Farming Forward- Challenges and Opportunities in a Changing Climate

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Consulting Conservation Scientist

May 2018



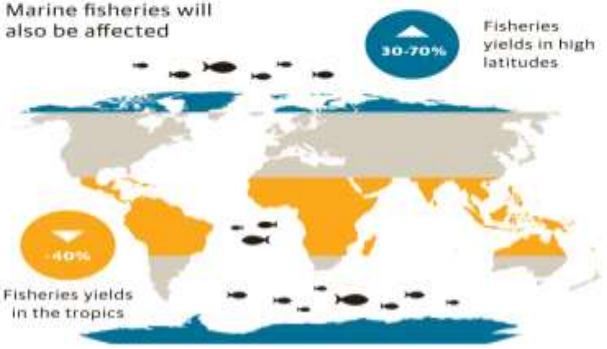
The future of food and farming: 2050s

By 2050, climatic impacts on food security will be unmistakable. There are likely to be 9 billion people on the planet, most people will live in cities and demand for food will increase significantly.

Widespread impacts on food and farming are highly likely

Average decline in yields for eight major crops across Africa and South Asia

Marine fisheries will also be affected



Heat and water may pass critical thresholds

Temperature increases of more than 4°C will endanger the ability of farms and ecosystems to adapt

Water cycles will be very different and less predictable

Changes in the intensity, frequency and seasonality of precipitation

Sea level rises and melting glaciers

Changes in groundwater and river flows

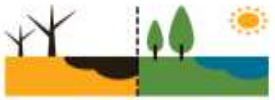
We will need major innovations in how we eat and farm

To cope with climatic changes, we may need to consider:

Completely different diets

Shifting production areas for familiar crops, livestock and fisheries

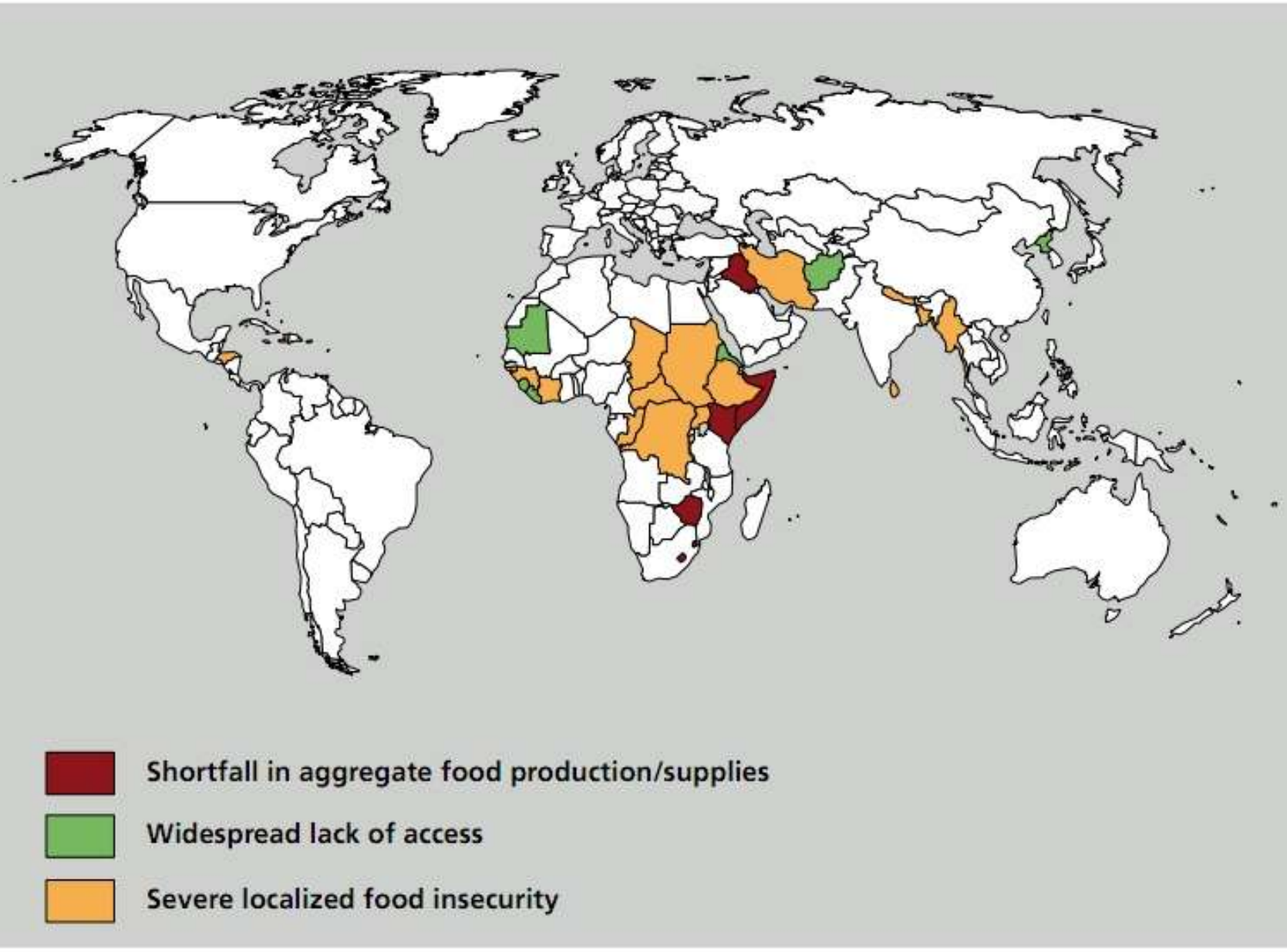
New approaches to managing waste, water and energy in food supply chains



Restoring degraded farmlands, wetlands and forests

SOURCES: Porter, J. R., Xie, L., Challinor, A., Cochrane, K., Howden, M., Iqbal, M. M., Lobell, D., Travasso, M. I. 2014. Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. http://www.ipcc-wg2.gov/
With data from Cheung et al 2010, Cochrane et al 2009, Knox et al 2012

CGIAR
Research Program on Climate Change, Agriculture and Food Security
CCAFS


Shortfall in aggregate food production/supplies
Widespread lack of access
Severe localized food insecurity

Most of us are fortunate…
But what If?

Low income/poor

You live where agriculture is rain-fed, or glacier fed

You have few resources to adapt

A food security challenge

A national security challenge

A moral challenge










2010s: The Decade of Change?

- Global demand for food -9.5-10 billion by 2050
- U.S. demand for:
  - Health/ food connections
    - Obesity and health care costs-less processed, more fruits and veggies
  - Local food
    - Food Safety, Security, Quality, and Integrity
    - Climate Change and Emergency Preparedness
    - Supporting Local Economies
    - Food equity/justice

So What Does the FUTURE Hold ?

Growing Food
- Challenges and Opportunities –

- Nationwide US
- Extreme weather
- Floods and droughts
- High temperature stress
- New pests and diseases
- Less predictable weather

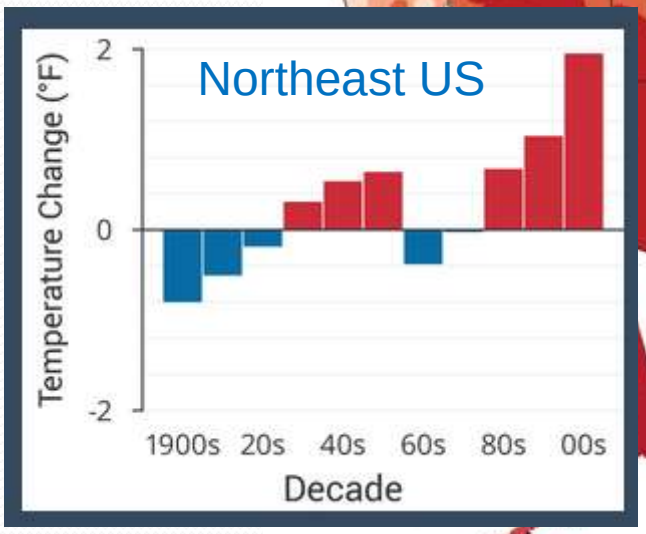
- Northeast US
  - Adequate water
  - Longer and warmer growing seasons
  - Shifts in productivity elsewhere
  - Potential to expand and diversify
  - Markets – 24% U.S. population
  - Job creation, economic growth
  - Protection of ecosystem services

Goals for Farmers

- Increased understanding of climate change impacts, adaptation and/or mitigation strategies
- Increased adoption of appropriate farm management practices by farmers to enhance climate change resilience
- Increased understanding of challenges and opportunities for agriculture by consumers, policy makers and elected officials
- Increased knowledge of Federal and State Programs and Risk Management and Crop Insurance Tools (US)
- Increase planning for climate extremes and emergencies
- Gender based shared learning to better understand impacts and develop solutions
- **Resilient, adaptive, economically successful agriculture**

The Climate is already changing…

2016 was the hottest year on record globally (2017 second hottest year), and temperatures from 2001 to 2012 were warmer than any previous decade in every region of the United States.

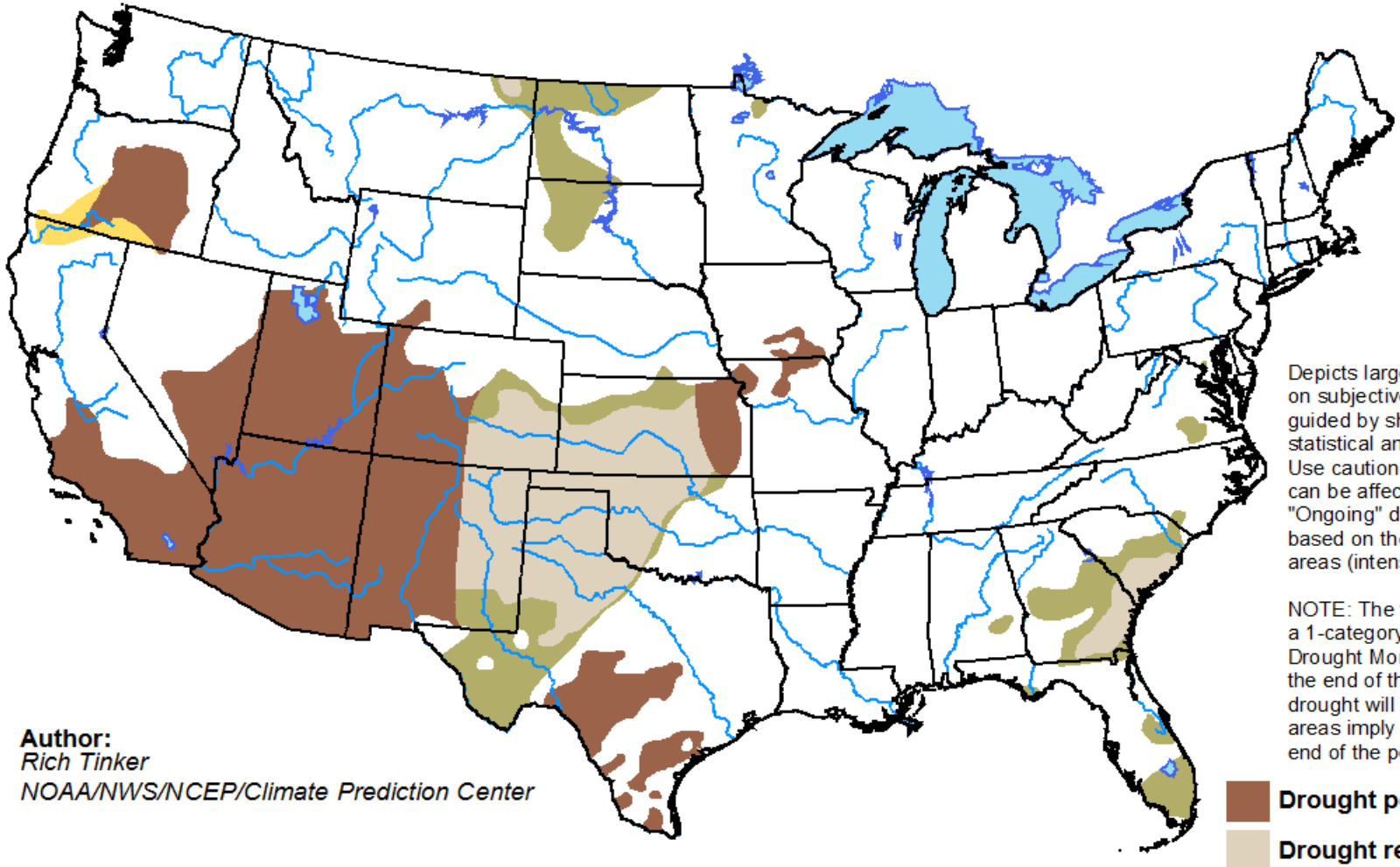


2014 was 0.01 C above that of the next warmest year (2010) but by much less than the margin of uncertainty (0.05 C). Therefore it is impossible to conclude which of 2014, 2010, or 2005 was actually the warmest year.

U.S. Seasonal Drought Outlook

Drought Tendency During the Valid Period

Valid for April 19 - July 31, 2018
Released April 19, 2018



Depicts large-scale trends based on subjectively derived probabilities guided by short- and long-range statistical and dynamical forecasts. Use caution for applications that can be affected by short lived events. "Ongoing" drought areas are based on the U.S. Drought Monitor areas (intensities of D1 to D4).

NOTE: The tan areas imply at least a 1-category improvement in the Drought Monitor intensity levels by the end of the period, although drought will remain. The green areas imply drought removal by the end of the period (D0 or none).

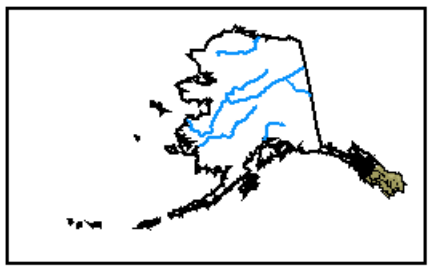
Drought persists

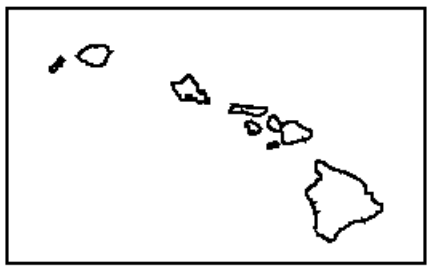
Drought remains but improves

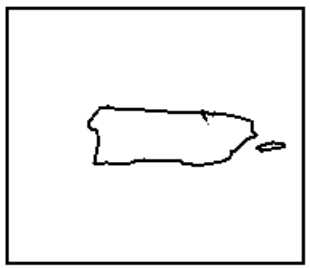
Drought removal likely

Drought development likely

Author:
Rich Tinker
NOAA/NWS/NCEP/Climate Prediction Center



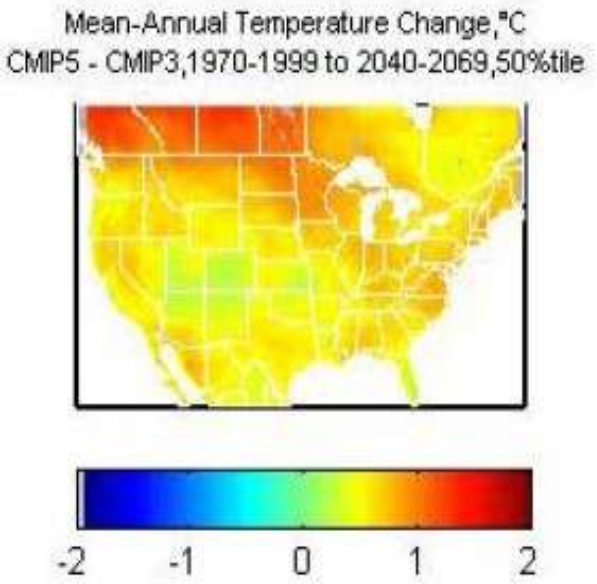


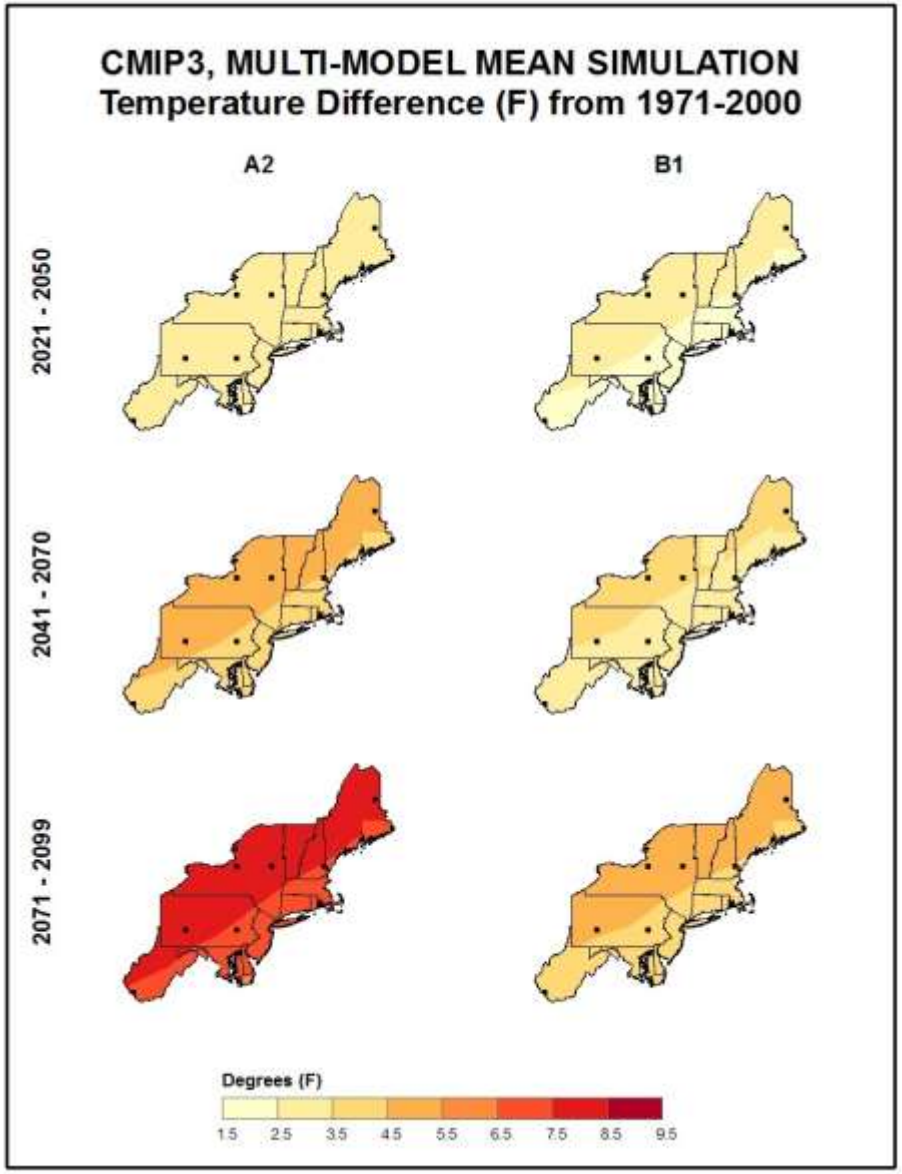


http://go.usa.gov/3eZ73

It Gets Even Warmer

U.S. Global Change Research Program
National Climate Assessment





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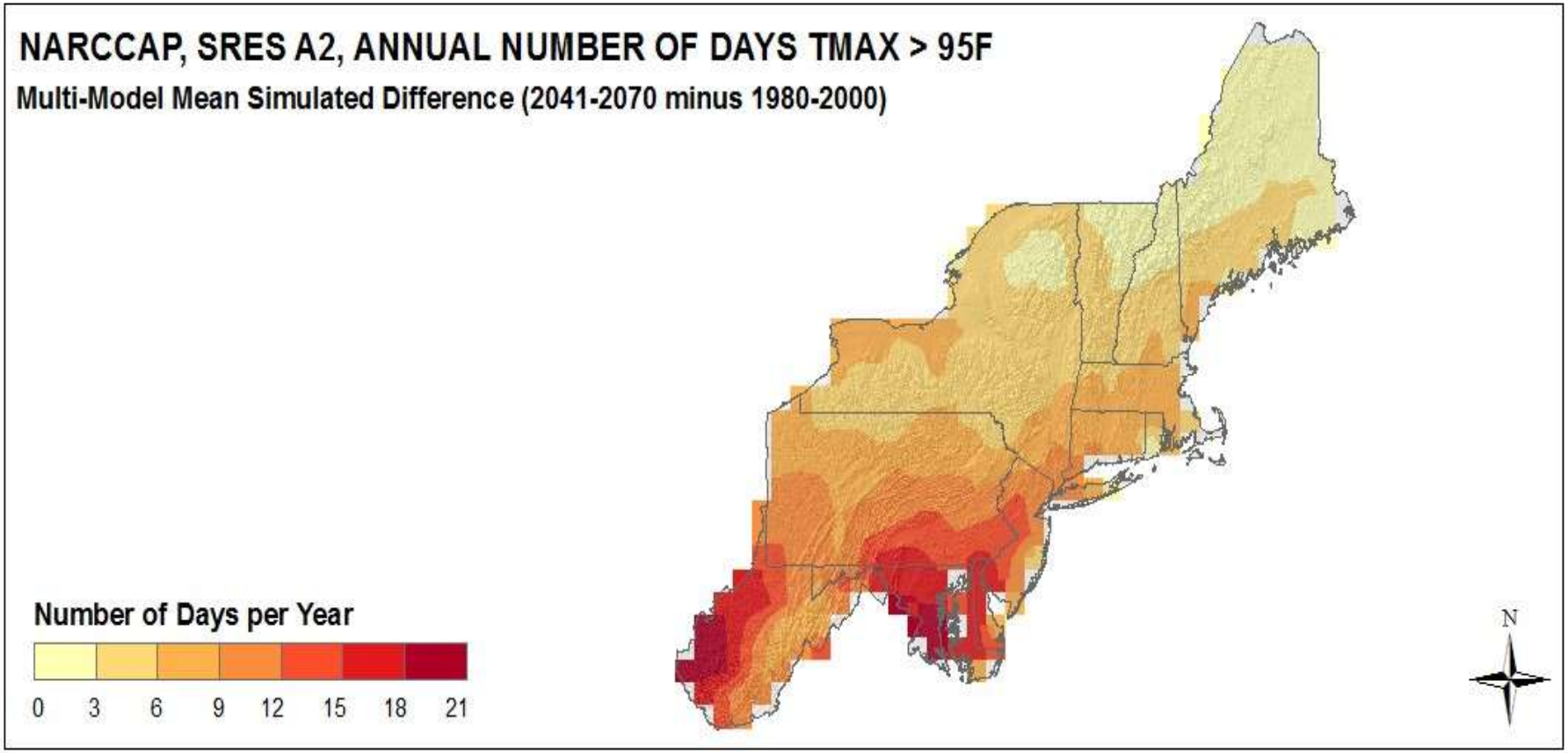
Very Warm Days Get Hotter

U.S. Global Change Research Program
National Climate Assessment



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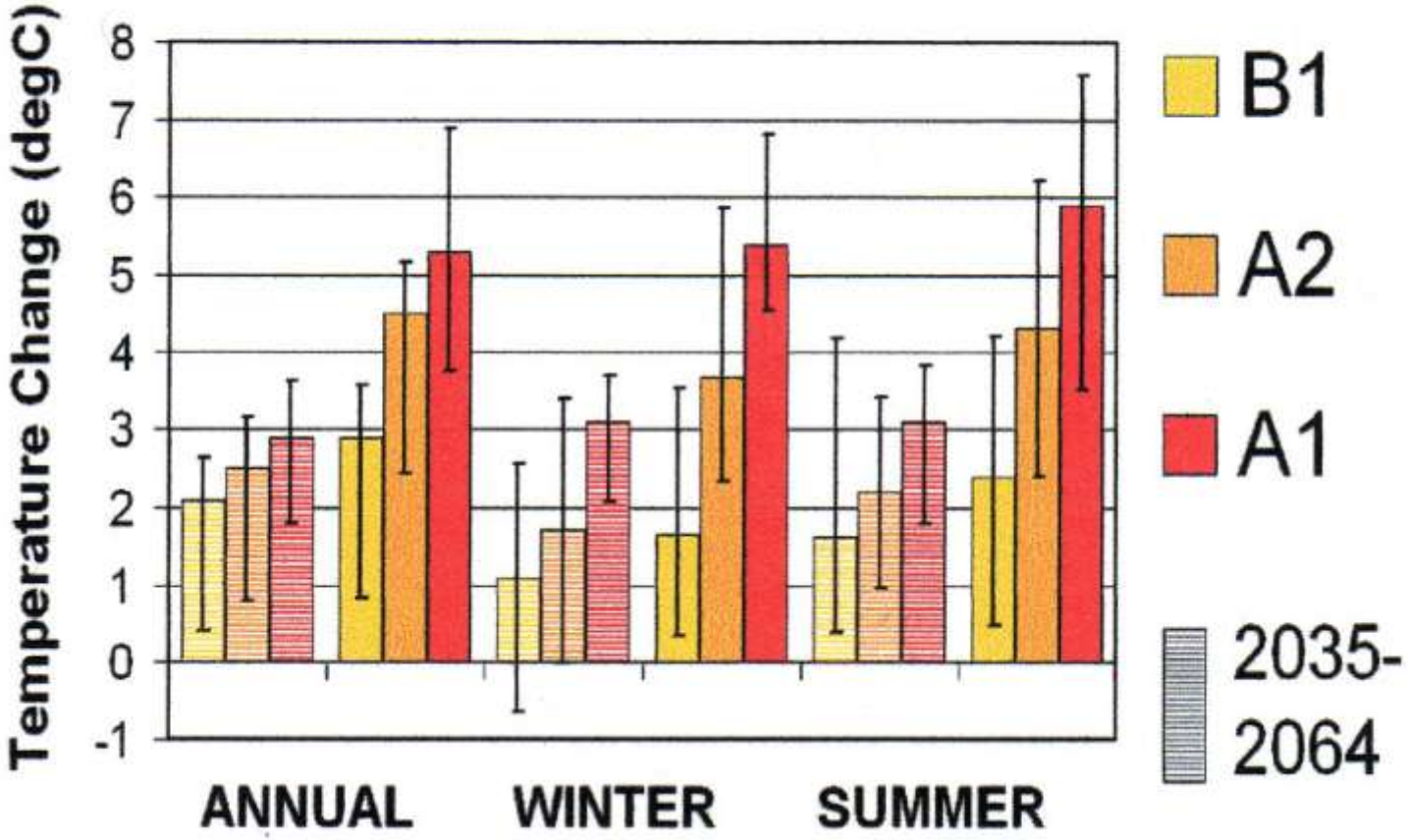
In ALL Seasons



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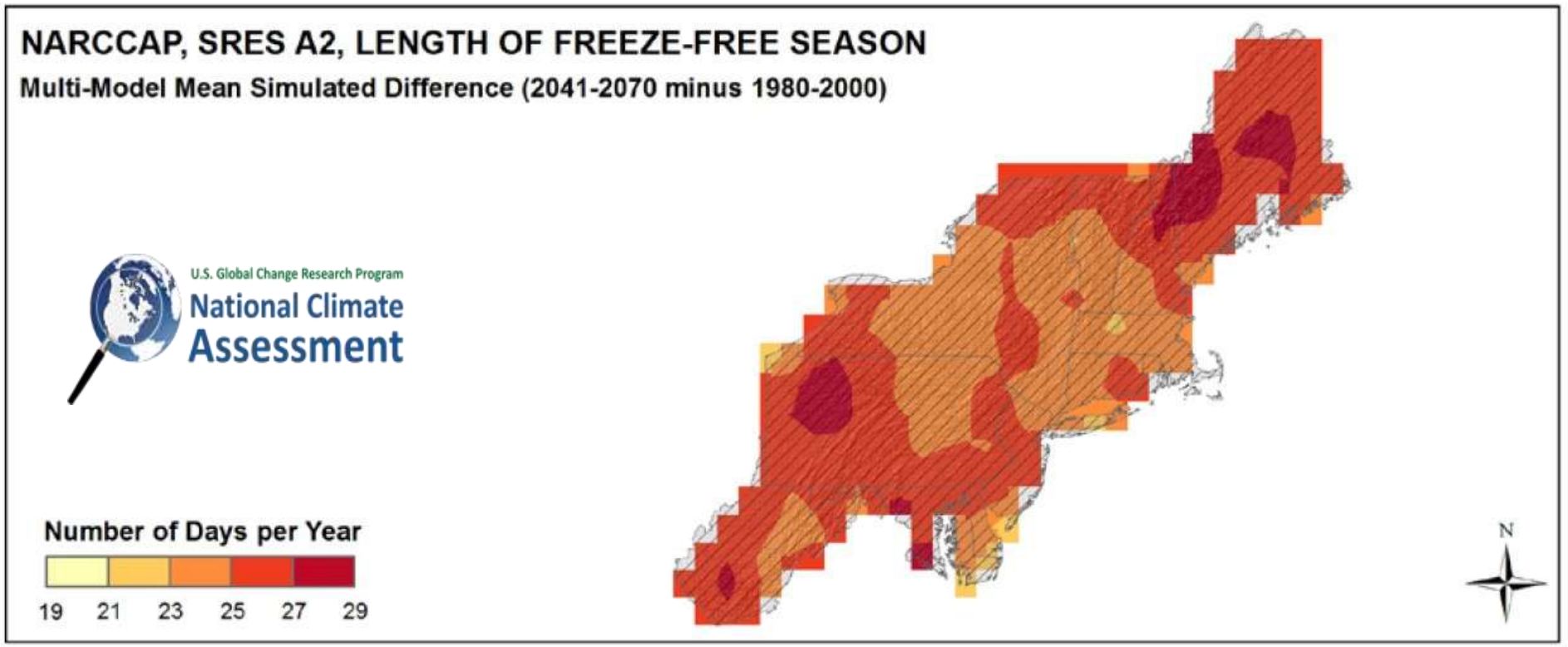
Freeze Free Season Increases by 3 weeks



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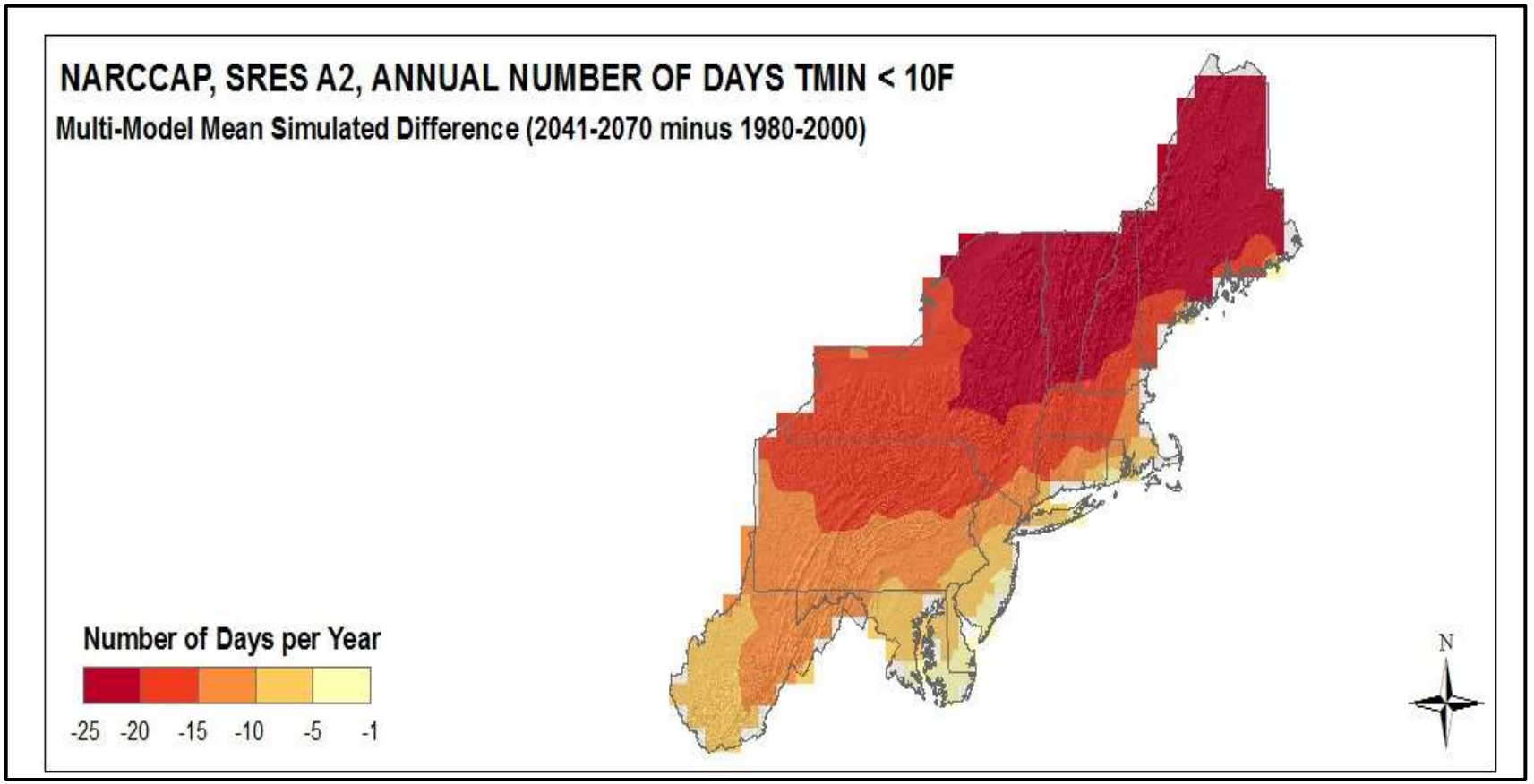
Very Cold Days Become Fewer



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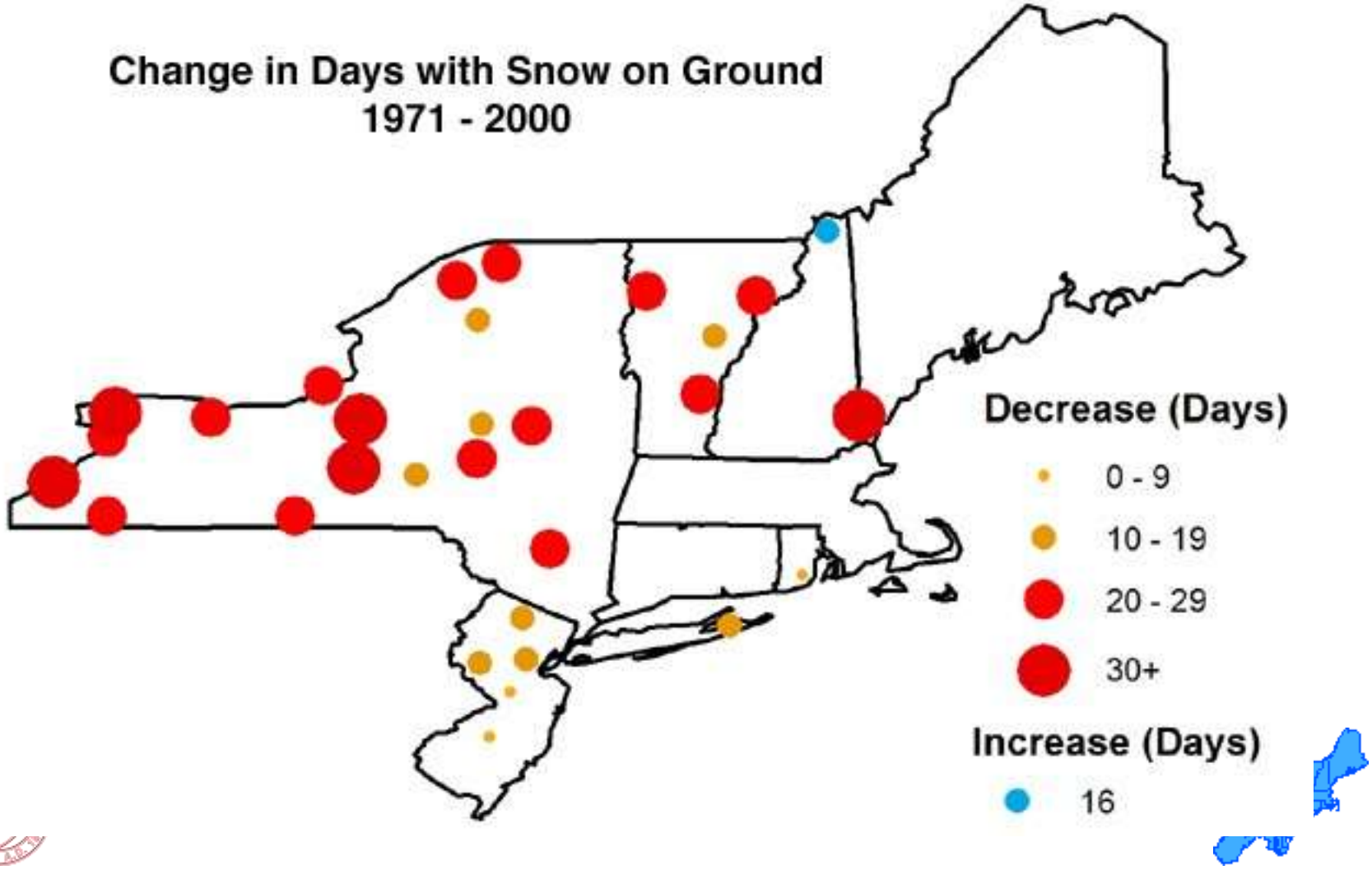
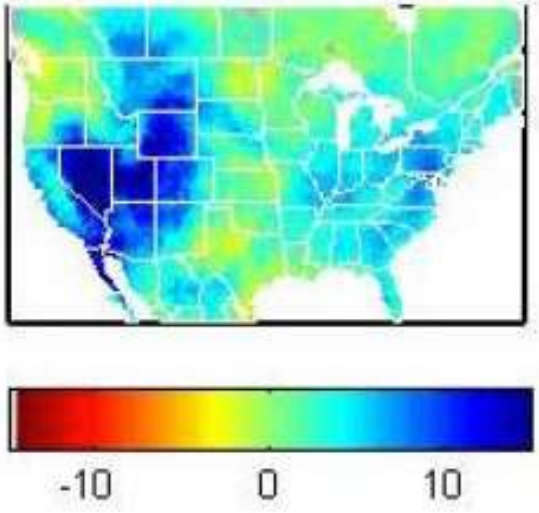
Days with Snow Cover Have Declined



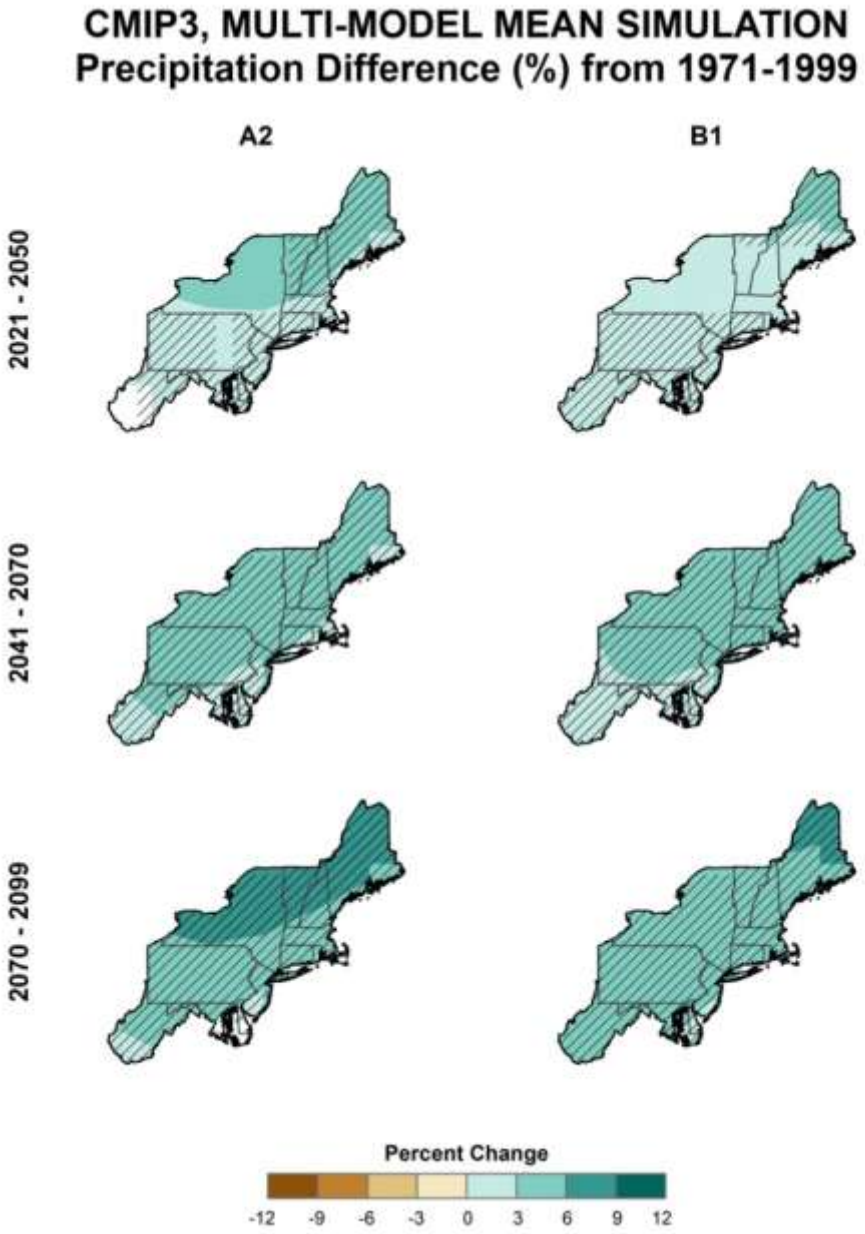
The Growing Season Ends Later

U.S. Global Change Research Program
National Climate Assessment

Mean-Annual Precipitation Change, percent
CMIP5 - CMIP3,1970-1999 to 2040-2069,50%tile



Up to 10% More Rain



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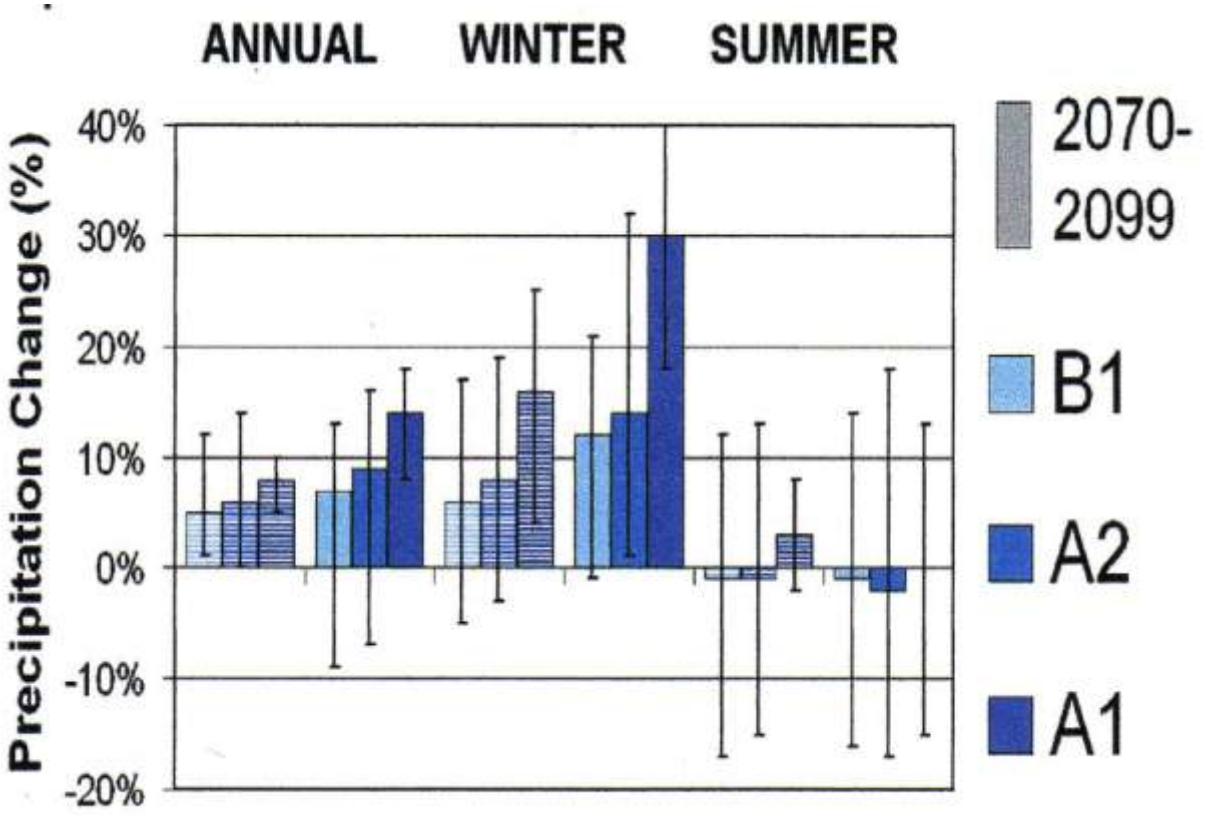
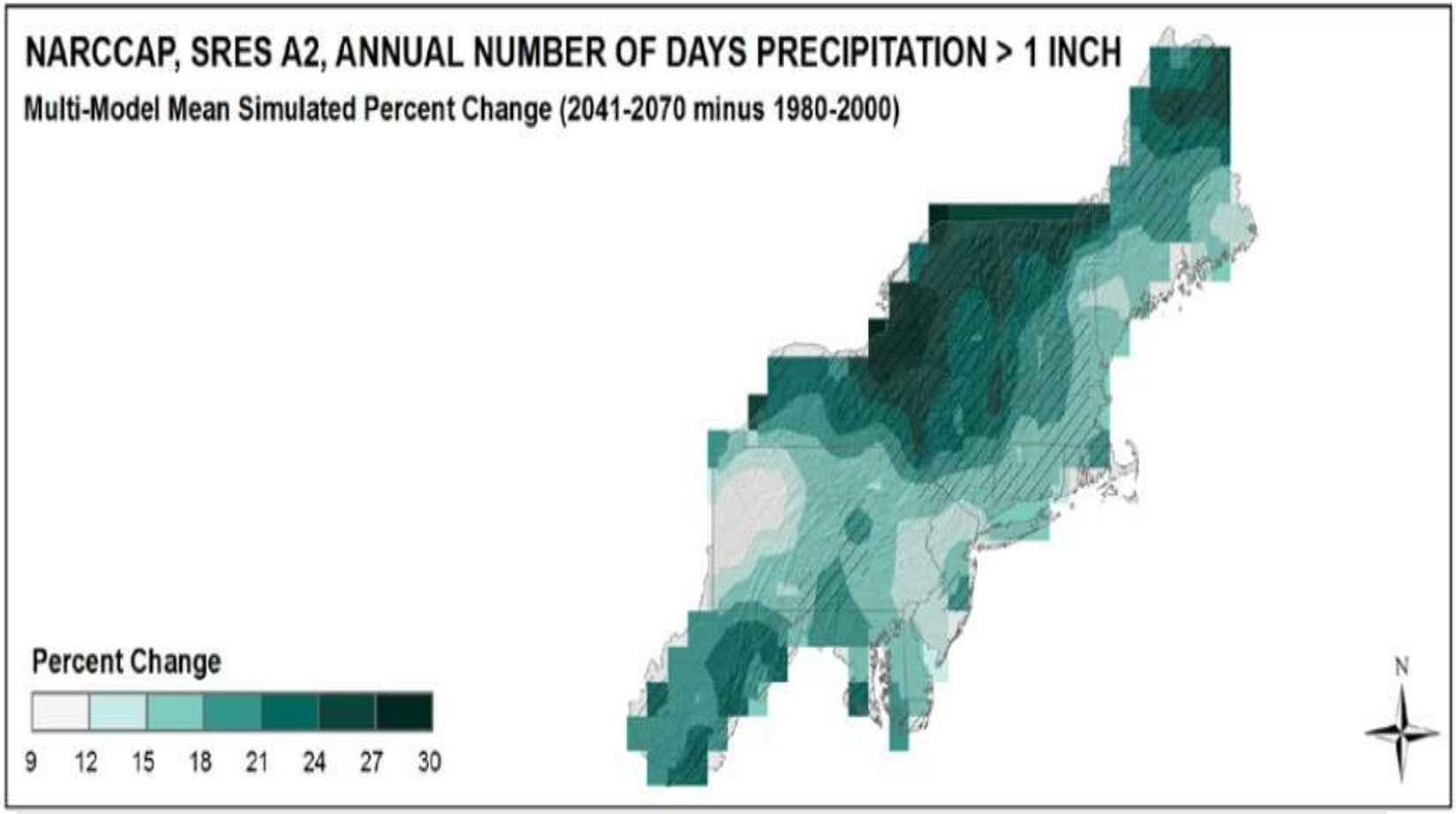
Most of the Increase in WINTER



Extreme Rainfall Trends Continue to Increase

U.S. Global Change Research Program
National Climate Assessment



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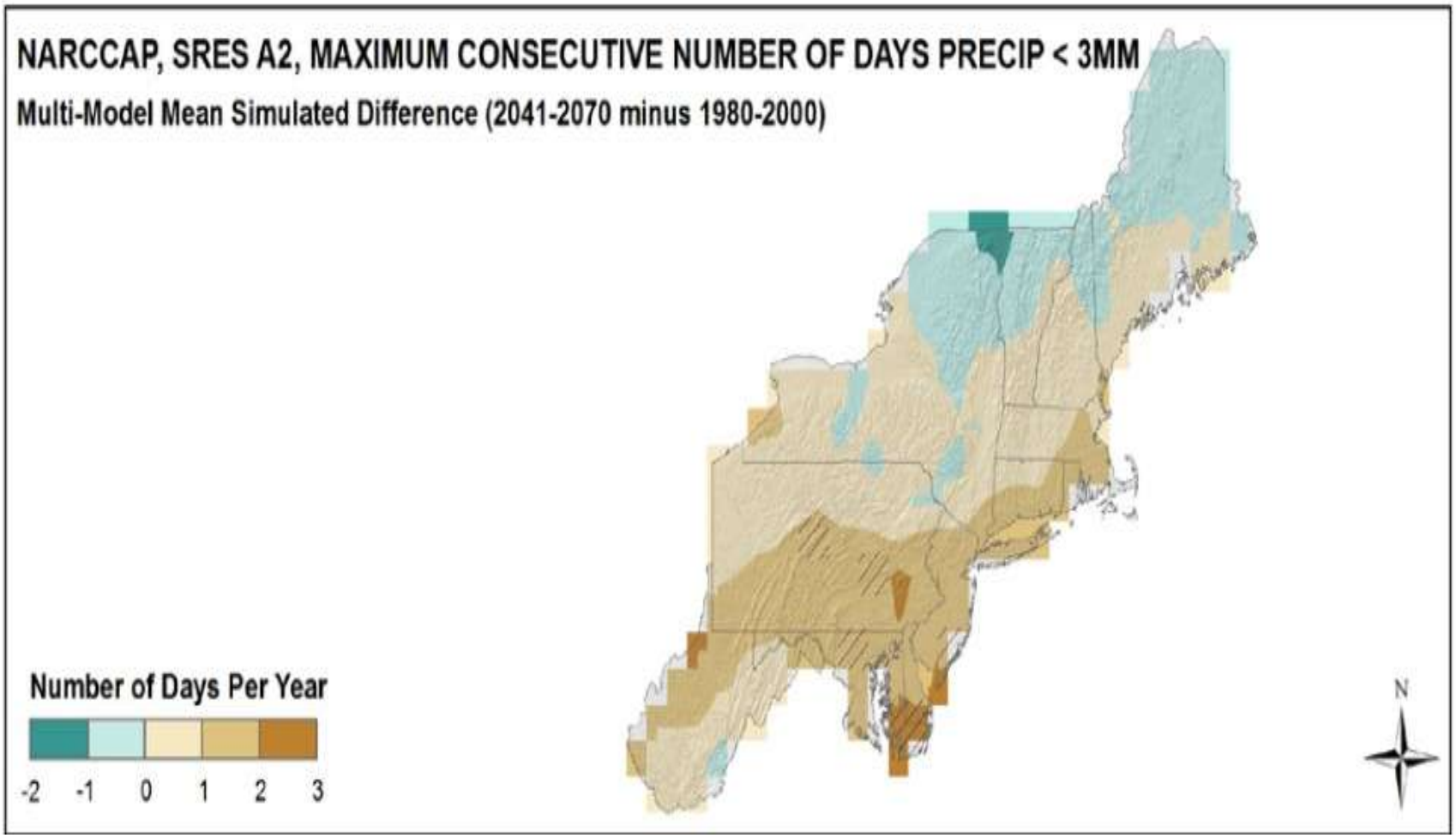
Dry Period Length

U.S. Global Change Research Program
National Climate Assessment



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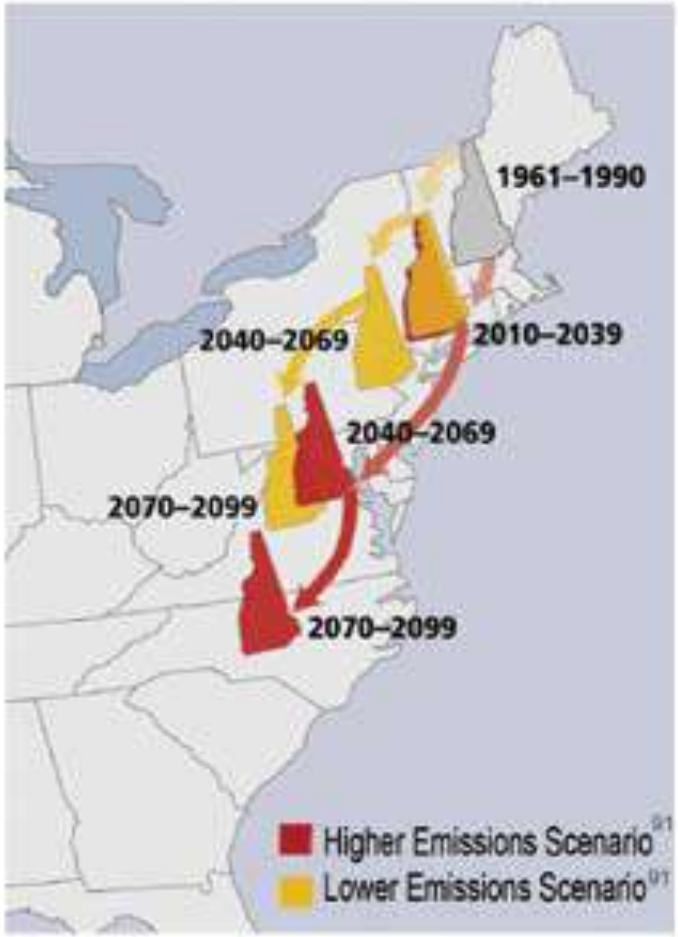
Climate Change Impacts

Climate on the Move: Changing Seasons in New England



- More frequent days with temperatures above 90°F
- Short periods of drought
- A longer growing season
- Increased heavy precipitation
- More overall precipitation, mostly in winter
- Earlier spring snowmelt resulting in earlier peak river flows
- Warmer winters with fewer chilling days
- Less predicable weather: frost dates, precipitation, dry periods


PIZZERIA NAPOLETANA
EST. 1925


CONNECTICUT GROWN
Strawberries
PICK YOUR OWN

Key Climate Impacts

- ✓✓Increased heat stress
  - Crop yield/quality and livestock productivity suffer

Key Climate Impacts

- ✓✓Increased weed pest and disease pressure
  - Earlier emergence and more over wintering

Key Climate Impacts

✓✓Too much water

Change in precipitation mainly due to “big” events

Key Climate Impacts

NYS ClimAID

✓✓Short-term summer drought risk

Irrigation needs?
Competition for water?

Key Climate Impacts

✓✓Opportunities for Perennial Fruit Crops

Less winter freeze damage

New varieties

More peaches, red wine grapes?

Key Climate Impacts

✓✓Challenges for Perennial Fruit Crops

Spring frost/freeze risk?

Key Climate Impacts

✓✓Longer Growing Seasons

New Varieties
Double Cropping

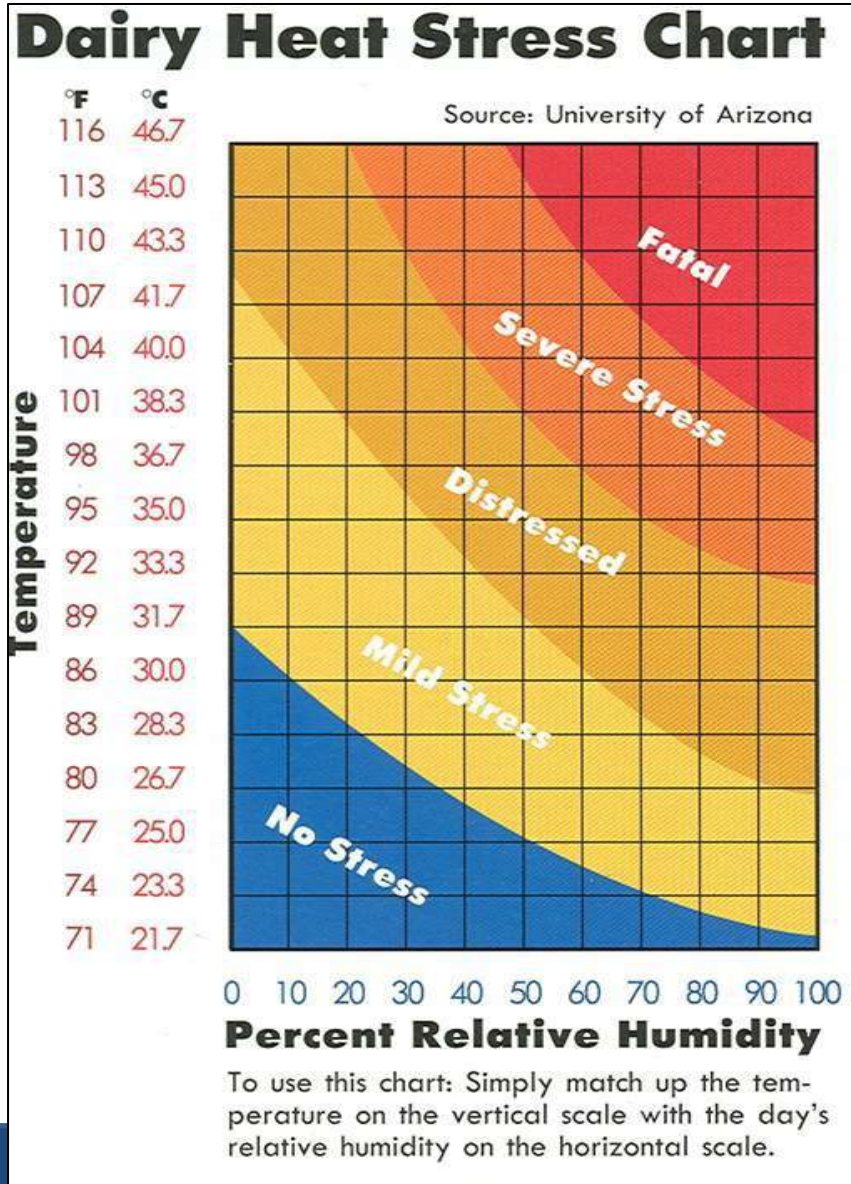
More melons, tomatoes, peppers?

How does Climate Change Impact Crops?

- Cool-season crops will be of lower yield or quality
  - Sweet corn
- Reduced grain yield (rapid maturation and moisture)
  - Field corn, nutrient content…
- Reduced vernalization lower some fruit yields; increased frost risk?
  - Apples
- New pests and diseases are able to over-winter, emerge early; increased pesticides
  - Flea beetle, SWD?
- Some warmer season crops will do better
  - Red wine grape, peaches, watermelon
- Water stress in crops…(too much, little, uneven amounts)
- Soils that are too warm or cool and wet

How does climate change impact livestock?

- Warming Temperatures
  - Livestock
    - Heat stress in dairy cattle
  - Higher body temperatures
  - Increased respiration rates
  - Less activity
  - Increased water intake
- Performance
  - Dry matter intake down by 10-20%
  - Milk production down by 10-25%
  - Reproductive processes decrease



Interacting Factors

Increasing temperatures

Water

More variability, risk

CO_2

- C_3 - 95% of plants
  - Wheat, rye, oat, barley, potatoes
  - Benefit with increase, but offset with high T^o and water stress
- C_4 - Sugar cane, corn
  - No benefit
- Bugs eat more, weeds harder to kill

Decision-Making Under Uncertainty

Farmers will require new climate-based decision tools for strategic adaptation.

- Is this "normal" bad weather or climate change??
- Do I invest in a new drainage system?...
- Or irrigation system?
- Or both?
- And when?

Highlights

The Spectrum of Agricultural Adaptation Strategies

- Resistance
  - Keep doing the same things
- Resilience
  - Try doing some things differently, adapt if they succeed or fail
- Transformation
  - Change to a new way of doing things

Constraints to Farmer Adaptation

•**Physical and ecological limits** (e.g., when the magnitude and pace of climate change are beyond our capacity to adapt)

•**Technological limits** (e.g., suitable varieties, or systems to protect from extreme weather risks not available)

•**Financial barriers** (e.g., an individual farmer, region, or nation, lacks the capital for strategic adaptation)

•**Informational barriers** (e.g., lack of weather and climate information, lack of Extension support for farmers, too much or misinformation)

•**Cognitive barriers** (e.g., underestimates of risks of inaction; confused by uncertainties, statistics, models, scientific jargon)

•**Gender, Social and cultural barriers** (e.g., the gender, social, cultural group(s) one belongs to can limit adaptation response)

Adaptation

Farm-level adjustments that build resilience

- **New varieties, new crops**, change planting dates
- **Diversify** cropping systems at farm and regional scales
- **Develop new strategies for new pests**, diseases and weeds
- **Improve soil resilience** to drought and flooding; expand into new sites less prone to water stress; new irrigation and drainage systems
- **Fruit crop frost protection** (site selection, misting, air circulation)
- **Improve cooling capacity** of livestock facilities

Agriculture Adaptation

Beyond the farm:
A role for universities, government agencies, NGOs

- **New decision tools** to explore costs, risks, benefits, and strategic timing of adaptation
- **Develop new crop and livestock options** (e.g. breeding)
- Improved delivery of real-time local weather data
- **Enhanced pest monitoring** and regional data sharing
- **Disaster risk management** and better **crop insurance** programs
- **Financial assistance for adaptation** investments
- **Land use and climate change policies** that integrate economic, environmental and equity issues

- **Engage, educate, empower, and provide secure land tenure for women farmers**

How are farmers adapting to climate change?

1. Risk Assessment
2. Diversification
3. Improvement of soil health
4. Use of conservation practices
5. Newly adopted production systems

Diversification…

- **Markets**
- **Crops**
- **Animals**
- **Products**
- **Household Income**
- **Land use**

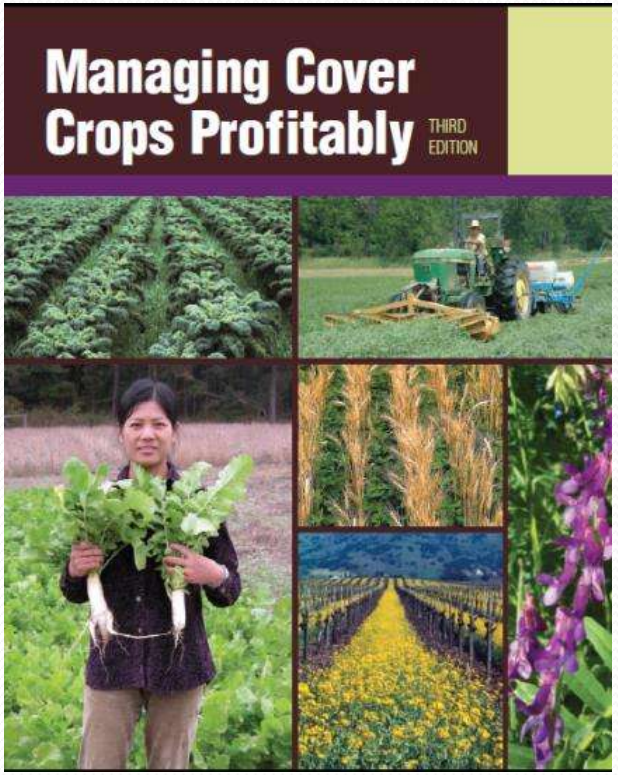
Newly Adopted Production Systems

High tunnels, hoop houses
Greenhouse/Controlled environment
Mulches and Row covers
New (different crops/varieties/breeds)
Low pre-harvest investment crops
Intensive rotations
wet and drought resistant crops


Improvement of Soil Health
1. Nutrient management
2. Irrigation
3. Organic matter (OM) management
4. Erosion control

Keep soil covered as much as possible

- Control Erosion
- Protect Soil Aggregates
- Suppresses Weeds
- Conserves Moisture
- Cools the Soil
- Provides Habitat for Soil Organisms

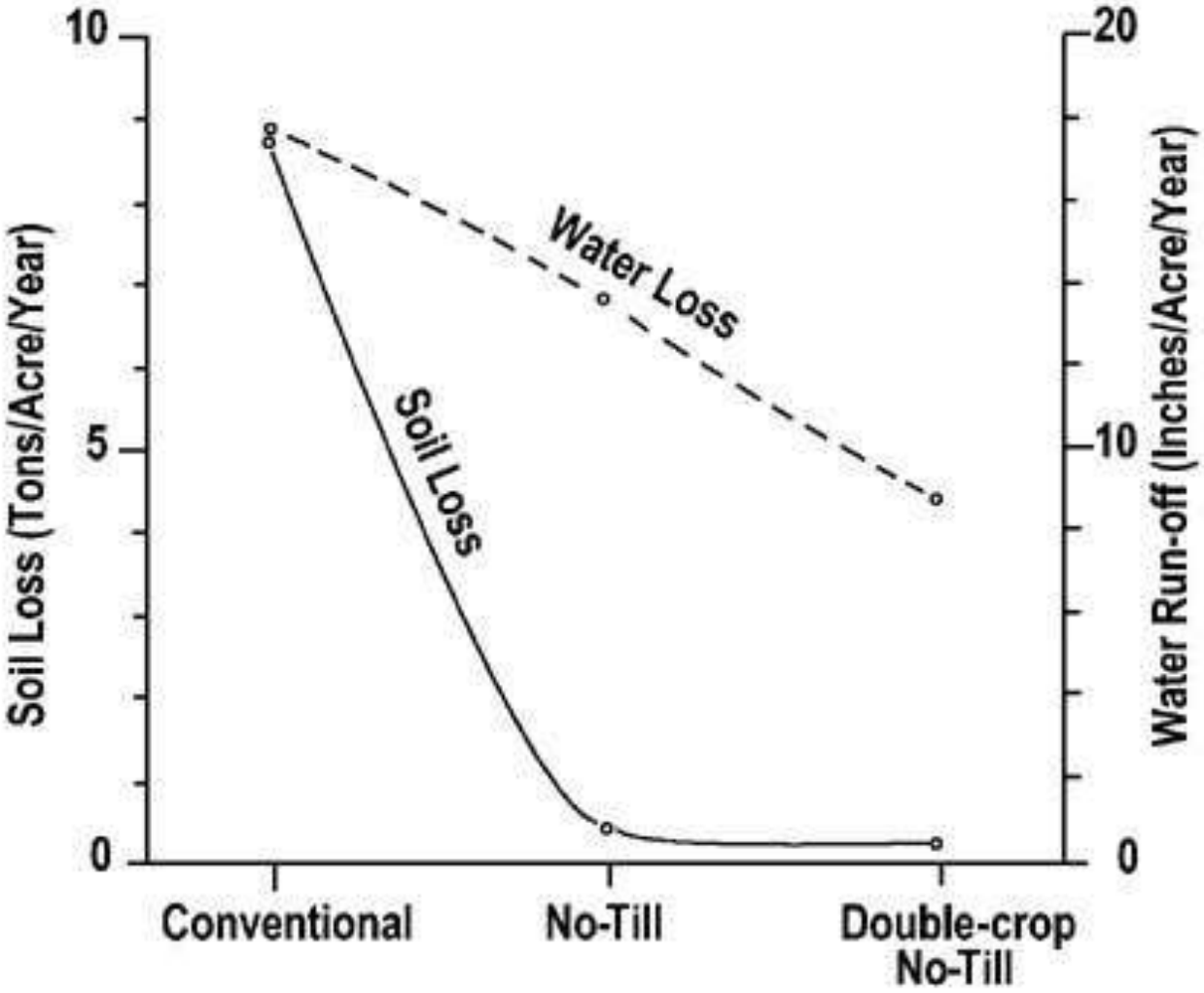


David Lamm, “Soil Health Farming in the 21st Century: a practical approach to improve Soil Health Planning Principles”

Reduced Tillage and Infiltration

- No-, zone-, strip-, ridge-till, etc.
- Less macro-fauna disturbance (i.e., earthworms)

(Dan Brainard, msue.anr.msu.edu)



(Source: Herbek, AGR-101; www2.ca.uky.edu)

Organic Matter and Infiltration

Cum. Infiltration (m^3/m^2)

0.12
0.10
0.08
0.06
0.04
0.02
0.00

0 30 60 90 120 150 180 210 240 270 300

Minutes

High O.M.

Low O.M.

(Colla et al., 2000)

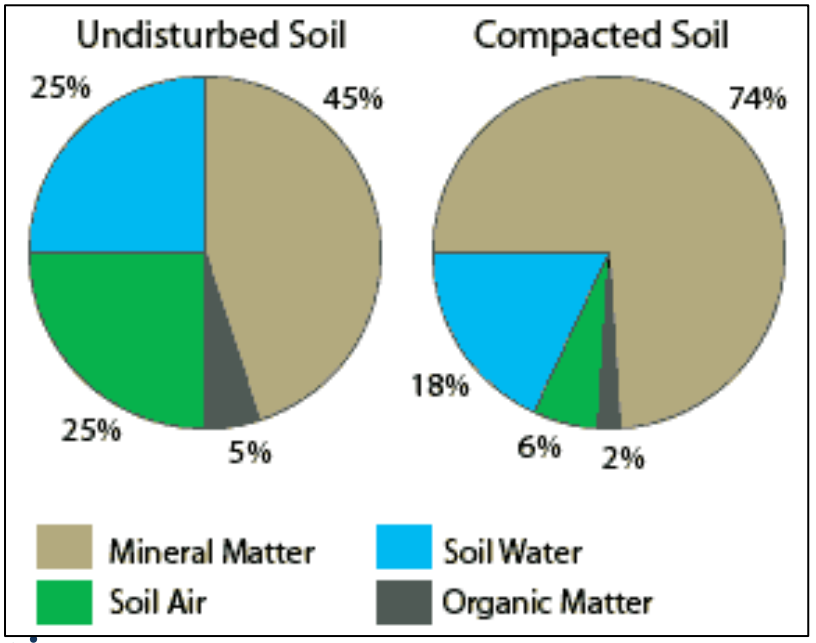
Nutrient Management Impacts

Climate Stressor	Nutrient Management Vulnerability and Response
Increasing temperatures	• Increased volatilization of N, leading to increased need for incorporation • More rapid nitrification, leading to increased leaching and need to manage
Drought	• Reduced nutrient use efficiency, leading to residual P and N in soil in winter
Extreme rainfall events	• Increased runoff and nutrient/sediment transport • Manure storage structures potential overflow • Stressing of all BMPs linked to water cycle

Adapted from: Delaware Climate Change Impact Assessment: Ch. 7, Agriculture. 2014

Drought Resilience

- Crops can't use water that doesn't infiltrate
- Organic matter
  - For every 1% increase in OM, another inch of water available (Emerson, 1995)
- **Avoiding compaction**
  - Deep moisture
  - Increased storage
  - Increased conductivity
- **Role for moisture sensors**
  - Drought and compaction prevention



(Courtesy USDA-NRCS)

Extreme precipitation- Infrastructure adaptation: use of woodchips in heavy use area

Rainwater harvesting/catchment with storage

Cistern and gutters used to capture high tunnel roof runoff

Extreme Heat and Humidity Adaptation:

soakers, fans, high roof, shade in pastures, different breeds

Mitigation: Reduce emissions, use less fossil fuels.

Use of biomass heaters for greenhouses.

New Initiatives

- Cornell Institute for Climate Change & Agriculture (CICCA)
  - Goal is to build capacity to grow and strengthen agriculture in the face of a changing climate.

- USDA Climate Change Hubs
  - Climate change requires "*All hands on deck*"
    - ARS, NRCS, FS, Land Grants, Cooperative Extension, stakeholders and more
  - Coordination and partnerships across US

CICCA
Cornell Institute for Climate Change & Agriculture

Rapidly selecting more resilient crops

- High-Throughput Phenotyping (observable characteristics)
  - Canopy height, reflectance, temperature, starch content, photosynthetic activity… simultaneously
  - Identify drought/heat tolerance

Pick me!

And impact of climate change on nutritional quality of crops.

Funded in part by USDA NIFA Capacity Funds and NSF

CSF
Climate Smart Farming

http://climatesmartfarming.org/tool/

newa.cornell.edu/index.php?page=all-weather-data

Search

New York State Integrated Pest Management Program

NEWA Network for Environment and Weather Applications

Enter Search... Search

Weather Data | Pest Forecasts | Station Pages | Crop Management | Crop Pages | About Weather Stations

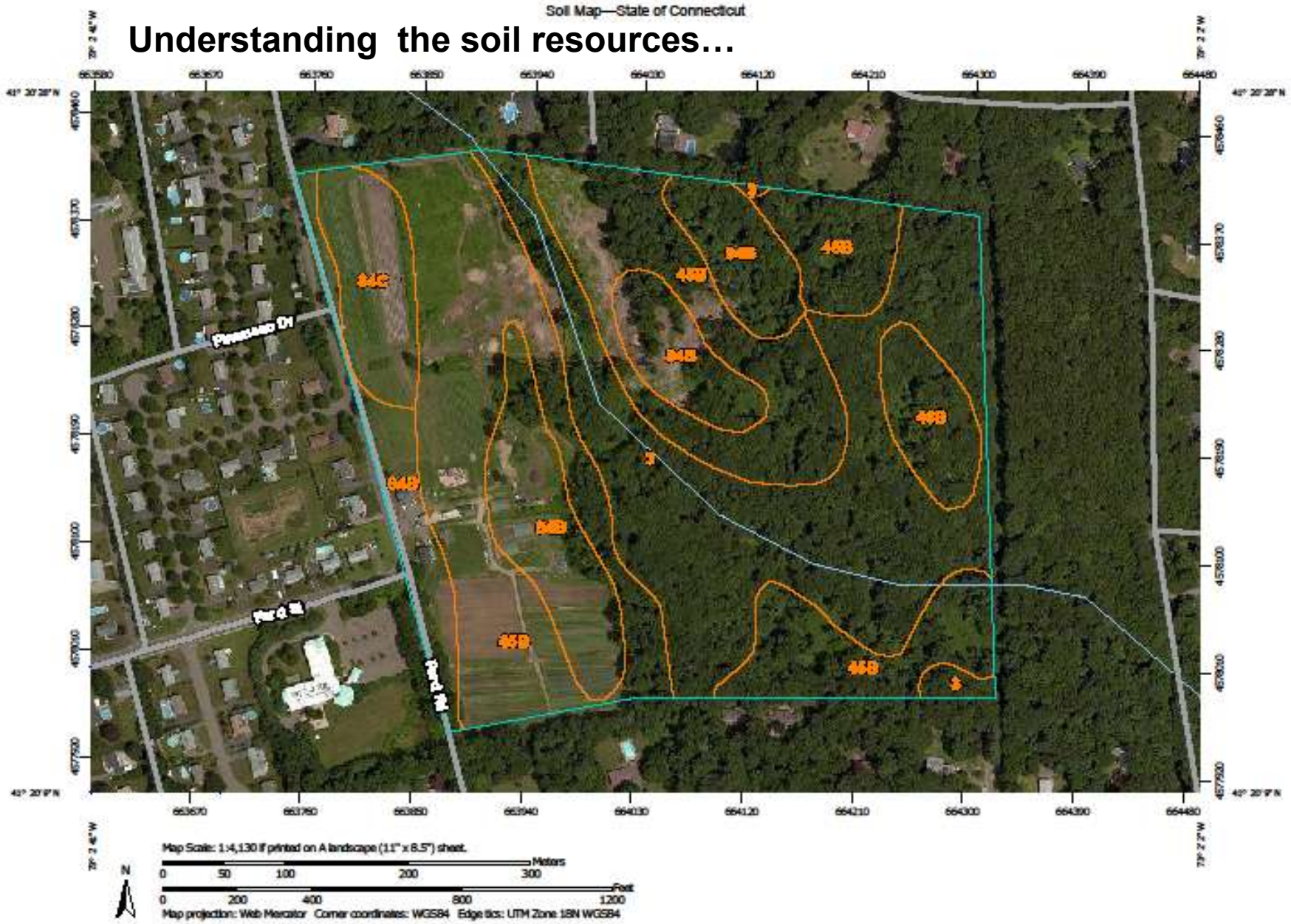
All Weather Data

S. Glastonbury - Daily Data Summary

Date	Avg Air Temp (°F)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Soil Temp (°F)	Total Precip (inches)	Leaf Wetness Hours	RH Hrs ≥ 90%	Avg Wind Spd (mph)	Solar Rad (langleys)	Avg Soil Tension (kPa)
04/01/2018	44.5	54.4	34.7	46.9	0.00	2	0	5.0	284	191.8
04/02/2018	33.3	40.3	28.5	34.3	0.34	5	7	2.0	279	133.1
04/03/2018	35.2	39.1	29.1	36.5	0.53	12	17	1.8	137	91.6
04/04/2018	44.8	54.5	36.5	43.0	0.13	17	16	4.7	67	124.4
04/05/2018	33.9	41.0	27.4	39.1	0.00	0	0	6.2	445	198.7
04/06/2018	35.0	47.4	23.1	36.3	0.15	11	7	1.7	179	134.2
04/07/2018	37.9	44.8	31.6	46.4	0.00	4	5	4.8	417	63.7
04/08/2018	33.2	42.1	26.6	41.1	0.00	0	0	5.8	417	143.5
04/09/2018	28.2i	33.7i	24.4i	31.0i	0.00i	0i	0i	3.6i	129i	199.9i
Monthly summary	36.2	54.5	23.1	39.4	1.15	51	52	4.0	2354	142.3

Examples from Massaro Community Farm Woodbridge, CT

Understanding the soil resources…



Adaptation

High tunnel location

- **Allows snow removal between tunnels**
- **Allows rotation, reduces pests/disease**
- **Placed on well drained soils reduces wet soil issues early/late season**

Adaptation/Mitigation

Micro-irrigation

- **Drought protection**
- **Frost protection**
- **Reduces some disease/pests**
- **Prevents erosion**
- **Can reduce fertilizer use**
- **Uses less water**

Adaptation

Raised beds, cross slope

- **Prevent waterlogged plants**
- **Prevent erosion**
- **Captures moisture**
- **Soil warms faster**
- **Can be covered with plastic/mulches**

Adaptation

Pollinator and other beneficial insect habitat

- **Alternative pollinators**
- **Host plants for beneficial organisms**

Adaptation

Crops in high tunnels, greenhouses

- **Extend growing season**
- **Allows alternative crops**
- **Reduced pests/disease**
- **Protects from extreme weather**
- **Efficient water use**

Mitigation/Adaptation

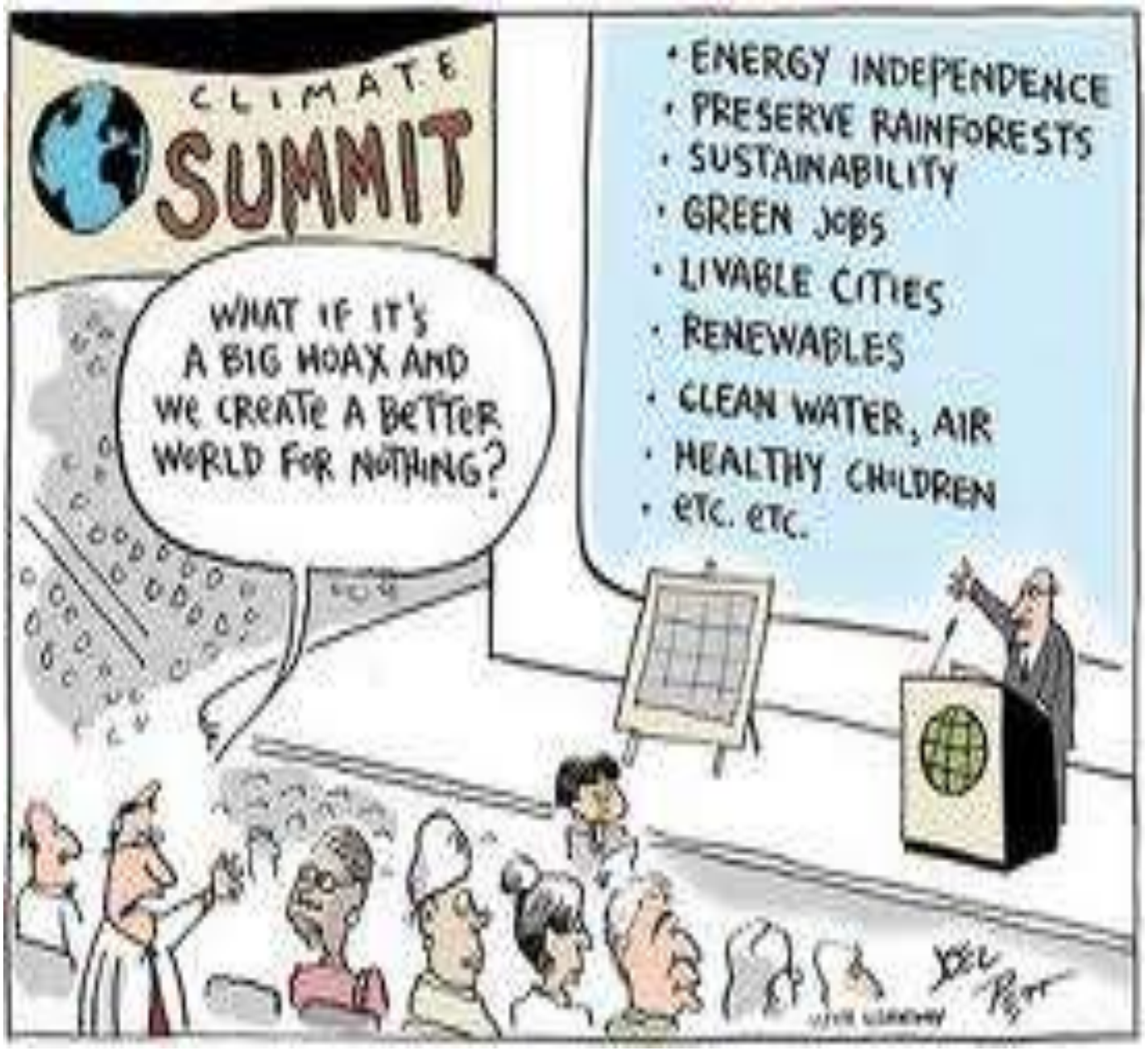
Green manure & cover crops

- **Organic Production**
- **Stores carbon**
- **Increase available water**
- **Prevent erosion**
- **Controls**
- **weeds/disease**

Mitigation

Solar Panels

Reduces fossil fuel use


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.

In 2050, what will they say about us?

Did we try?

What will you do (or are doing) to mitigate and adapt to climate change?

- At home?
- At your school?
- In your community?
- Politically?
- Your consumer choices?
- In your yard?

10 minute sharing exercise with a partner….

Adaptation/Mitigation Strategies for Consumers

- Reduce food waste, recycle/compost
- Reduce water use, capture runoff

- Buy less processed and packaged food

- Eat seasonally, and be flexible and prepared for the variability

- Eat locally/ regionally and ask for it from our institutions and businesses

- Consume less meat

- Support agriculture/local food friendly regulations

- Support better land use/ water resource planning, and planning that considers agriculture as a long term sustainable land use
- Invest in renewable energy sources and conservation

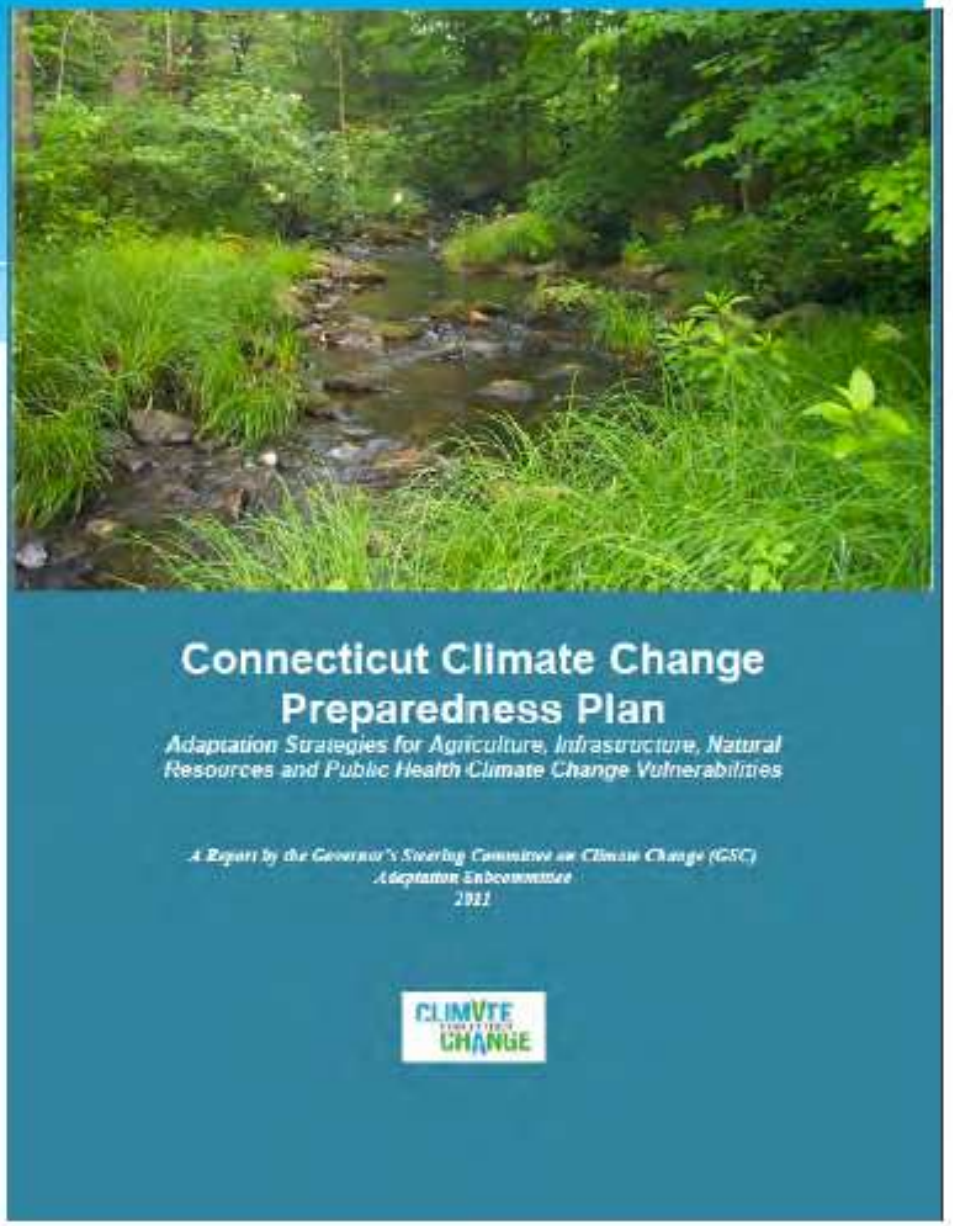
Big Picture Adaptation/Mitigation Strategies

- Inform and educate population about the impacts of climate change
- Better Land Use, Water Resources and Transportation Planning
- Use of a systems approach to planning
- Create policies/programs of incentives /disincentives to further protection, conservation, reuse, and recycling
- Protect prime farmland, wetlands, floodplains, riparian areas, recharge areas, coastal zones from development
- Protect, adapt, or retreat human communities/infrastructure from areas susceptible to impacts of climate change
- Diversification of agriculture, food system, transportation, etc.
- Protect critical habitats and landscapes that help species adapt
- Support funding for Research, Extension and Technical Assistance
- Use Best Practices and develop new and improved technology/techniques
- Improved Financial, Risk Management, and Emergency assistance tools
- Build more diverse regional and local economies and systems
- Invest in renewable energy sources and conservation
- Reduce emissions and store carbon
- Better/additional weather and climate information and modeling

The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health 2010

Agriculture
Infrastructure
Natural Resources
Public Health

www.**ct**.gov/**deep/climatechange**



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