Do Migrating States Matter?

A farm field perspective of climate change

Dave Mortensen
Professor – Weed Ecologist
Ecology IGDP
Department of Crop and Soil Sciences
Penn State University
dmortensen@psu.edu

Northeast Weed Science Society Symposium *Effect of Climate Change on Weeds*

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Fall 2007 Ecology seminars

Spring 2007: Ecology and Climate Change

Spring 2006: Ecology Across Scales

Spring 2007: Ecology and Climate Change

Climate change is the theme of the Spring 2007 Penn State Ecology seminar series, which involves speakers from universities, government agencies and research institutes/centers.

when	who	where
Jan 21	Al Gore's *An Inconvenient Truth*	2pm, Schlow Centre Regional Library
Jan 22	**Richard Alley** (Penn State) *Climate change: why is it coming, what it might mean*	3:35-4:35pm, 101 ASI
Jan 29	**Lewis Ziska** (USDA) *Climate change and weed ecology*	3:35-4:35pm, 101 ASI
Feb 5	**John Magnuson** (University of Wisconsin) *Freshwater ecosystems and climate change: impacts on lake ice, fishes and hydrology*	3:35-4:35pm, 101 ASI
Feb 12	**Allison Thomson** (Joint Global Change Research Institute) *Climate change and agriculture: impacts, adaptation and mitigation*	3:35-4:35pm, 101 ASI
Feb 26	**Patrick Megonigal** (Smithsonian Environmental Research Center) *Priming the microbial pump: enhanced soil organic matter decomposition at elevated* CO_2	3:35-4:35pm, 101 ASI
March 19	**Eric Davidson** (Woods Hole Research Center) *The temperature sensitivity of decomposition of soil organic matter: moving beyond Q10*	3:35-4:35pm, 101 ASI
April 2	**Mark Bush** (Florida Institute of Technology) *Ecological and evolutionary implications of past and future Amazonian climate change*	3:35-4:35pm, 101 ASI
April 9	**Paul Moorcroft** (Harvard University) *How close are we to a predictive science of the biosphere?*	3:35-4:35pm, 101 ASI
April 16	**Julio Betancourt** (United States Geological Survey) *Patterns, sources and ecological impacts of decadal-to-multidecadal climate variability*	3:35-4:35pm, 101 ASI
April 26	**Terry Root** (Stanford University) *Global change in plants and animals: a fingerprint for warming and evidence of cause*	4-5pm, 101 ASI
April 27	**Stephen Schneider** (Stanford University) *Can we define, let alone fix, "dangerous" climate change?*	1:25-2:25pm

atmospheric carbon dioxide: Possible effects on arctic tundra. Oecologia 58:286-289.

Billings, W.D., J.O. Luken, D.A. Mortensen, and K.M. Peterson. 1984. Interactions in increasing atmospheric carbon dioxide and soil nitrogen on the carbon balance of tundra microcosms. Oecologia 65:26-29.

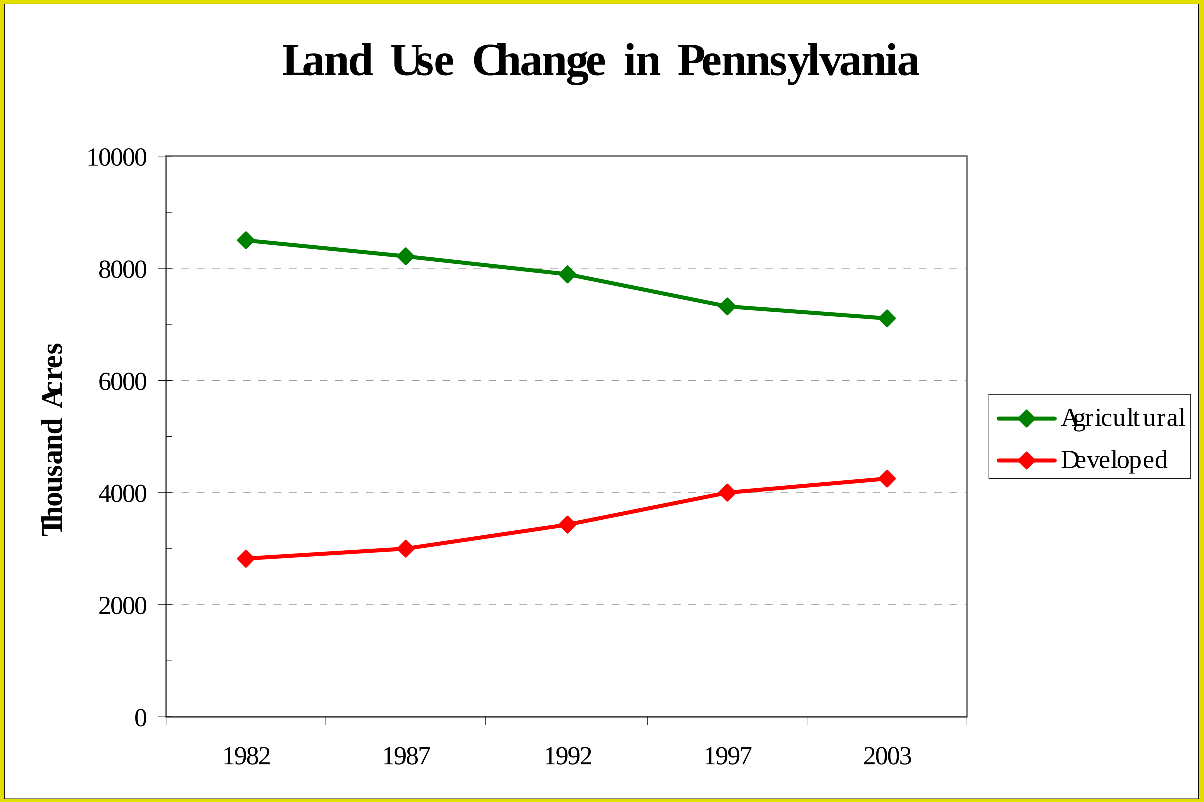
Land Use Change

Area and Land Cover

Pennsylvania:
28,995,200 acres

Agricultural Land:
1982: 8.5 million acres
2003: 7.1 million acres

Developed Land:
1982: 2.8 million acres
2003: 4.2 million acres



Source: National Resource Inventory 1997 Summary & 2003 Annual Report

Let the East Bloom Again

Drought in the Southwest coupled with increased need for biomass fuels will transform and expand agriculture in the eastern and northeastern US.

RICHARD T. McNIDER and
JOHN R. CHRISTY
September 22, 2007, New York Times

Jonathan Rosen

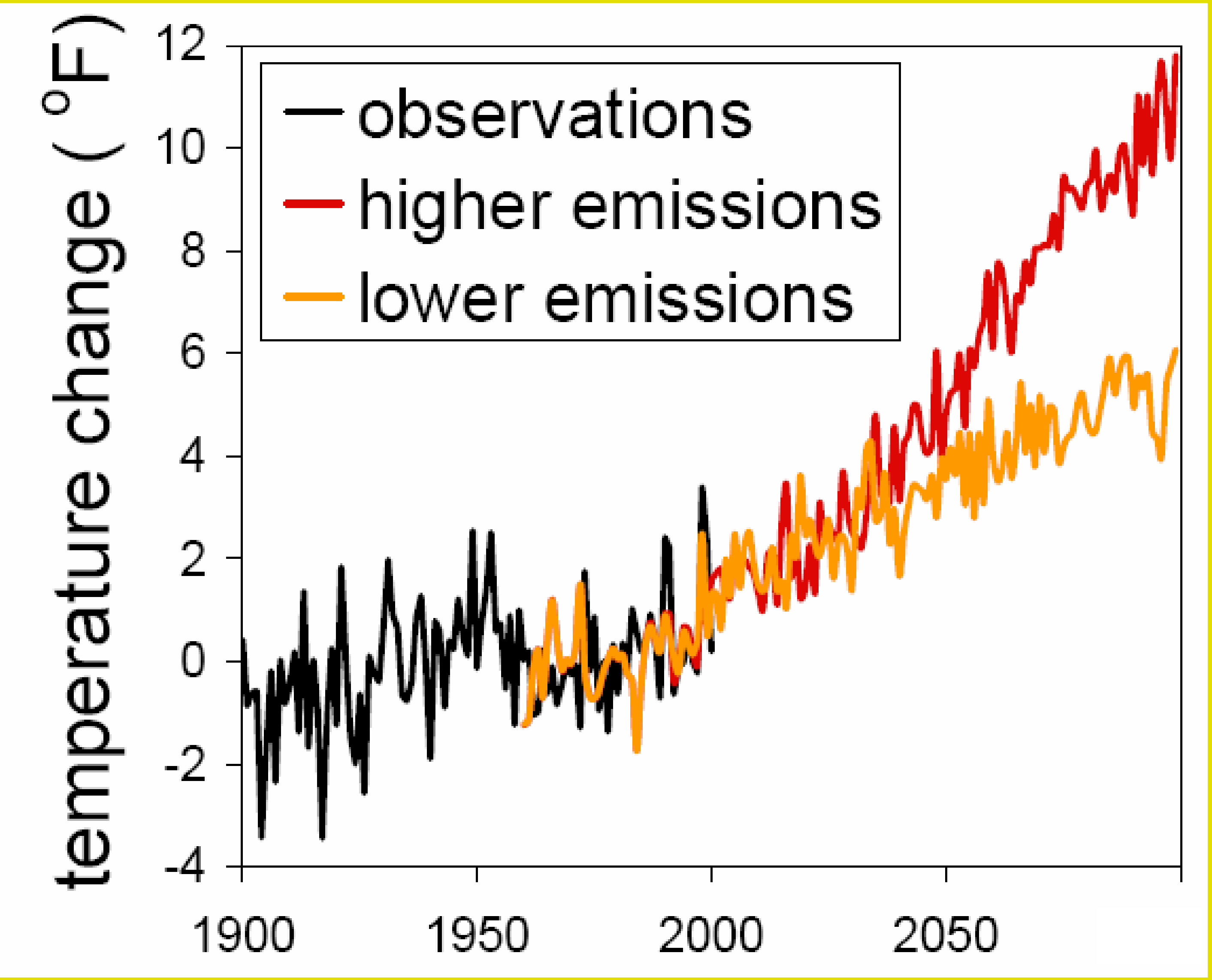
Indicators of Climate Change in the Northeast 2005

Confronting Climate Change in the U.S. Northeast. 2007. Peter C. Frumhoff, James J. McCarthy, Jerry M. Melillo, Susanne C. Moser, Donald J. Wuebbles. Union of Concerned Scientists.

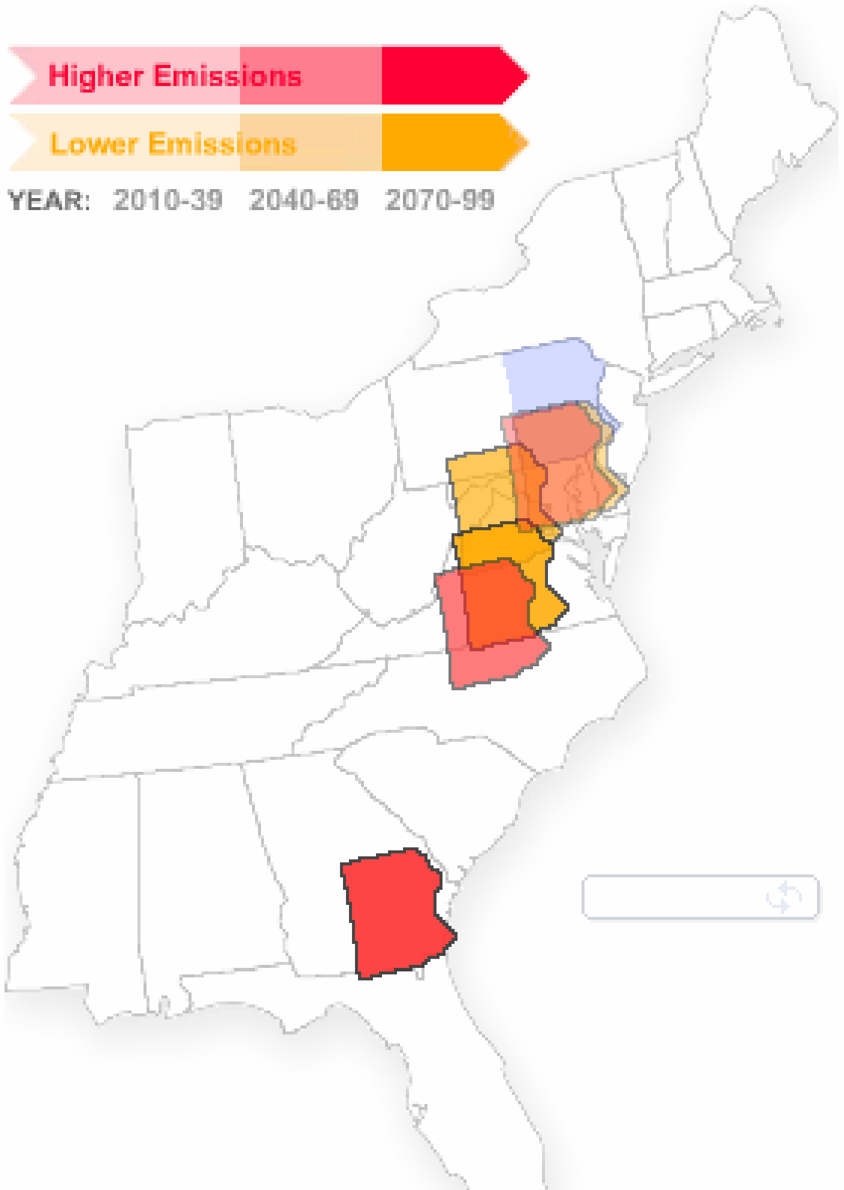
Indicators of Climate Change in the Northeast 2005. 2005. Cameron P. Wake, The Climate Change Research Center, University of New Hampshire and Clean Air – Cool Planet.

Climate Impacts web-site hosted by the Union of Concerned Scientists for the *migrating states* graphics

Observed and model-based changes in annual average temperature for the Northeast relative to 1961-1990 average temperature.



Indicators of Climate Change in the Northeast 2005



http://www.climatechoices.org/ne/impacts_ne/climates.html

Lower-Emissions Scenario:
a shift away from fossil fuels in favor of clean energy technologies, causing heat-trapping emissions to decline by mid-century

Higher-Emissions Scenario:
continued heavy reliance on fossil fuels, causing heat-trapping emissions to rise rapidly over the century

Characteristics of a typical northeastern field season 50-100 years from now…….

- winters could warm by 8 to 12^{o}F and summers by 6 to 14^{o}F
- more frequent extreme heat days (>90^{o}F)
- longer by 15-40 days
- the frequency of late summer and fall droughts is projected to increase significantly
- have more heavy rainfall events
- as winter temperatures rise, more precipitation will fall as rain and less as snow with the winter snow season cut in half
- these combine to result in a wetter winter and spring and drier summer and fall

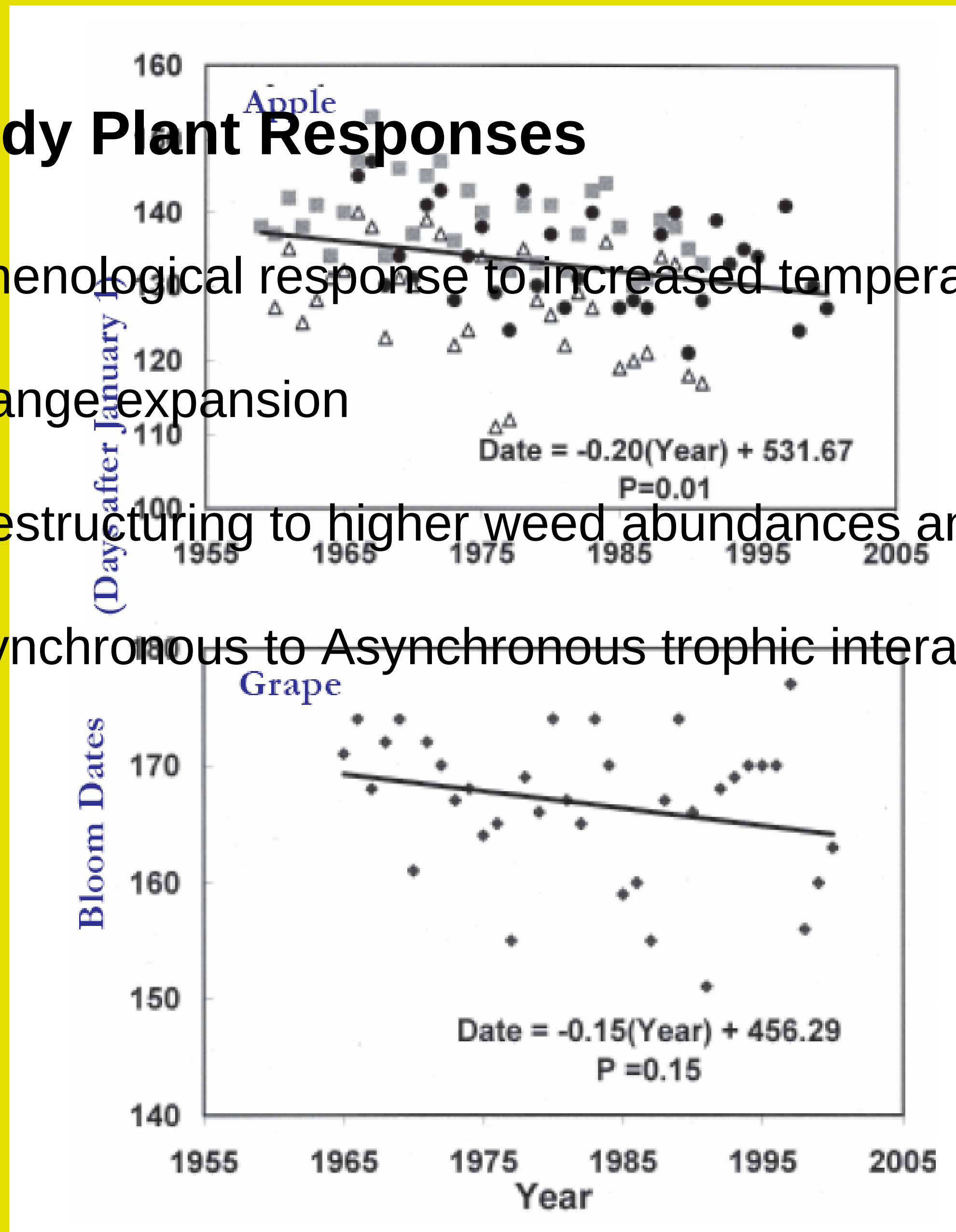
Projected changes (in days) in key indicators related to plant growth in the Northeast, as simulated for a lower- and higher-emissions scenario.

	2035-2064		2070-2099	
	Lower emissions	Higher emissions	Lower emissions	Higher emissions
Onset of summer	-6	-11	-9	-21
End of summer	+10	+16	+12	+23
First frost (fall)	+1	+16	+6	+20
Last frost (spring)	-8	-14	-16	-23
Length of growing season	+12	+27	+29	+43
First leaf (spring)	-3	-5	-7	-15
First bloom (spring)	-4	-6	-6	-15

Indicators of Climate Change in the Northeast 2005

Weedy Plant Responses

- Phenological response to increased temperature
- Range expansion
- Restructuring to higher weed abundances and diversity
- Synchronous to Asynchronous trophic interactions



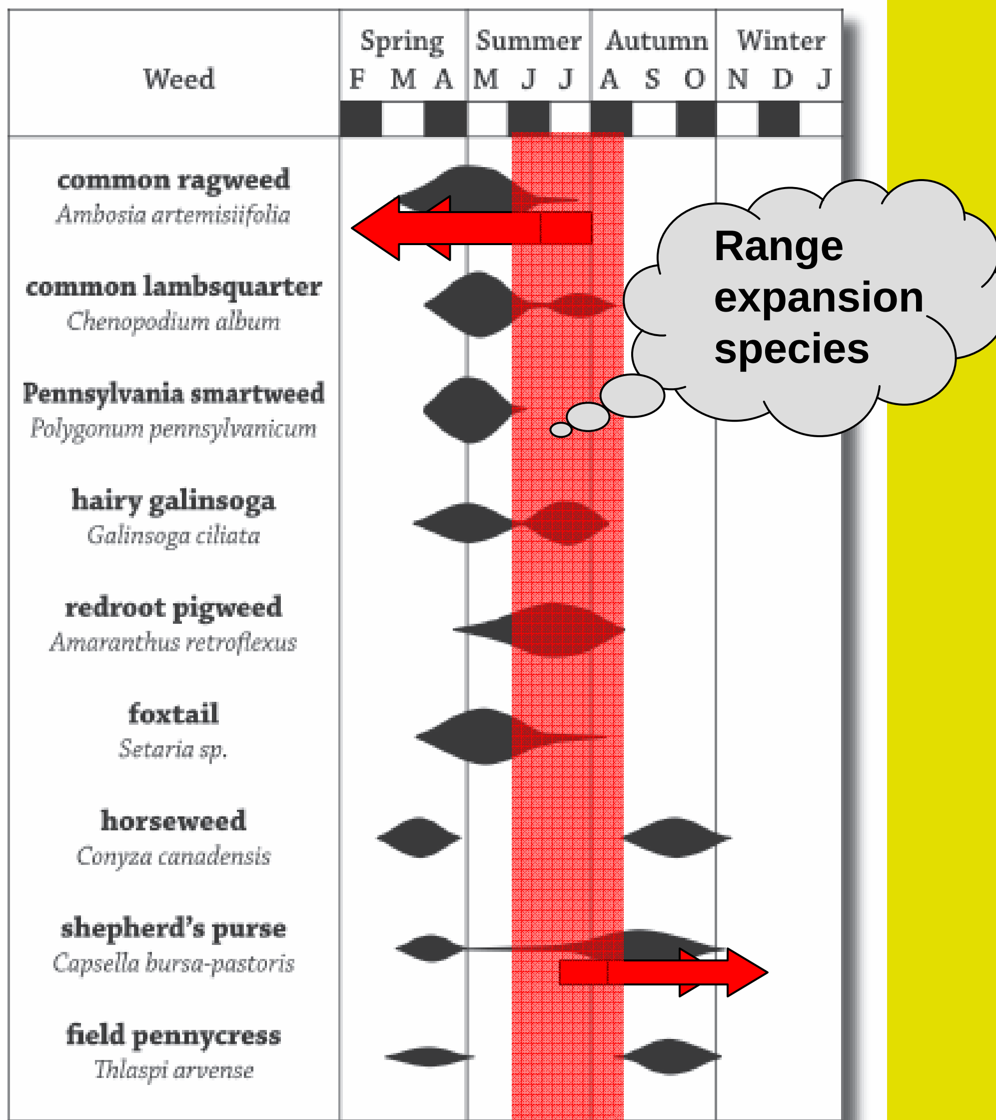
Cameron P. Wake, The Climate Change Research Center, University of New Hampshire. Indicators of Climate Change in the Northeast 2005.


WEED GERMINATI

When Do Wee

Tilled June 10th<

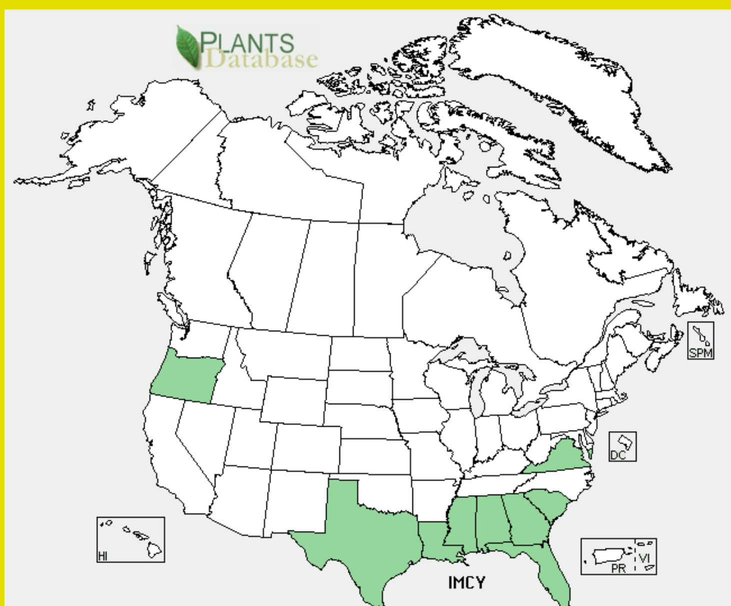
Tilling time *does* make a difference!



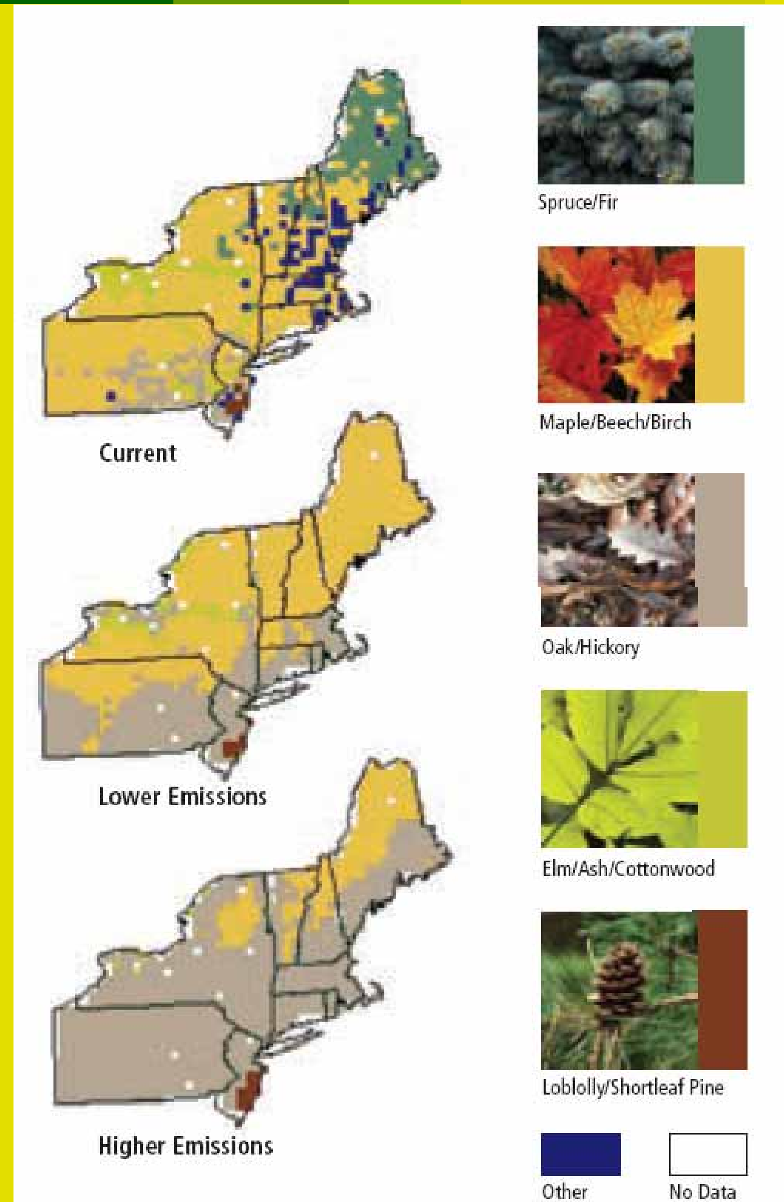
Proportion of weed seeds germinating throughout the season in central Pennsylvania.

Range expansion and contraction

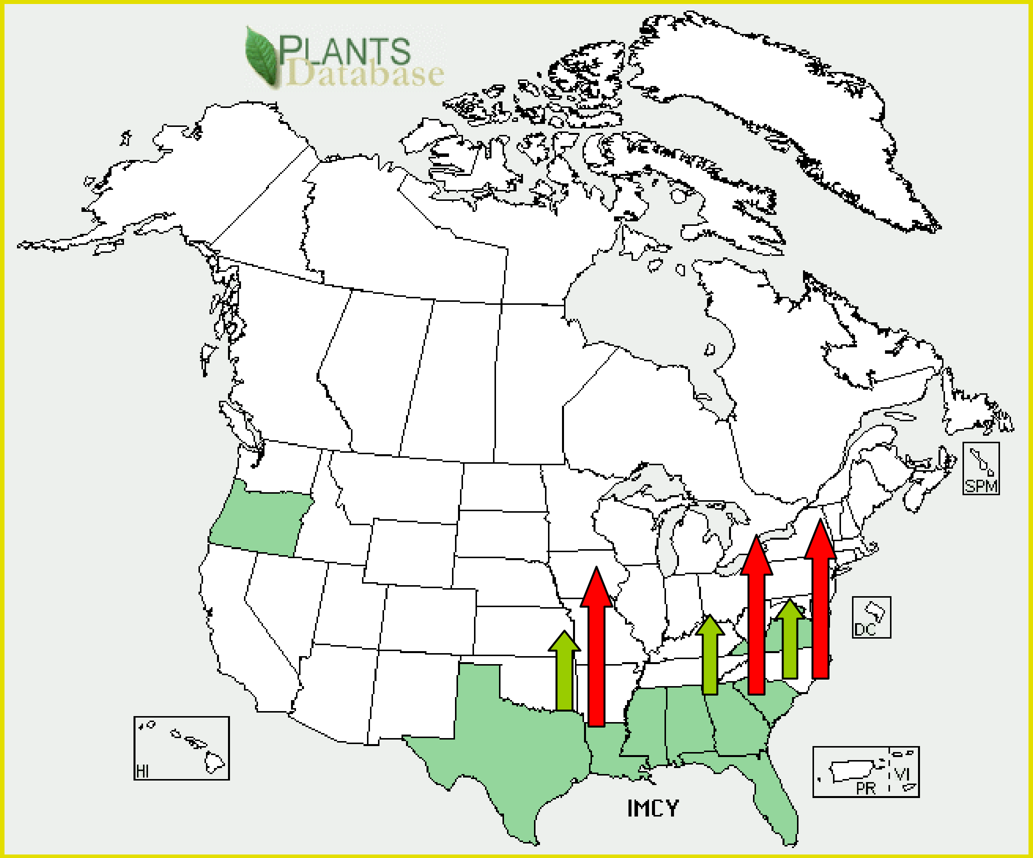
While northern migration of economically important woody species has been extensively studied (sugar maple for example), weedy tropical annuals and perennials will move north



USDA, NRCS. 2008. The PLANTS Database (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.



In Confronting Climate Change in the U.S. Northeast



Imperata cylindrica, cogongrass

Flint, E.P., D.T. Patterson, D.A. Mortensen, G.H. Riechers, and J.L. Beyers. 1984. Temperature effects on growth and leaf production in three weed species. Weed Sci. 32:655-663.

Patterson, D.T., and D.A. Mortensen. 1985. Effects of temperature and photoperiod on common crupina (*Crupina vulgaris*). Weed Sci. 33:333-339.

Patterson, D.T., A.E. Russell, D.A. Mortensen, R.D. Coffin, and E.P. Flint. 1986. Effects of temperature and photoperiod on Texas panicum (*Panicum texanum*) and wild proso millet (*Panicum miliaceum*). Weed Sci. 34:876-882.

Synchrony between weeds and other organisms

- Extend host range of weed that supports crop pathogen under weather conditions similar to host range of both non-natives

- Temperature shifts decouple biocontrol agents from host

APHIS Soybean Rust Hot Issues Web Page, Dan Borchert, Glenn Fowler and Roger Magarey (USDA-APHIS-PPQ-CPHST-PERAL)

↑ Growing Season Length

- change to longer season hybrids
- ↑ adoption of double cropping in the region
- ↑ yields of perennial crops

Field Working Days

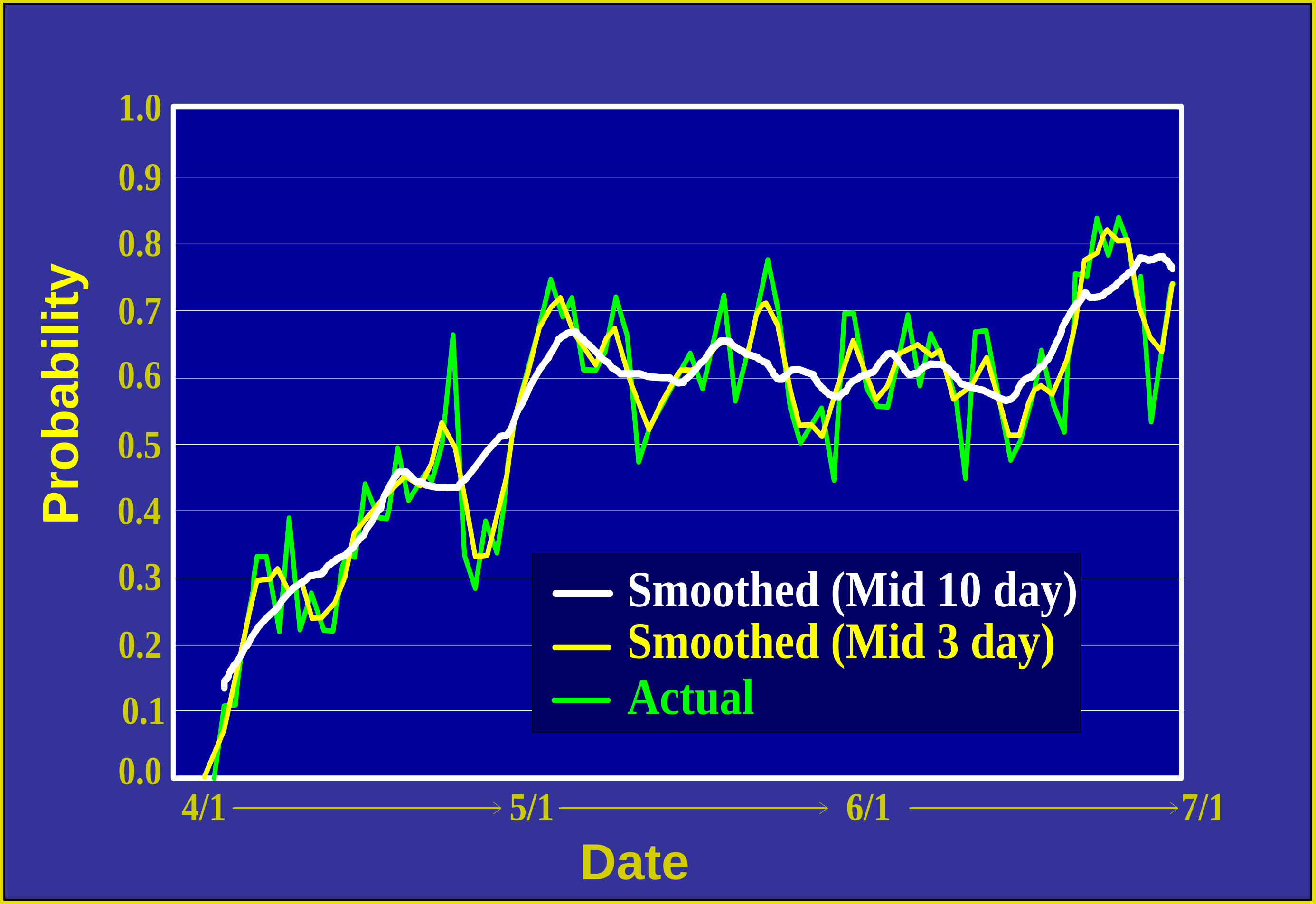
↓ Spring and Early Summer

↑ Summer and Fall

The time available to complete field operations

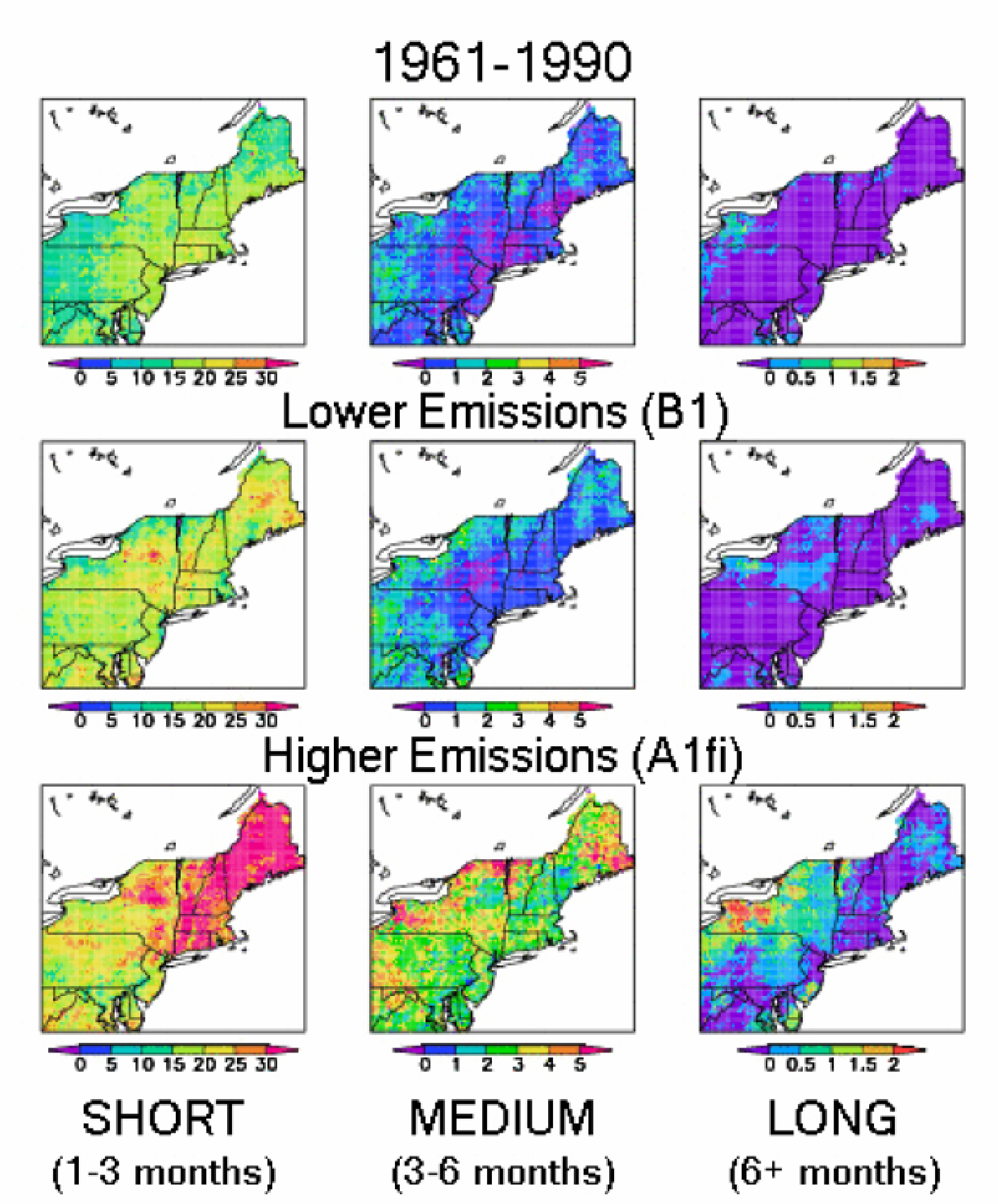
- **Impacts field acreage planted**
- **Impacts optimal machine size**
- **Impacts profitability**
- **Can vary significantly from year to year “Risk”**

Working day probability - April to June, Southwest Experiment Station in Lamberton, MN



↑ Drought frequency

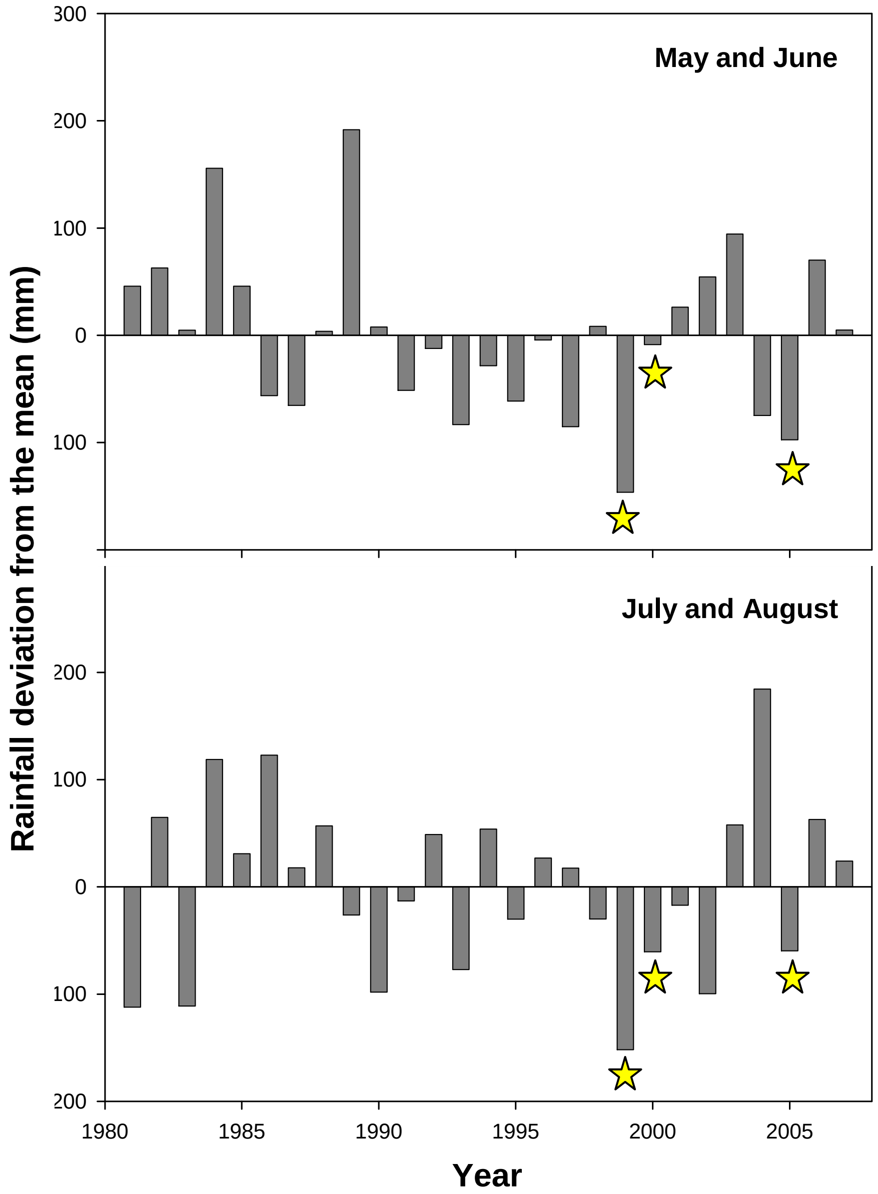
- drive change in crops grown in rotation
- ↑ adoption of irrigation in the region
- ↓ non irrigated annual crop yields
- require more robust weed management

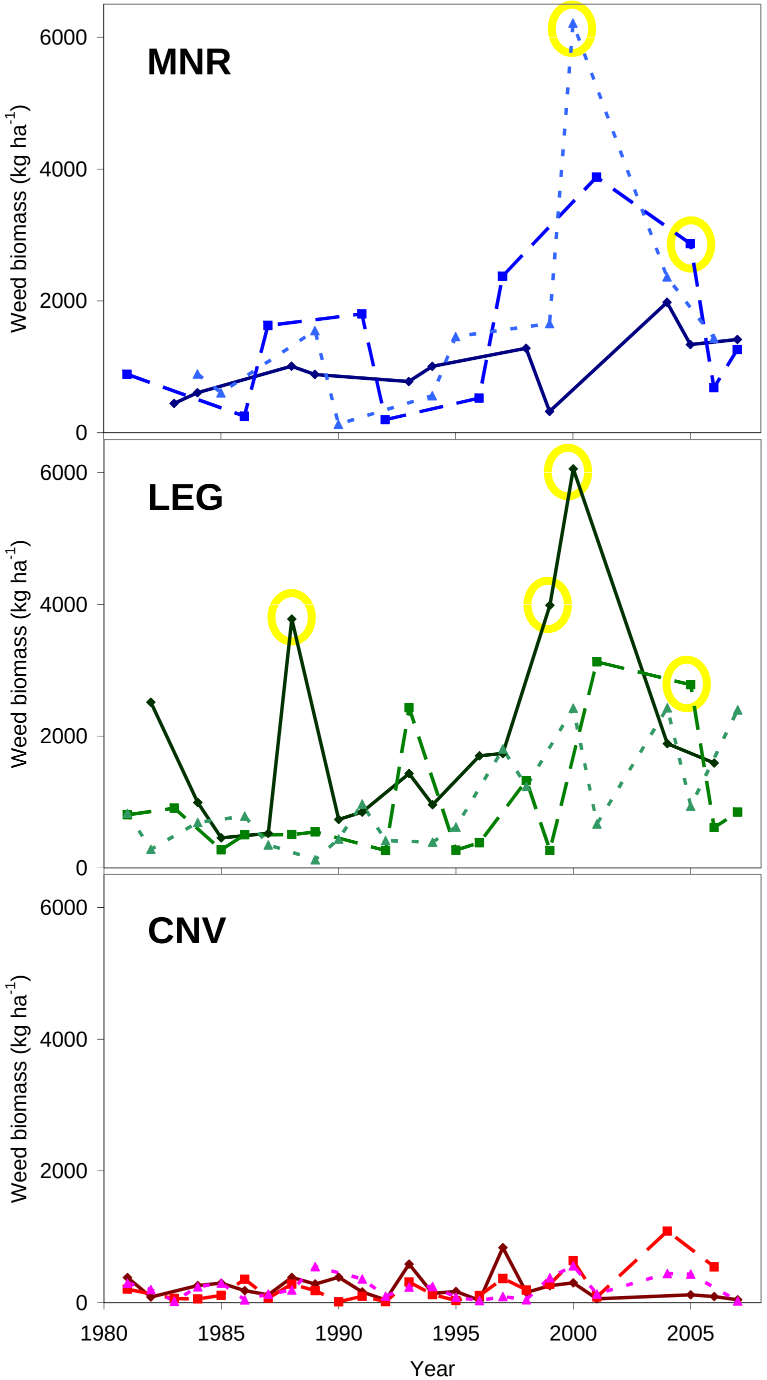


Indicators of Climate Change in the Northeast 2005

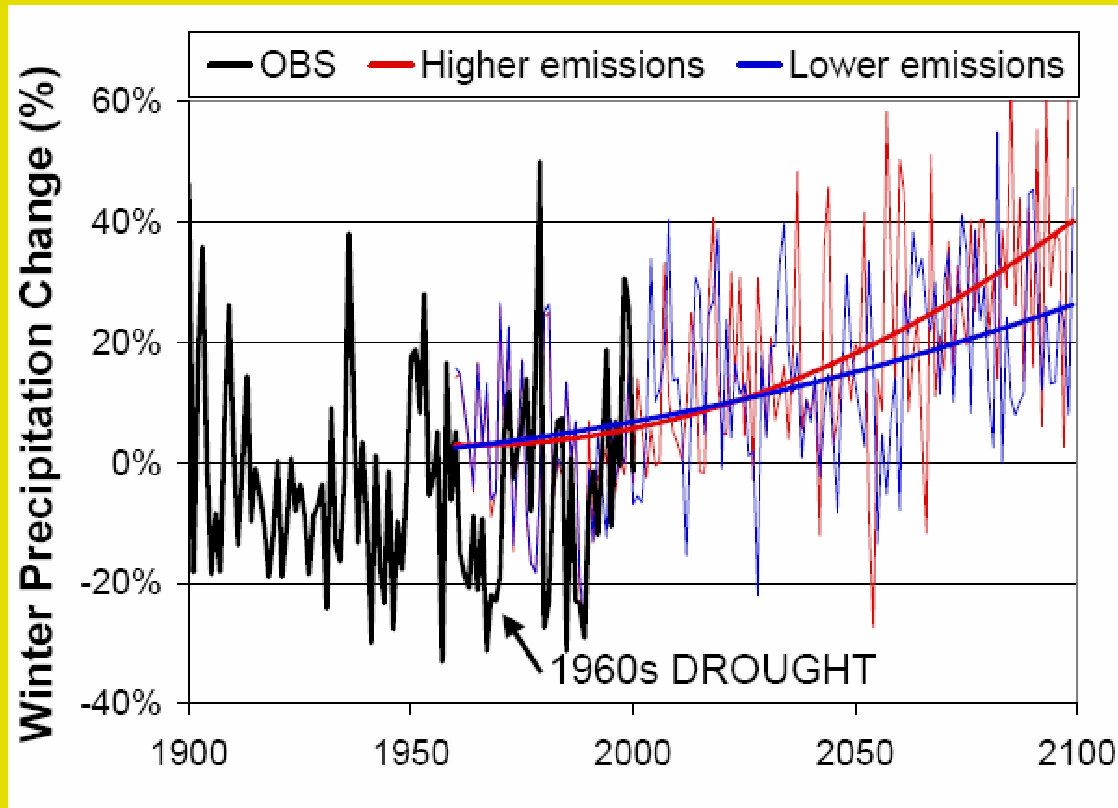
Each map shows the total number of short-term (1-3 month), medium-term (3-6 month) and longterm (6+ month) droughts occurring during the historic 30-year reference period (1961–1990) and the 30-year period at the end of the century (2070–2099) under a higher- and lower-emissions scenario.

In the organic systems, years with extremely high weed biomass levels also tended to be years with drought conditions





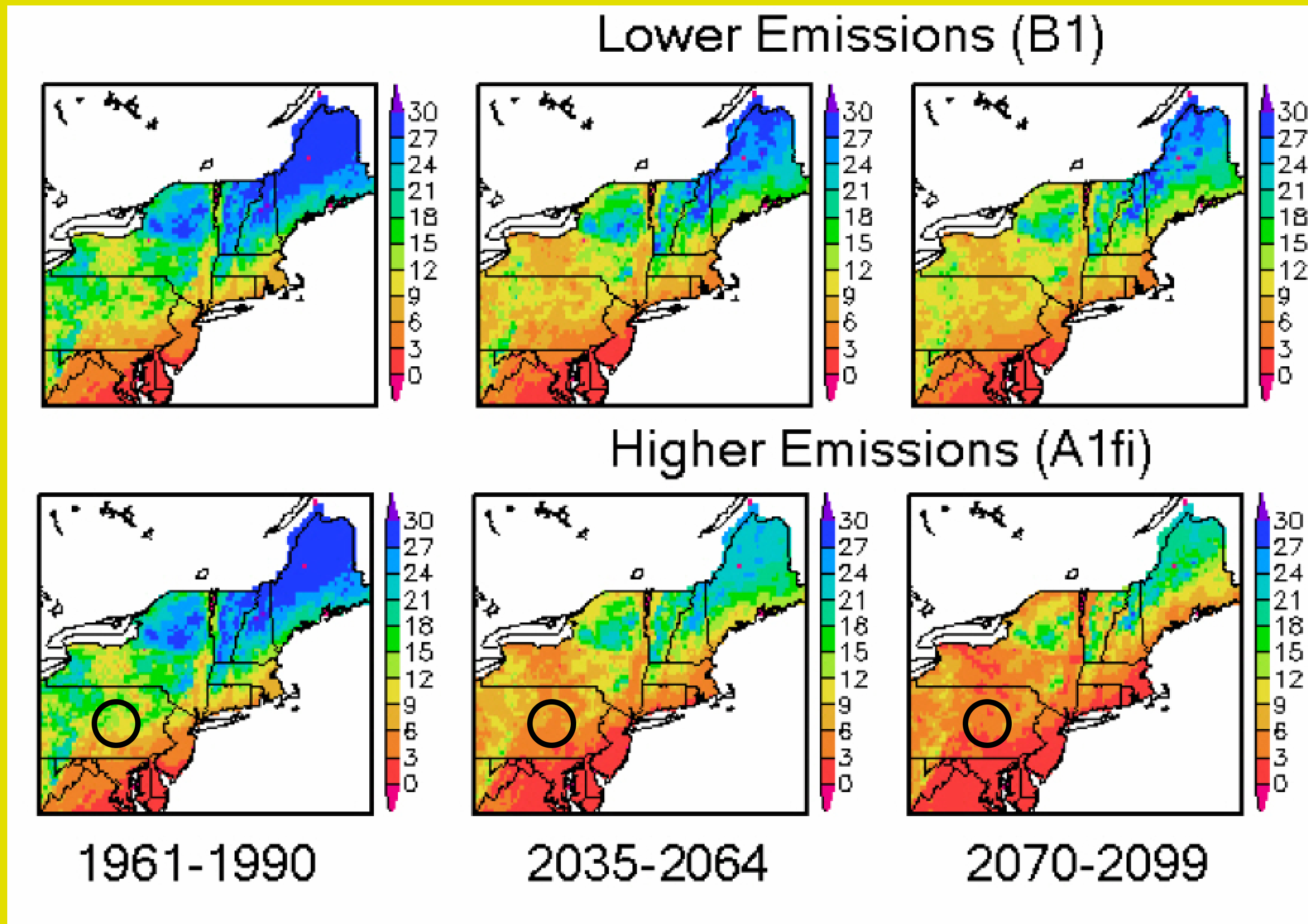
Observed and model-based winter precipitation for the Northeast, in units of percentage change relative to the 1961-1990 average.



⬆ winter precipitation and more of it as rain

- challenge CAFO designs in our dairy growing region
- ⬆ adoption of conservation tillage on conventional and organic farms
- ⬆ adoption of cover crops
- ⬆ perennial covers arranged deliberately to protect surface water runoff

The number of snow-covered days per month (December–February) in the Northeast, averaged over 30-year periods. Values are the averages of the HadCM3 and PCM simulations from the VIC model.



State College, Pennsylvania

snow covered days 15 to 9 to 3-6

The climate, weedy plant and crop management changes outlined in this talk are significant ones.

Northeastern farmers will face…………

- ❑ growing conditions like that of mid southern states
- ❑ a weedier world with higher weed abundance and higher weed diversity in their fields
- ❑ a more stochastic world in ways that matter, droughts and heavy rains
- ❑ a condition where water quantity and quality will be a considerably more important issue in this region

These changes represent a call to action for Northeast Weed Scientists and Farmers to develop and implement

- ❑ robust ecologically-based weed management systems that provide adequate weed suppression while protecting water quality

- ❑ conservation practices for conventional and organic production that minimize erosion in the winter and spring

- ❑ practices that reduce the farmstead carbon footprint

The Nature Conservancy

Easy Things You Can Do To Help Our Climate:

TIP: Travel light. Walk or bike instead of driving a car.

TIP: Teleconference instead of flying.

TIP: See the light. Compact fluorescent

TIP: Recycle and use recycled products.

TIP: Inflate your tires.

TIP: Plant native trees.

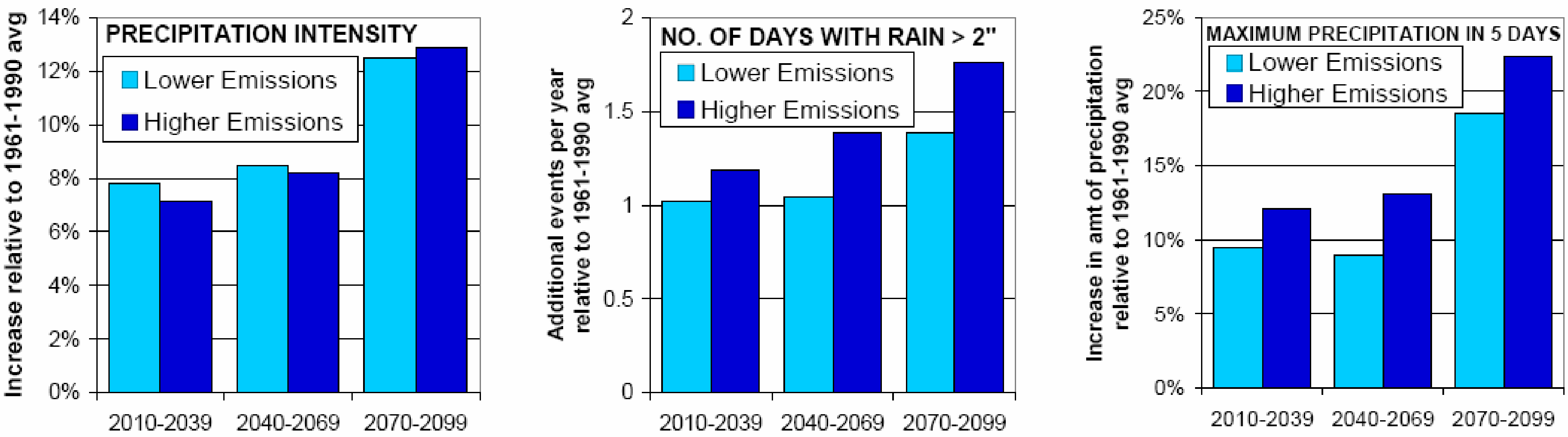
TIP: Turn down the heat.

TIP: Buy renewable energy.

TIP: Act globally, eat locally.

http://www.nature.org/initiatives/climatechange/activities/art19630.html

Figure 7. Projected increases in three indices of extreme precipitation: (1) precipitation intensity, (2) number of days per year with more than two inches of rain, and (3) maximum amount of precipitation to fall during a five-day period each year. Changes are shown for the lower- and higher-emissions scenarios. Model-simulated precipitation represents the average of the GFDL and PCM models (daily precipitation projections for the HadCM3 model were not available).



By the end of the century, short- and medium-term droughts in the Northeast are projected to increase dramatically under the higher-emissions scenario, with only slight increases under the lower emissions scenario (Figure 8). Under the higher-emissions scenario, short-term droughts are projected to occur as frequently as once per year in the north and eastern parts of the region. The frequency of medium-term droughts also increases substantially under this scenario. These changes result primarily from reductions in soil moisture during late summer and autumn, which in turn are caused by both increased evapotranspiration and stable or even reduced precipitation. Droughts longer than six months are still projected to be infrequent due to the high variability in the Northeast’s climate. Drier, hotter summers, coupled with wetter periods early in the year, have the potential to affect water supply and agriculture. Even very short (e.g., one- to four-week) water deficits during critical growth stages can have profound effects on plant productivity and reproductive success. With climate change, additional possible stresses on water availability may occur through changes in the amount of groundwater available in wells.

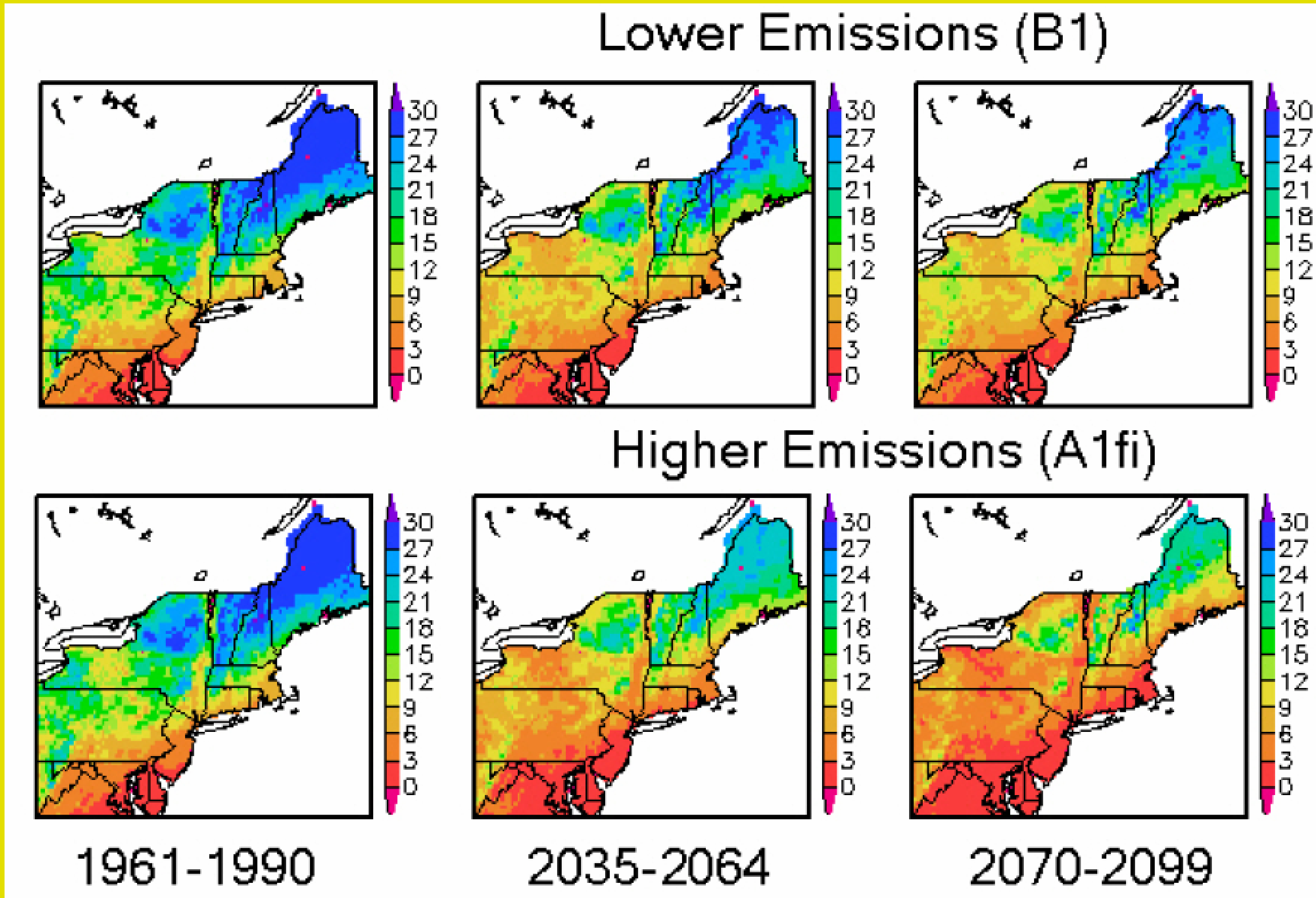


Figure 11. The number of snow-covered days per month (December–February) in the Northeast, averaged over 30-year periods. Values are the averages of the HadCM3 and PCM simulations from the VIC model.

	2035-2064		2070-2099	
	Lower emissions	Higher emissions	Lower emissions	Higher emissions
Onset of summer	-6	-11	-9	-21
End of summer	+10	+16	+12	+23
First frost (fall)	+1	+16	+6	+20
Last frost (spring)	-8	-14	-16	-23
Length of growing season	+12	+27	+29	+43
First leaf (spring)	-3	-5	-7	-15
First bloom (spring)	-4	-6	-6	-15

Table 2. Projected changes (in days) in key indicators related to plant growth in the Northeast, as simulated for a lower- and higher-emissions scenario.

Changes in species composition are often associated with changes in temperature and precipitation. Key concerns involve the potential for changes in predator-prey relationships, changes in pest types and populations, invasive species, and in key species that are truly characteristic of a region or are of economic significance. For example, lobster populations are associated with cooler waters and warming is thus likely to promote northward migration of the lobster population -- a key issue for New England. Coastal population pressures combined with sea-level rise are very likely to reduce habitat for migratory birds along the Atlantic Flyway. Warming is also likely to substantially limit trout populations -- a key issue for Pennsylvania. Changes in species mix and introduction of climate-driven invasive species are likely to also induce unanticipated feedbacks on ecosystems. The likely migration of sugar maple trees northward into Canada as climate warms would sharply reduce maple syrup production, a cultural tradition in the Northeast.

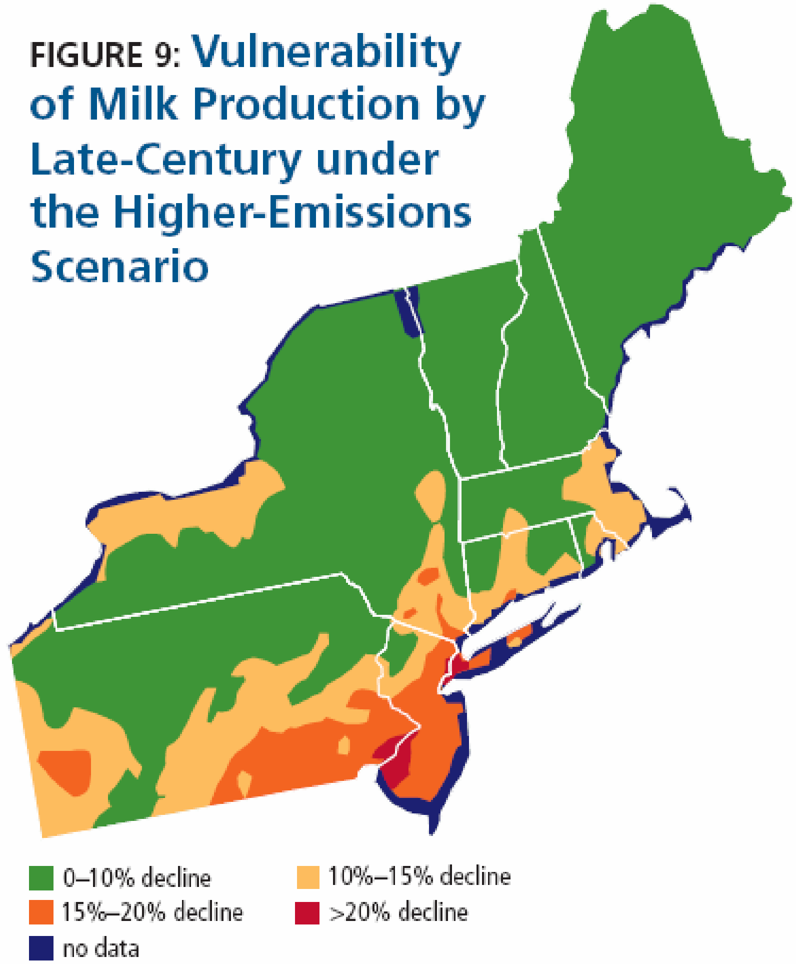
US Climate Change Science Program / US Global Change Research Program, Suite 250, 1717 Pennsylvania Ave, NW, Washington, DC 20006. Tel: +1 202 223 6262. Fax: +1 202 223 3065. Email: information@usgcrp.gov. Web: www.usgcrp.gov. Webmaster: WebMaster@usgcrp.gov Report issued 2000.

Averaged model-p
and summer temp
and higher emissi
modeled average.

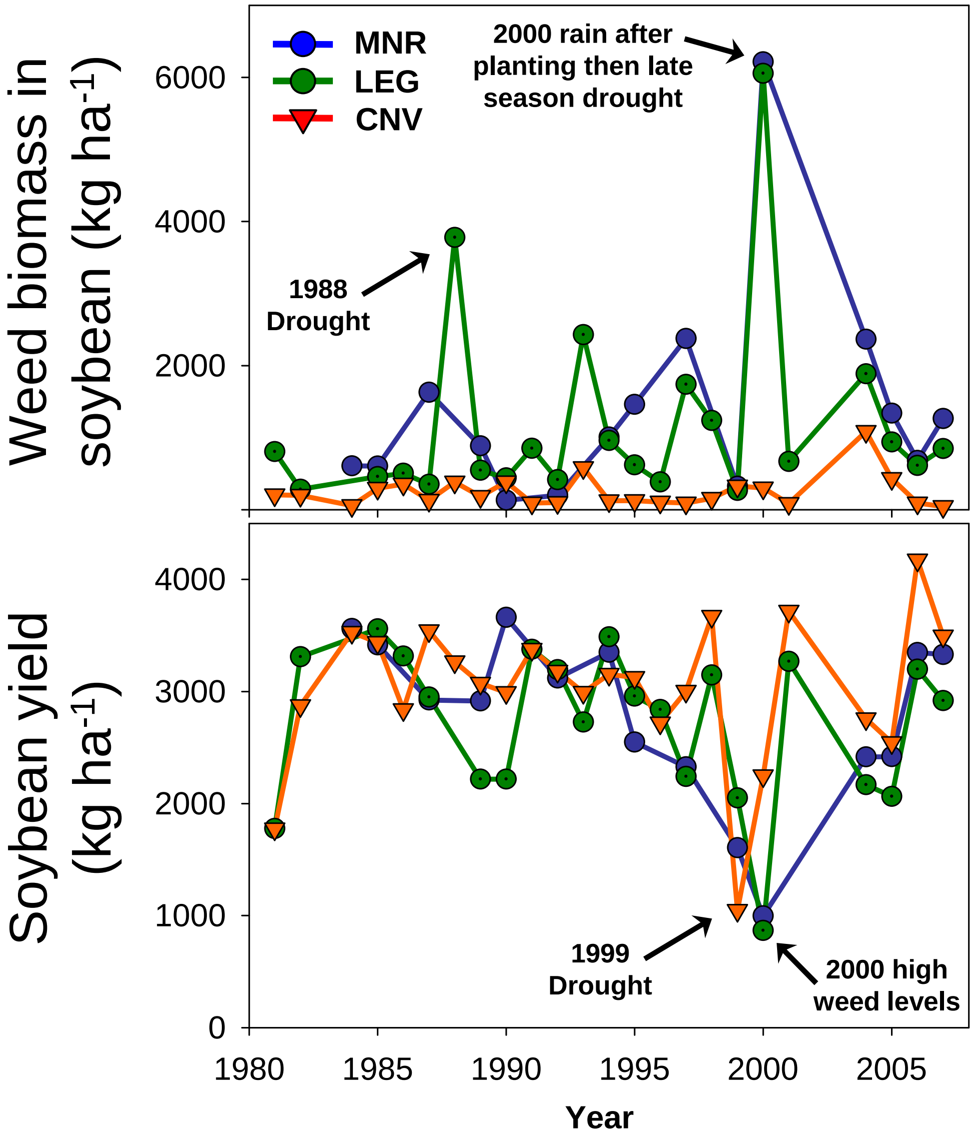
nter,
lower

	ANNUAL		JA)
	Lower emissions	Higher emissions	Higher missions
2010–2039	2.4	2.6	2.6
2040–2069	3.7	5.8	6.4
2070–2099	5.0	9.5	10.6

FIGURE 9: Vulnerability of Milk Production by Late-Century under the Higher-Emissions Scenario



Implications of mid to late season drought



Effect	Soybean Yield	Weed Biomass in Soybean
System	0.0297	0.0103
Year	<0.0001	<0.0001
System x Year	0.0157	0.0031

System	Slope	*P*-value	Slope	*P*-value
MNR	-35.7	<0.0001	61.1	<0.0001
LEG	-12.3	0.0986	30.3	0.0055
CNV	-5.8	0.3828	4.2	0.6781

- High weed biomass in the organic soybean plots in 2000 was likely a result of untimely rainfall after planting and late season drought conditions in 1999, which provided a nitrogen rich environment in 2000 giving weedy plants a competitive advantage (Fricks et al. 2007).
- The equilibrium weed biomass level in the two organic systems is likely to remain between 500 and 1700 kg ha^{-1}.