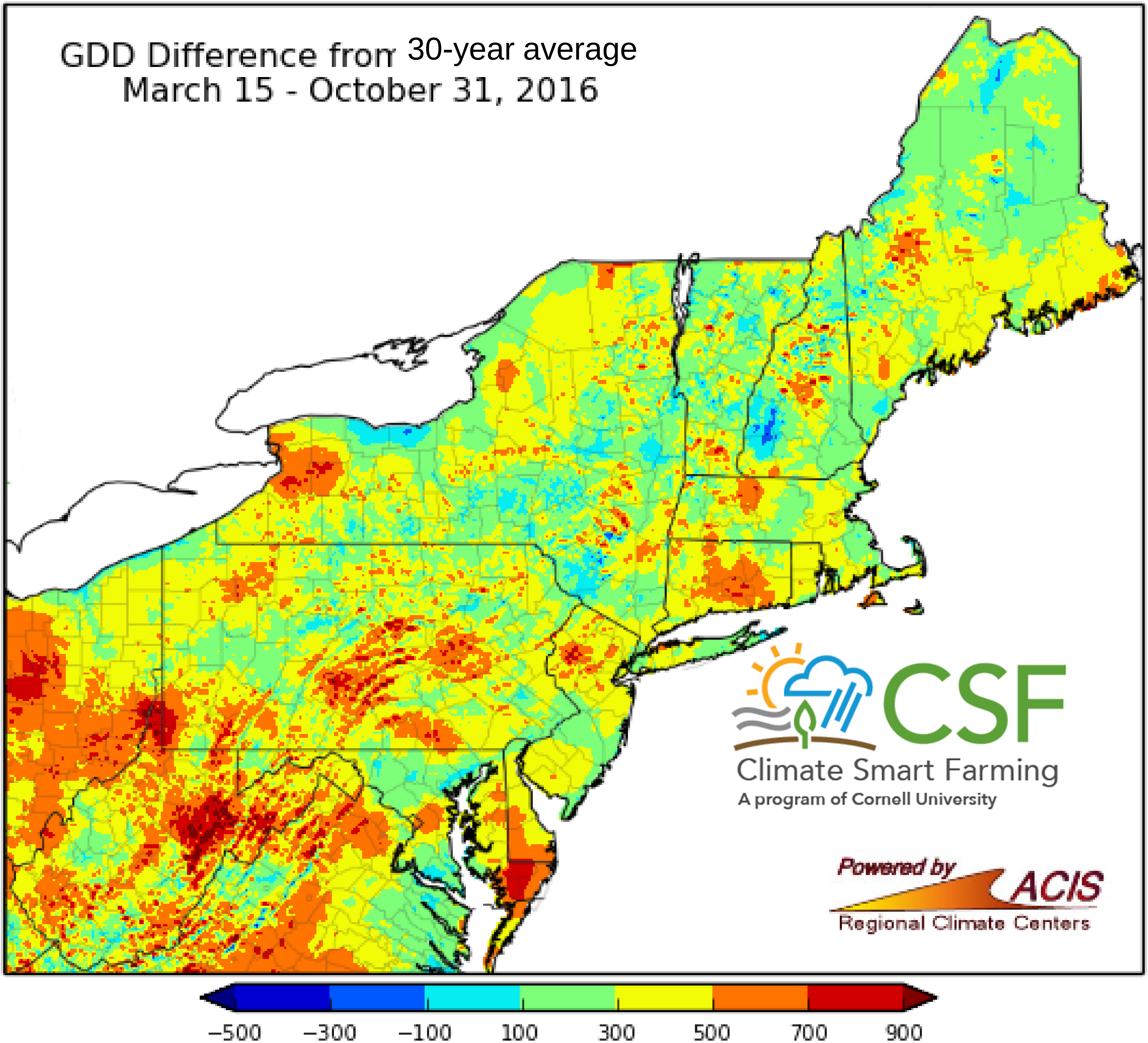


Average, maximum & minimum temperature increase in all seasons

Source: NOAA

The New Normal in Maryland

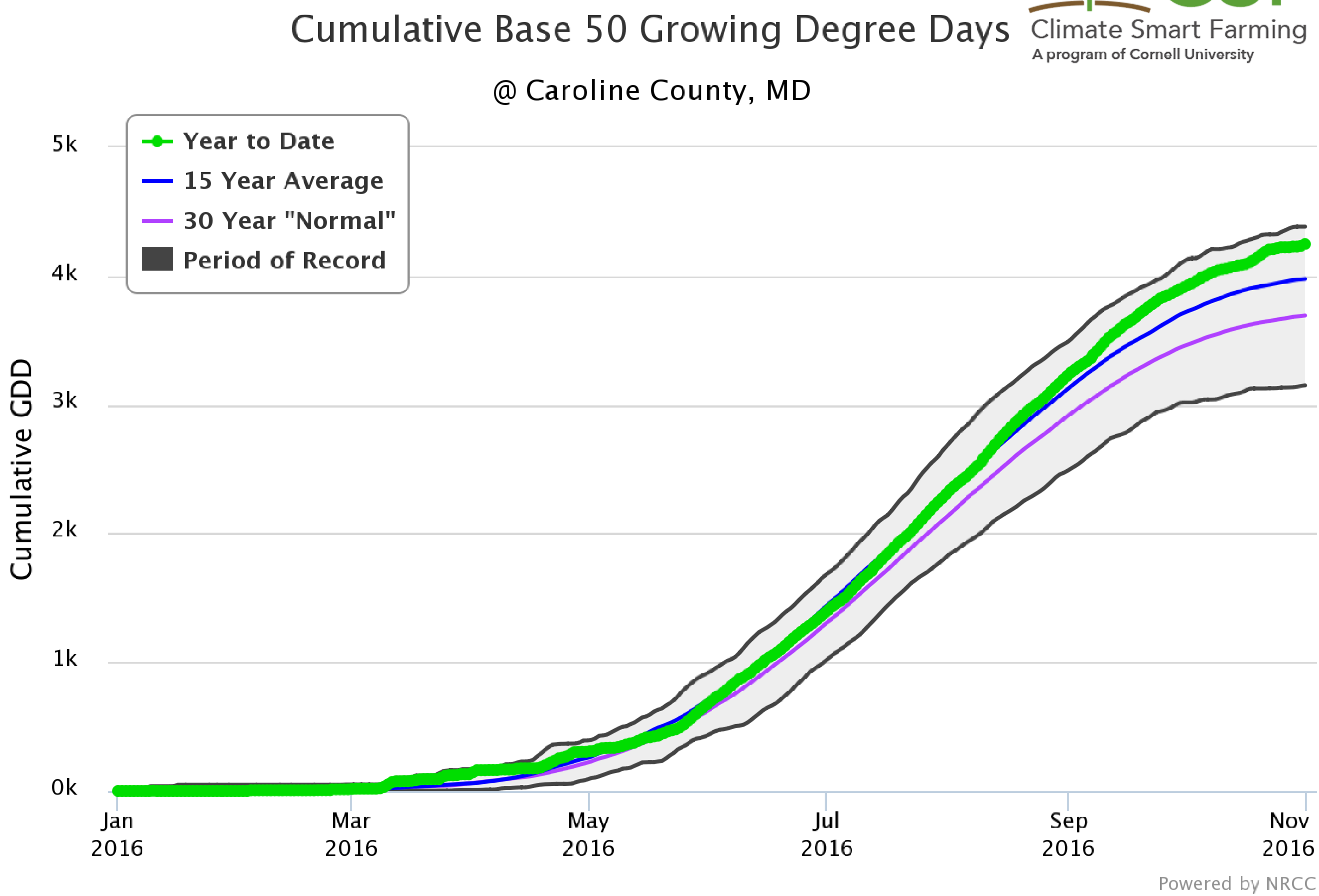
Growing Degree Days



The New Normal in Maryland

Growing Degree Days (2016)

Climate Smart Farming
A program of Cornell University



Effects of Climate Change: Temperature

Spring comes earlier

Fewer cold nights for required plant chilling

Potential to add additional crop into rotation?

Warmer winters = earlier blooming

February 2017 the warmest ever, then freeze in March

NY apples bloom 8 days earlier than in the 1960s

Grapes bloom 6 days earlier

Wolfe DW et al. 2005. Internat J Biometeor 49:303-309.]

Late spring cold snap ➔ freezing, fruit loss

Plant new orchards on hilltops, plant longer season varieties?

Effects of warmer winters, earlier springs

Pest insects

- better overwinter survival

- earlier appearance

- more generations/yr

- range expansion

- be vigilant & scout!!

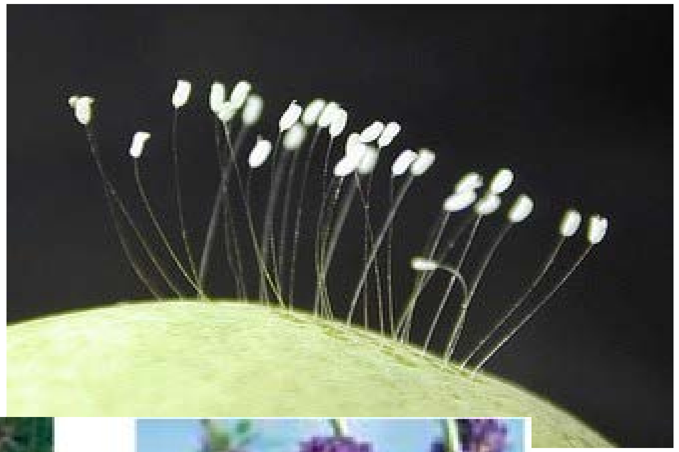
- expect the unexpected

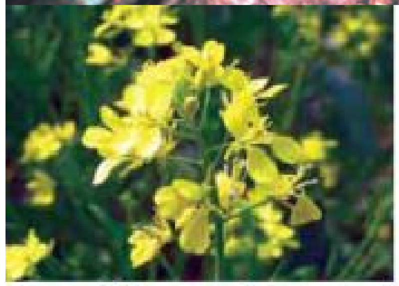
Insect control

Insectary plants attract beneficials, increase their diversity

Provide natural enemies nectar, pollen & protection from predators

Bachelor buttons in celery, beneficials reduce aphids

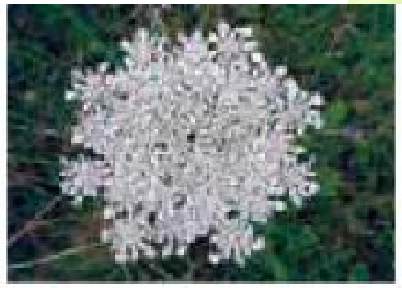




Mustard

Sunflower

Buckwheat



Carrot

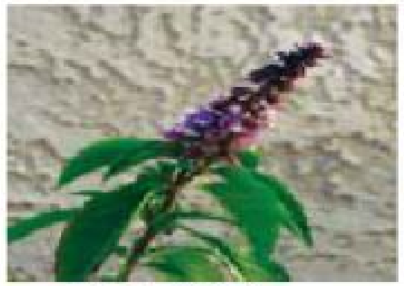
Alfalfa

Marigold

French bean

Maize/Corn

Cowpea

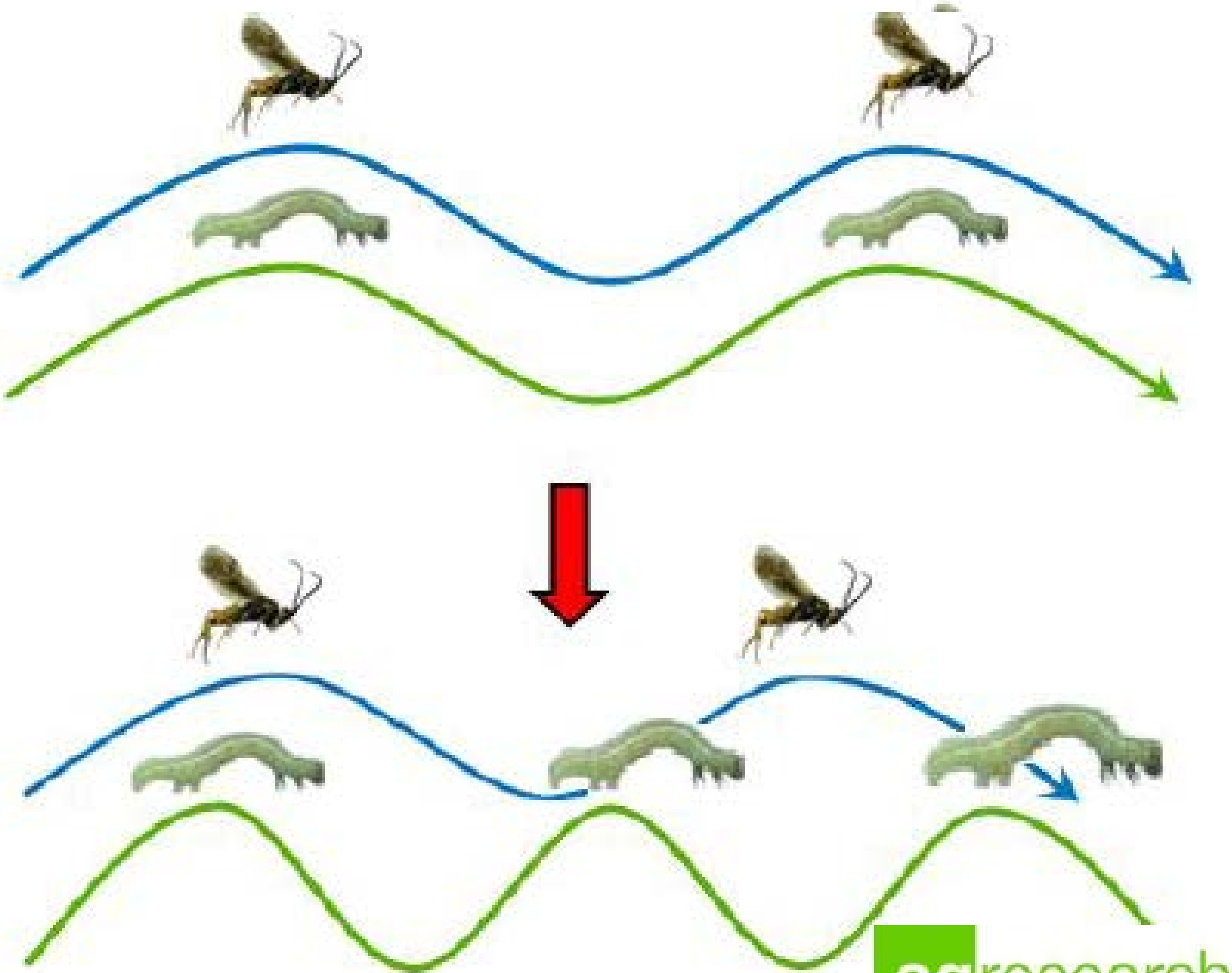


Spearmint

Mismatched timing in species interactions

Species respond differently to warming– impacts biocontrol:

Host adds a generation, parasitoid doesn't



Corn earworm in New Zealand

agresearch

Effects of warmer winters, earlier springs

Weeds

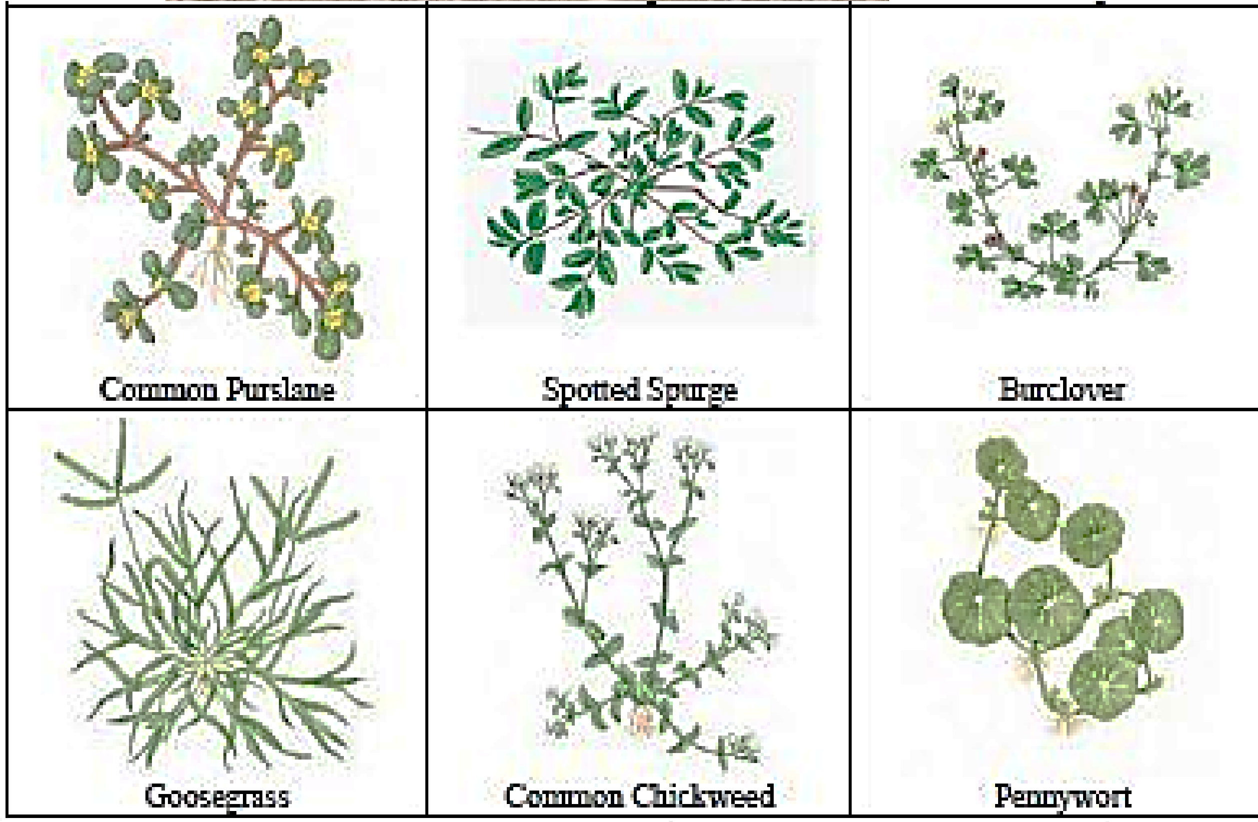
- weeds & invasives doing well under climate change

- better overwinter survival

- earlier appearance & flowering

- expect the unexpected

- mulch!
  cover crops between rows
  plant into dead cover crops



Credit: Texas A&M

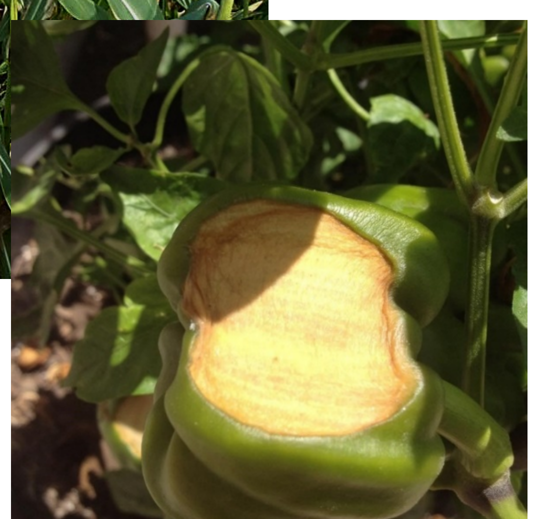
Summer heat stress: reduced pollination, sun scald

Sweet Corn Pollination Problems

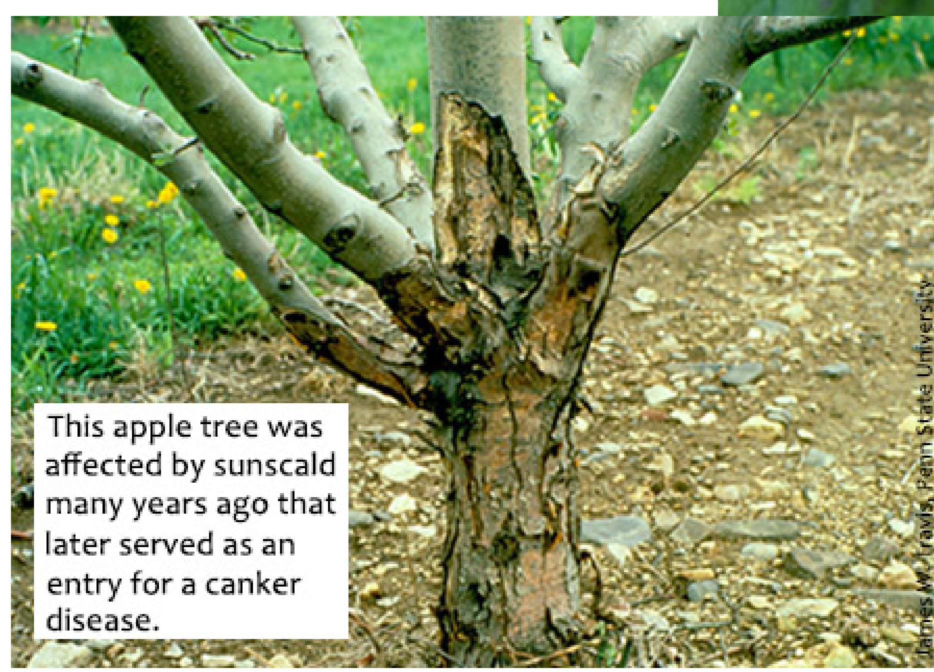
July 27, 2012 in Uncategorized, Weekly Crop Update

Gordon Johnson, Extension Vegetable & Fruit Specialist; gcjohn@udel.edu

- [Leaf Scald in Sweet Corn Again in 2012](#)
- July 12, 2012 *Gordon Johnson, Extension Vegetable & Fruit Specialist;* gcjohn@udel.edu



scald



ozone damage!

Heat stress reduces pollination, fruit set

Tomato Pollination and Excessive Heat July 12, 2012 *Jerry Brust, IPM Vegetable Specialist, University of Maryland*; jbrust@umd.edu

Yellow shoulders in tomatoes

Credit: Jerry Brust UME

Peppers drop flowers and fruit when
Day temp > 90
Nite temp > 75

Source: TAMU

Heat stress in corn & soybeans

Corn:

- Very hot days, leaf rolling
  1% yield loss/12 hrs but
  12% loss/12 hrs during silking
- Duration of heat ➔ more loss

- Pollination fails in hot weather
- Kernels abort

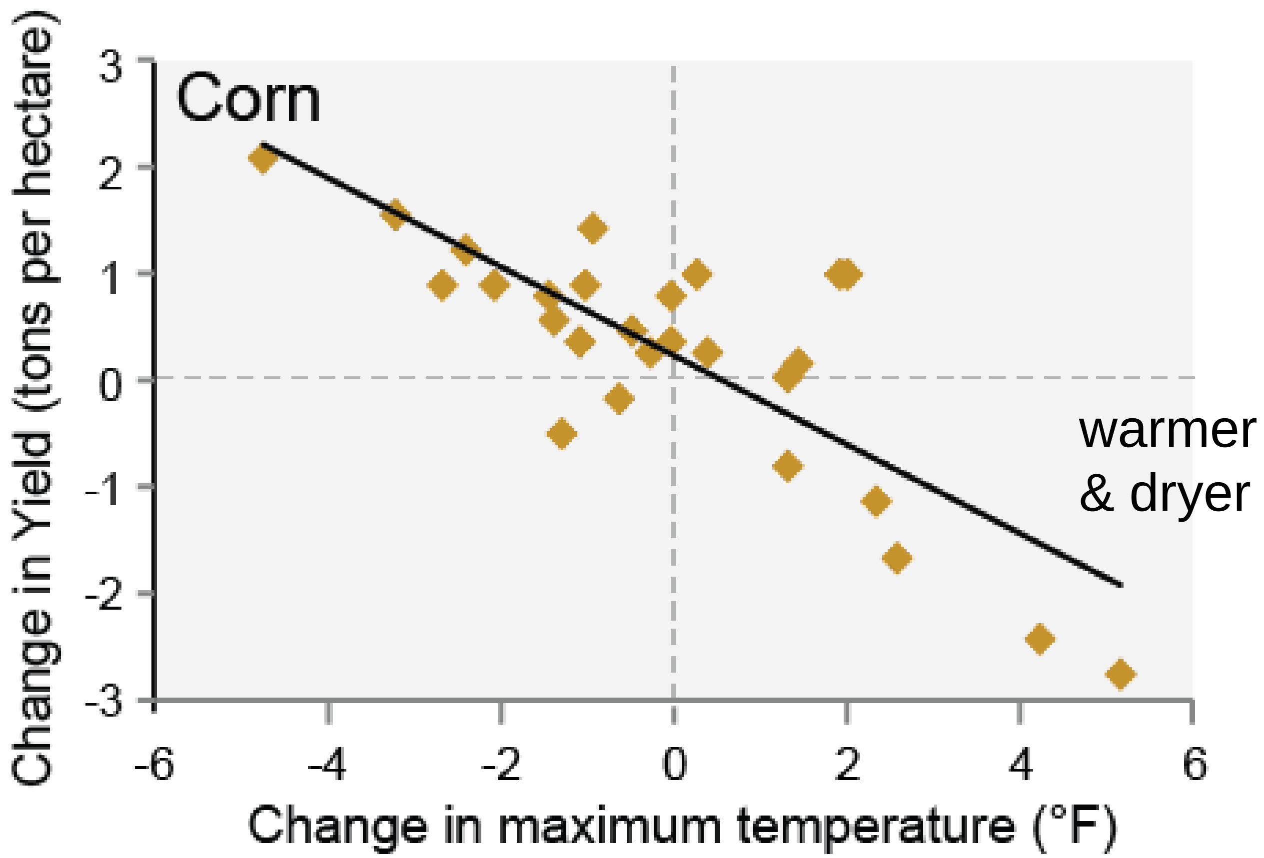
Soybeans:

- Temperature > 90º reduces pod formation

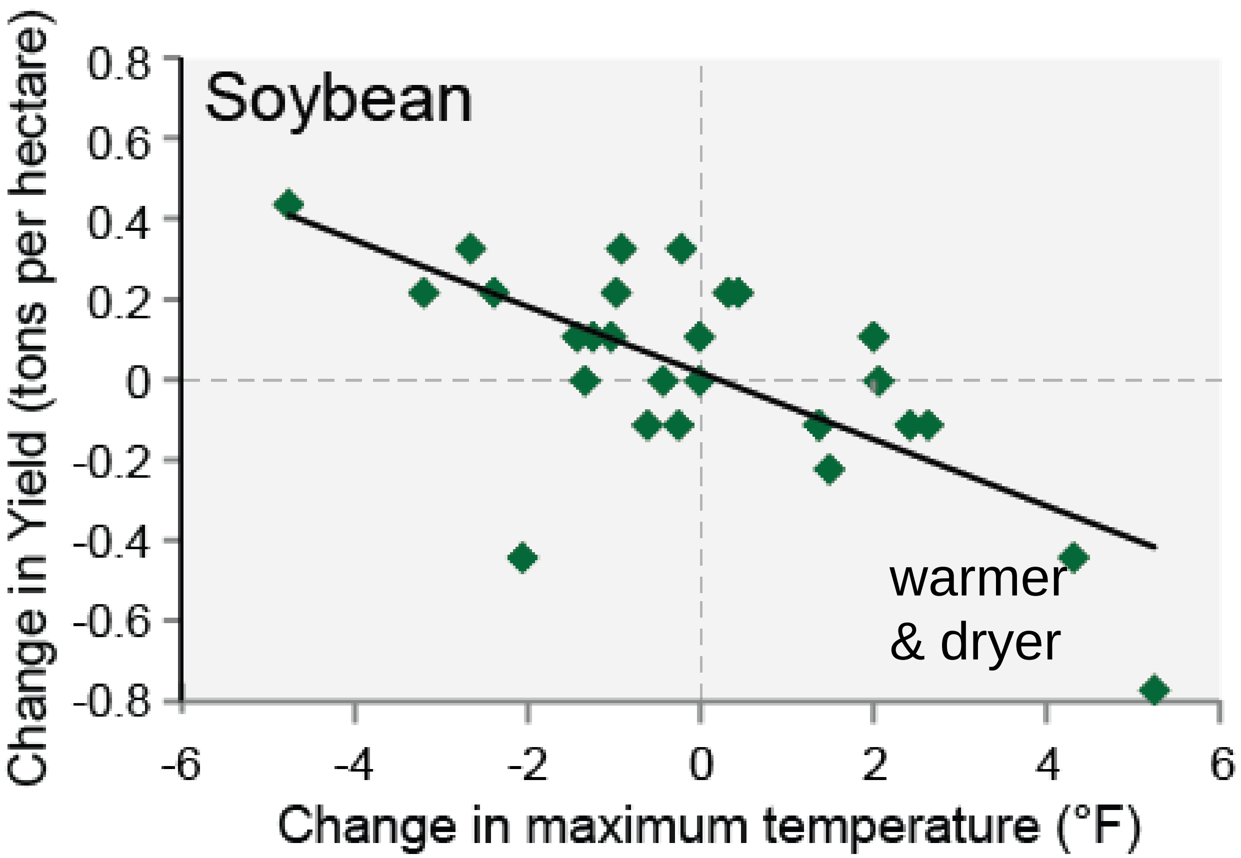
http://www.cornandsoybeandigest.com/corn/high-temperature-effects-corn-soybeans

Crop yields decline under high temperatures

National Climate Assessment 2014



relative to 1980-2007 average



relative to 1980-2007 average

Yield in wheat reduced by drought

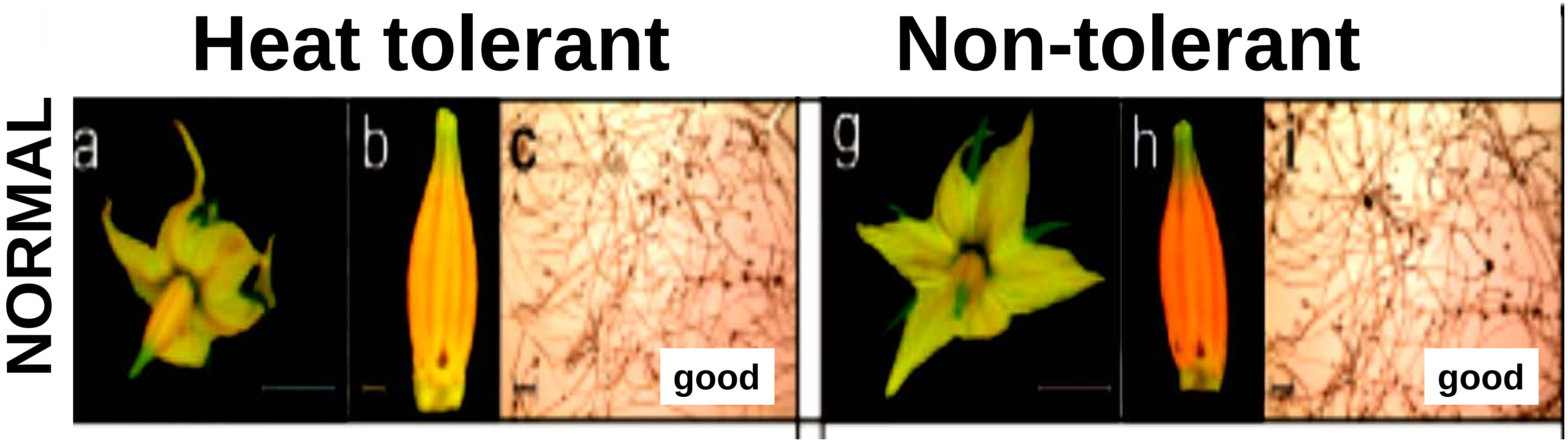
Adapting to increased temperature

- Plant earlier in spring, later in summer
- Stagger planting dates to hedge bets
- Mulch (plant material, white or reflective)
- Try heat tolerant varieties
- Build shade

Reflective mulch, shade cloth saves GA peppers (Carlos Diaz-Perez UGA)

Breeding heat-tolerant varieties with viable pollen at high temperatures

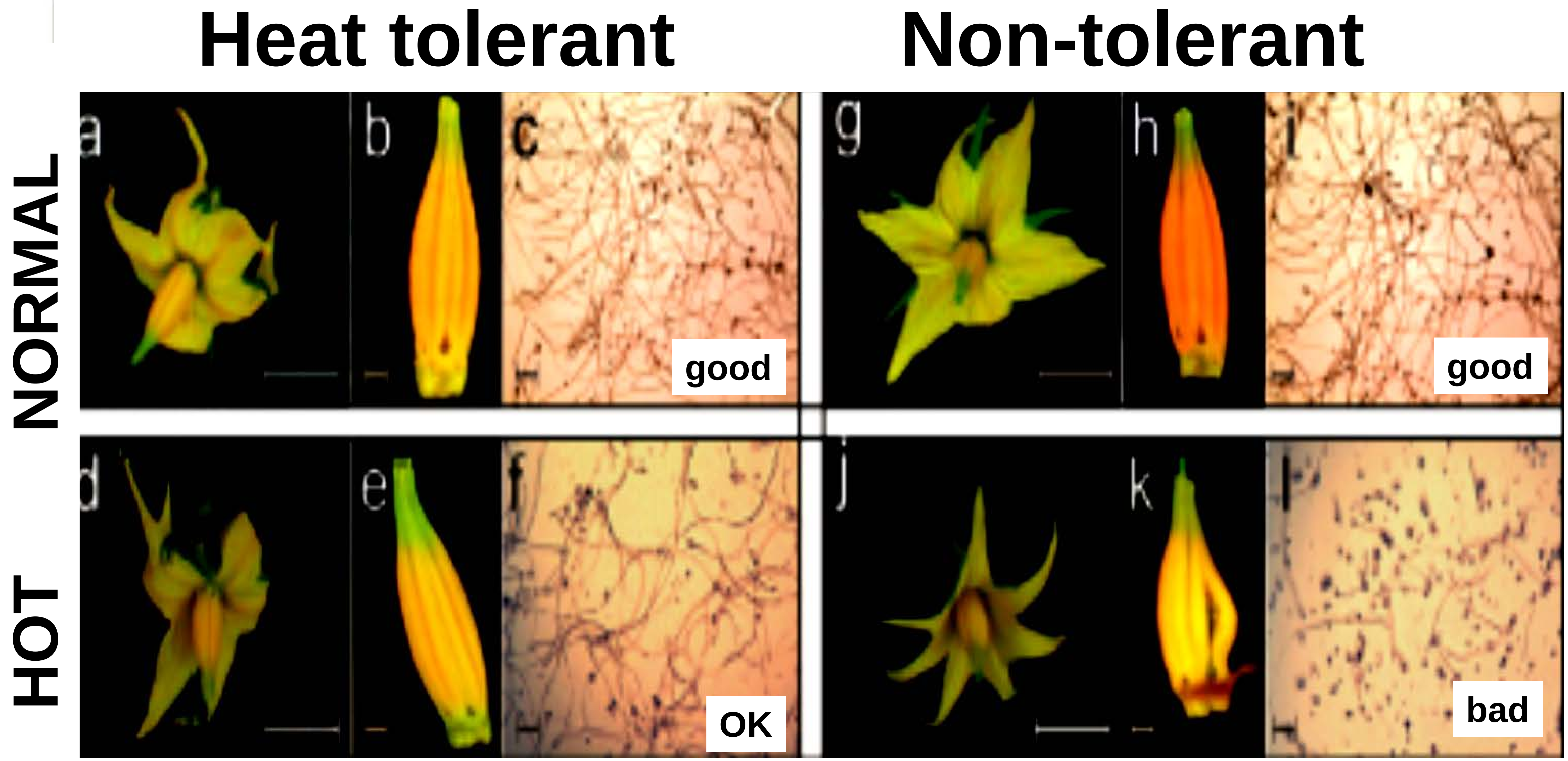
Tomatoes



Bita et al. 2011. BMC Genomics 12:384.

Breeding heat-tolerant varieties with viable pollen at high temperatures

Tomatoes



Bita et al. 2011. BMC Genomics 12:384.

Adapting to increased temperature

Add evaporative cooling?

2104: Oakmoor Orchard, BC lost 40% Granny Smith yield to sun scald.

Saved $47,000/yr with overhead evaporative cooling

http://www.sustainability.vic.gov.au/services-and-advice/business/energy-and-materials-efficiency-for-business/case-studies/agriculture-case-studies/oakmoor-orchards

Heat stress on dairy cows- reduced fertility, milk production, death

DAIRY COW TEMPERATURE HUMIDITY INDEX (THI)																			
Humidity %																			
Temp °F	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
72	64	65	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71
74	65	66	66	67	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73
76	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75
78	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
80	68	69	69	70	70	71	72	72	73	74	75	75	76	76	77	78	78	79	79
82	69	69	70	70	71	72	73	73	74	75	75	76	77	77	78	79	79	80	80
84	70	70	71	72	73	73	74	75	75	76	77	78	78	79	80	80	81	82	83
86	71	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	84
88	72	72	73	74	75	76	76	77	78	79	80	81	81	82	83	84	85	86	86
90	72	73	74	75	76	77	78	79	79	80	81	82	83	84	85	86	86	87	88
92	73	74	75	76	77	78	79	80	81	82	83	84	85	85	86	87	88	89	90
94	74	75	76	77	78	79	80	81	82	83	84	86	86	87	88	89	90	91	92
96	75	76	77	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94
98	76	77	78	80	80	82	83	83	85	86	87	88	89	90	91	92	93	94	95
100	77	78	79	81	82	83	84	85	86	87	88	90	91	92	93	94	95	96	98
102	78	79	80	82	83	84	85	86	87	89	90	91	92	94	95	96	97	98	100
104	79	80	81	83	84	85	86	88	89	90	91	93	94	95	96	98	99	100	101
106	80	81	82	84	85	87	88	89	90	91	93	94	95	97	98	99	101	102	103
108	81	82	83	85	86	88	89	90	92	93	94	96	97	98	100	101	103	104	105
110	81	83	84	86	87	89	90	91	93	95	96	97	99	100	101	103	104	106	107

HUMA				
Humidity %				
Temp °F	40	45	50	55
72				
74				
76				
78				
80	80	80	81	81
82	81	82	83	84
84	83	84	85	86
86	85	87	88	89
88	88	89	91	93
90	91	93	95	97
92	94	96	99	101
94	97	100	103	106
96	101	104	108	112
98	105	109	113	117
100	109	114	118	124
102	114	119	124	130
104	119	124	131	137
106	124	130	137	
108	130	137		
110	136			

Stress threshold for lactating cows. Respiration rate may exceed 60 BPM. Milk loses begin ~ 2.5 lbs/cow/day. Reproductive loses are detectabl
Caution for people depending on age, exposure and activity. People may not feel heat stress until 80°F and 40% humidity.

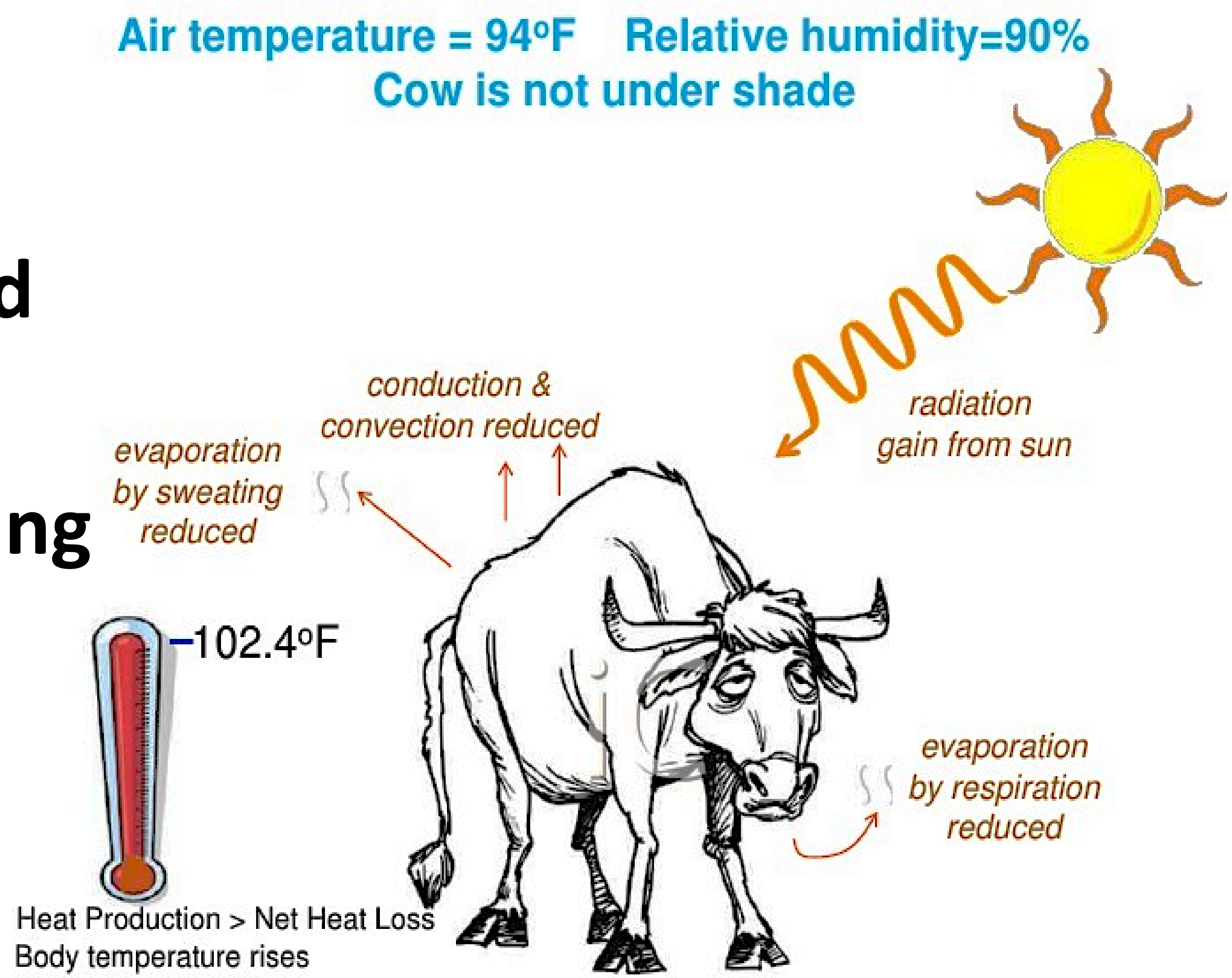
Mild to moderate stress for lactating cows. Respiration rates may exceed 75 BPM. Milk loses ~ 6 lbs/cow/day. Rectal temperatures will excee
Extreme Caution for people depending on age, exposure and activity.

Moderate to severe stress for lactating cows. Respiration rate exceeds 85 BPM. Milk loses ~ 8.7 lbs/cow/day. Rectal temperature exceeds 10
Danger for people depending on age, exposure and activity.

Severe stress! Life threatening conditions for lactating cows. Respiration rates are 120-140 BPM. Rectal temperatures may exceed 106

Adaptation to high temperatures - dairy

- provide shade
- ensure water availability and that cows drink
- give portion of feed in evening
- increase ventilation w/ fans
- evaporative cooling



THE COST OF HEAT STRESS IN BROILERS AND LAYERS

Increased mortalities

- Sudden death syndrome

Lost fertility

- In males (up to 30%) and females

Productivity Losses

- Depressed appetite
- F.C.R. down by 10%-12%
- Slower growth up to 25% less protein and fat
- Lower egg yield (8%-10) fewer lighter eggs eg - 4g @ 30°C environmental temperature
- Decline in shell quality - more downgrading
- Inferior carcass quality - overfat downgrades
- Indigestibility
- Loss of acid/base balance

Increase in Metabolic Disorders

- Incidence of Ascites increases
- Bone Metabolism is disturbed, eg Tibial dyschondroplasia
- Bigger output of urine - Wet droppings

Add Capital Investment

To provide

- Shade
- Fans
- Cooler pads
- Water sprinklers

Lower Resistance to Disease

Caused by suppression of the immune system (lowered serum immunoglobulin)

- Spread of intercurrent diseases of respiratory and digestive systems
- Mal absorption syndrome

https://www.heatstress.info/Heatstressincattlepoultryandswine/costofheatstressinlayersandbroilers/tabid/2132/Default.aspx

Adaptation to high temperatures- poultry

- increase ventilation in poultry houses
- insulate poultry houses- spray foam
- evaporative cooling
- ensure adequate water, flavor water?

https://www.poultryventilation.com/

Recirculating Evaporative Cooling System

http://www.thepoultrysite.com/articles/386/basic-introduction-to-broiler-housing-environmental-control/

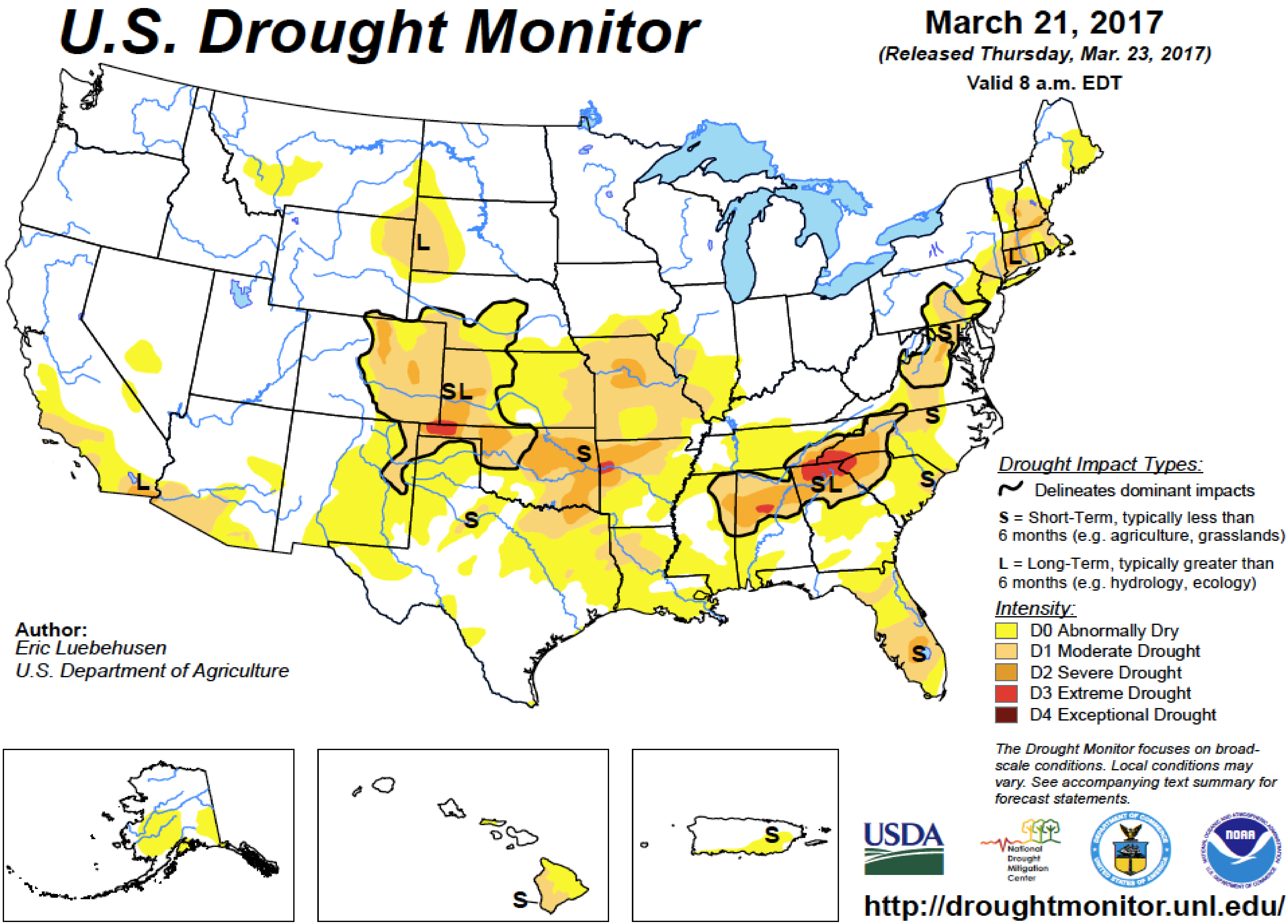
Heat and drought a bad combination

Table 1. Potential corn evapotranspiration and yield loss per stress day during various stages of growth.

Growth Stage	Evapotranspiration Inches per day	Estimated Yield Loss Percent Per Day (Avg)
V12-V16	.21	3.0
V16-Tasseling	.33	3.2
Pollination (R1)	.33	6.8
Blister (R2)	.33	4.2
Milk (R3)	.26	4.2
Dough (R4)	.26	4.0
Dent (R5)	.26	3.0
Maturity (R6)	.23	0

Source: Rhoads and Bennett (1990) and Shaw (1988)

Use online tools to stay aware



Adapting to Drought

- Add irrigation, build storage capacity
- Increase soil health
  - more organic matter holds water
  - boost soil microbes that help plants fight drought
- Plant into mulched cover crops
- Plant earlier, stagger planting dates
- Use drought-resistant varieties

Establishing cover crop for next year

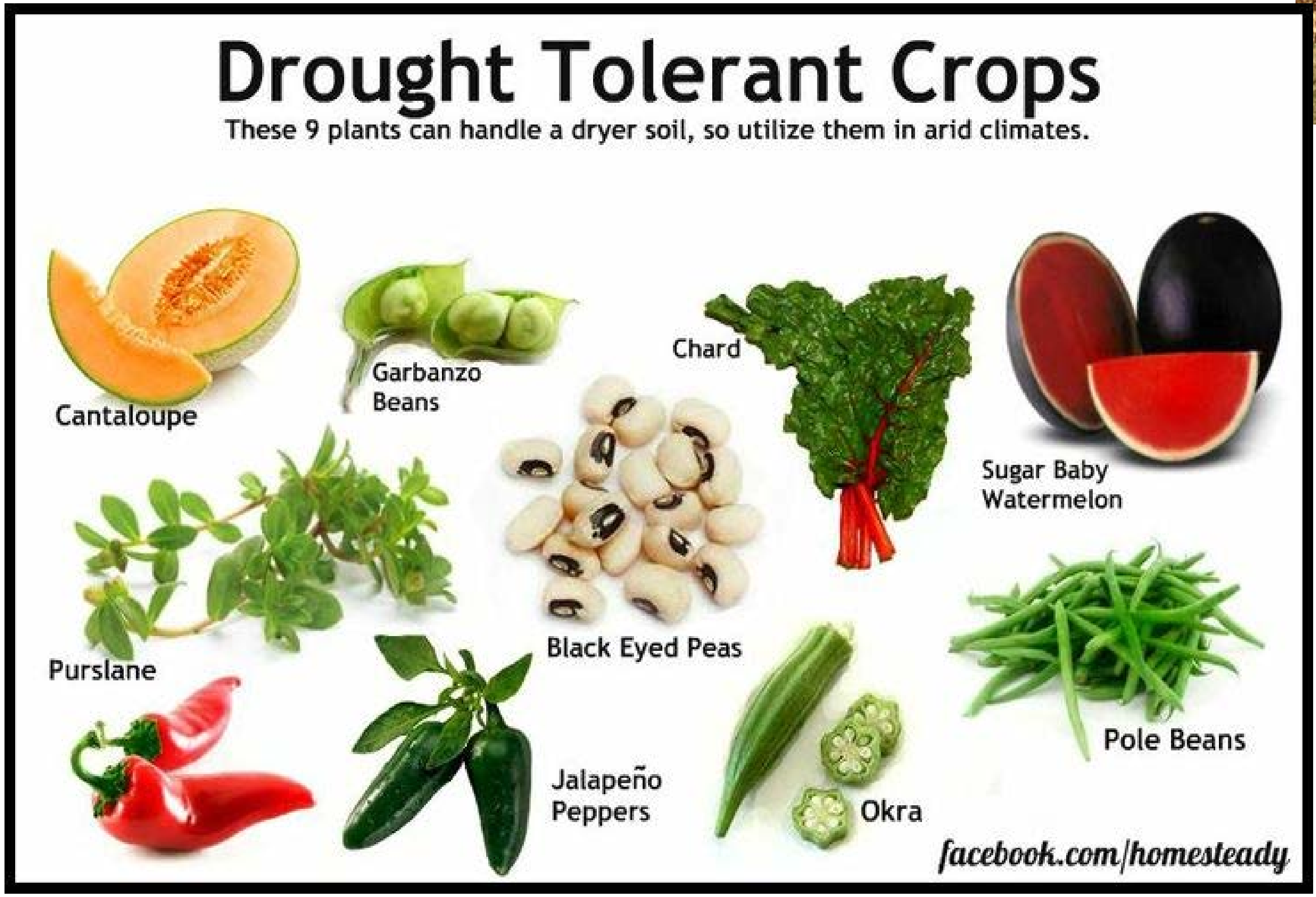
- Plant cover crops into corn or soybeans

- Better establishment
- Provides more N and biomass
  for mulch in next crop
- Improves soil health, controls weeds
- Cornell Cover Crop Decision Tool

http://blogs.cornell.edu/whatscroppingup/2016/03/15/cover-crop-interseeding-research-in-new-york/

Drought: Plant different crops/varieties

-Useful for UME to compile lists
- heat tolerant crops?
- drought tolerant crops?



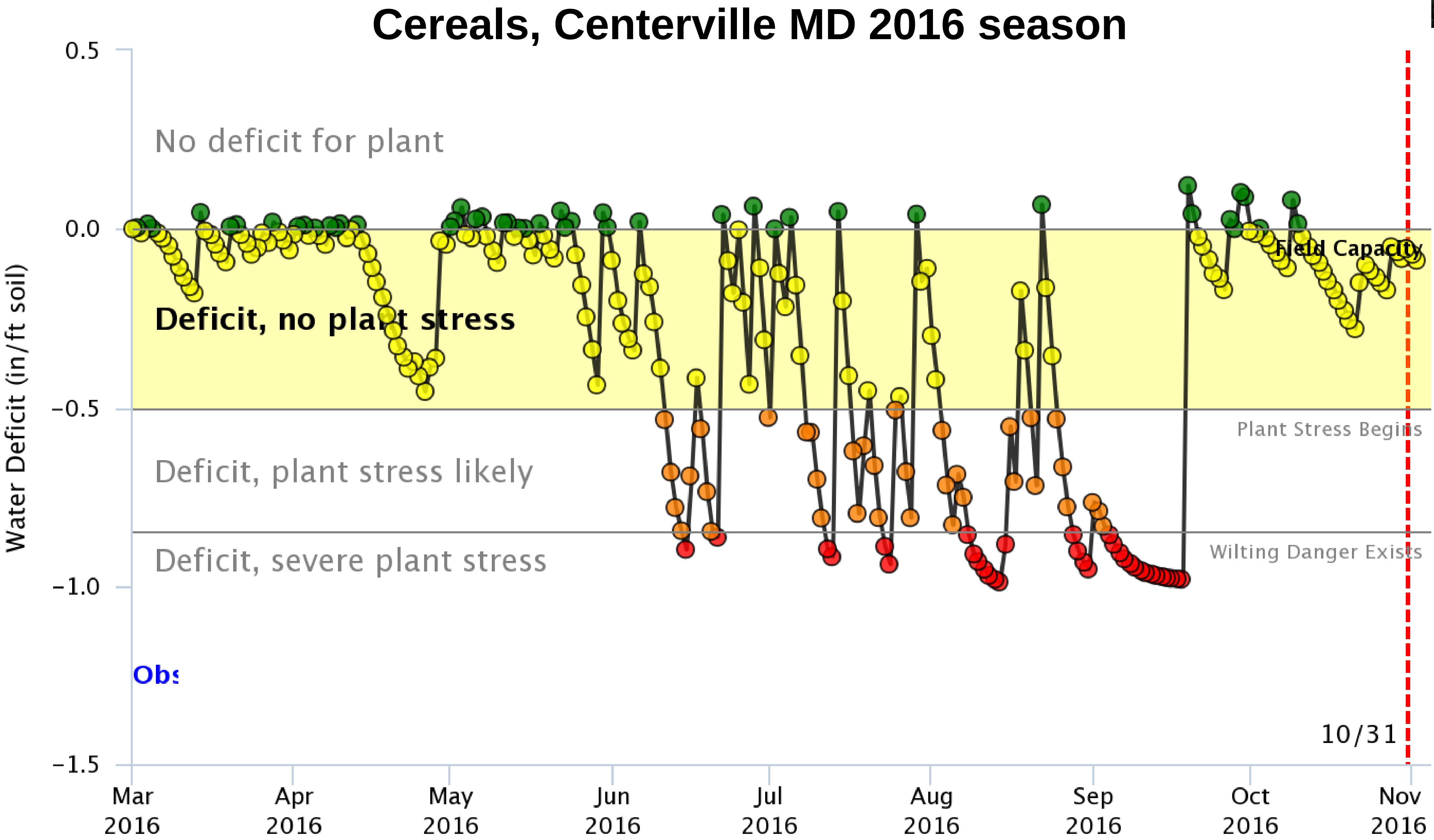
Instead of corn,

try sorghum

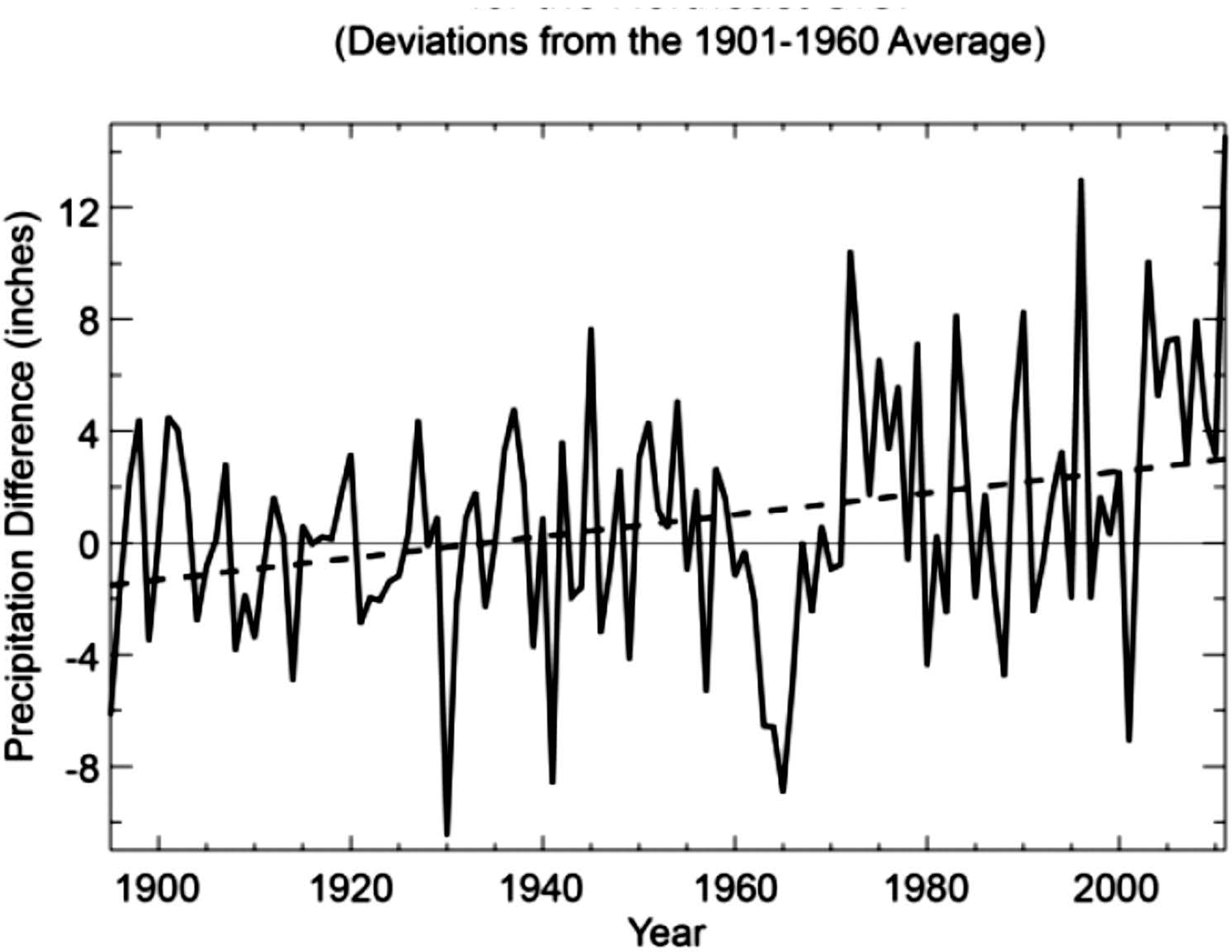
Irrigation: Use water wisely

- Minimize evaporation
- Use online tool to time irrigation:

  Cornell Climate-Smart Farming Water Deficit Calculator



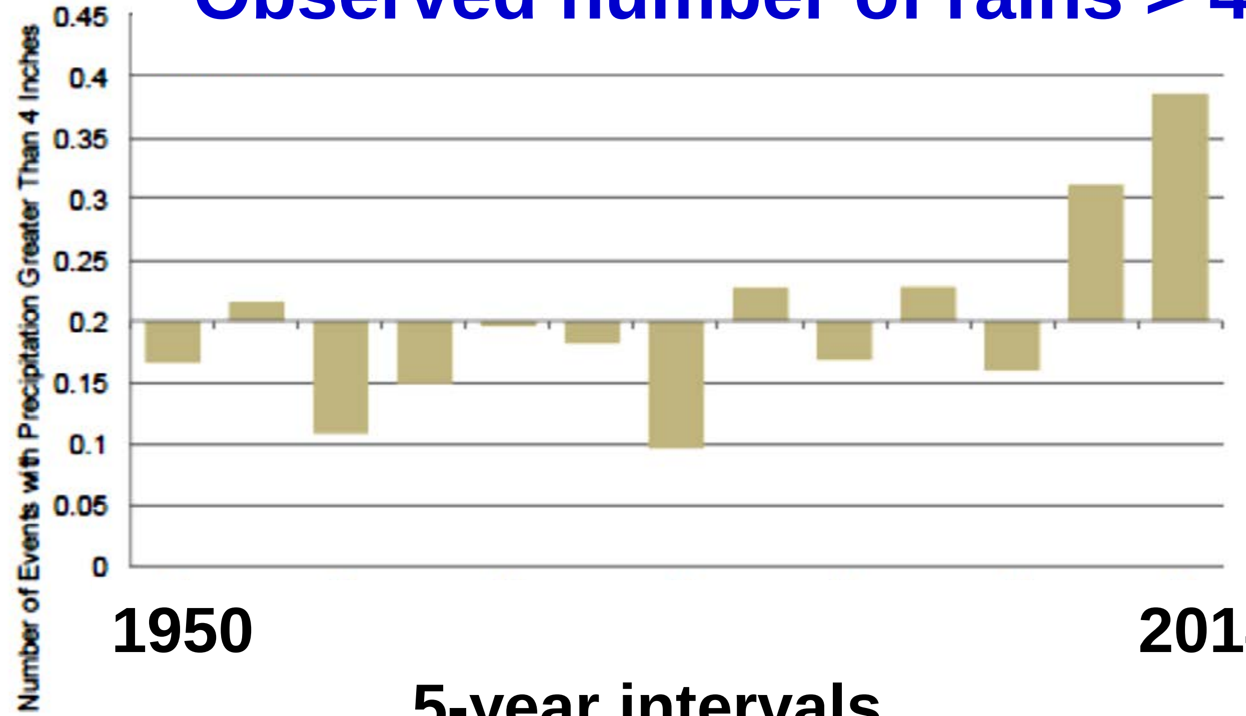
Precipitation: 5” more/year than in 1900



What does this look like for Maryland?

Rainfall

Observed number of rains > 4”

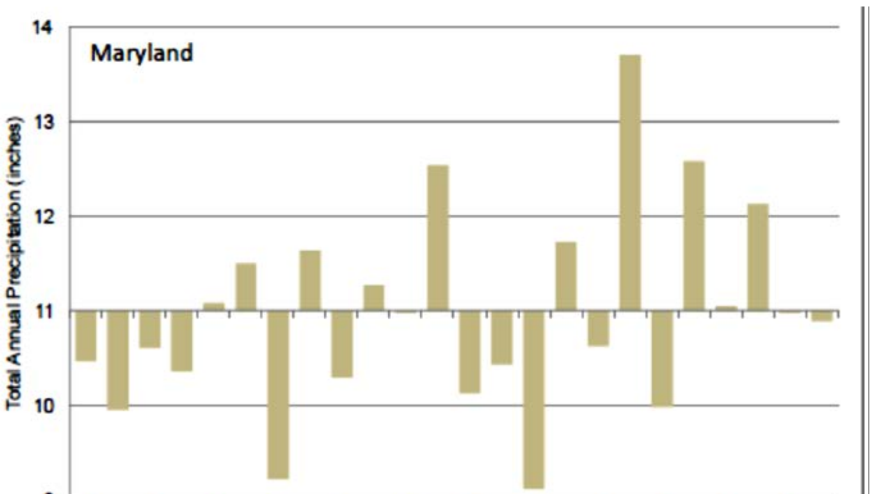


1950 2014

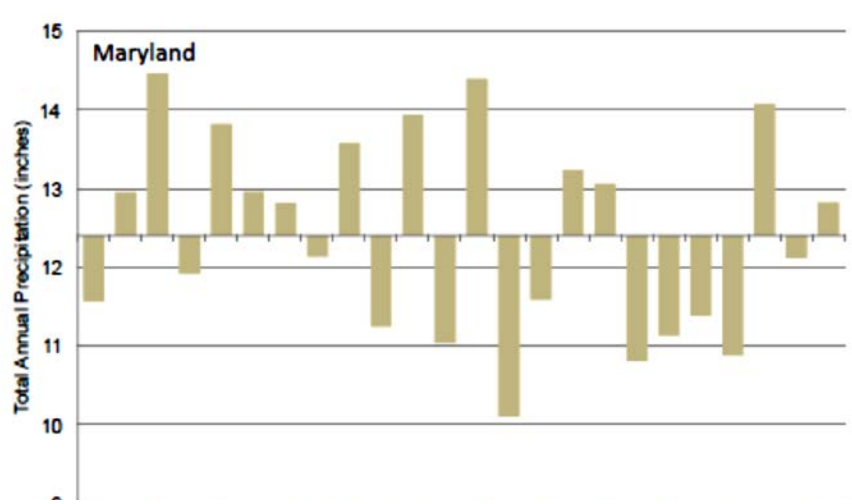
5-year intervals

Observed rainfall in

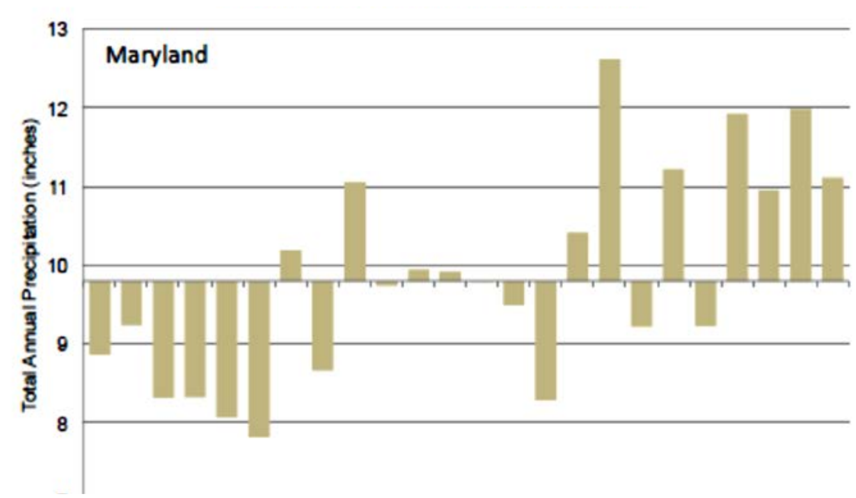
Spring



Summer

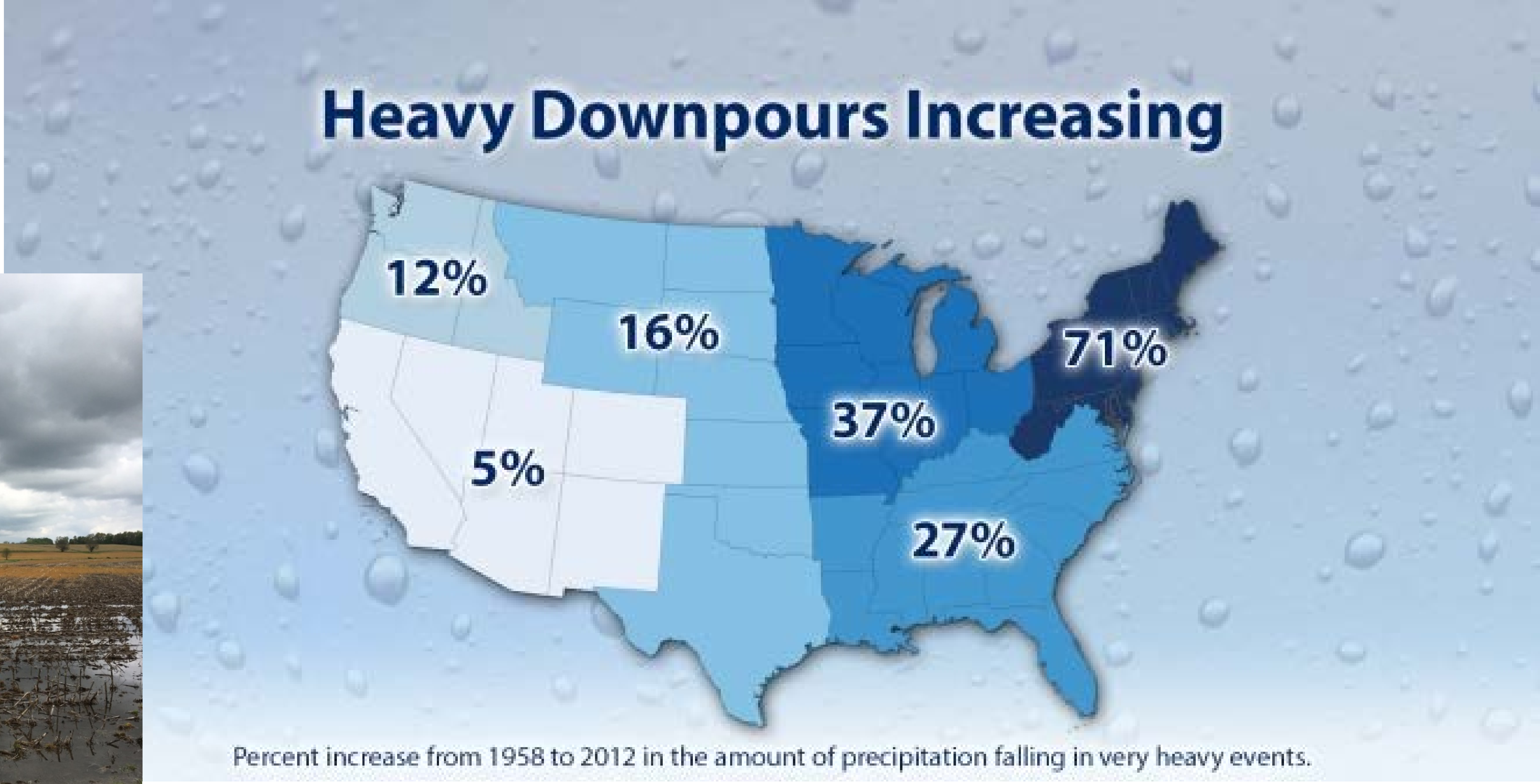


Fall



1950 2014 1950 2014 1950 2014

Source: NOAA



More rain in spring and fall
➔ flash floods

- **Delay planting, cause soil compaction**
- **Wash out or contaminate fields,**
- **Stunt or kill plants,**
- **Increase disease,**
- **Cause problems at harvest**

Spring/Fall flooding: adaptation strategies

-Improve drainage

Credit: Yoncong Li,UFL

- Improve soil health for better infiltration

- Prevent erosion– use cover crops

- Graft onto flood-resistant rootstocks

- Stagger planting dates

- Diversify crops

- Protect manure storage

Beware: Floods can compromise food safety

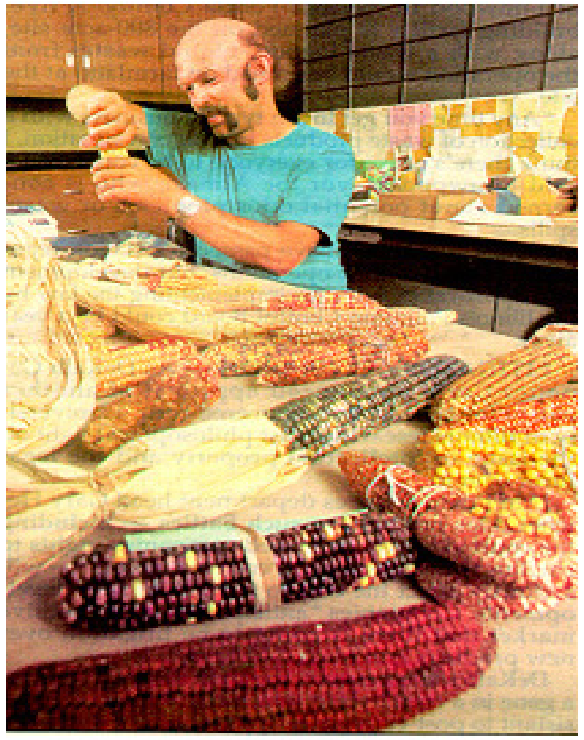
Spring/Fall flooding: adaptation strategies

Breed flood tolerant crops

Both classical plant breeding & GMO w/ flood tolerance gene(s)

Discovery of flood tolerant corn in South America

Cross w/ US inbreds
➔ 50% flood tolerant



Martin Sachs, ARS,UIUC

Or, try something totally different

Flood and salt tolerant beach mallow for poultry Bedding

– U Delaware

http://www1.udel.edu/udaily/2014/mar/mallow-chicken-bedding-031914

Flooding: adaptation strategies

Replant??

Use Decision Support Tools

FAST

CORN REPLANTING DECISION TOOL

Print | Help | Main Menu

Normal Yield and Price Expectations		
Expected Normal Yield (bu/ac)	200	
Expected Market Price ($/bu)	$6.05	/ bu.
Original Planting Information		
Original Plant Date	4/5/2011	
Actual Stand from Initial Planting	20,000	/acre
Yield Potential of Damaged Field	81%	
Estimated Expected Yield of Damaged Field	162	/acre
Replanting Information		
Expected Replant Date	5/15/2011	
Replant Seeding Rate (seeds/ac)	35,000	
Estimated Yield of Replanted Field	89%	
Estimated Expected Yield of Replanted Field	178	/acre
Replant Costs		
Seed Price per Unit	$150.00	/ unit
Seed Cost	$65.63	/acre
Equipment Cost (incl. fuel & labor)	$12.00	/acre
Additional Herbicide Cost	$20.00	/acre
Additional Insecticide Cost	$0.00	/acre
Other Replant Costs (interest, drying, etc)	$10.00	/acre
	$107.63	
Crop Insurance Replant Payment		
Was a farm-level insurance purchased (e.g., RP, RPwExcl, or YP)	Yes	
Crop insurance replant payment	$48.08	/acre

This is the maximum replant payment. Criteria must be met before a payment is received including: 1) corn was planted after the earliest planting dates (April 6 in Illinois), 2) the lower of 20 acres or 20% of acres need to be replanted, 3) the original stand will not produce 90% of the guarantee, 4) replanting must be judged as practical. Discuss these issues with a crop insurance agent before replanting.

Estimated Return to Replanting		
Yield Gain from Replanting (%)	8%	
Yield Gain from Replanting (bu/ac)	17	
Estimated Gross Income from Replanting ($/ac)	$100.31	/acre
Estimated Net Income from Replanting ($/ac)	$40.77	/acre

http://farmdoc.illinois.edu/pubs/FASTtool_special_PDM.asp

But beware compaction!

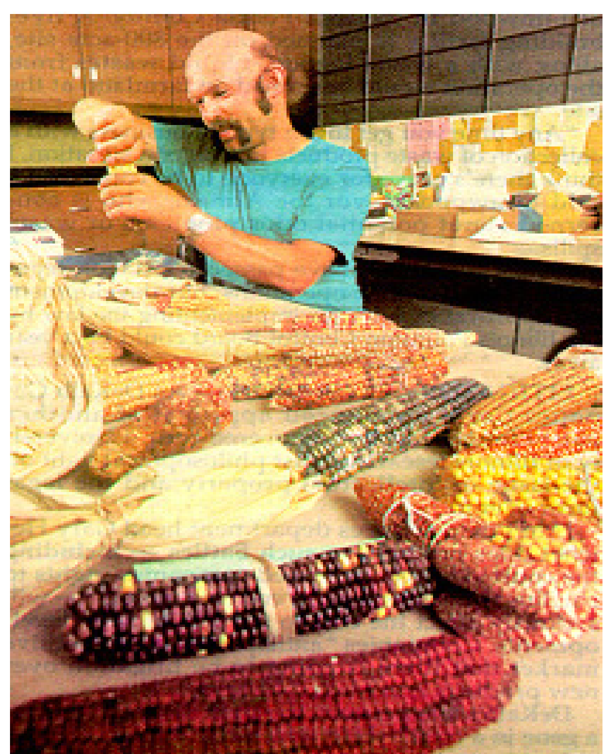
Flooding: adaptation strategies

Breed flood tolerant crops

Both classical plant breeding & GMO w/ flood tolerance gene(s)

Discovery of flood tolerant corn in South America

Cross w/ US inbreds ➔ 50% flood tolerant



Martin Sachs, ARS,UIUC

Or, try something totally different

Flood and salt tolerant beach mallow for poultry Bedding

– U Delaware

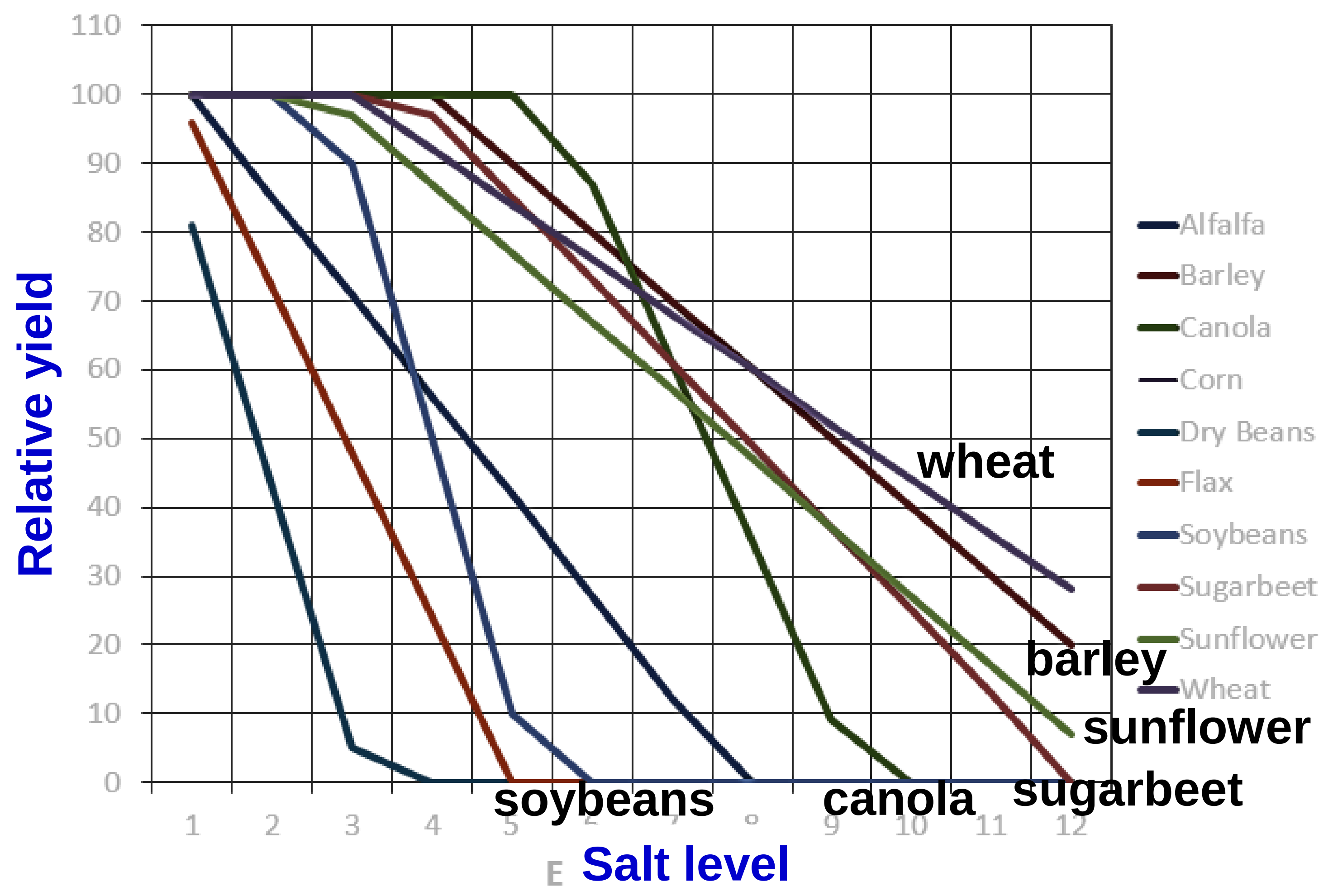
http://www1.udel.edu/udaily/2014/mar/mallow-chicken-bedding-031914

Salination: sea level rise and storm surge

Salination -- storm surge may possibly be leached out with irrigation

Salination -- rising water table fewer options

- **salt tolerant variety**
- **salt tolerant crop**



Variety trials reveal genetic variation in salt tolerance in wheat

Gordon Johnson, U Del

New opportunities?

California then

and now

If Maryland could ramp up fruit & vegetable production could gain some of California's lost market share

Feb. 2017

Effects of climate change on fruit and vegetable crops

Climate Impacts	Adaptive solutions
Flooding	
* wash out or delay planting	* increase drainage
* damage roots	* raise beds?
* contaminate soil	* plant high value or flood intolerant crops out of flood plain
* contaminate crop	* use cover crops to control erosion
* cause delayed harvest/ spoilage	* increase organic content of soil
* increase disease	
* cause erosion	
* cause soil compaction	
Drought	
* stunt growth	* drip irrigation (on timer or computerized)
* prevent flowering or fruit set	*use online tool to plan irrigation
* increases variability of yields	* mulch
* reduces high-value crop quality	* increase organic content of soil
* affect pollinators?	* use cover crops and mulch in spring
* affect soil (micro)biota?	* enhance water capture and storage
i.e., mycorrhizae, Rhizobium, nematodes	* explore drought tolerant varieties
High daytime temperatures	
* at critical times, can affect flowering, pollination	
* reduces yield	* change or stagger planting dates
* exacerbates drought	* explore heat tolerant varieties
* warmer winters, risk of freeze damage in perennials	* explore new crops
* increased ozone damage	* diversify varieties or crops to reduce risk?
??effects of duration of heat??	* plant new orchards on hills to avoid late freezes?

For copy of this handout, email me: svia@umd.edu

Important Resources for Climate-Smart Farming

Northeast and Northern Forests Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies

Photo Credit: Scott Bauer (2007)

Authors: Daniel Tobin, The Pennsylvania State University; Maria Janowiak, Northern Forests Sub Hub; David Y. Hollinger, Northeast Hub Lead; R. Howard Skinner, Northeast Hub Co-Director; Christopher Swanston, Northern Forests Sub Hub Lead; Rachel Steele, National Climate Hubs Coordinator, Rama Radhakrishna, The Pennsylvania State University; and Allison Chatrchyan, Cornell University.

Northeast Hub
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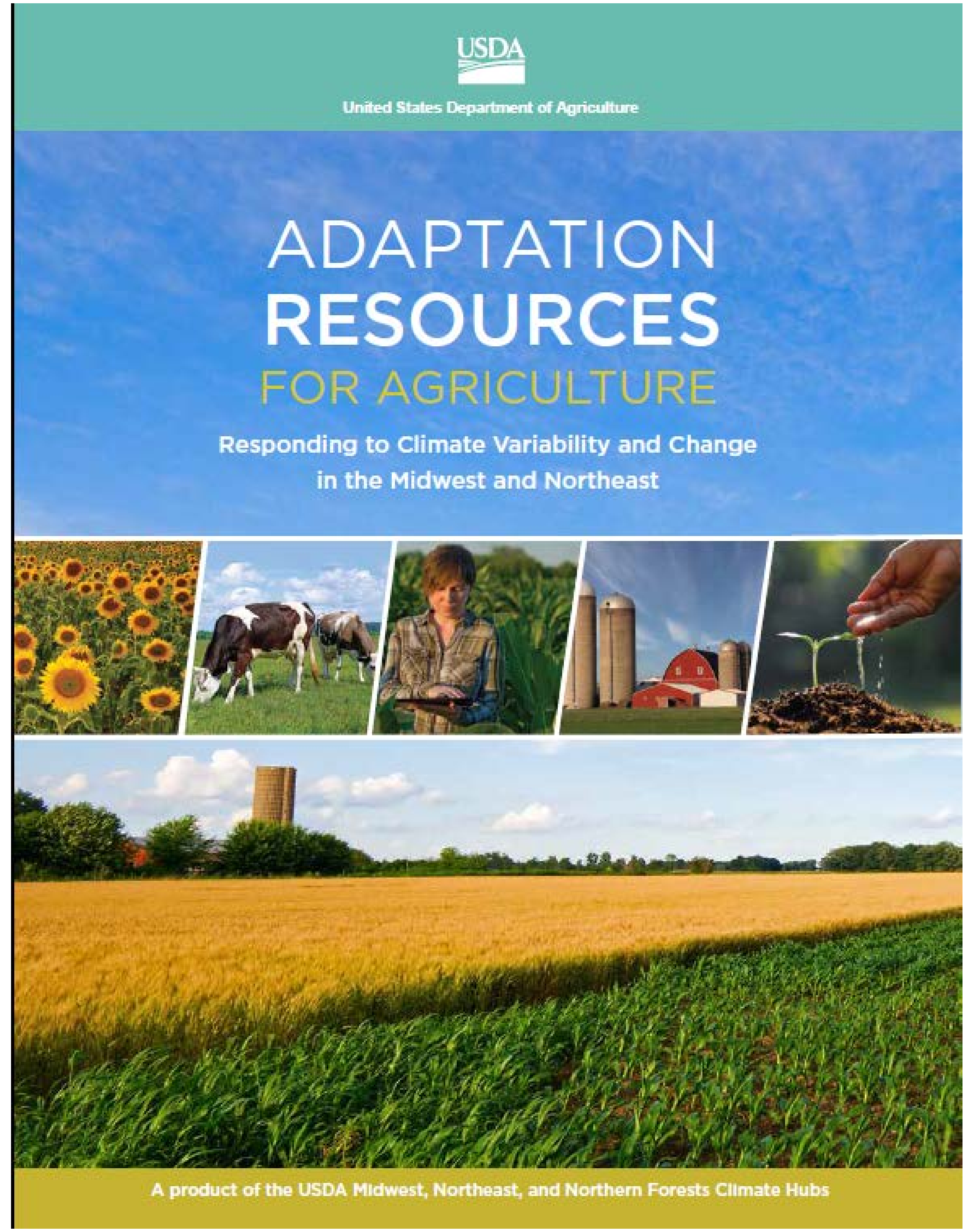
June 2015

Contributors: Our thanks to Darren Hickman, NRCS; Juliet Bochicchio, RD; Wendy Hall, APHIS; Marlene Cole, APHIS; Sharon Hestvik, RMA; Donna Gibson, ARS; Peter Kleinman, ARS; Lynn Knight, NRCS; Leon Kochian, ARS; Lindsey Rustad, FS; Erin Lane, FS; John Niedzielski, FSA; and Paul Hlubik, FSA. We acknowledge ICF International for its contributions to the Greenhouse Gas Profile. We also acknowledge Pennsylvania State University and Cornell University for their support.

Edited by: Terry Anderson, ARS.



Let me know if you would like to work on an adaptation plan specifically for your farm; svia@umd.edu

UNIVERSITY OF MARYLAND EXTENSION

Solutions in your community

Announcing the NEW University of Maryland Extension Team

Climate Science for Farmers

The University of Maryland Extension is proud to announce the formation of the new Climate Science for Farmers Extension team. The team will be headed by Dr. Sara Via, Professor, Department of Entomology,

Interested in climate smart farming?

Email me: svia@umd.edu