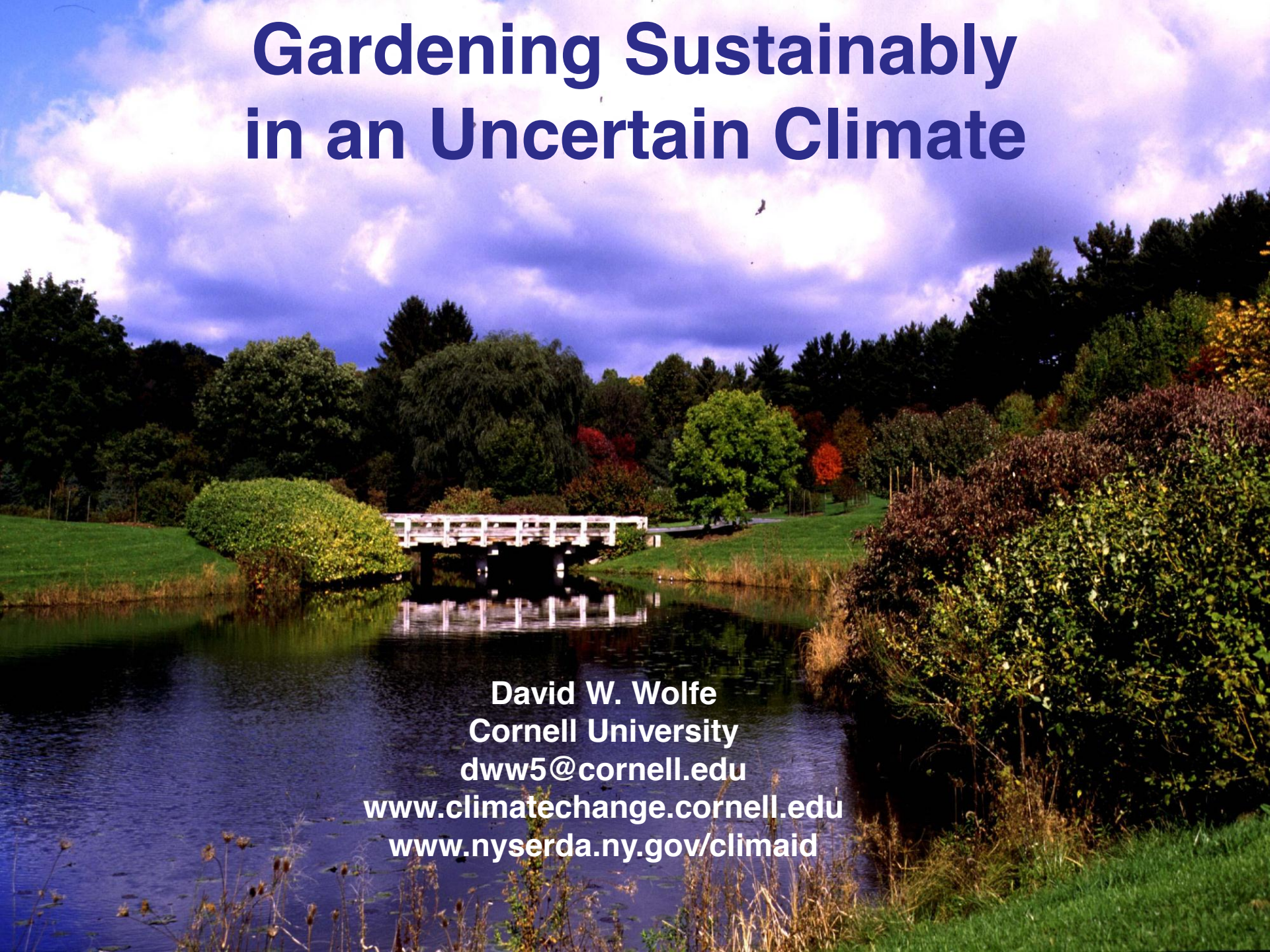
# Gardening Sustainably in an Uncertain Climate



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# Global Climate Change

**<u>What we know with high certainty</u>:**

**-The climate is always changing due to "natural forcing"**

**-But seldom has the pace of change been as rapid as it is today**

**-Rapid increase in carbon dioxide and other greenhouse gases are primarily responsible for recent and projected rapid warming**

**-More warming at higher latitudes**

**-Glaciers worldwide are melting**

**-Sea level worldwide is rising**

**-The living world is already responding to climate change**

# The New "Plant Hardiness Zone Map"

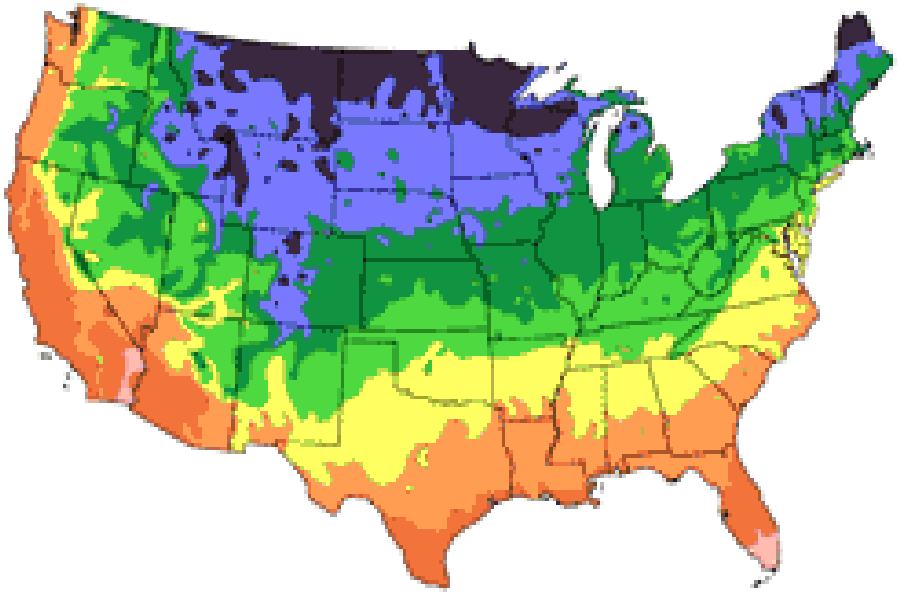
**Climate envelopes affecting biosphere are shifting**

(maps based on minimum winter temperatures; prior 15 years of weather station record)

| 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° |

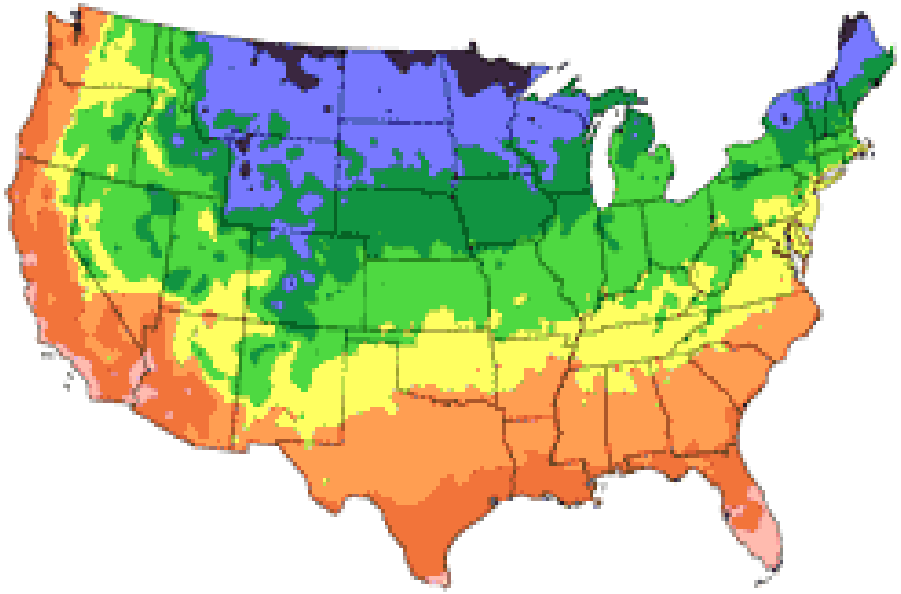
**Source: www.arborday.org**

1990 Map



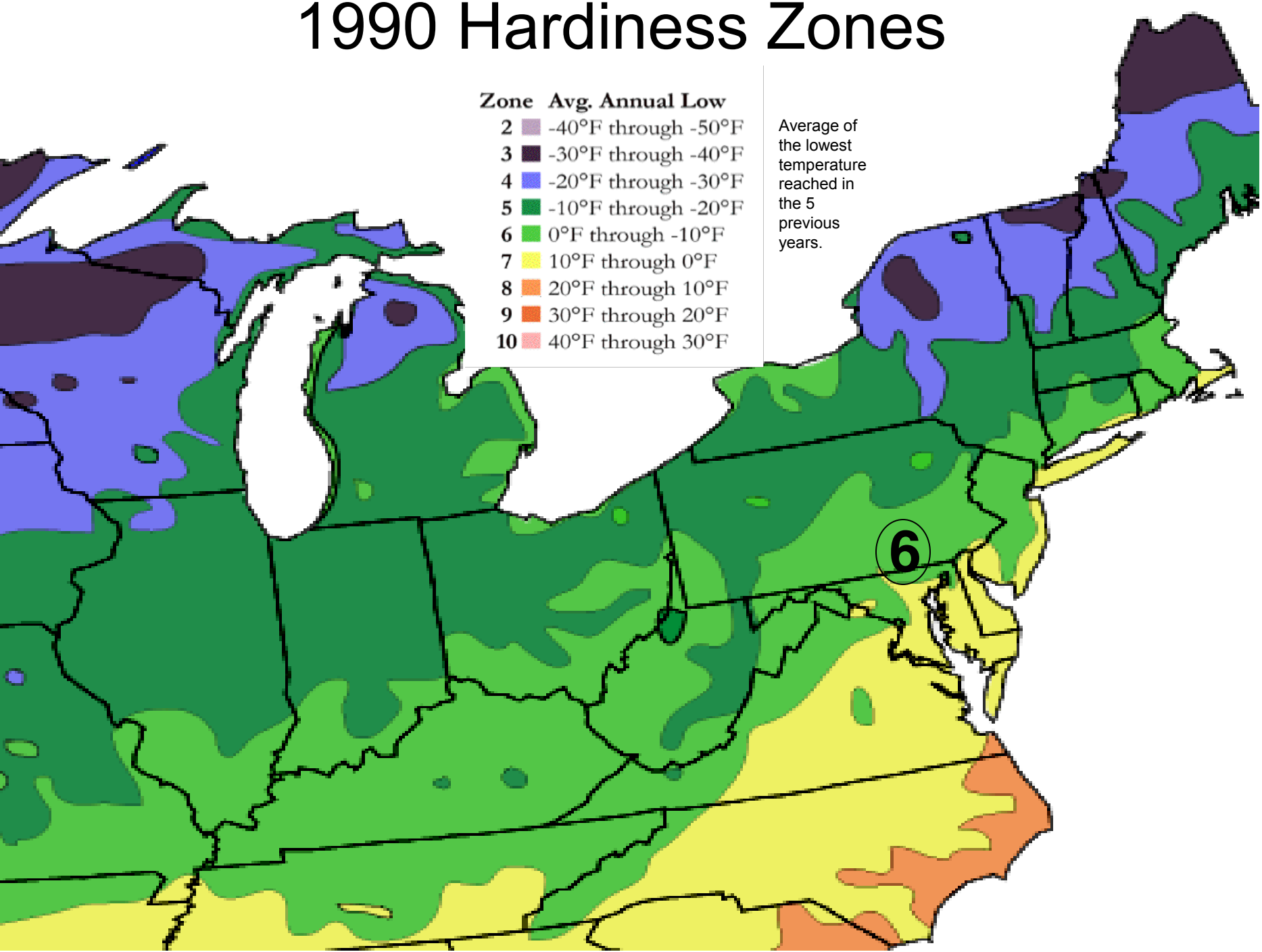
After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued January 1990.

2006 Map

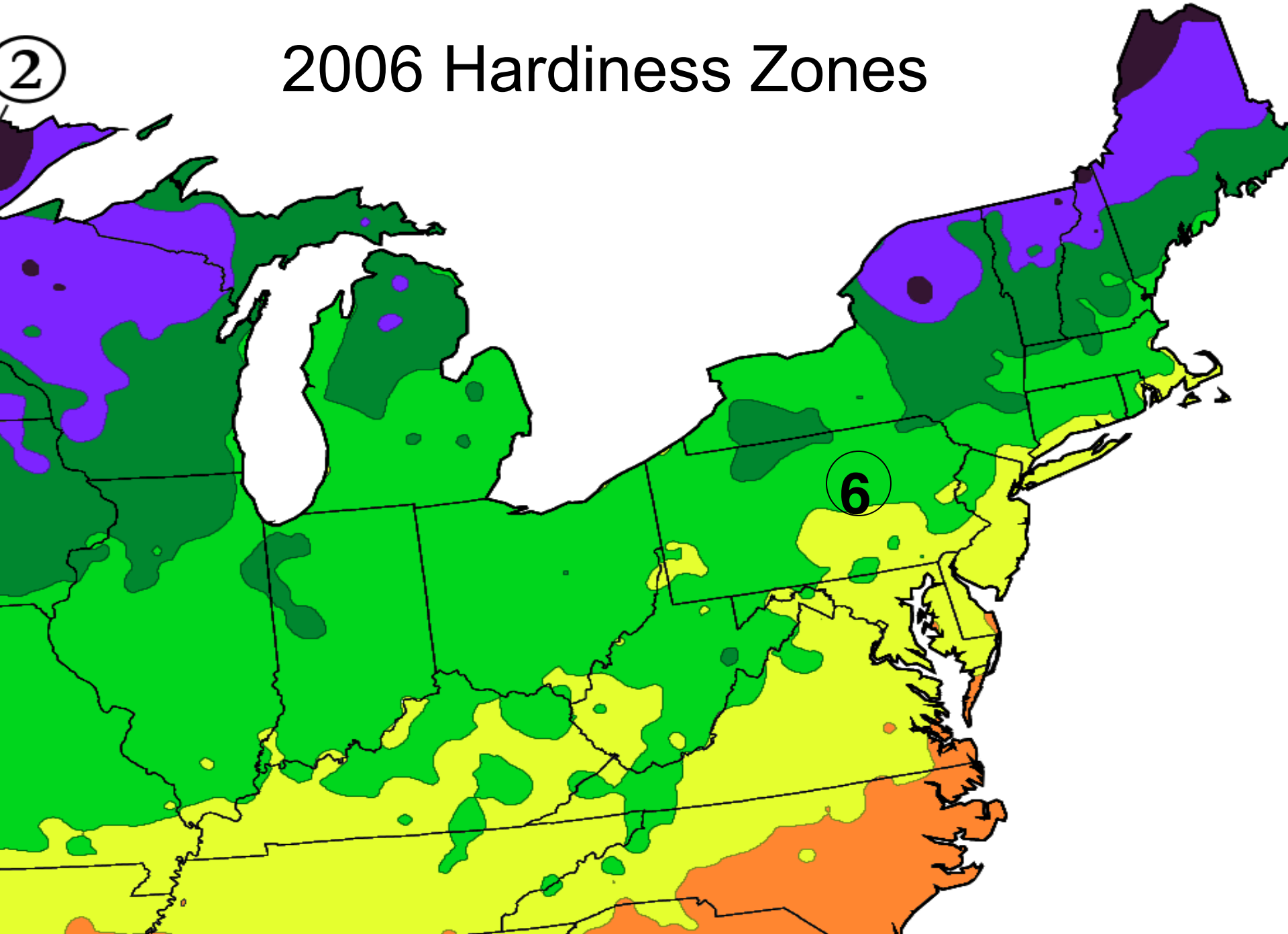


National Arbor Day Foundation Plant Hardiness Zone Map published in 2006.

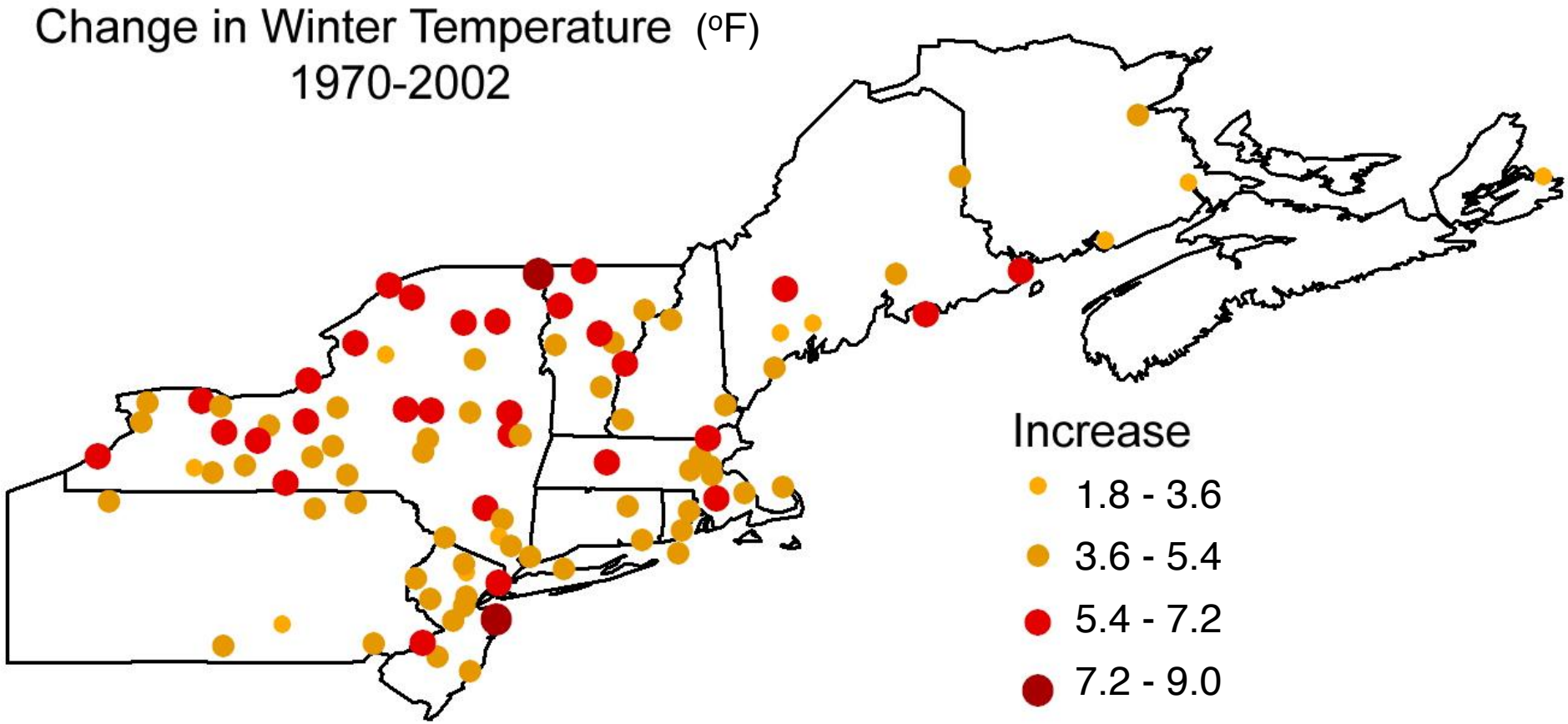
# 1990 Hardiness Zones



# 2006 Hardiness Zones



# NE winters have warmed 4.4 F since 1970




Source: C. Wake, University of New Hampshire

# It is not just weather instruments telling us the climate is changing. The living world (plants, insects, birds and other animals) are responding to change. For example, in the Northeastern US….

Grapes are blooming 6 days earlier

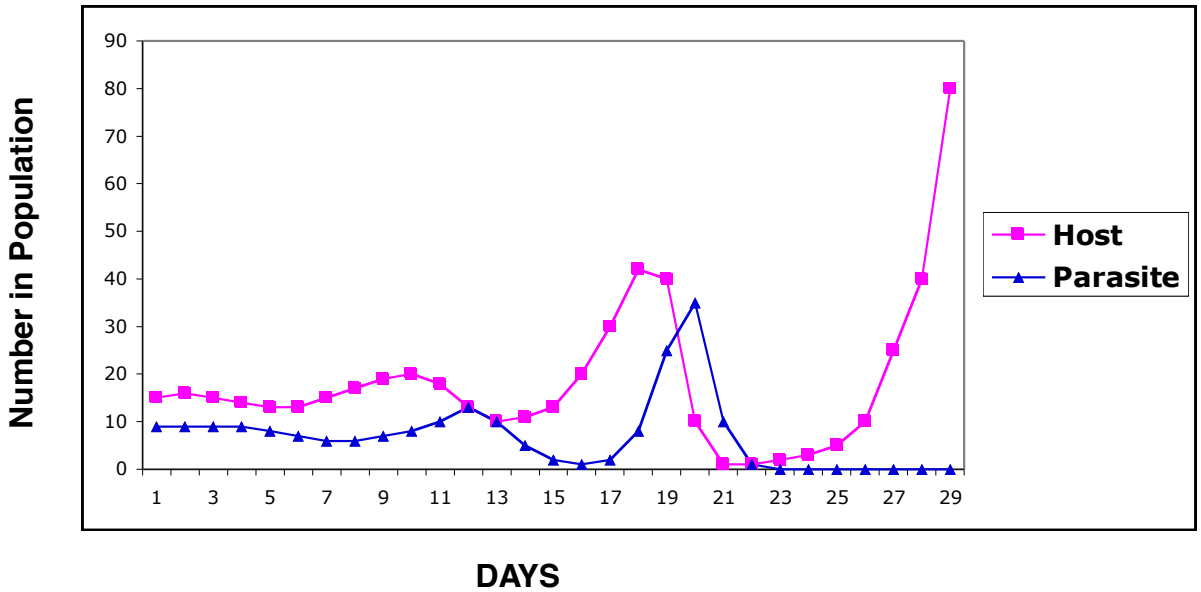
Apples are blooming 8 days earlier than they were in the 1960s

Lilacs are blooming 4 days earlier

[Source: Wolfe DW et al. 2005. Internat J Biometeor 49:303-309.]
National Phenology Network: http://www.usanpn.org

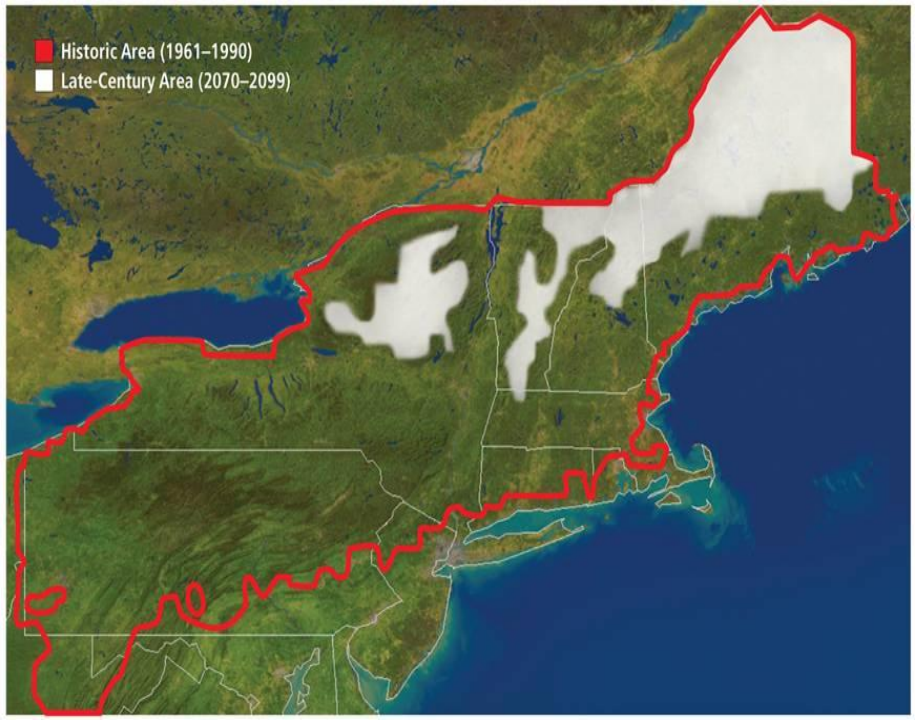
# As each species responds uniquely to climate change: How will this affect the synchrony between organisms?

Plants and pollinators?




Natural enemies of insect pests?

# Projected Change in Snow Cover Days
## (days with fewer than 30 days of snow cover)




**Deer benefit from less snow because they can feed on more exposed vegetation all winter.**

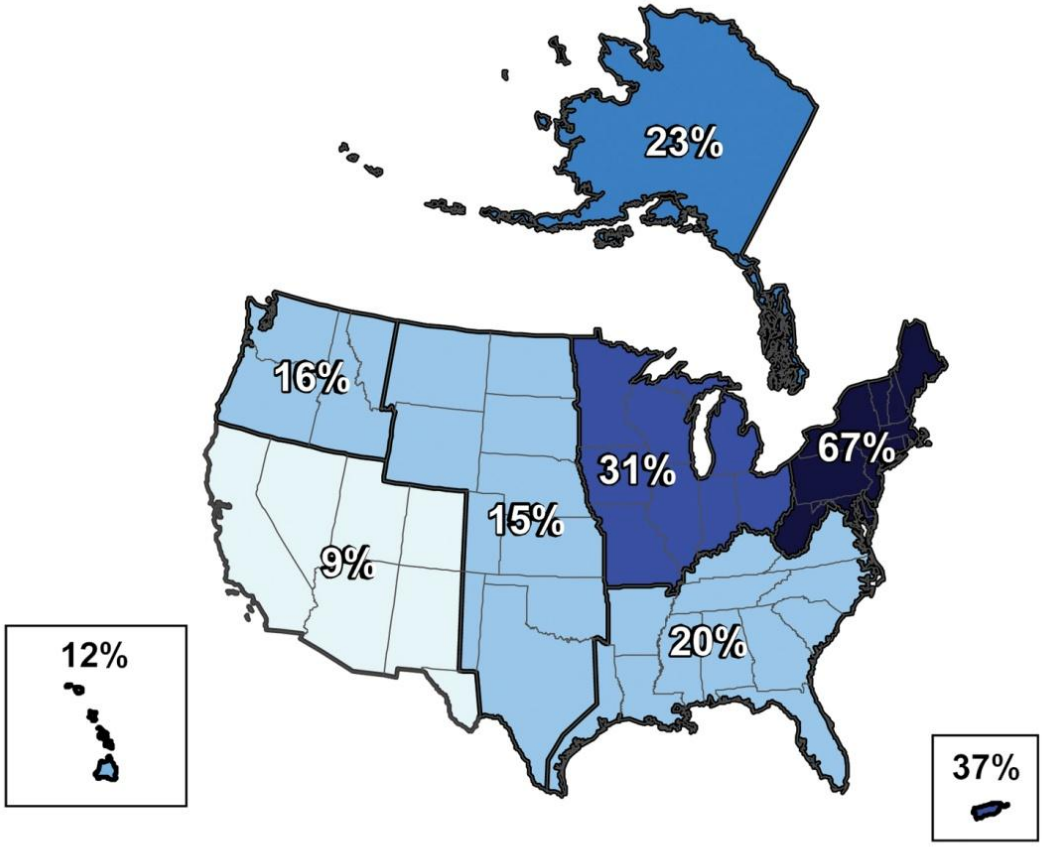

**Snow cover affects soil temperatures and microbial activity that determines nitrogen retention in soils and nitrous oxide ($N_2O$) release into the atmosphere.**

# Expect the unexpected:

## More frost and freeze damage in a warmer winter world?

Apple blossoms under snow

# More of our rain is coming in heavy downpours leading to flooding




Updated from Groisman *et al.*[113]

# What About Extreme Events?

## 2011Tropical Storms Irene and Lee

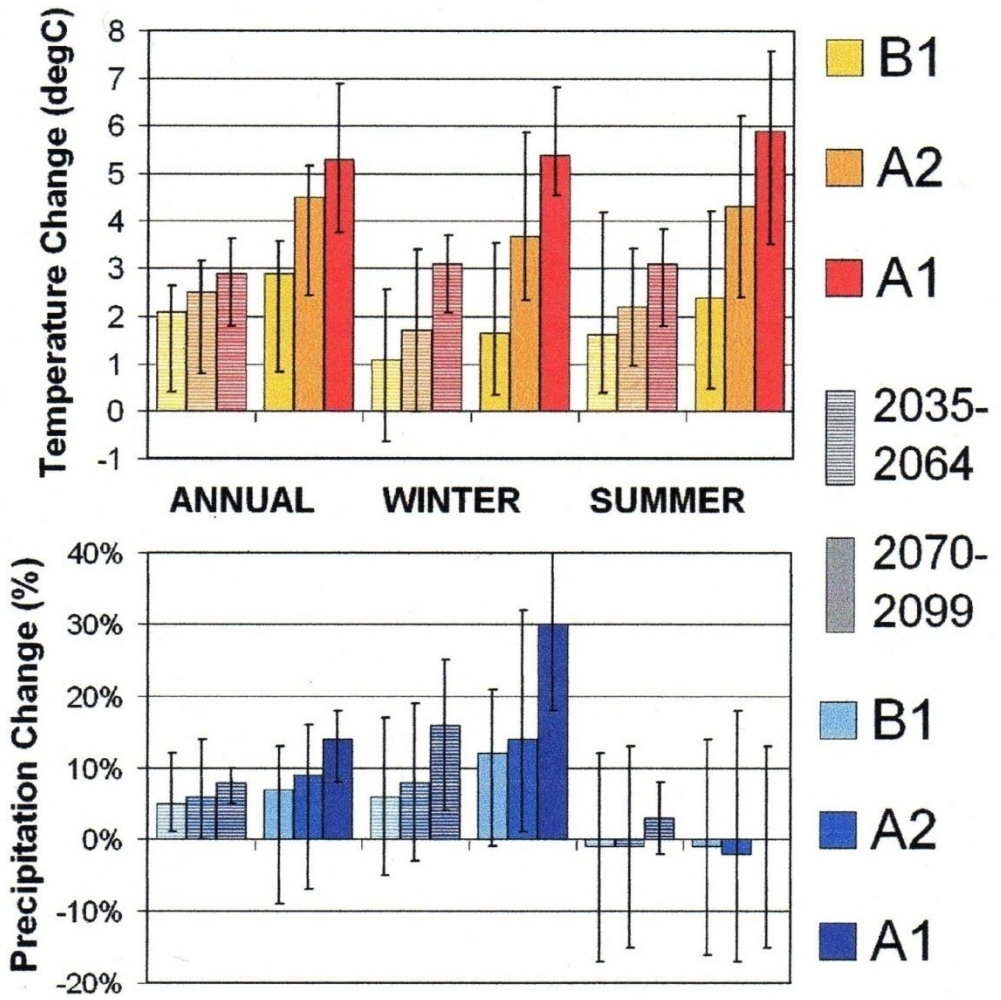
# Yet …More Summer Droughts May Slow Growth:

**-Warmer, longer summers will increase water use by vegetation (potential evapotranspiration)**

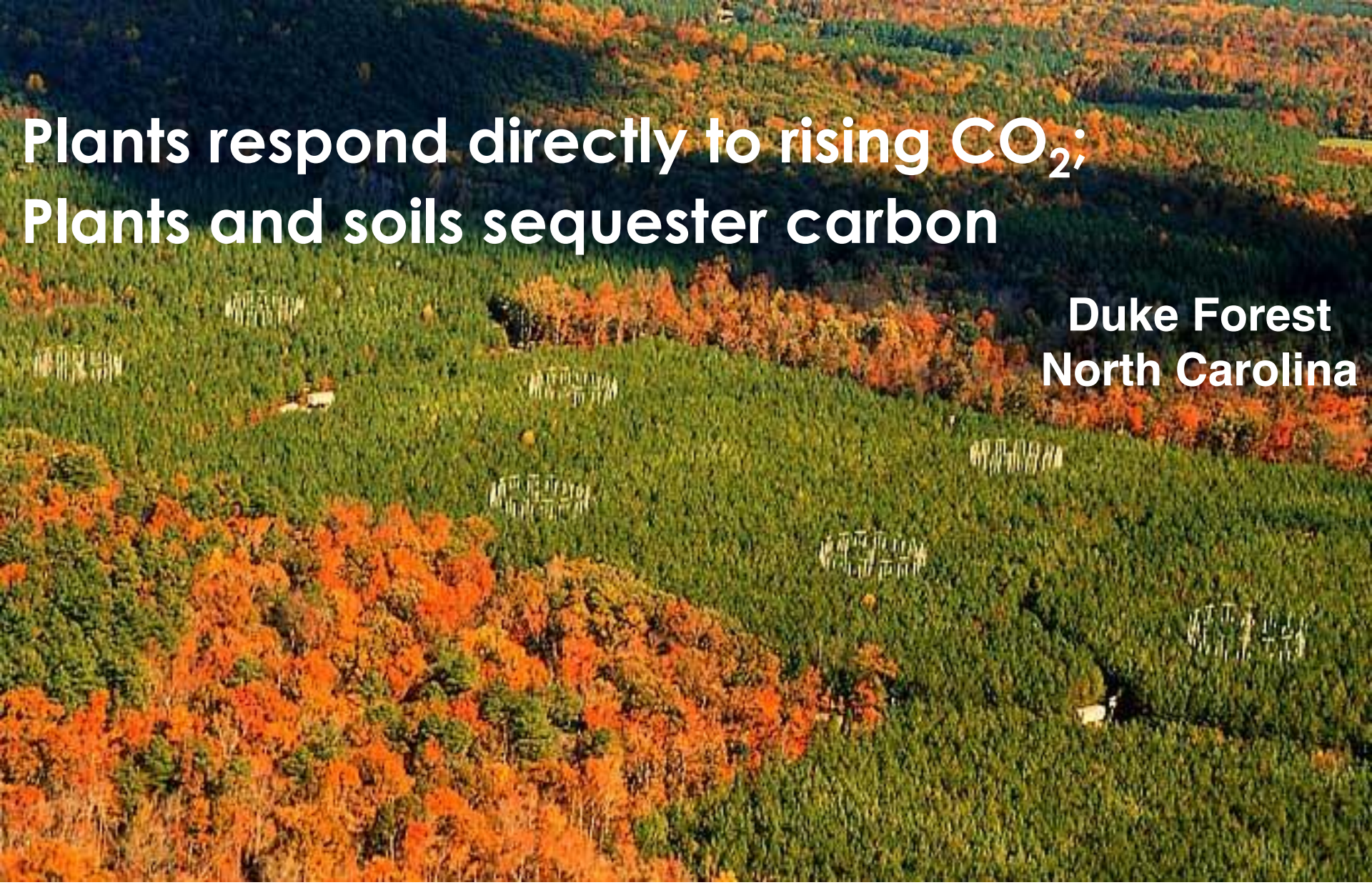
**-Summer rainfall not projected to increase**

Seasonal Temperature

Rainfall




Hayhoe et al. 2007. *Climate Dynamics 28:381-407*


Plants respond directly to rising $CO_2$;
Plants and soils sequester carbon
Duke Forest
North Carolina

# Many plant species respond positively to rising $CO_2$, but not all plants are equally desirable

**Poison ivy growth increase at Duke FACE ring = +149%, and more allergenic.**

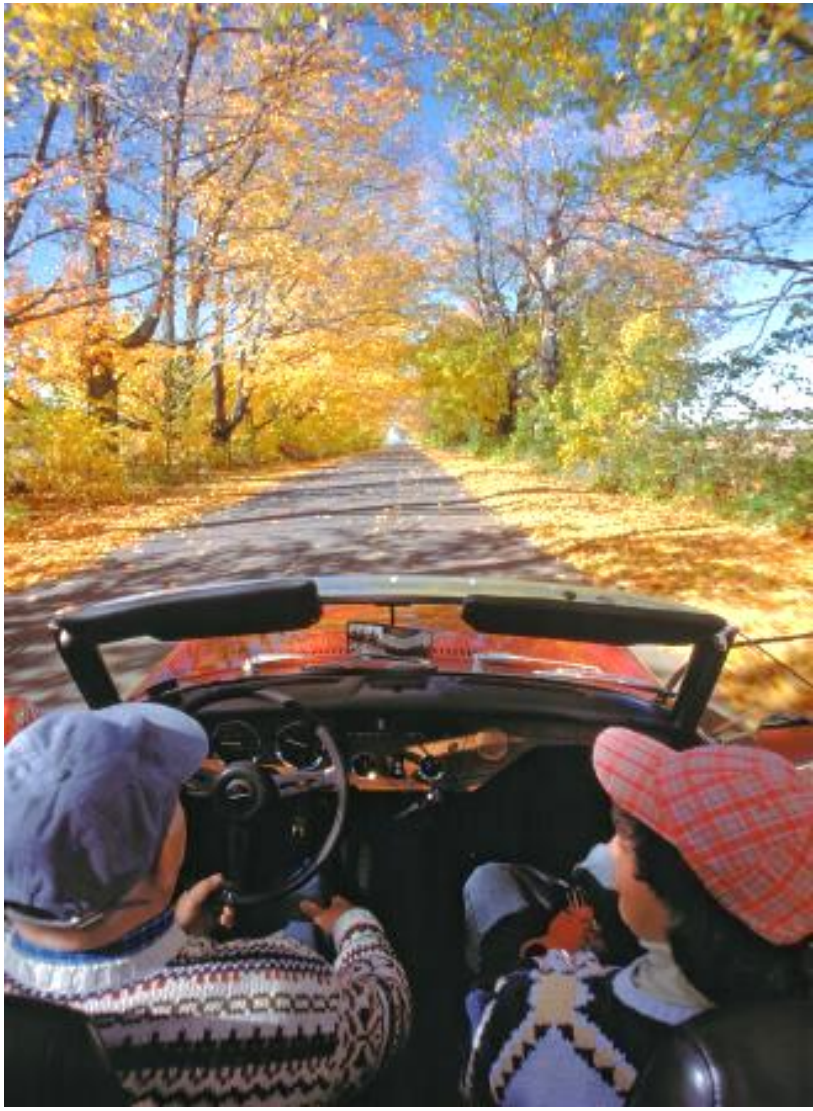
(Mohan et al. 2006. Proc. Nat. Acad. Sci. 103(24): 9086-9089).

# And high $CO_2$ reduces herbicide efficacy

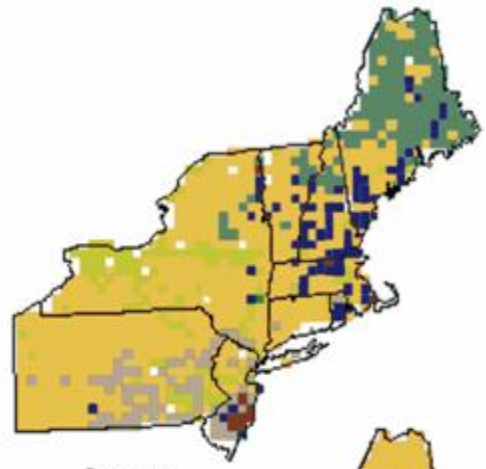
**Ambient $CO_2$** **Future $CO_2$**

(Ziska et al. 2004 Weed Sci 52:584-588; Ziska et al. 1999. Weed Sci 47:608-615.)

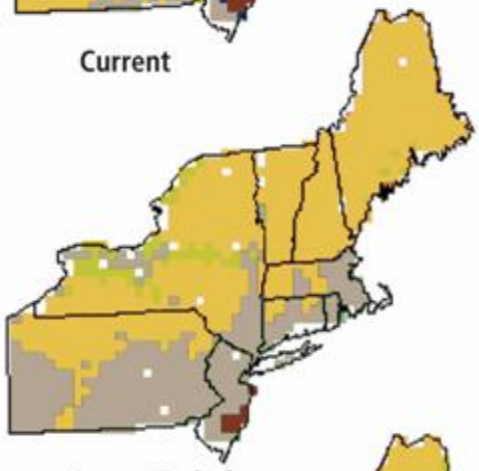
# Climate change will forever alter the fabric of our forests and other natural landscapes…



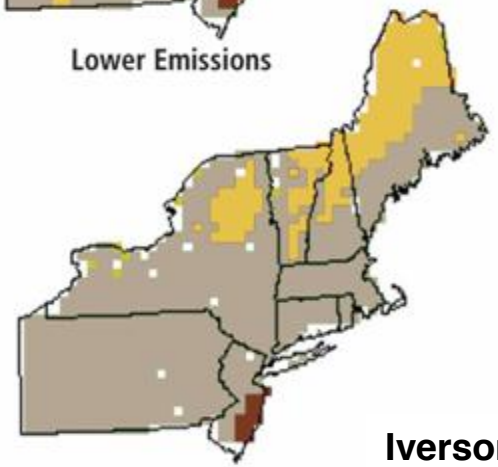
…with implications for ecosystem “services”



Current



Lower Emissions



Higher Emissions

Source: NECIA, 2007 (see: www.climatechoices.org/r

Spruce/Fir

Maple/Beech/Birch

Oak/Hickory

Elm/Ash/Cottonwood

Loblolly/Shortleaf Pine

Iverson et al. 2008. *MITI.* 13:487-516.

# Ecosystems will be disassembling and re-assembling in new ways.

Will species be able to move and adapt to climate change?

Do we manage for stability, or facilitate change?

What is an invasive species in this context?

# Species in NY with potential for substantial % change

**Losing suitable habitat**

- Red maple
- Sugar maple
- White ash
- American beech
- Black cherry
- Eastern hemlock
- Eastern white pine
- Quaking aspen
- Yellow birch
- Balsam fir, red spruce

**Gaining suitable habitat**

- White oak
- Black oak
- Chestnut oak
- Eastern redceder
- Flowering dogwood
- Honey locust

Iverson et al. 2008. *Mitigation Adaptation Strategies Global Change* 13:487-516.

## For gardeners and farmers. . .

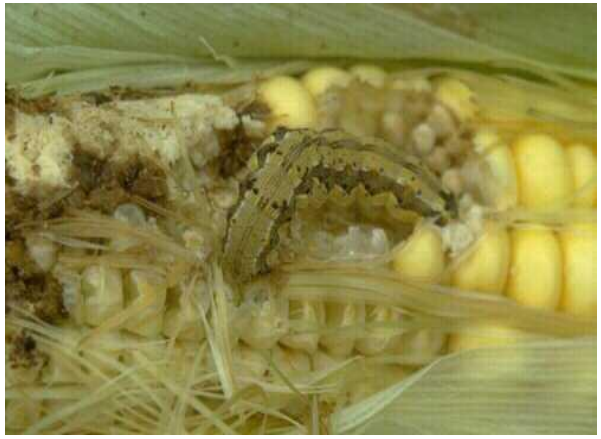
### Climate change might allow exploration of new species and varieties,

**but will also bring with it increased weed, disease, and insect pressure, damaging summer heat stress, and new challenges for water management**

# Warmer winters in NE = more pest pressure

Many insects benefit: better overwinter survival; more generations per season; northward expansion of range

**Flea beetle**

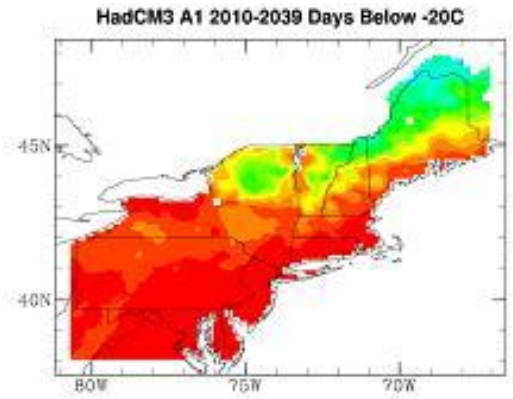
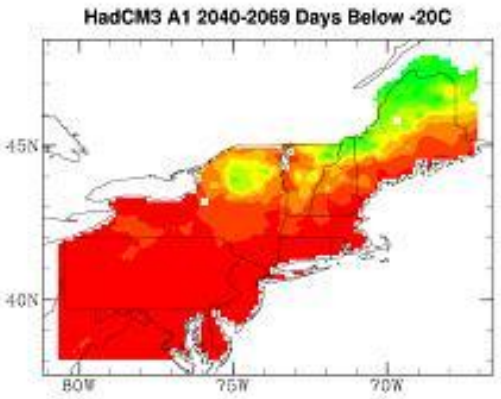
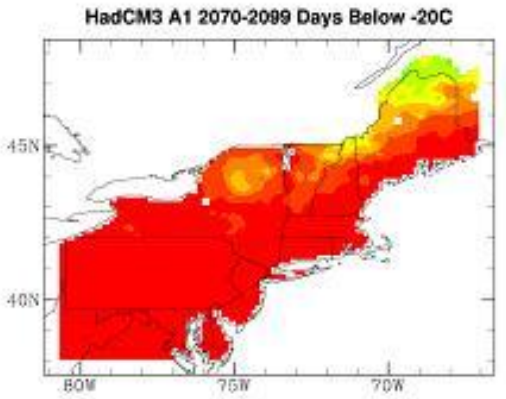
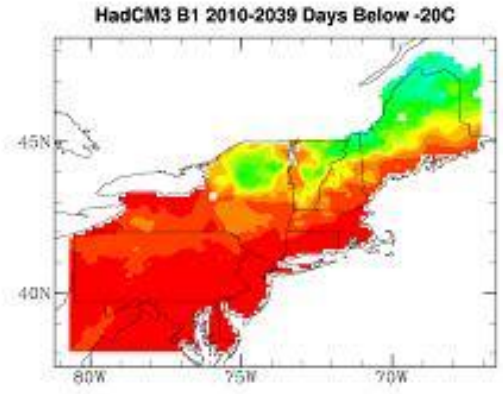
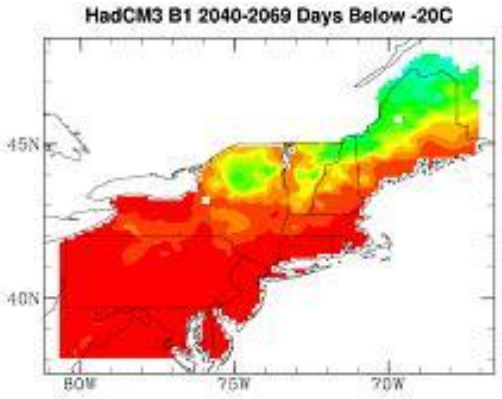
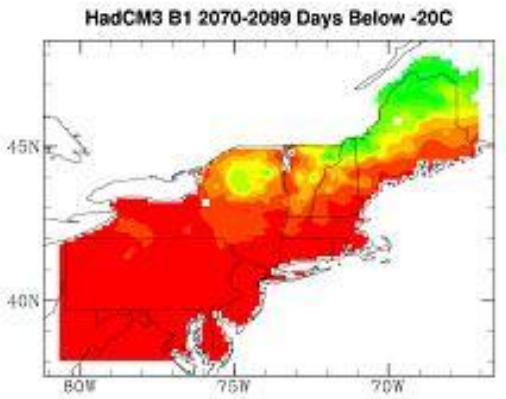


**Corn earworm**

Invasive weeds benefit

**Kudzu**

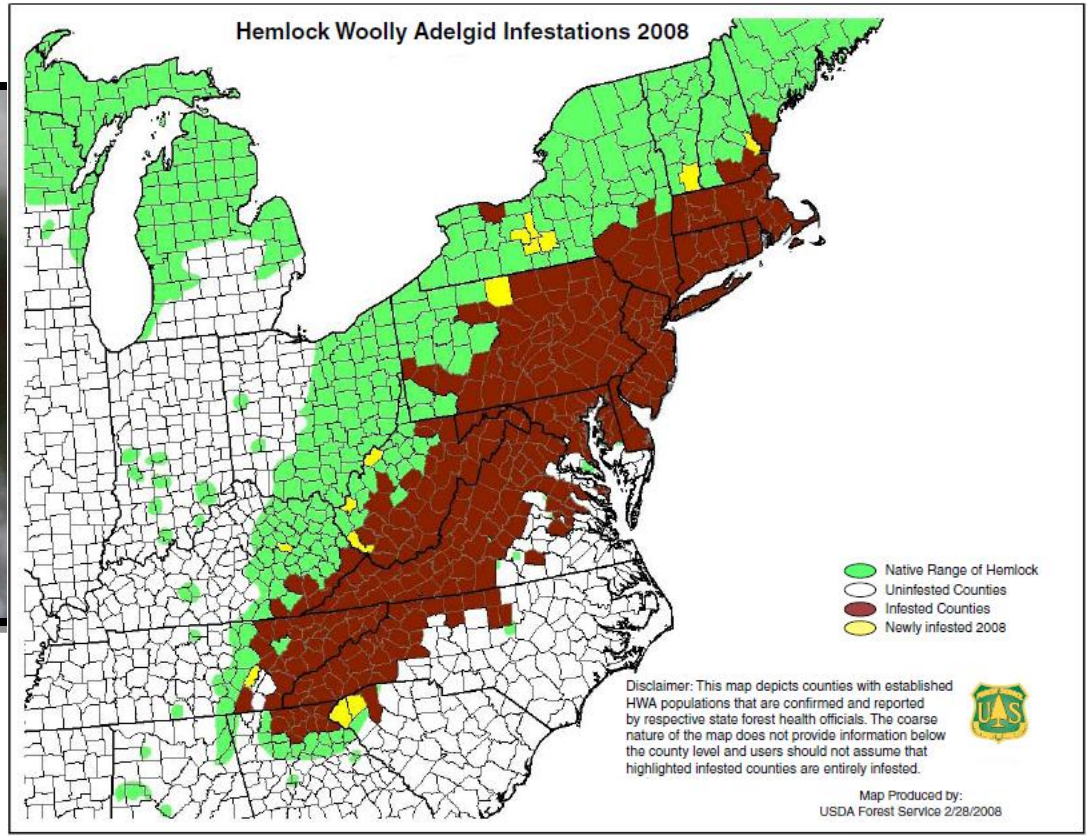
# Days Below -4 F
## (dark orange= potential spread of Kudzu range)

| | 2010-39 | 2040-69 | 2070-99 |
|---|---|---|---|
| "Business as usual" |  |  |  |
| Lower emissions |  |  |  |



**Wolfe et al. 2008. *Mitgation Adaptation Strategies Global Change* 13:555-575.**

# Hemlock Wooly Adelgid is Moving Northward



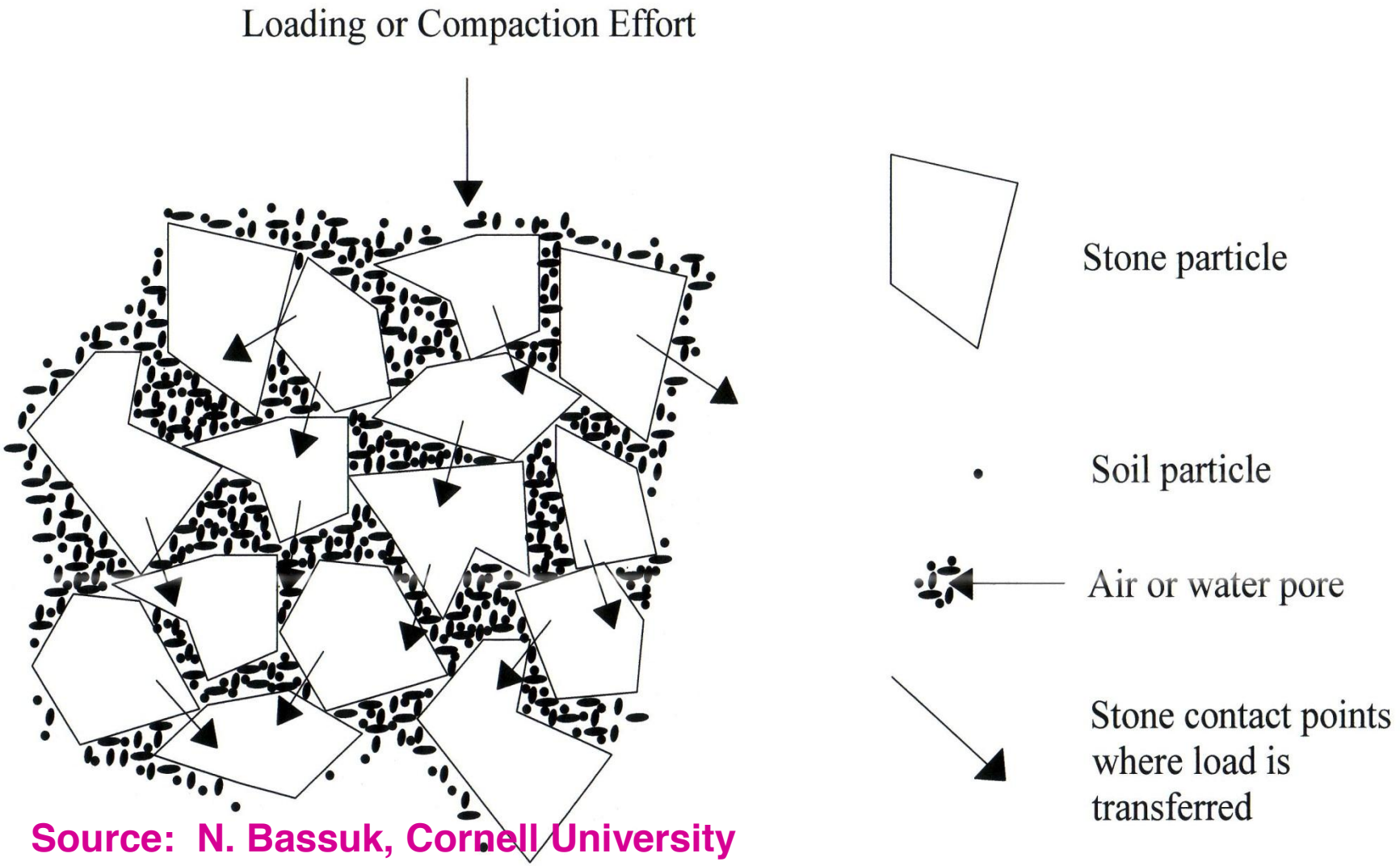
# Adapting to Climate Change

- Plant selection- diversification- experimenting with new species and varieties tolerant to new weather extremes, able to take advantage of longer growing season
- Earlier planting dates
- More vigilant weed and pest monitoring and control
- Improved water management
  - Build healthier soil with more organic matter for better water holding capacity, better drainage
  - Increase irrigation capacity
  - Drainage systems
- Frost and freeze protection:
  - Freeze blankets
  - Mist irrigation
  - Modify pruning timing and severity

# Landscape Adaptation

Required compaction prior to laying pavement.

# "Structural Soil" allows required compaction AND good drainage and root penetration

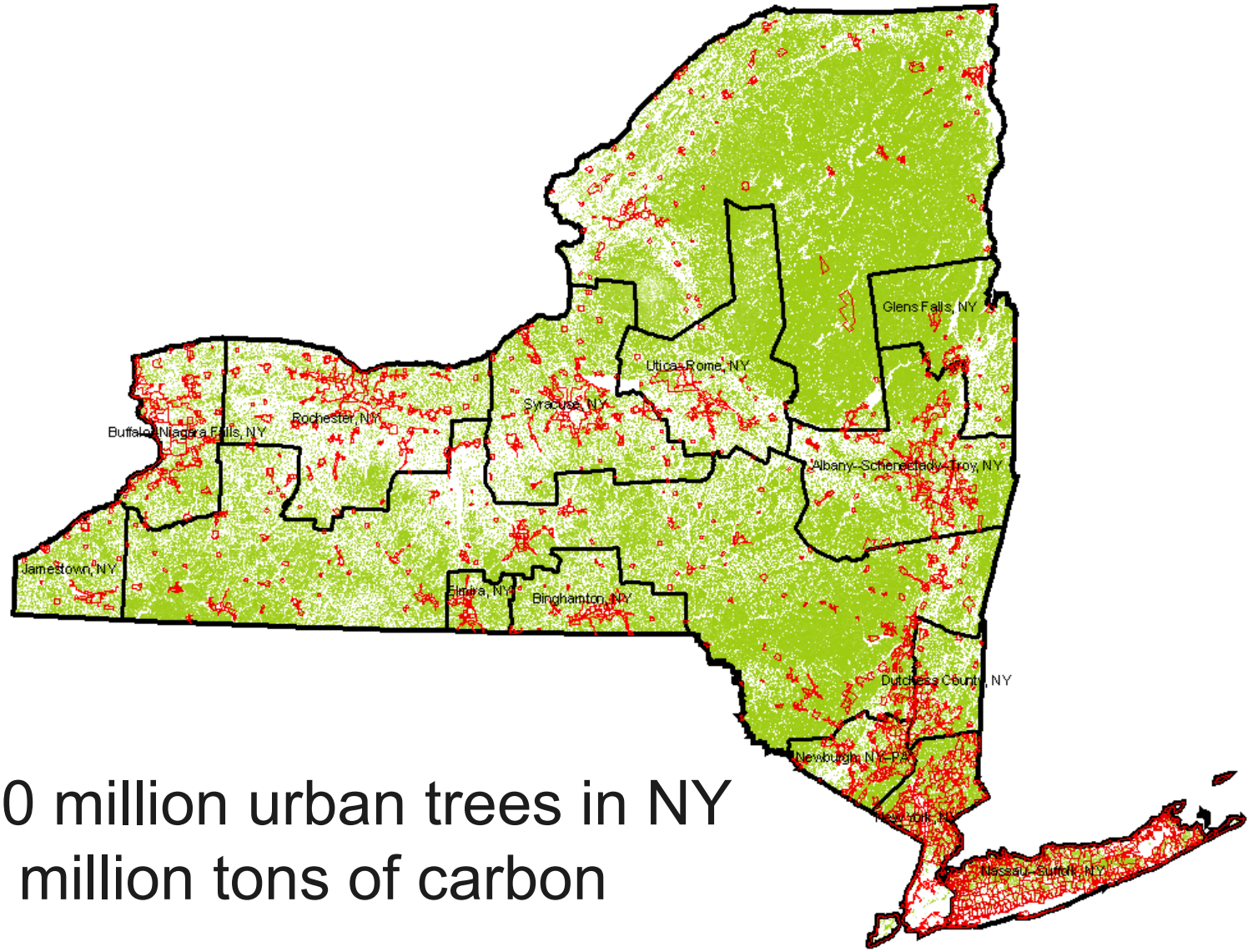



Source: N. Bassuk, Cornell University

# Growing a Greener Garden
## (Mitigation: Becoming Part of the Solution)

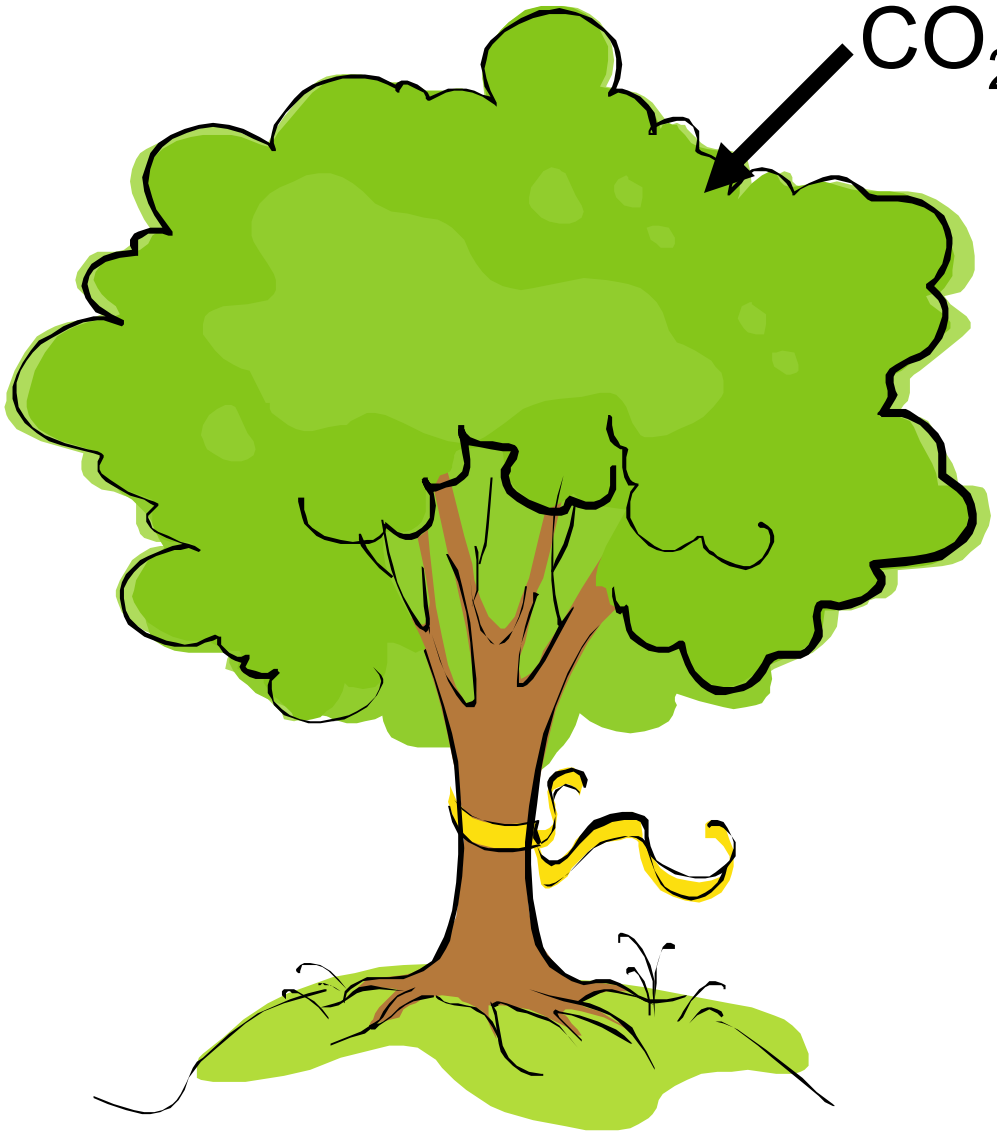
## Plant a tree?

# Urban and Community Trees

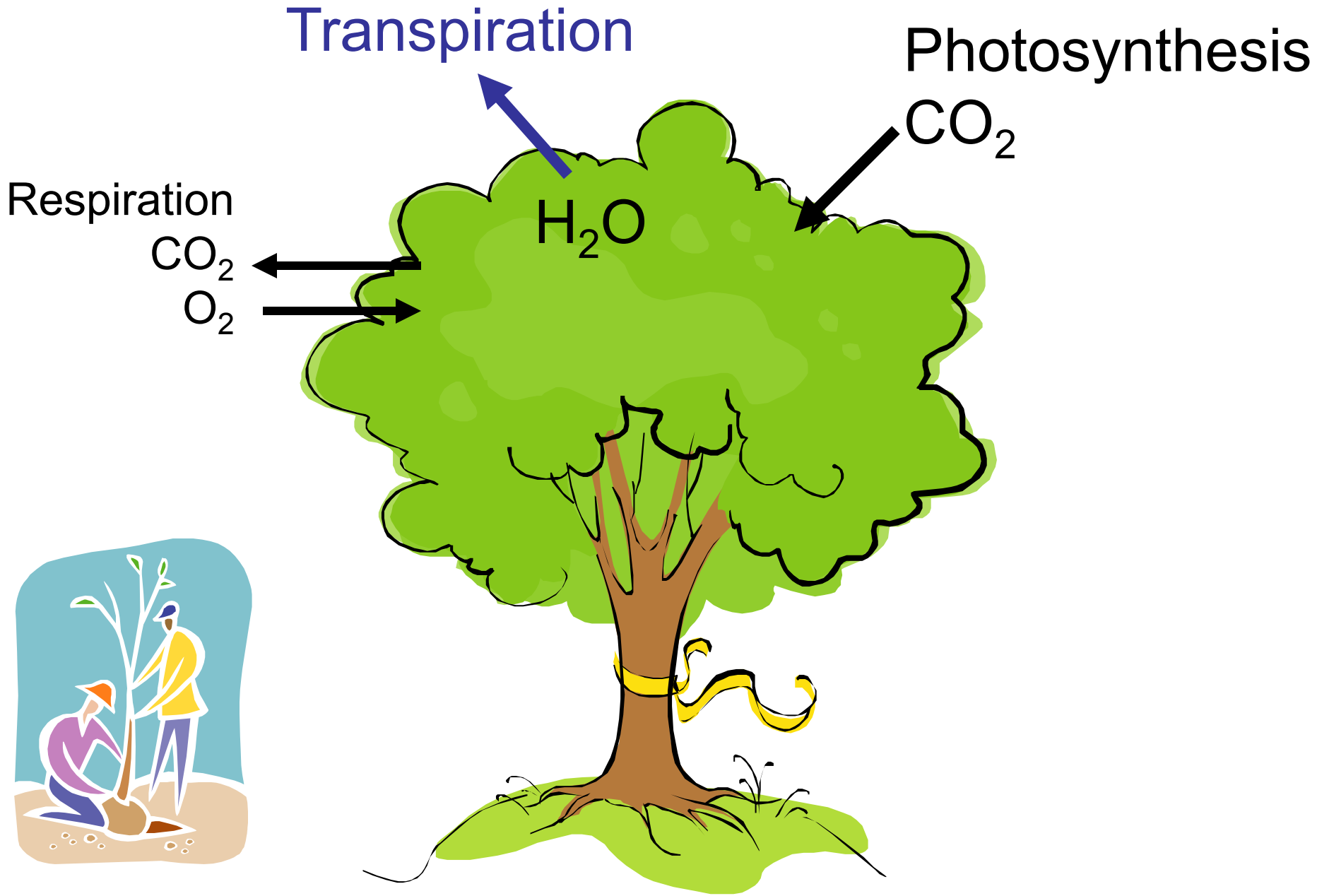



300 million urban trees in NY
47 million tons of carbon

# Plant a tree?

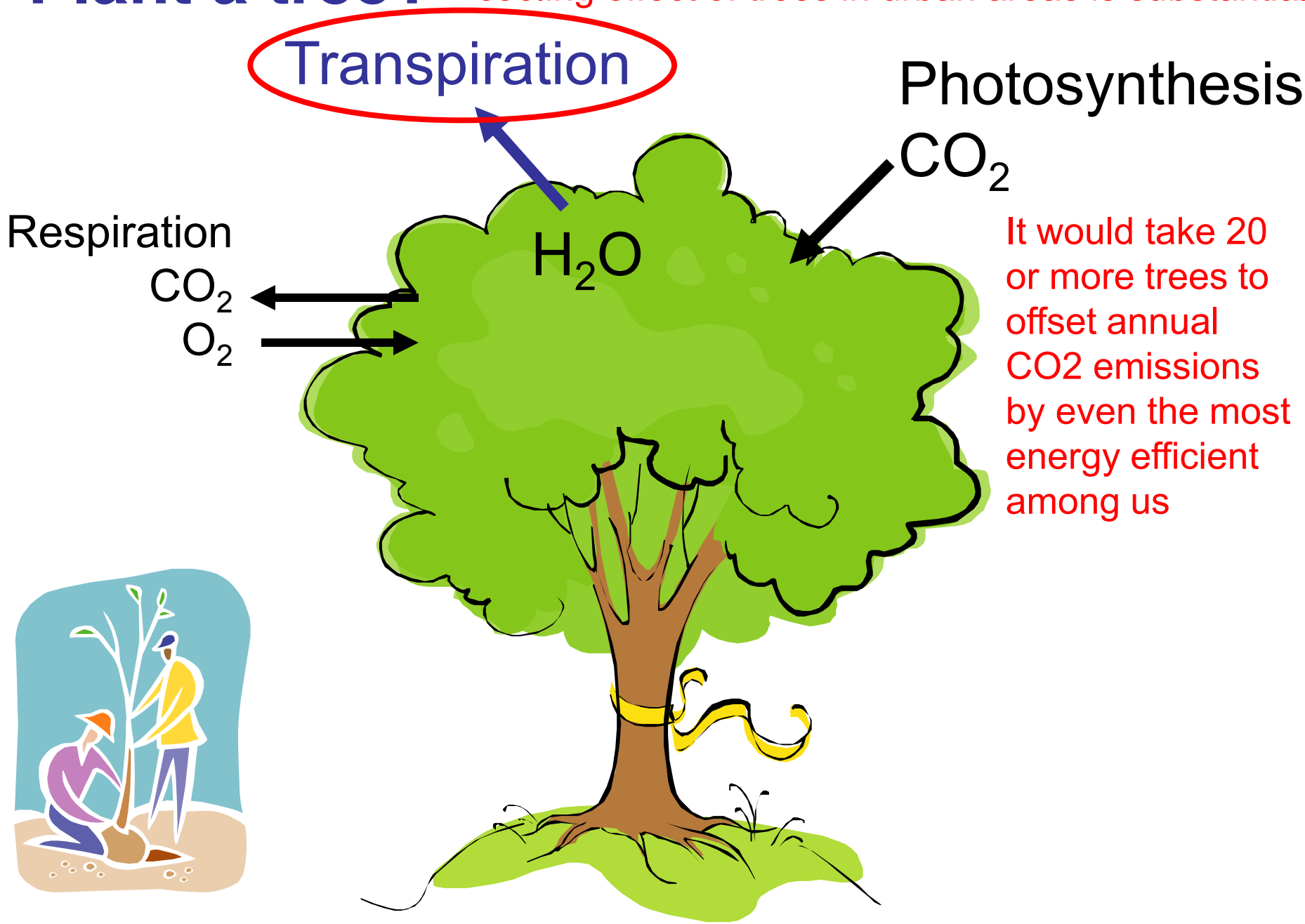


# Plant a tree?



# Plant a tree?

Offset greenhouse gas emissions due to the cooling effect of trees in urban areas is substantial




It would take 20 or more trees to offset annual CO2 emissions by even the most energy efficient among us

# Growing a Greener Garden
## (Mitigation: Becoming Part of the Solution)

- **Plant trees (and other perennials) in the garden (cools the environment , reducing human energy use, and sequesters carbon in above- and below-ground biomass)**
- **Do *less* to do *more*…**
  - **Reduce frequency and intensity of tillage (increases organic matter and thus C in soil)**
  - **Reduce and improve efficiency of N fertilizer use**
  - **Mow the lawn less often (reduces fossil fuel use, allows grass to grow deeper roots and accumulate more C**
  - **Reduce use of fossil fuels and replace with renewables**
  - **Reduce use of disposable products like plastics**
- **Grow, consume and buy local foods in season**

# Nitrogen (N) Management and Greenhouse Gases

-Synthetic N fertilizers are <u>energy-intensive to produce</u>

- <u>All</u> N fertilizers (including manure and other organic sources) give off <u>nitrous oxide</u> ($N_2O$), a potent greenhouse gas, as they degrade in soils

- N management is often inefficient

# Excess Nitrogen in the Environment: homeowners are a big contributor

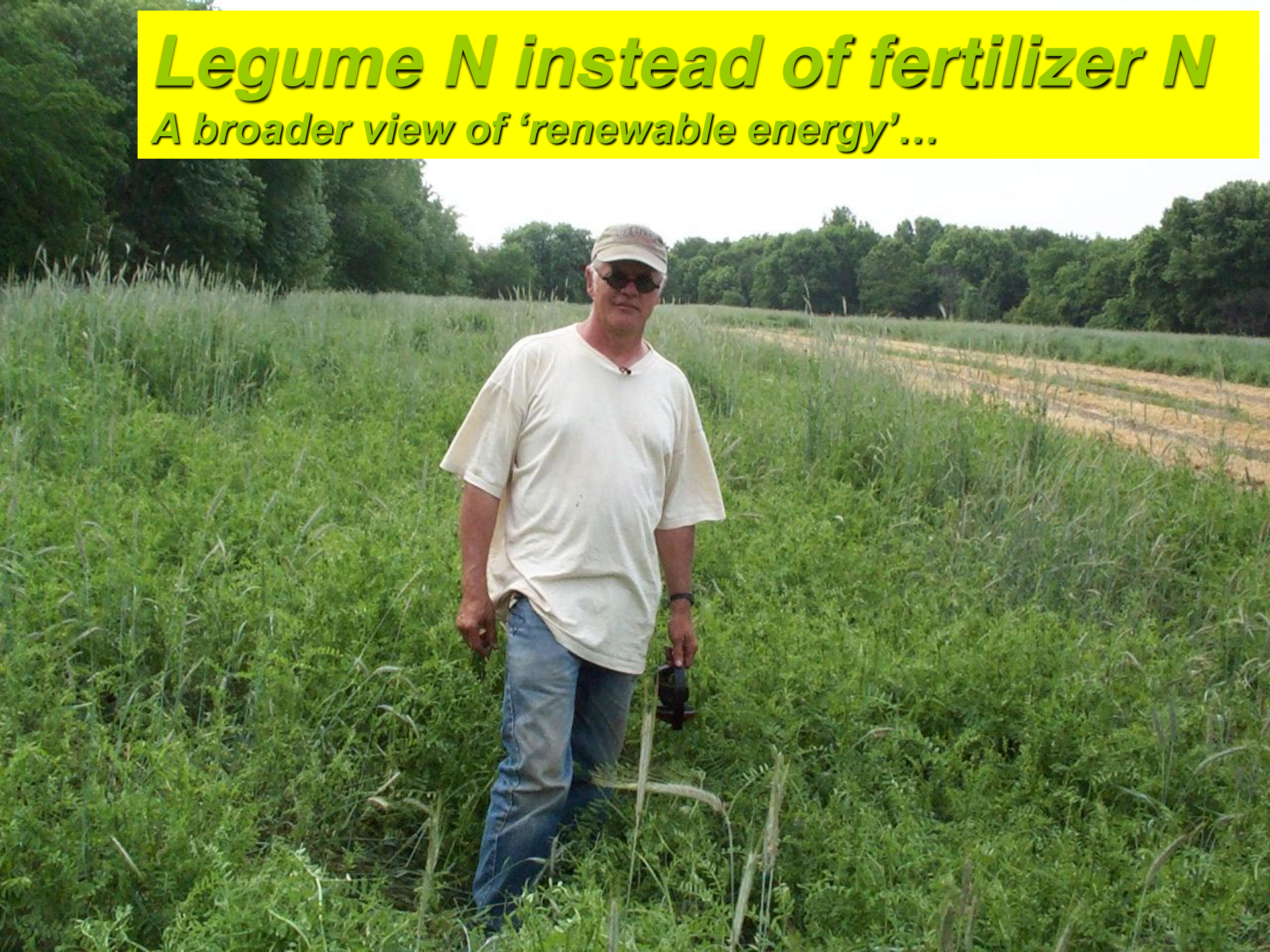
**There are over 3 million acres of lawn in New York state alone!**

# Improving N Use Efficiency for Lawns

- Select grasses with relatively low N requirement (e.g., fine fescues over Kentucky Blue Grass)
- Consider clover (legume) mix
- Mow high ($\geq$ 3 inches) to promote root growth
- Recycle lawn clippings
- Use organic N sources
- Urea is preferable to ammonium sulfate or ammonium nitrate
- Healthy mature lawns, shaded areas, may only need 2 applications per year (early summer and late fall) and lower annual rate (e.g., 1 lb N/1000 sq ft.)

# Legume N instead of fertilizer N

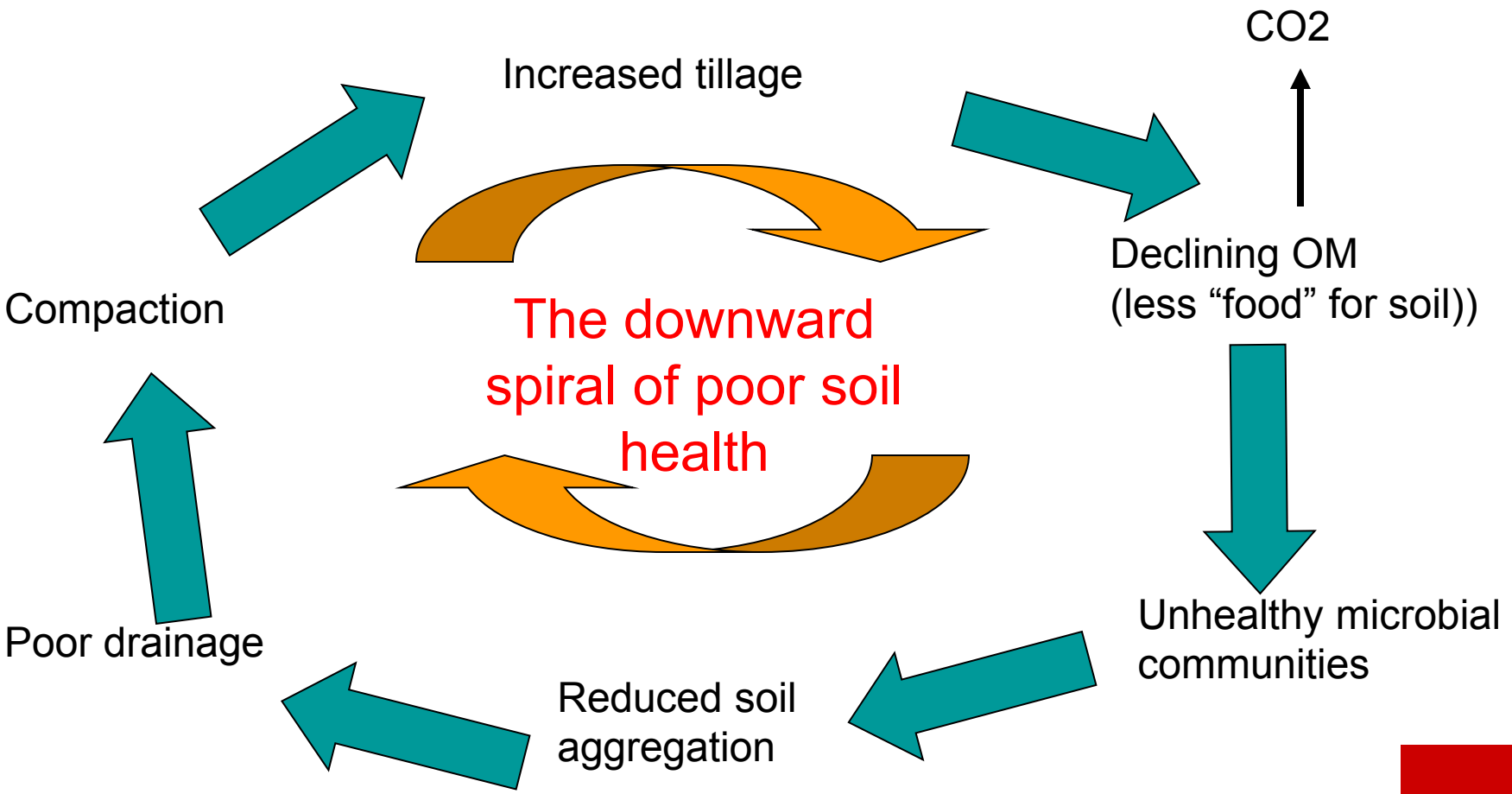
## A broader view of 'renewable energy'…




The Energy-Waste Management Challenge:
Re-coupling animal and crop production systems
to re-cycle nitrogen, carbon, energy

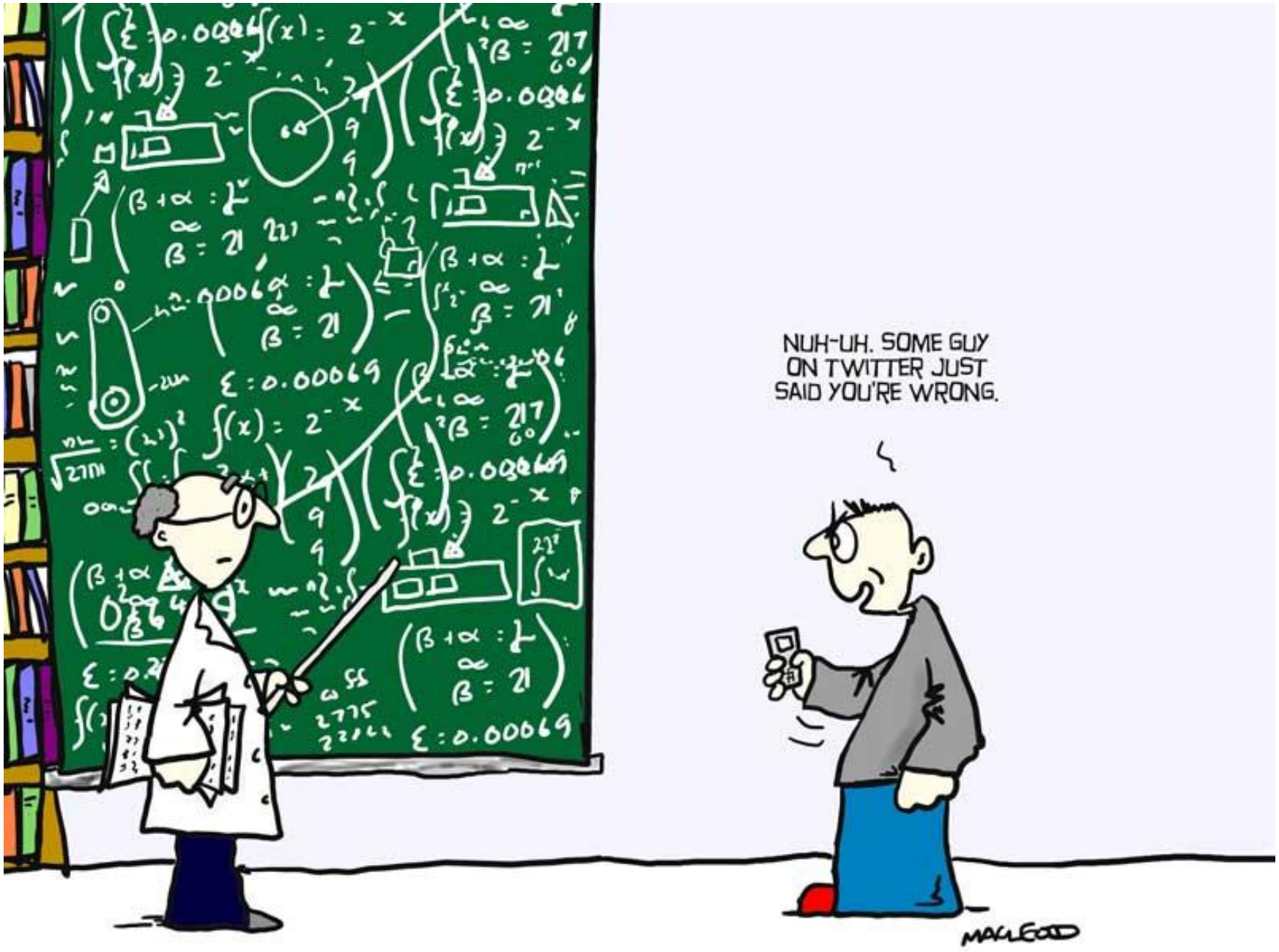
# Tillage, Soil Health, and Carbon

Assessing the whole soil system

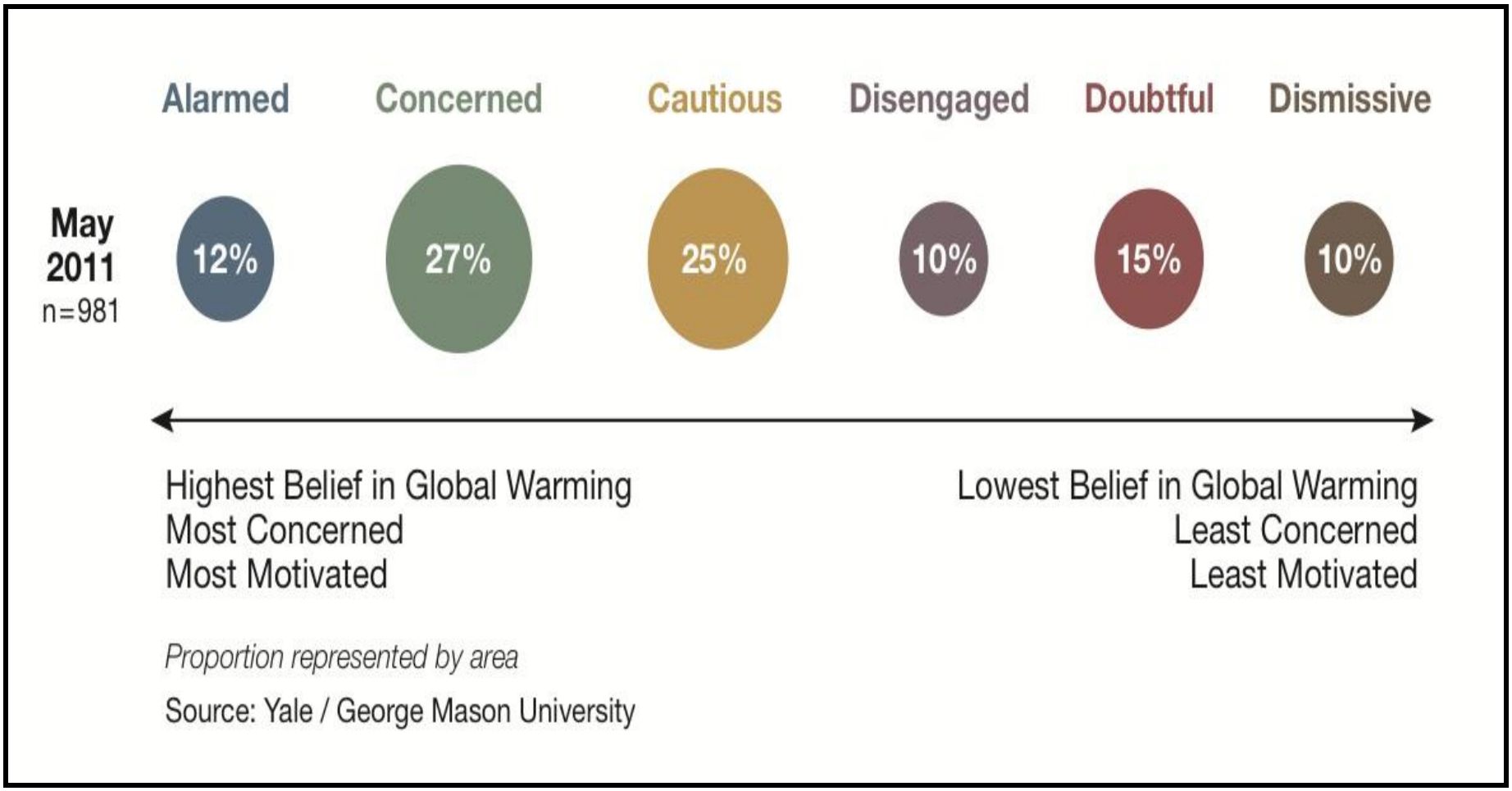



CORNELL

# The Communication Challenge


NUH-UH. SOME GUY ON TWITTER JUST SAID YOU'RE WRONG.
MACLEOD

# Global Warming's Six Americas



# Concluding Remarks

- **The pace of change today and projected for this century is such that we cannot rely on historical records to tell us what to expect from the weather, and what plants to grow.**
- **Longer growing seasons and shifts in hardiness zones will allow gardeners to explore new species and varieties, but some long-time favorites may no longer be suitable to the shifting climate.**
- **Insect, weed and disease pests will be changing and more difficult to control**
- **Water management will be more challenging with threats for more short term flooding and summer drought.**
- **There are many things gardeners can do to lead the way in climate change adaptation and mitigation.**

# Thank you!

## Collaborators

Jonathan Comstock
Art Degaetano
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Alan Lakso
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Curt Petzoldt
Abby Seaman
Vern Grubinger
Lauren Chambliss

## Websites:

www.climatechange.co
www. nyserda.ny.gov/cl
www.sap43.ucar.edu
www.ipcc.ch

USDA United States Department of Agriculture

Northeast Region SARE Sustainable Agriculture Research and Ed

Cornell University Cooperative Extension

NYSERDA New York State Energy Research and Development Authority