

Thank you for joining us.
This webinar is scheduled for
November 27th 2018 1:00pm – 2:00pm eastern

Impacts and Opportunities of Climate Change on Northeast Crops and Livestock

Today's Presenters:

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Challenges and Opportunities for NE Crop Production in a Changing Climate

David Wolfe (dww5@cornell.edu)

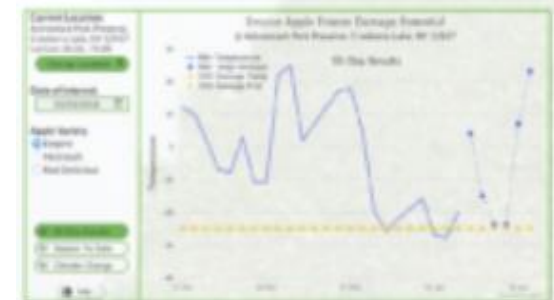
Cornell University, Ithaca, NY

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CSF Apple Stage / Freeze
Damage Probability



Charts observed/forecasted daily minimum temperatures vs. apple hardiness thresholds in order to assess potential risk for freeze damage.

Climate Change and NE Ag

Challenges

- Increased frequency of temperatures exceeding thresholds for damage
- Increased risk of both drought and flooding, and difficult to predict
- Climate change is more complicated than just “warming”. Water challenges can offset longer frost-free period
- Increased and changing pest, disease, weed pressure

Opportunities

- New heat stress challenges less severe than some competing regions
- Relative to other regions- we have water!
- Longer frost-free period allows exploring higher yielding crop varieties; double-cropping

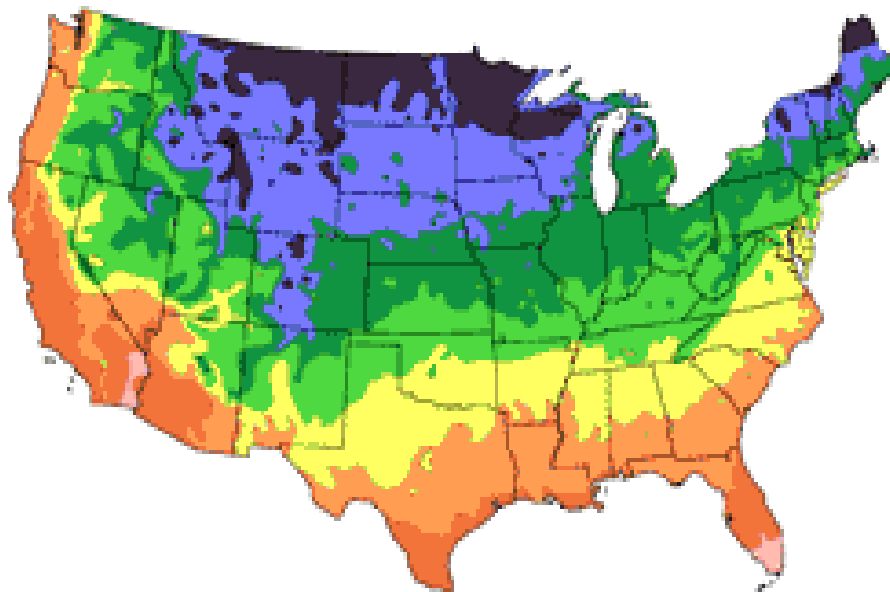
The New “Plant Hardiness Zone Map”: an ecological perspective on recent change

Climate envelopes affecting biosphere are shifting (maps based on minimum winter temperatures; prior 15 years of NOAA records)

Source: www.arborday.org

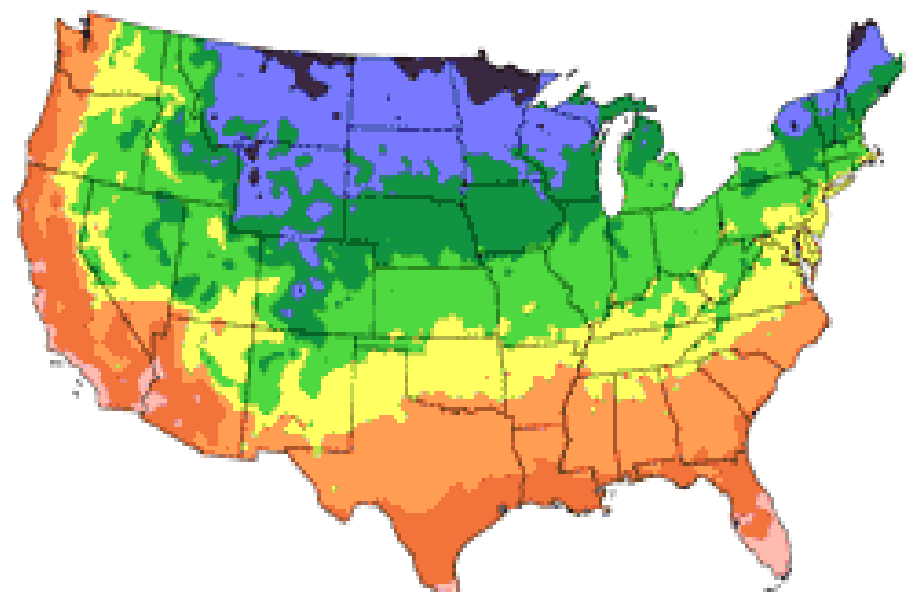
Zone	Avg. Annual Low
2	-40° through -50°
3	-30° through -40°
4	-20° through -30°
5	-10° through -20°
6	0° through -10°
7	10° through 0°
8	20° through 10°
9	30° through 20°
10	40° through 30°

1990 Map



After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued January 1990.

2006 Map



National Arbor Day Foundation Plant Hardiness Zone Map published in 2006.

Longer frost-free period, warmer winters: Shifts in range and more intense pest pressure

Better insect overwinter survival in temperate regions; more generations per season; northward range expansion

Many invasive weeds benefit



Flea beetle



Corn earworm



Kudzu

Climate change trends are complex:

**A longer frost-free period
does not mean a longer growing season
if rains restrict field access when you need to:**

Plant



Side-dress



Harvest



Expect the unexpected:

More frost and freeze damage in a warmer winter world?



Apple blossoms under snow

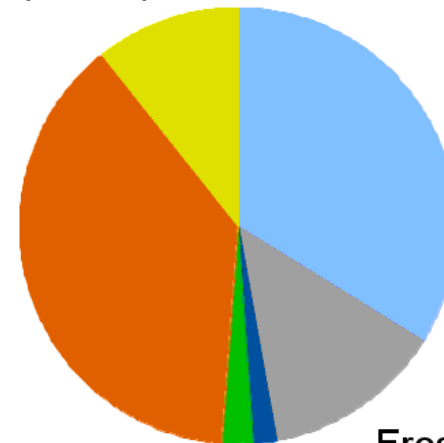
Recent causes of weather-related crop losses in the Northeast

Causes of Loss, FSA Noninsured Crop Disaster Assistance Program Acres (Northeast U.S., 2013-2016)



Heat (10.7%)

Drought (38.1%)



Excess Moisture (33.8%)



Frost/Freeze (13.4%)

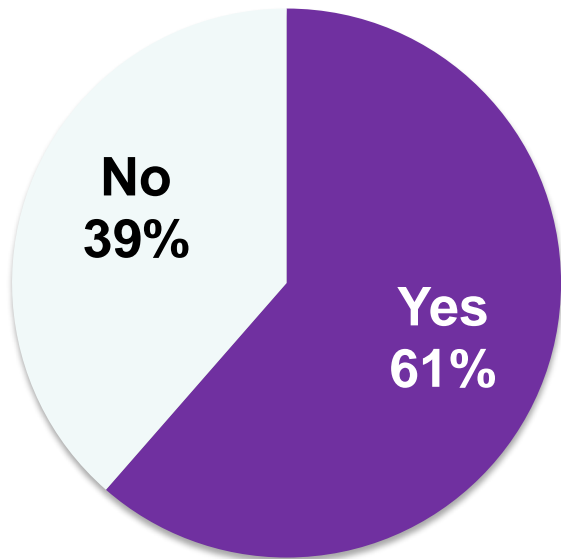
Other (2.3%) Hail (1.7%)



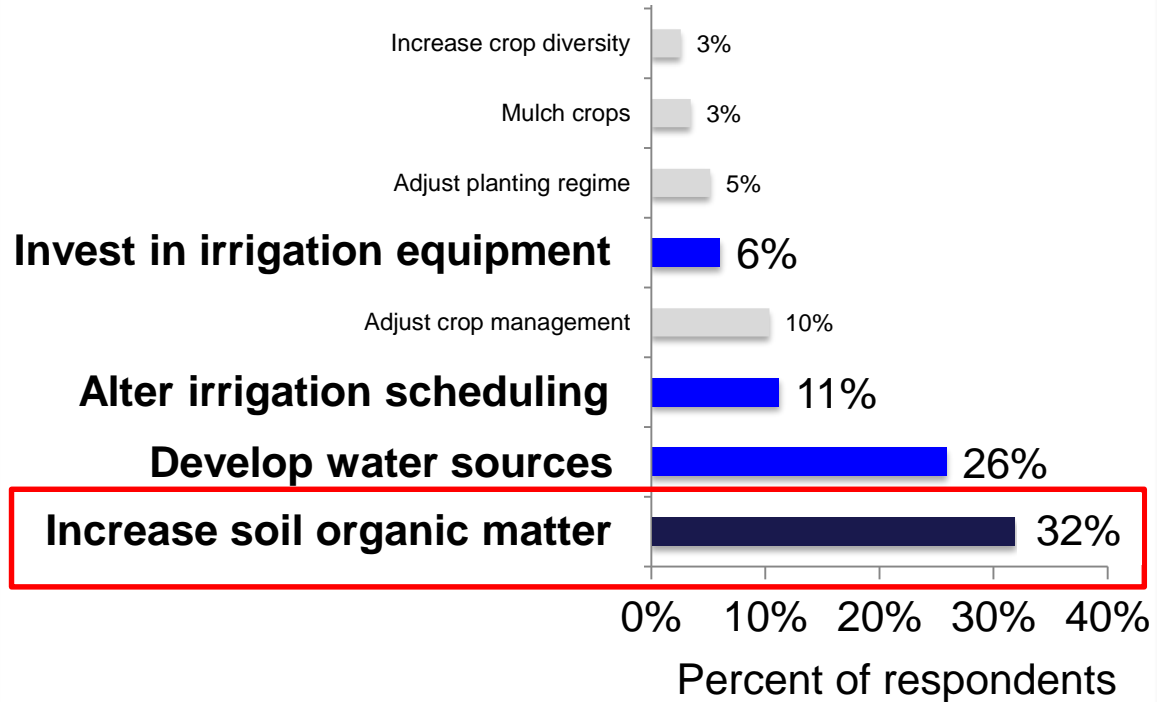
Farmer Survey (n=183) Regarding 2016 NY Drought

Farmer Strategies to Build Resilience

Did what you experienced in 2016 changed your perspective on future drought?



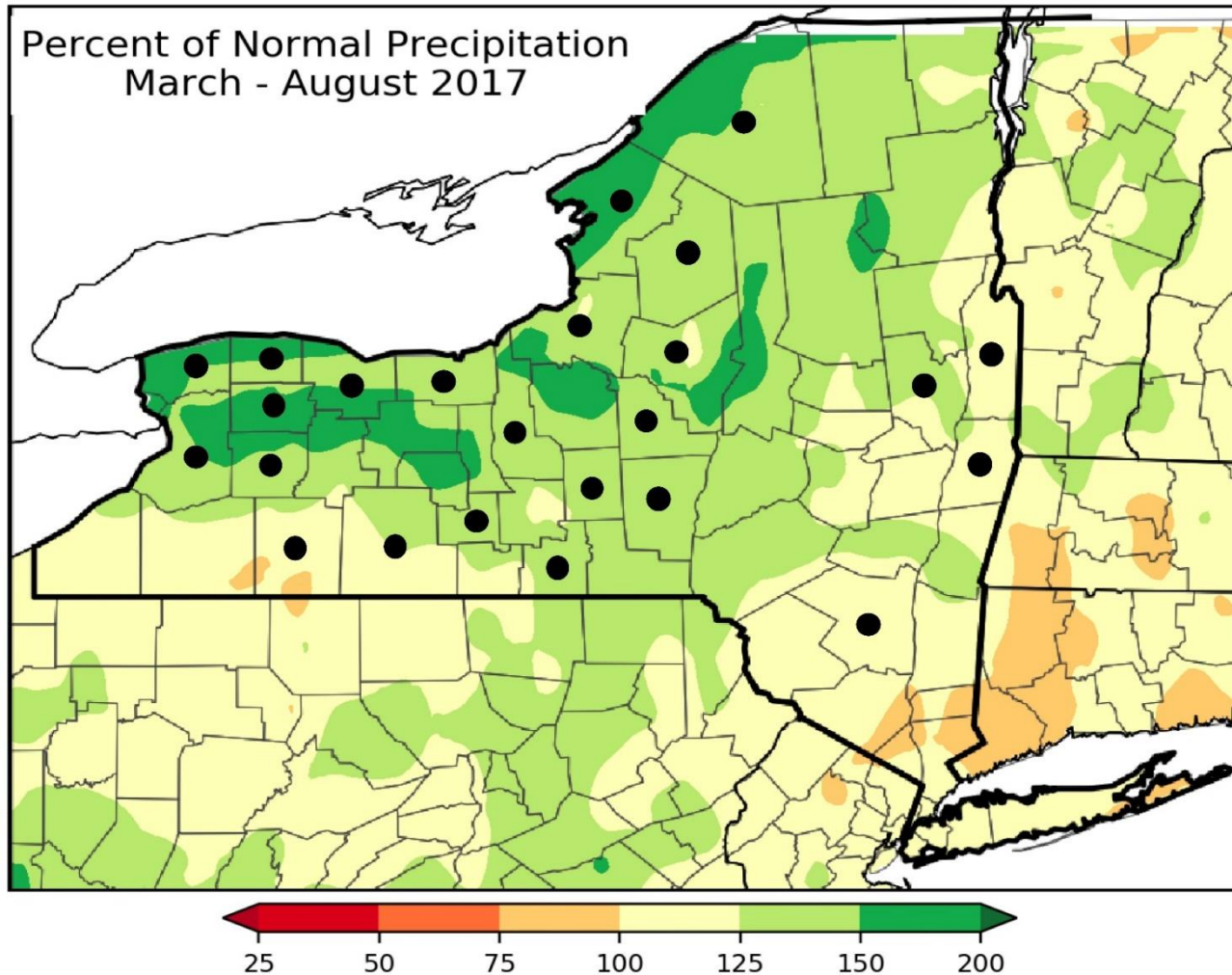
Are you planning to do anything different after experiencing the 2016 drought?



And then flooding in WNY in 2017!

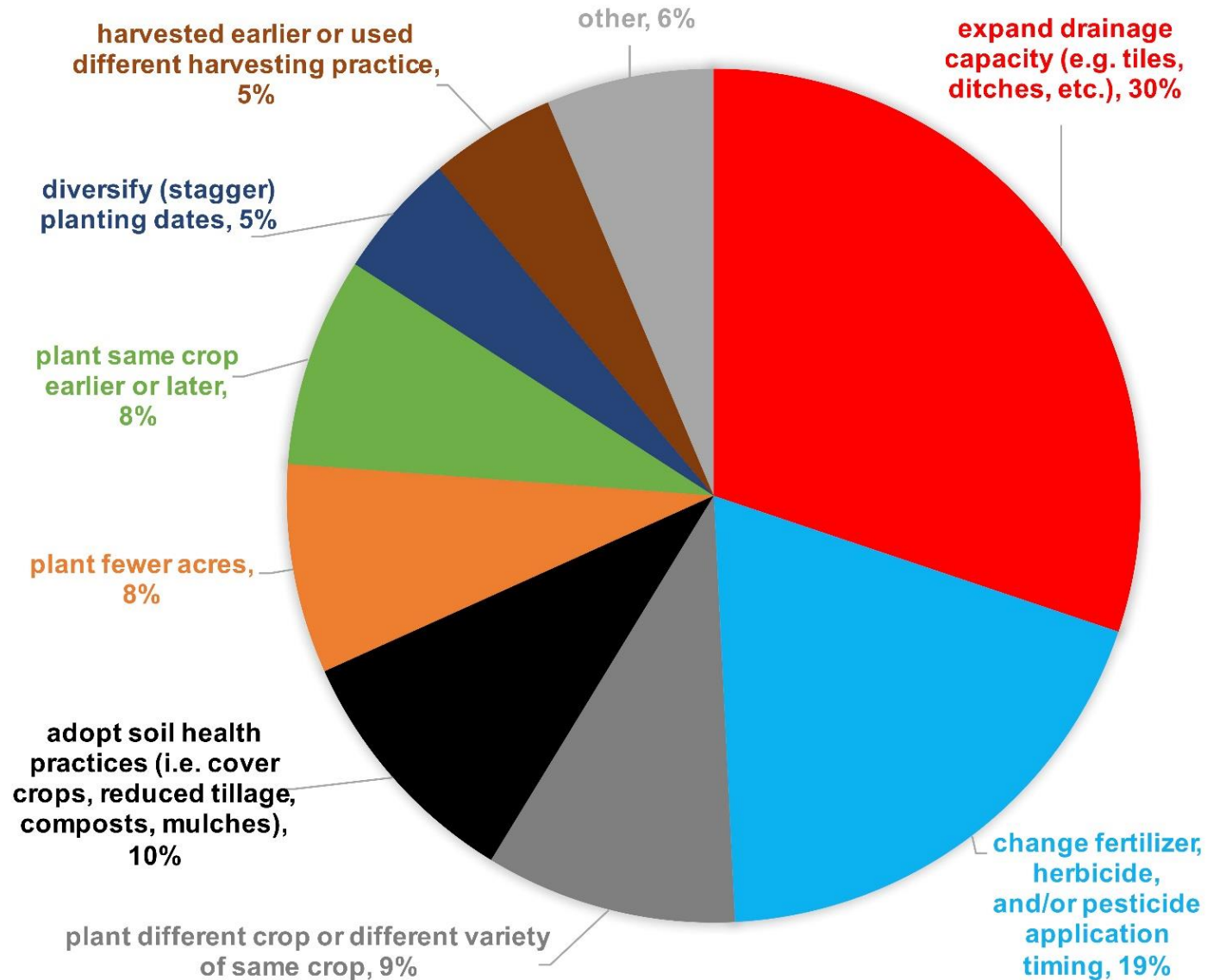
Impacts and Farmer Response

Dots =
counties
where
farmers
responded
to heavy
rainfall/
flooding
survey
(n=45)



S Sweet and D. Wolfe. 2018. Anatomy of a wet year: Insights from New York farmers. Cornell Inst for Climate Smart Solutions. Issue 4, March 2018 (www.climatechange.cornell.edu)

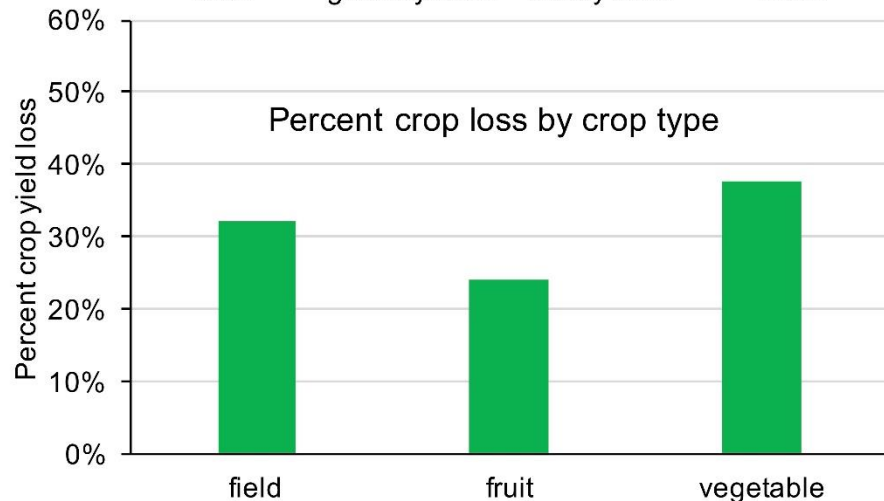
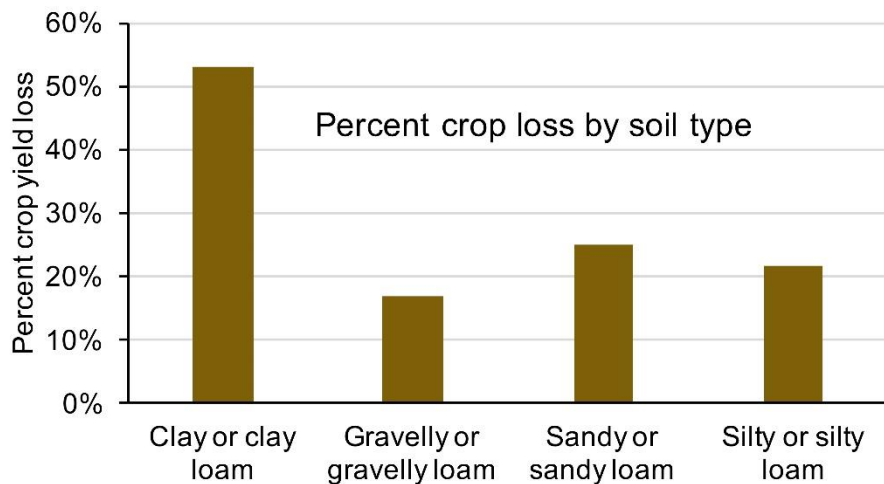
What would you have done differently if you had known how wet this summer would be?



And then flooding in WNY in 2017!

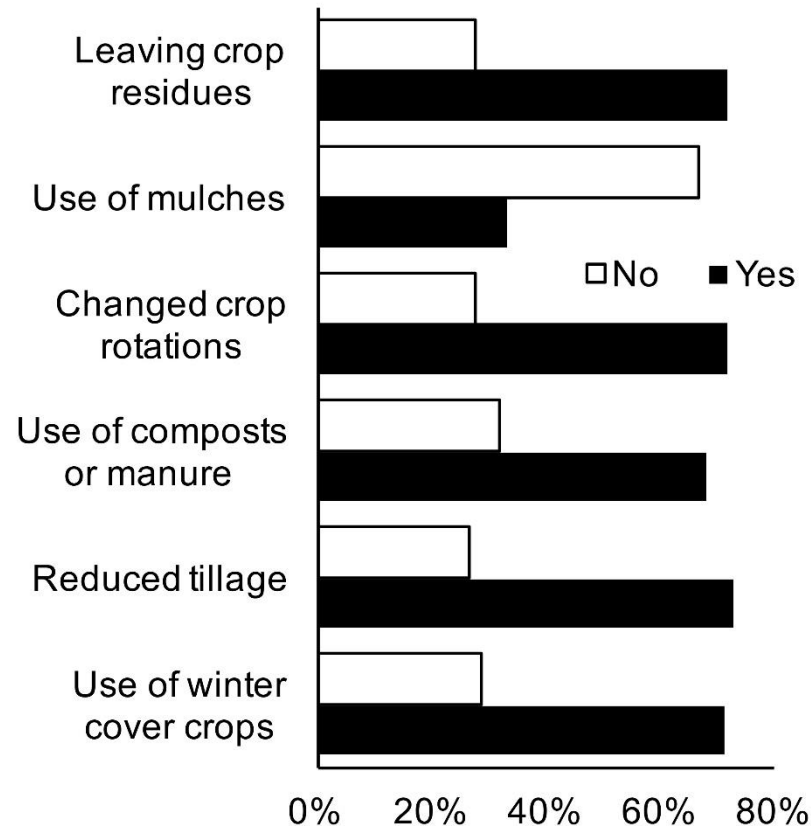
Impacts and Farmer Response

Factors contributing to flooding losses: crop disease, lack of field access, erosion



Soil Management and Flooding Resilience

Did any soil health practices you have adopted on your farm lessen the impact of heavy rainfalls in 2017?



Farmers and Climate Change

A group of farmers, mostly men wearing hats and casual work clothes, are gathered in a field of young green plants. One man in a purple shirt is speaking to the group. The background shows a line of trees under a clear sky.

All farmers are concerned about extreme weather events and uncertainty about the weather.

Many farmers are concerned that extreme weather is becoming more frequent and less predictable

Many farmers have recognized they cannot rely on historical weather patterns for making farm management decisions

Recent polls indicate the majority of farmers accept that the climate is changing (e.g., Arbuckle et al. 2013. *Climatic Change* 118:551-563)

Soil Health Management: Low-Cost Climate Change Resilience While Reducing the Carbon Footprint of Agriculture:



Building soil organic matter (reducing tillage, using cover crops, manure and composts):

- Adaptation: increases resilience to drought and flooding
- Mitigation: stores carbon in the soil that otherwise would be in the air as CO₂

Farm-level adjustments (“adaptation”) to build resilience to climate change

Crop, Soil, and Water Management

- **Diversify** cropping systems at farm and regional scales
- **New varieties** (breeding and biotechnology)
- **Integrated Pest Management (IPM) 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 fans)
- **Larger scale farm equipment** to cover more acreage faster, to cope with shrinking windows for field access

Farmers will require new weather and 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?



Financial Barriers; Equity Issues

Will small family farms have the capital and strategic information to adapt?



Agriculture Adaptation Beyond the Farm

A role for universities, government agencies,
NGOs, communities

- **Financial assistance for adaptation** investments
- **New decision tools** to explore costs, risks, benefits, and strategic timing of adaptation
- **Improved weather and seasonal climate forecasts**
- **Plant breeding and biotechnology**
- **Enhanced pest monitoring** and regional data sharing
- **Disaster risk management** and better **crop insurance** programs
- **Land use and climate change policies** that integrate economic, environmental and equity issues
- **Community planning for “bad” years**, threats to food security

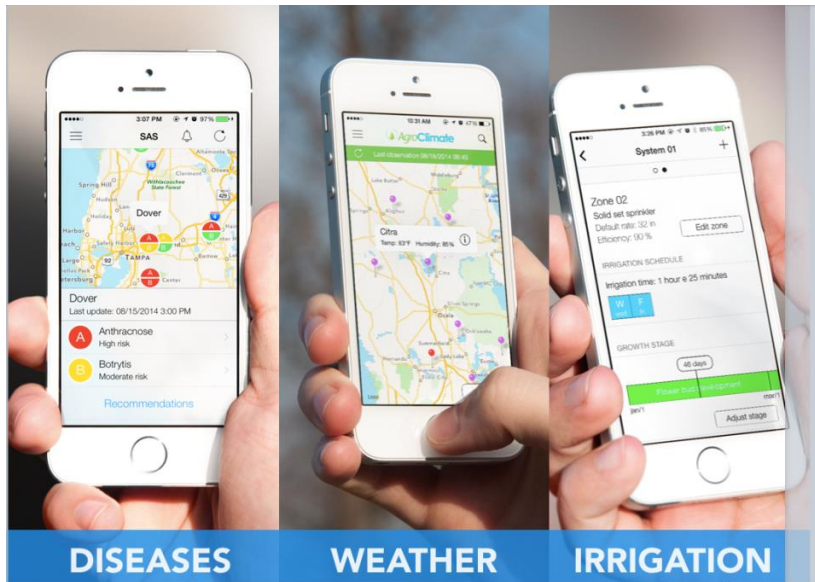
New decision tools, field sensor technology, data analytics can assist farmer adaptation



Temperature



Leaf wetness



DISEASES

WEATHER

IRRIGATION

Plant Breeding and Biotechnology: crucial, but not a “silver bullet”

- Given unpredictable nature of climate change, difficult to identify an optimum crop trait for any region
- Stress tolerant varieties often have low yield in optimum years
- Stress tolerance is often complex and multi-genic
- Unique suites of genes are required depending on timing of stress (e.g. at germination vs. at pollination)
- Need more research investment in high-value fruit and vegetable crops important to the NE economy
- For some farmers:
 - Concerns about corporate control and/or access to seed and other products of biotechnology
 - Concerns about consumer and trade partner acceptance of “GMO” crops

Farming Success in a Changing Climate: Being Prepared Makes Good Business Sense

- **Taking advantage of changing market opportunities**
- **Strategic decisions such as:**
 - **Diversifying crops, varieties, planting dates, etc.**
 - **Capital investments such as new drainage or irrigation systems**
- **Anticipating new weed, disease, insect pests**
- **Avoiding unintended consequences, such as:**
 - **Increased chemical loads to waterways**
 - **Undesirable land use change and degradation**
- **Promoting policies that support farmer needs for adaptation and mitigation**
- **Increasing profits by better energy and greenhouse gas management; knowledge of energy policy incentive programs**
- **Protecting national interests: ag economy, food prices, food security**



Climate change effects on livestock in the Northeast US and strategies for adaptation

A. N. Hristov, A. T. Degaetano, C. A. Rotz, E. Hoberg, R. H. Skinner, T. Felix, H. Li, P. H. Patterson, G. Roth, M. Hall, T. L. Ott, L. H. Baumgard, W. Staniar, R. M. Hulet, C. J. Dell, A. F. Brito, D. Y. Hollinger

NE states included in the analysis

CONNECTICUT
DELAWARE
MAINE
MARYLAND
MASSACHUSETTS
NEW HAMPSHIRE
NEW JERSEY
NEW YORK
PENNSYLVANIA
RHODE ISLAND
VERMONT
WEST VIRGINIA

CONN: CONNECTICUT
MASS: MASSACHUSETTS
NH: NEW HAMPSHIRE
RI: RHODE ISLAND
VT: VERMONT



Structure of the livestock industries in the NE US

- **Dairy** is the main livestock industry. Total milk and dairy product sales in the region exceeded \$7.5 billion in 2014
 - Sales of dairy products represented **32% of all farm receipts**
- **Poultry production** in the NE includes broiler chicken, egg, and turkey operations, providing \$4.50 billion in cash receipts in 2015
 - Poultry and egg production in the region represents 9.4% of the total value produced in the USA
- **Beef animals** in the NE represent 3.7% of the national cattle inventory
 - 2% of the national cattle and calf farm receipts, at \$1.69 billion in 2014
- The NE **equine industry** is an important segment of animal agriculture; the total value of horses in the NE is between \$1.4 and \$4.3 billion
 - The GDP impact of the region's horse industry is estimated at \$7.5 billion, which is about 7.4% of the national impact of \$101 billion in 2005
- **Sheep, goats, and pigs** are additional livestock sectors in the NE
 - The swine industry had a \$362.5 million production value in the NE in 2013



The NE dairy industry



- The dairy cow population in the NE is about **1.4 million with 80% on PA and NY dairies**
- Current NE **milk production is 13.8 billion kg/year, or 14.6% of the U.S. total**
 - About **20% of the organic milk produced in the U.S. comes from the NE**
- Farm size varied with **1.5% of herds having less than 30 cows, 26% at 500 or more and a median herd size of about 200 cows**



Poultry industry in the NE

- Poultry operations in the NE are CAFO with **environmentally-controlled housing systems**
 - Broiler farms with 100,000 birds or more in annual sales contribute about **98.6% of total broiler production** and represent 30% of broiler farms in the NE
 - There are 235 medium and large layer farms with 20,000 layers or more representing less than 1% of layer operations in the NE, but **producing 84% of the layer inventory**
- **Main broiler producing states** MD, DE, PA, and WV
- **Pennsylvania accounts for 64% of the layer inventory and 86% of the total egg production in the NE**
- **Pennsylvania and WV account for 96% of all turkey production**



Summary of climate trends in the NE



- **More extremely warm nights** (minimum temperature $>21^{\circ}\text{C}$)
- **Fewer extremely cold and cold nights** ($<-18^{\circ}\text{C}$ and $<0^{\circ}\text{C}$)
- **Warmer average winter and summer temperatures**
- **More days with heavy rain** (generally >5.0 to 7.6 cm events)
- **Higher annual precipitation**

Climate change effects on forage production



Table S2. Potential changes in forage crop productivity and quality associated with climate change. Projected changes will have both positive and negative effects

Change in climate	Change in forage productivity	Change in forage quality
Elevated air temperature	<p>Perennial cool-season forages will begin growth earlier in the spring and go dormant later in the fall</p> <p>Increase productivity of annual and perennial forages with longer growing season</p> <p>Favorable for warm-season forage species because of longer growing season and greater photosynthetic efficiency at temperatures > 29°C</p> <p>“Summer slump” associated with cool-season forages will be more pronounced</p>	<p>Reduced digestibility associated with increased lignin deposition in plant cell wall and lower leaf:stem ratios</p> <p>Decrease in crude protein content of forage</p>
Decreased winter soil temperature (due to less snow cover)	<p>Increased winter damage to sensitive perennial forage species. Result in possible species shift or stand loss, especially in northern areas of the region, and reduced production</p>	

Climate change effects on forage production



Table S2. Potential changes in forage crop productivity and quality associated with climate change. Projected changes will have both positive and negative effects

Change in climate	Change in forage productivity	Change in forage quality
Less frequent but more intense precipitation	<p>Warm-season forage and weed species have competitive advantage over cool-season species during long periods with limited soil moisture</p> <p>Cool-season forages have competitive advantage during wet and cool periods</p> <p>Increased challenge to successful forage establishment and early access of grazing animals to wet fields</p>	<p>Warm-season weed encroachment reduces forage quality</p> <p>Reduced quality associated with “rained on” forage while drying</p> <p>Postponed harvest may decrease forage quality</p>
Elevated CO ₂	<p>Increased productivity of cool-season (+30%) and warm-season (+10%) forage species</p>	<p>Elevated plant nonstructural carbohydrates, decrease in crude protein content, but no effect on forage digestibility</p>



Forage production summary

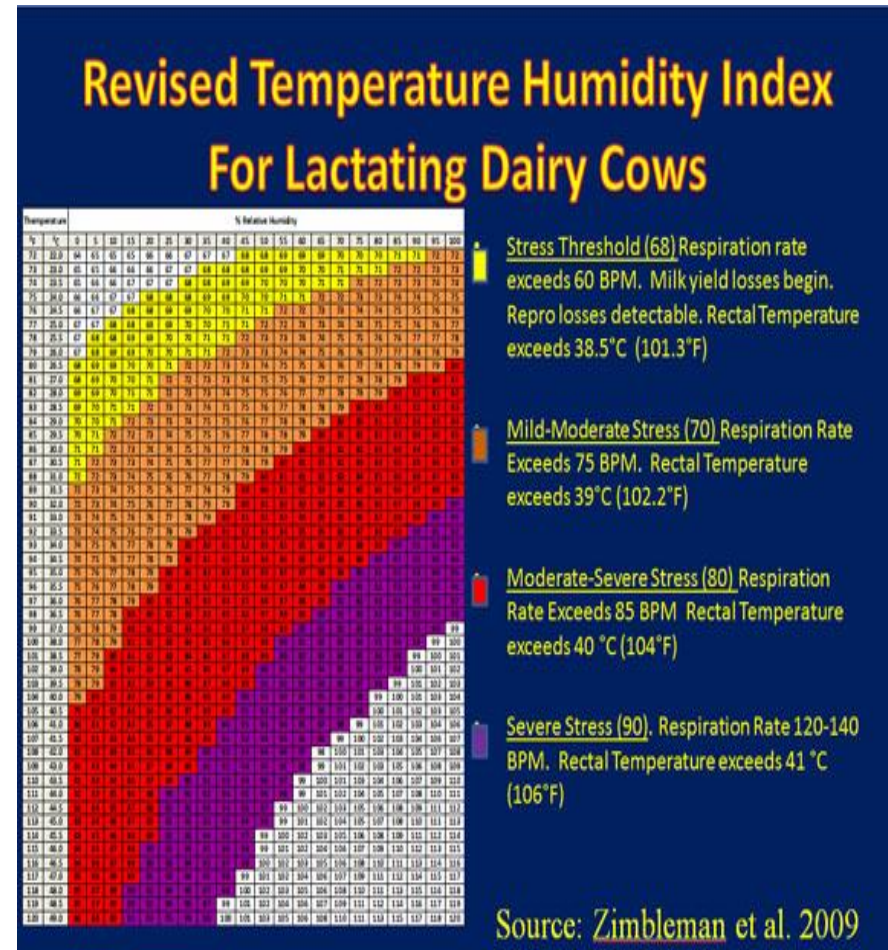


- Reduced snow cover could increase exposure to extremely cold temperatures by reducing the insulating effect of snow
- Impacts of climate change on the predominant annual forages such as whole-crop corn and small grains should generally be positive
- Forage yields of small grain crops should increase due to elevated atmospheric CO₂ levels and air temperatures
- A trend toward warmer temperatures may allow better success with no-till and cover crop establishment in northern portions of the region



Climate change effects on livestock

- Animals have a **Thermo-Neutral Zone (TNZ)**
 - as an example, for dairy/beef cattle TNZ is between **5 and 25°C**
- **Below the TNZ**, animals will require extra energy to maintain body functions and have to increase feed intake
- **Above the TNZ**, animals are under heat stress of various severity
 - **A major effect of heat stress is decreased DMI**



The main effect of climate change in the dairy industry will be through decreased DMI

- **DMI loss estimation:**

- $DMI_{Loss} = 0.0345 \times (THI_{max} - THI_{threshold})^2 \times D$

- **THI_{max}:**

- $THI_{max} = 0.8 \times \text{maximum ambient temperature in } ^\circ\text{C} + [(\text{minimum humidity} \div 100) \times (\text{maximum ambient temperature in } ^\circ\text{C} - 14.3)] + 46.4$

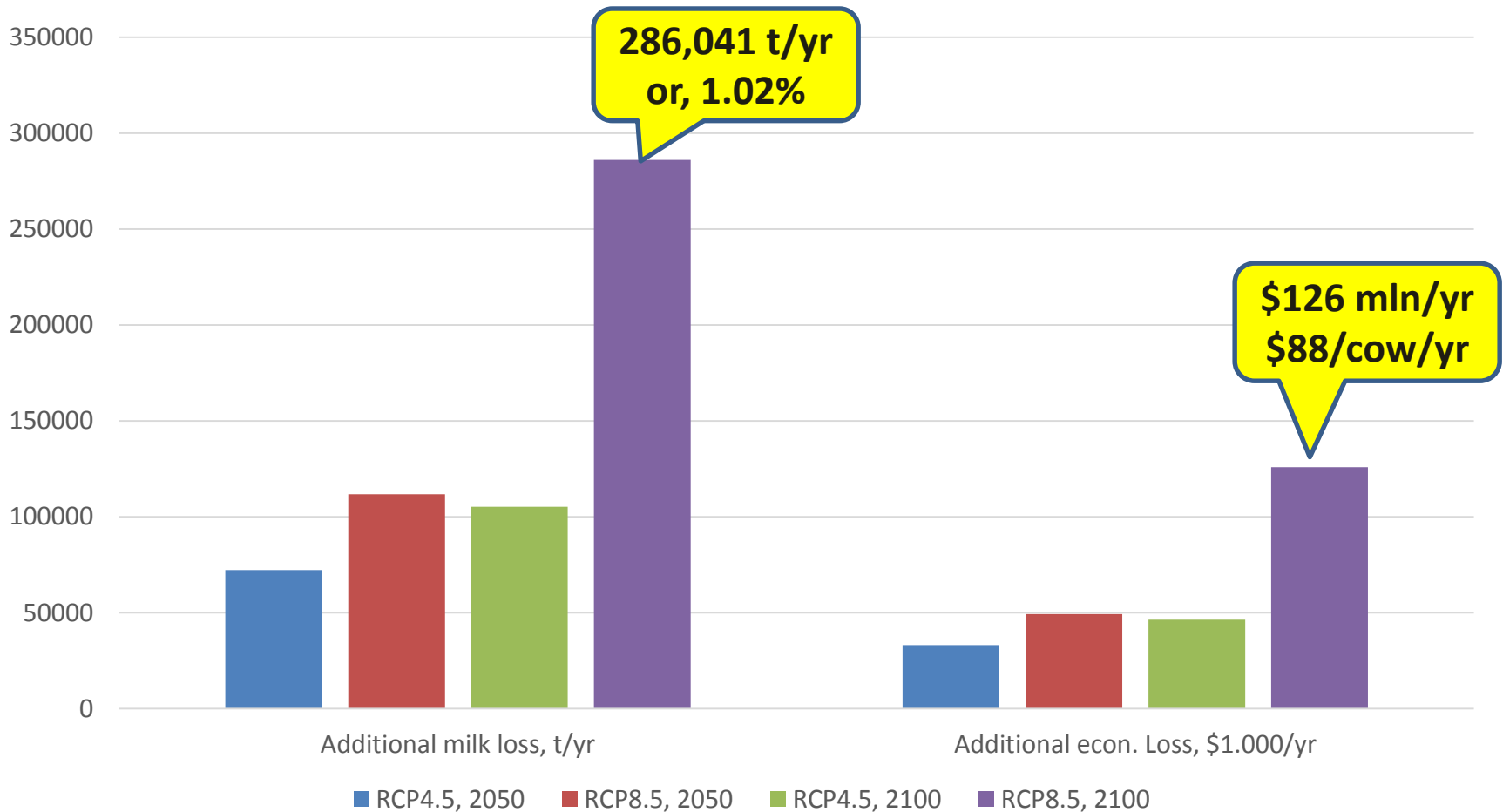


Other potential effects of heat stress in dairy cattle

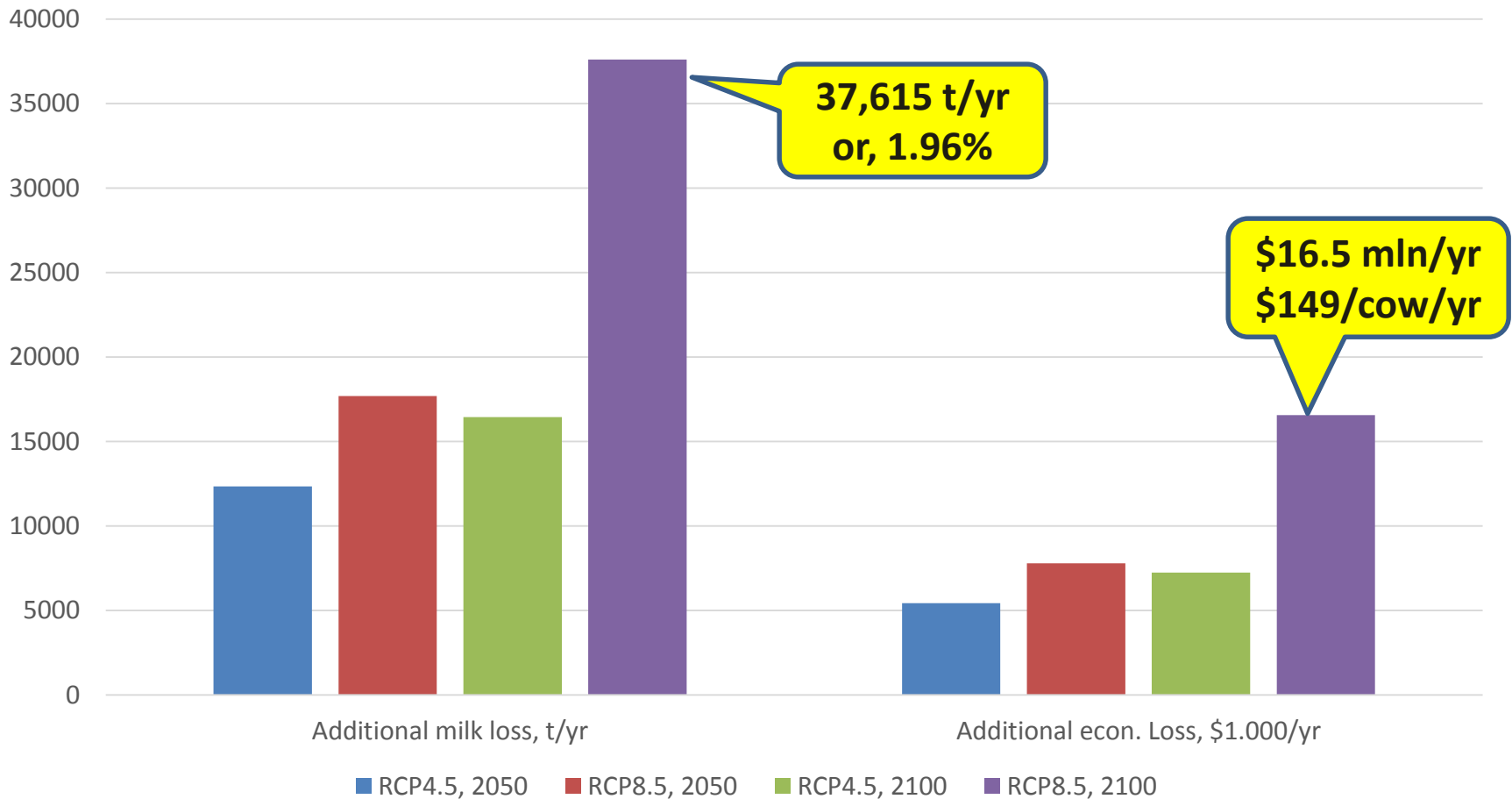


- Studies have shown **decreased milk protein yield**
- **Increased mortality, increased incidences of diseases, decreased reproductive performance,** and decreased heifer feed intake and daily gain
 - Heat stress reduces fertility by affecting the ovaries, uterus, and the hormones regulating their function
- The **physiological responses** to heat stress in dairy cattle include altered hormonal status, reduction in rumination and nutrient absorption, suboptimal immune function, and **increased maintenance requirements**

Example effects of climate change on the dairy industry: NE



Example effects of climate change on the dairy industry: Lancaster County, PA





Climate change effects in the poultry industry



- Projections in the NE for warmer winter and summer temperatures and fewer extreme cold nights **would benefit broiler production** by reducing fuel usage and disease challenges through better ventilation and an improved housing environment
- Future housing will most likely require **greater insulation and greater ventilation** fan capacity to offset warmer temperatures
 - Some of the added cost (i.e., increased ventilation and cooling) **will be offset by energy savings during warmer winters**
- **Heat stress** can reduce pullet growth, egg production, and the quality of eggs
 - Heat stress also **reduces shell thickness** leading to a greater percentage of cracked or broken eggs and economic loss



Climate change effects in the beef industry



- Overall, based upon average temperature increases ranging from 3.9 to 6.5°C, **impact of climate change on beef cattle and beef production losses in the NE should be minimal**
- Increased moisture in the region may have an impact on beef cattle grazing operations
 - Housing is not generally considered necessary for grazing cattle; however, **increased winter precipitation may reduce pasture stocking rates and increase housing needs for grazing beef**



Climate change effects in the equine industry



- Overall, predicted climate changes for the NE are **likely to have an economic impact** on the horse industry through:
 - additional management of land and forage resources
 - building of shelters
 - climate monitoring and heat abatement at equine events
- The horse industry is composed of a great diversity of operations making any **realistic estimate of an economic impact due to climate change beyond the scope of this report**

Climate change effects on manure management



- Using current manure handling methods, projected climate changes in the NE may **increase ammonia losses 20% by midcentury and up to 39% by 2100**
- With wetter and warmer conditions, **nitrous oxide emissions are projected to increase** about 12% by midcentury and 24% by 2100 on NE dairy farms
- Increases in precipitation and storm intensity are **projected to increase P losses** as much as 40% by midcentury and 87% by 2100
- Projected climate changes may **increase methane emissions from manure** management by about 4% by midcentury and 8% by 2100
- Warmer temperatures and a longer growing season may **allow more time for manure handling, tillage, and planting of crops**
- Thus, the **net effect of climate change on these operations may be minor or difficult to predict**



Summary/Conclusions

- Overall, increased average maximum temperatures, days with temperatures exceeding 25°C, higher annual precipitation in the NE, and increased atmospheric CO₂ concentration are expected **to either increase or decrease forage productivity depending on the crop, and may decrease protein content and forage digestibility**
- In the dairy sector, **additional loss in milk production** due to decreased feed intake is estimated to be **up to 1% of the projected annual milk production through 2100**
 - Increased temperatures **may reduce fertility in dairy cattle and heat stress-induced inflammation** may limit energy available for productive functions
- **Broiler production in the region may benefit from warmer winter** and summer temperatures
 - Providing adequate housing and ventilation to offset climate changes will be important for both the broiler and layer industries and may increase the price of eggs
- The effects of climate change on the beef industry in the NE are **expected to be minimal**
- Climate change is expected to have an **economic impact on the horse industry**
- Increased temperatures and more intense storms will likely **increase nutrient losses and gaseous emissions from animal manure**
- **Continued animal health monitoring is necessary** to address responses of host animals, pathogens, and disease vectors to climate change



QUESTIONS?

IAC: C #44118
2134
Control

IAC: C #44118
1940
Control

IAC: C #44118
2082
Control

1831

1845

1845

1991

2026

1940

1940

GREENFEED

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