

# CLIMATE CHANGE AND ITS EFFECTS ON ECOSYSTEMS

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*H2H Conservation in a Changing Climate*



[www.forestadaptation.org](http://www.forestadaptation.org)

# Northern Institute of Applied Climate Science

Climate

Carbon

Bioenergy

**NIACS is a regional multi-institutional partnership**

## Forest Service

- Northern Research Station
- Eastern Region
- Northeastern Area S&PF

## Non-FS partners

- Michigan Technological University
- National Council for Air & Stream Improvement
- Trust for Public Land



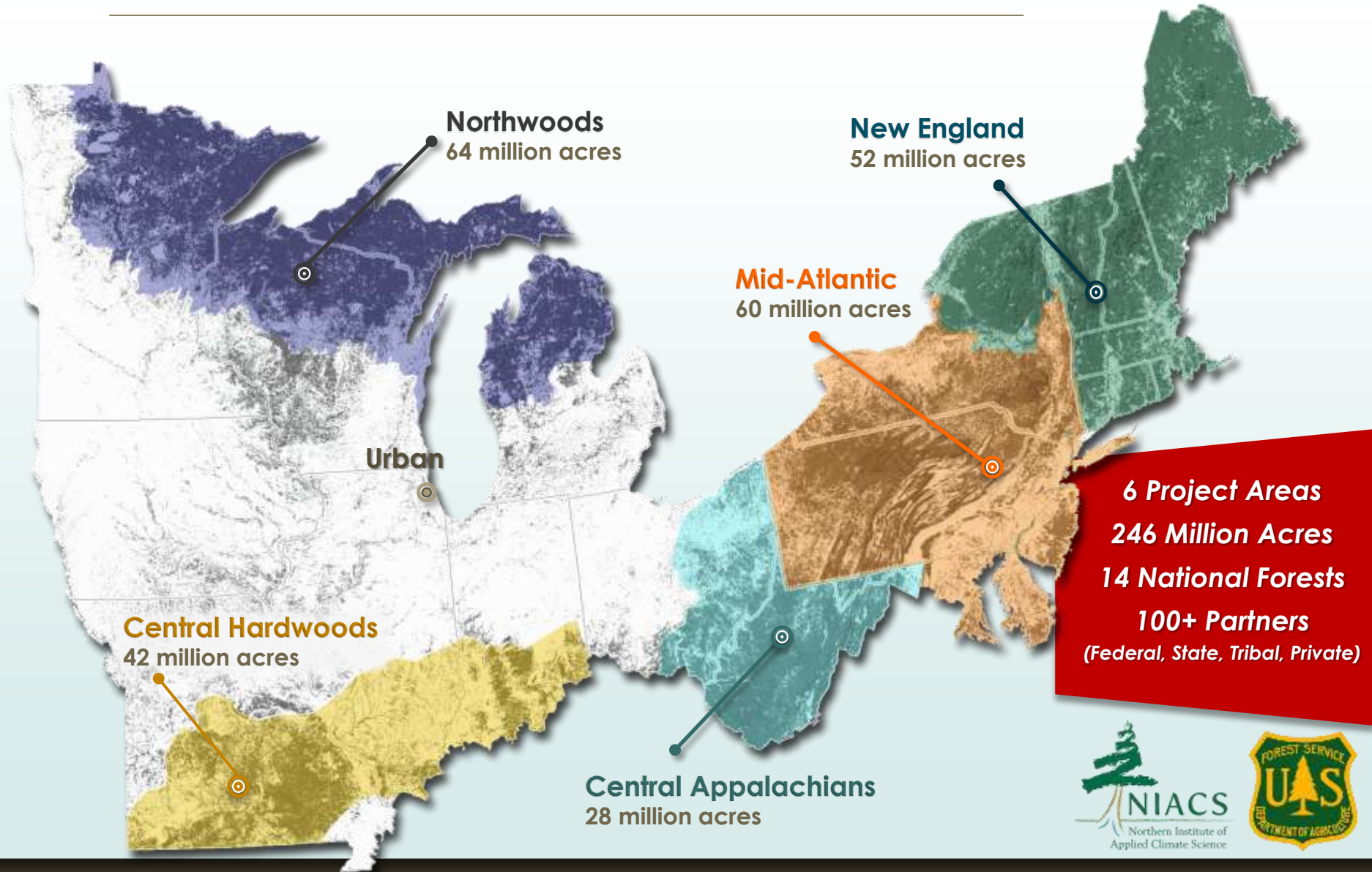
[www.nrs.fs.fed.us/niacs/](http://www.nrs.fs.fed.us/niacs/)



**Michigan Tech**  
**ncasi**



# CLIMATE CHANGE RESPONSE FRAMEWORK



Climate-Informed  
Conservation and Forest Management

[forestadaptation.org](http://forestadaptation.org)

# Climate Change Response Framework

Structured, process oriented, works on multiple scales

## Components:



Partnerships

Vulnerability Assessment

Forest Adaptation Resources

Adaptation Demonstrations

## Progress:

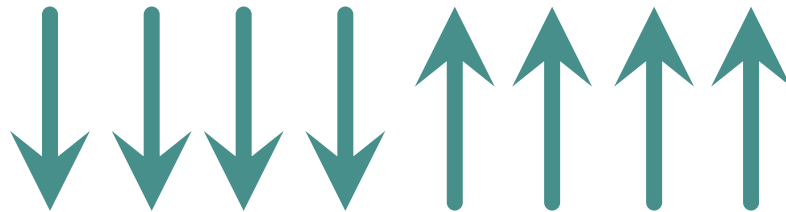
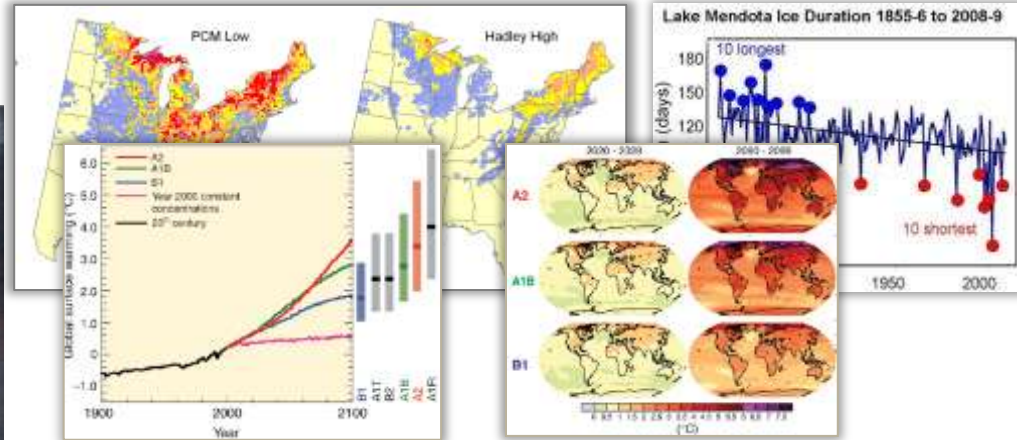
100+ partner organizations  
(and counting)

5 published assessments,  
1 in press, 2 in prep

Published in 2012, updated  
and online versions in prep

60+ demonstrations  
underway

# Applied Climate Science



Scientists still disagree about climate change, right? So who am I supposed to believe?

# Disagreement?

## **Intergovernmental Panel on Climate Change (2007)**

- Evidence for climate change is “unequivocal”
- It is “extremely likely” that humans are major contributors
- Future changes depend partly on human actions

## **18 National Academies have endorse the consensus position in IPCC 2007**

- National Academy of Sciences (USA)
- Royal Society of Canada

# Disagreement?





# Scientists still disagree about climate change, right? So who am I supposed to believe?

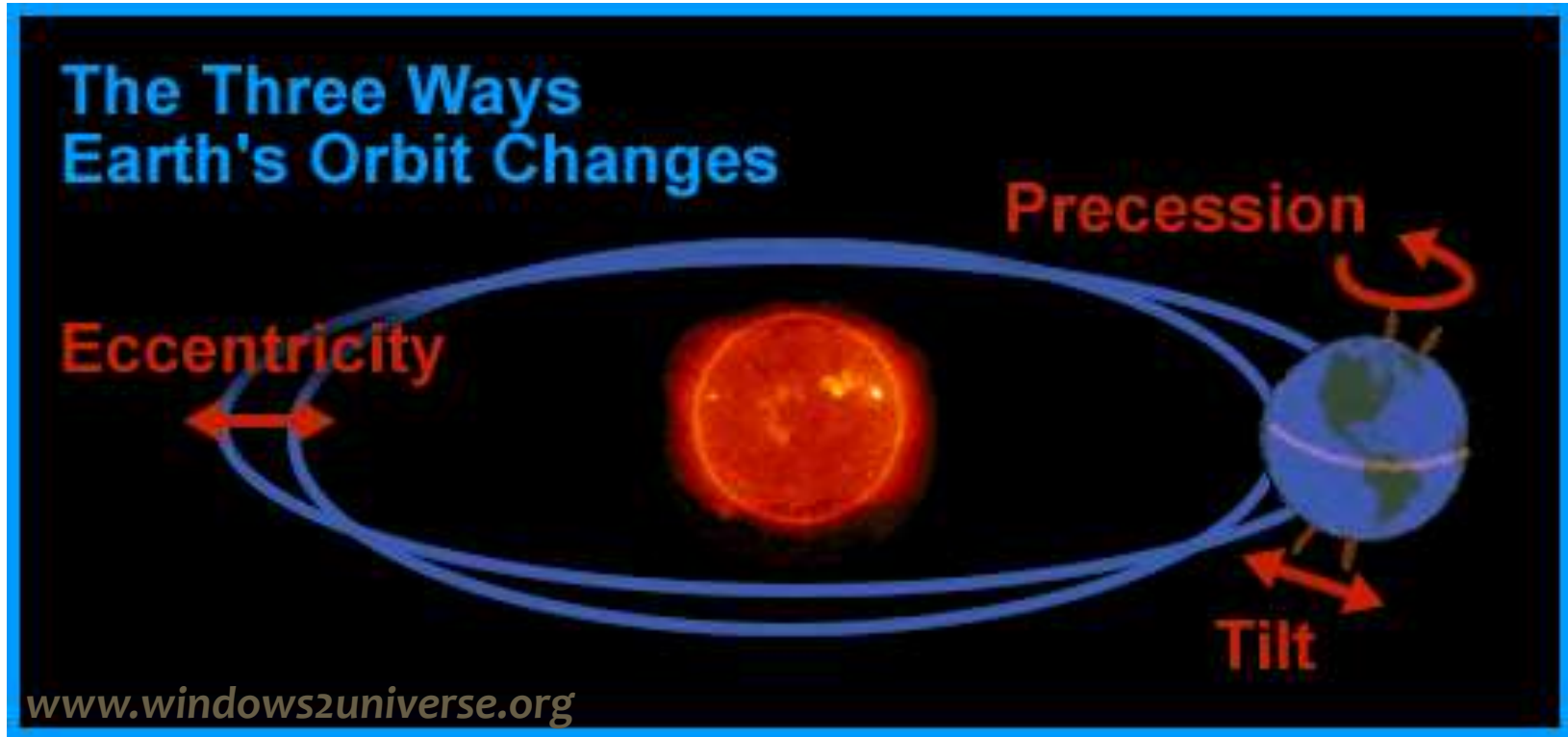
- No scientific debate on “if”.
- Current scientific debate revolves around how much, how fast, and feedback mechanisms.
- Most climate scientists agree humans are a driver.

**A practical risk assessment may be a better strategy than belief.**

Hasn't climate always changed?  
Why worry now?

# Change happens.

## Milankovitch Cycles

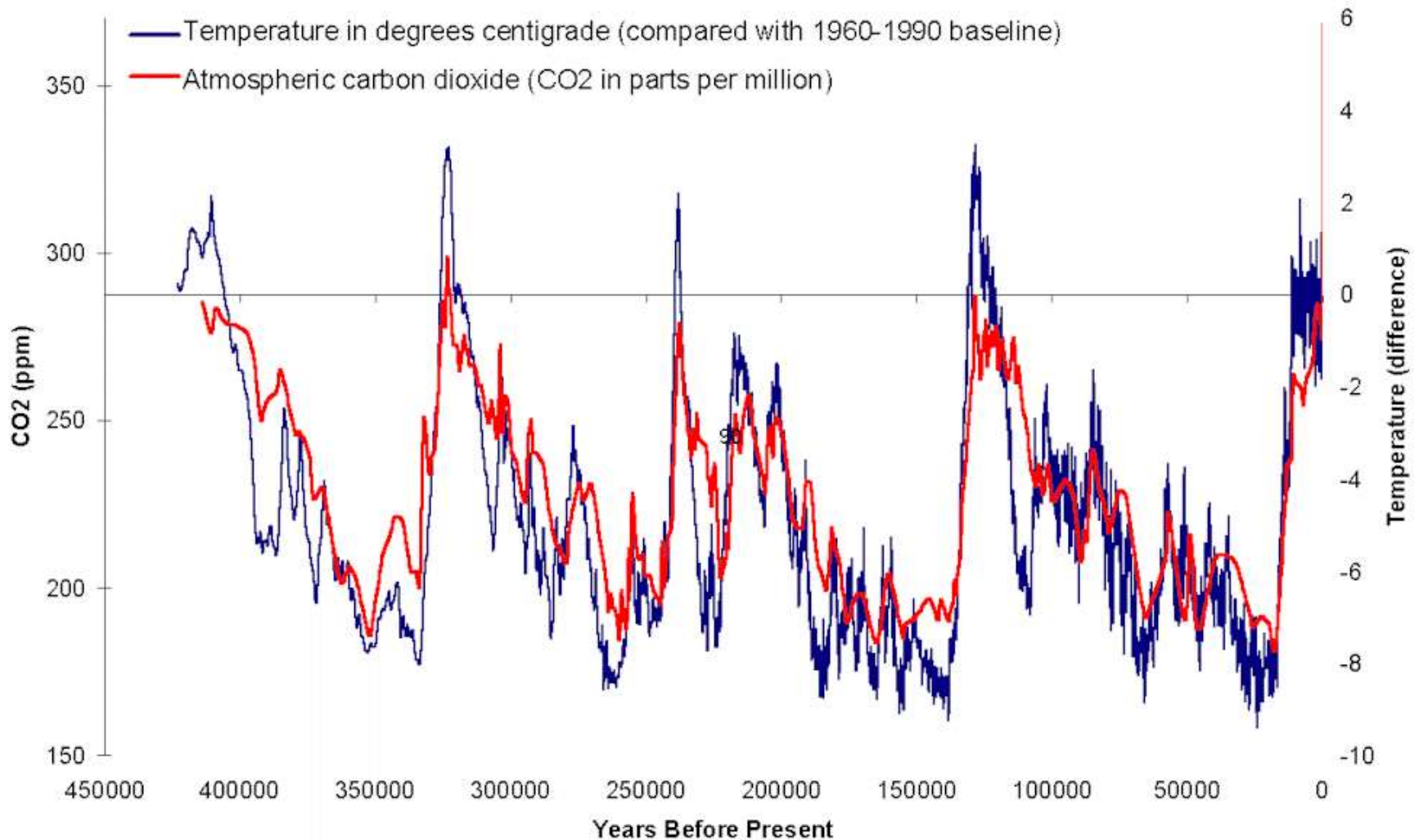


**Eccentricity** – more or less oval orbit, every ~100,000 years

**Precession** – earth wobbles on its axis, every ~23,000 years

**Tilt** – earth shifts its tilt every ~41,000 years

# Change happens.

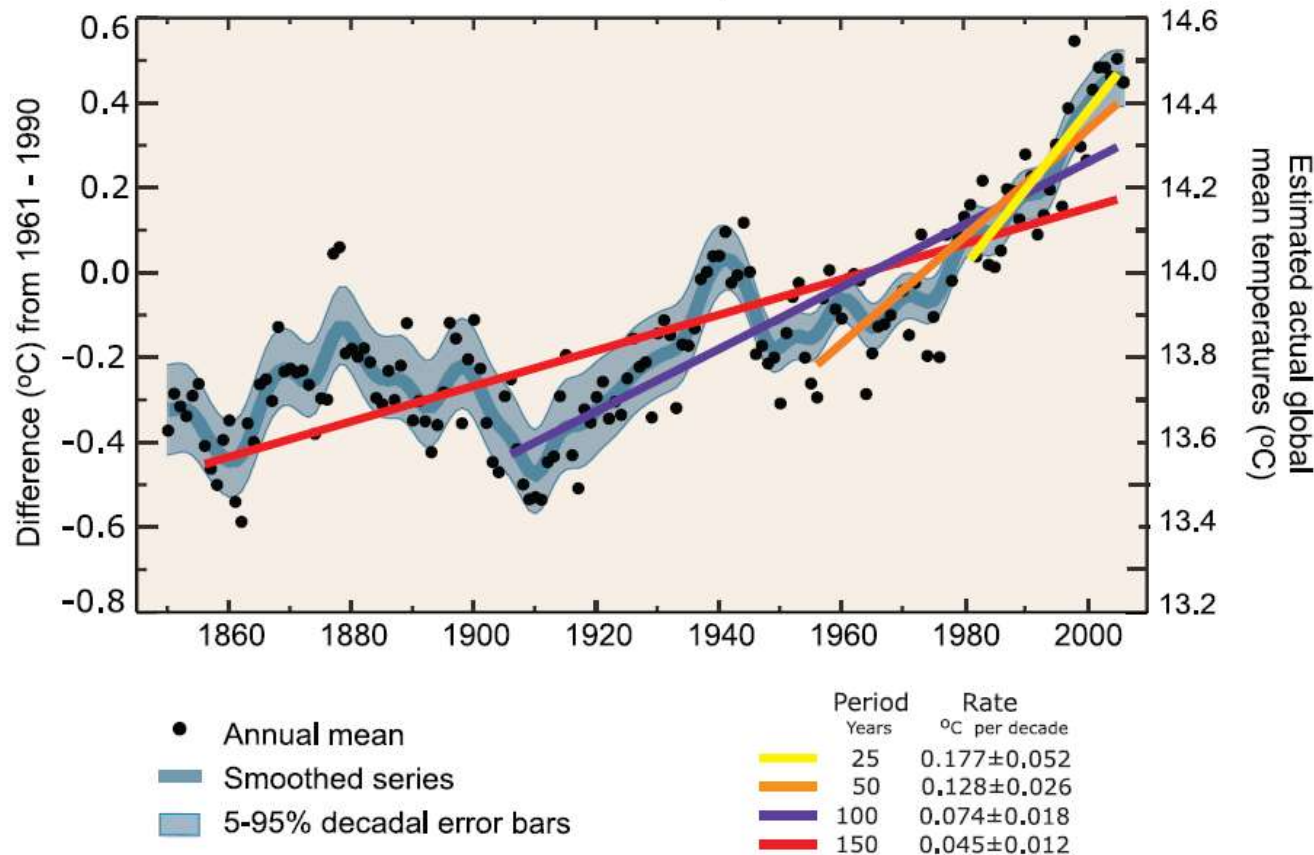


<http://www.brighton73.freeseve.co.uk/gw/paleo/400000yrfig.htm>;

see also: Hansen et al. 1990, Petit et al. 1999, Shackleton 2000, Ruddiman 2006, Shakun et al. 2012

# Change happens.

The average global surface temperature has risen 1.4 °F over the past 100 years



# Hasn't the climate always changed?

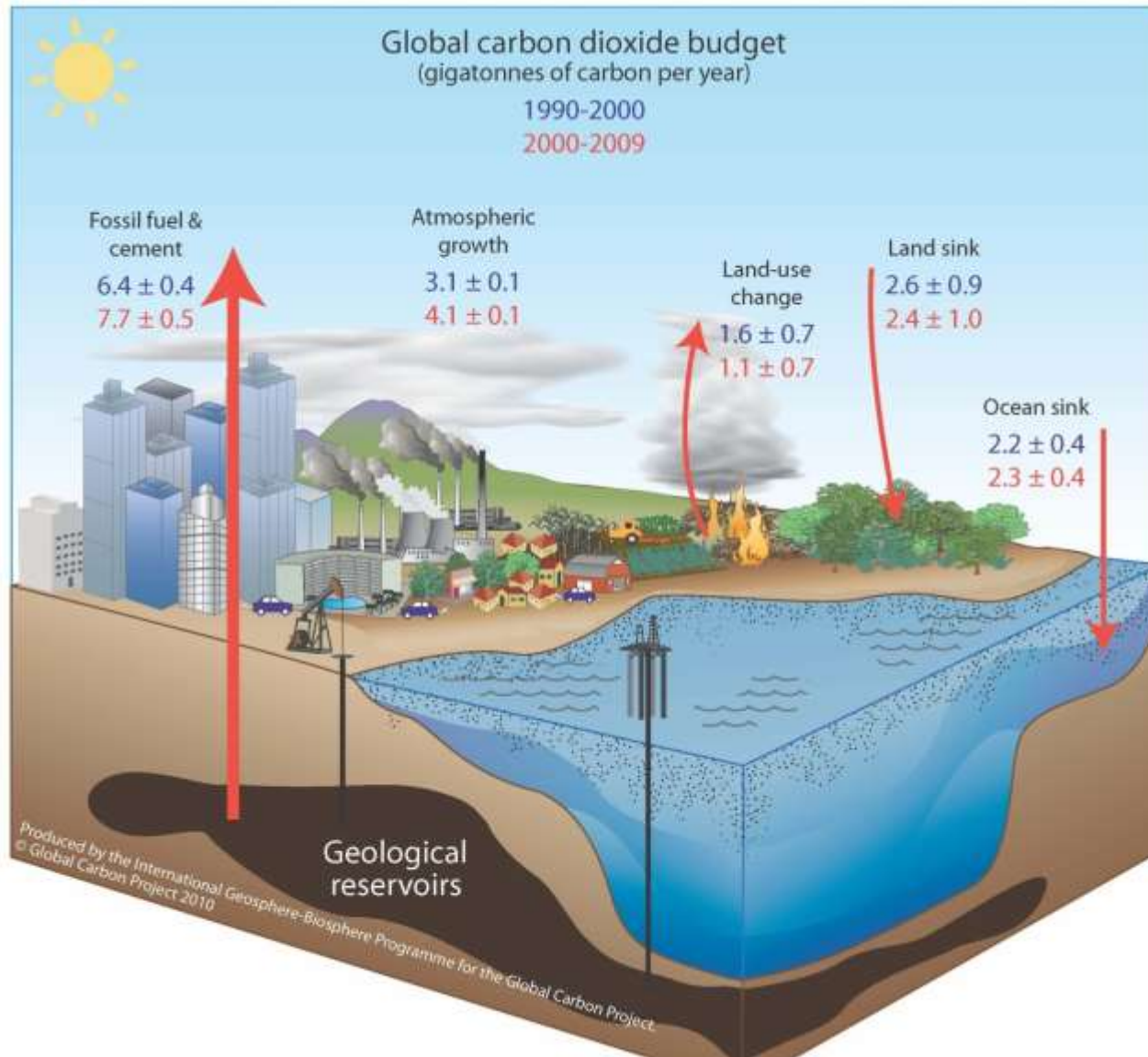
## Why worry now?

- Milankovitch cycles have previously driven climate changes.
- Humans are driving the current change.
- The change is very rapid.

**The rapidity and potential severity of climate change will affect forestry, agriculture, infrastructure, demographics, economies, ... virtually everything.**

The atmosphere is massive, how  
can we actually change it?

# Anthropogenic change?





# Anthropogenic change?

Billion tons of Carbon (GTC)

Soils and Vegetation  
(2300\*)

Permafrost  
(additional 1600)

Annual  
emissions  
● (7.7)

Industrial  
Emissions  
(347‡)

Atmosphere  
(762)

Surface  
Ocean  
(900)

Deep &  
Intermediate  
Ocean  
(37,100)

\*~ 2300 = Vegetation (550±100)  
and soils to 1m (1600-2000).  
Soils to 3m. = 2300.

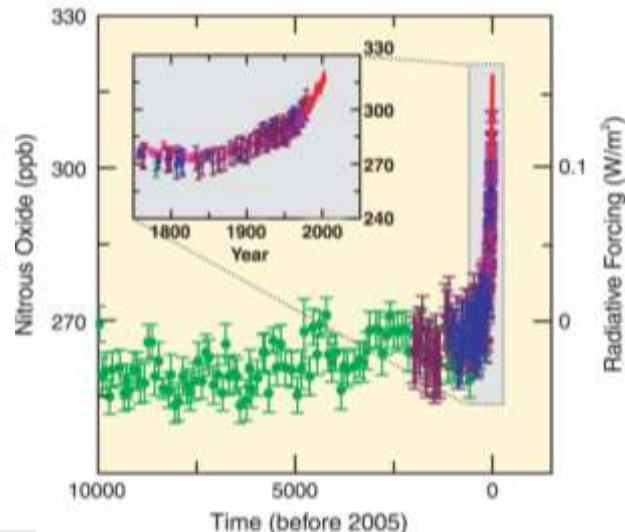
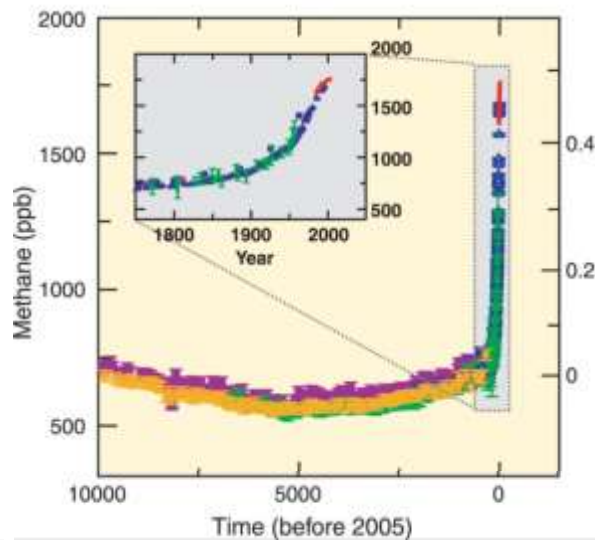
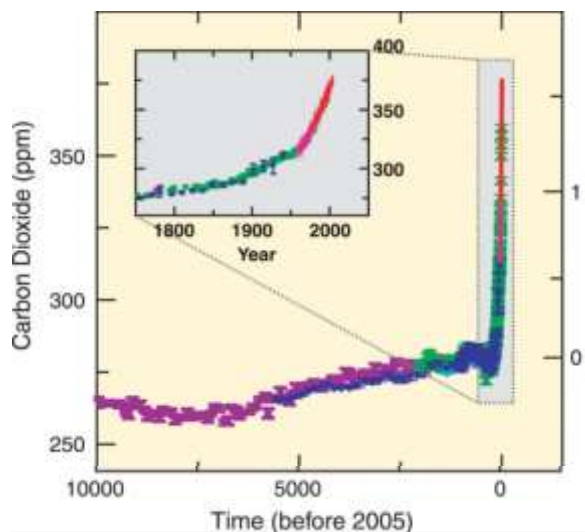
‡ Industrial emissions from  
fossil fuels and cement,  
1751-2008.

Data sources: Boden et  
al. 2011, Friedlingstein  
et al. 2010, Houghton  
2007, IPCC 2007,  
Tarnocai et al. 2009.

*Figure modified from [Climatesafety.org](http://Climatesafety.org)*

# Anthropogenic change?

- Global GHG emissions from human activities increased 70% between 1970-2004
- Emissions of CO<sub>2</sub>, the most important anthropogenic GHG, grew about 80% between 1970 and 2004.



# The atmosphere is massive, how can we change it?

- We move massive amounts of carbon into the atmosphere.
- Fossil carbon is an addition – it has been isolated from the carbon cycle for millions of years.
- Land cover change transfers carbon to the atmosphere.

**The measurement record clearly shows our additions to the atmosphere.**

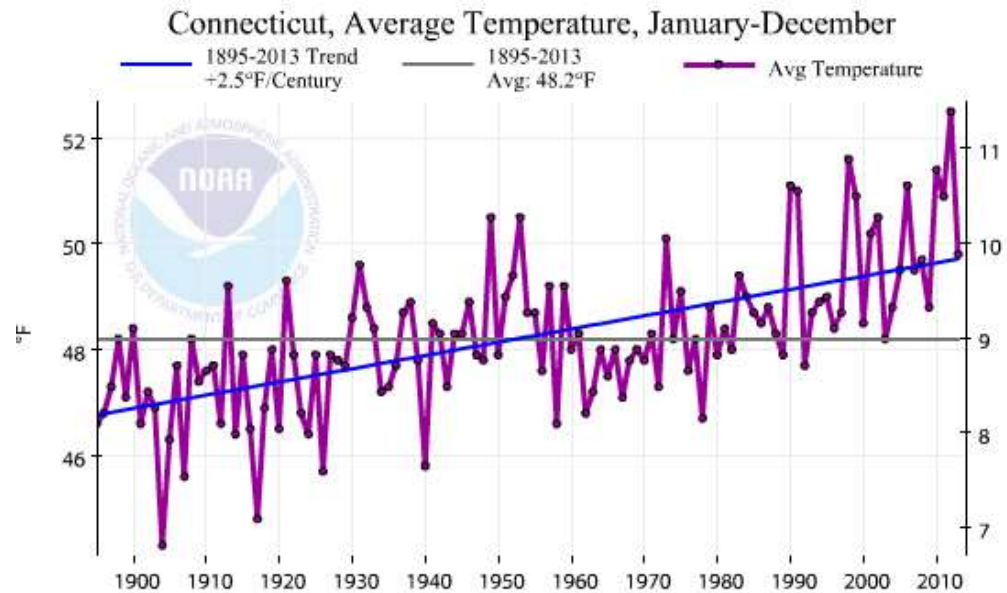
*How has climate changed  
over the past century?*

# Observed Climate Trends

## Warmer temperatures

- CT temperatures increased more than 2.5°F since 1895
- Winter has warmed most
- Extremely hot days have increased
- Longer growing season
- Plants flowering more than a week earlier at Walden pond since 1880s

## Annual Temperature Change since 1895

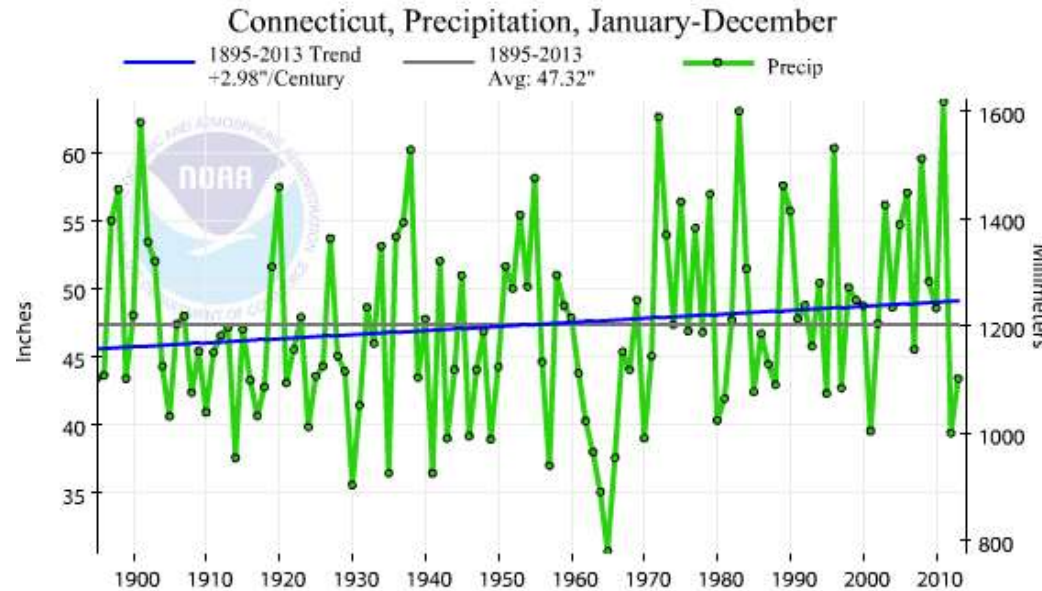


# Observed Climate Trends

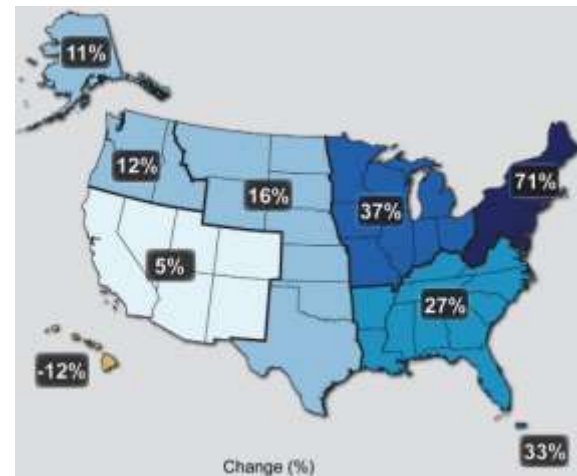
## Altered Precipitation

- CT precipitation increased nearly 3" since 1895
- Extremely high variability from year to year
- Slight decrease in spring; increase of 2" in fall
- Substantial increases in extreme rain events: 71% increase across northeast since 1958

## Annual Precipitation Change since 1895



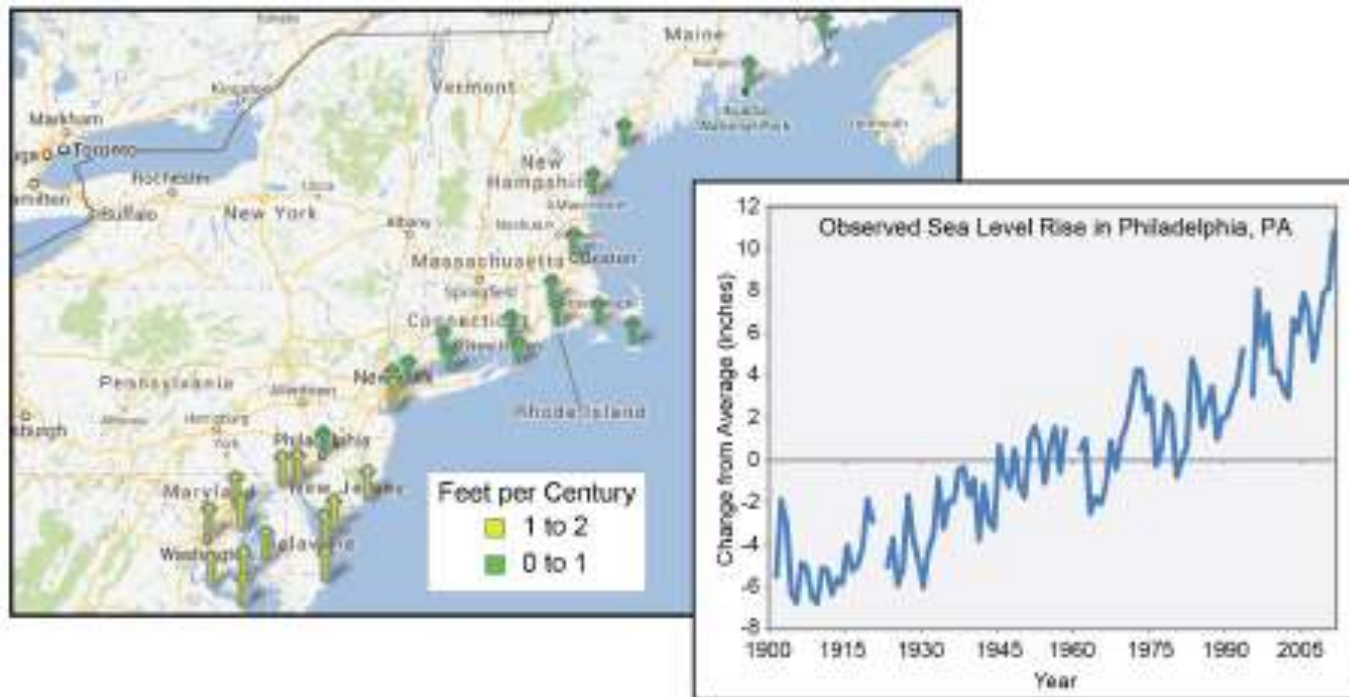
Increase in Extreme Rain Events since 1958



# Observed Climate Trends

## Sea-level Rise

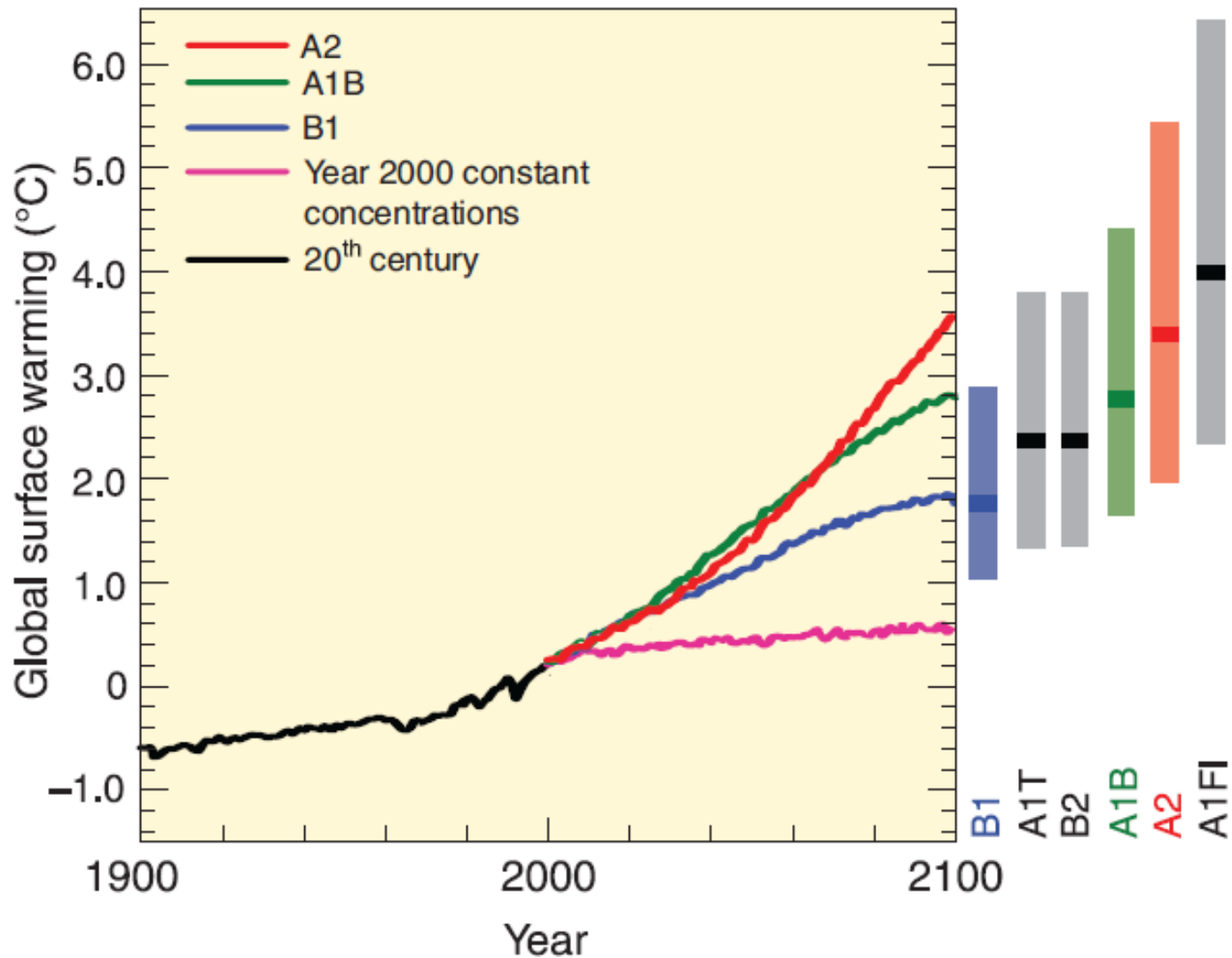
- Sea level rose about 1 foot since 1900
- Increases in coastal flooding



*How is the climate expected to change over the next century?*



# Future Changes – inherent uncertainty



# Anticipated Climate Changes

## Warmer temperatures

- 3-9°F increase annually

## Altered precipitation

- High variability: slight decrease to more than 15% increase
- Generally increasing in winter & spring
- Potential decreases or less substantial increases in summer & fall
- More extreme rain

## Sea-level Rise

- 12 to 23” by end of century



*Hammonasset Beach State Park will be mostly inundated by sea level rise by the end of the century. (Photo Credit: CT DEEP)*

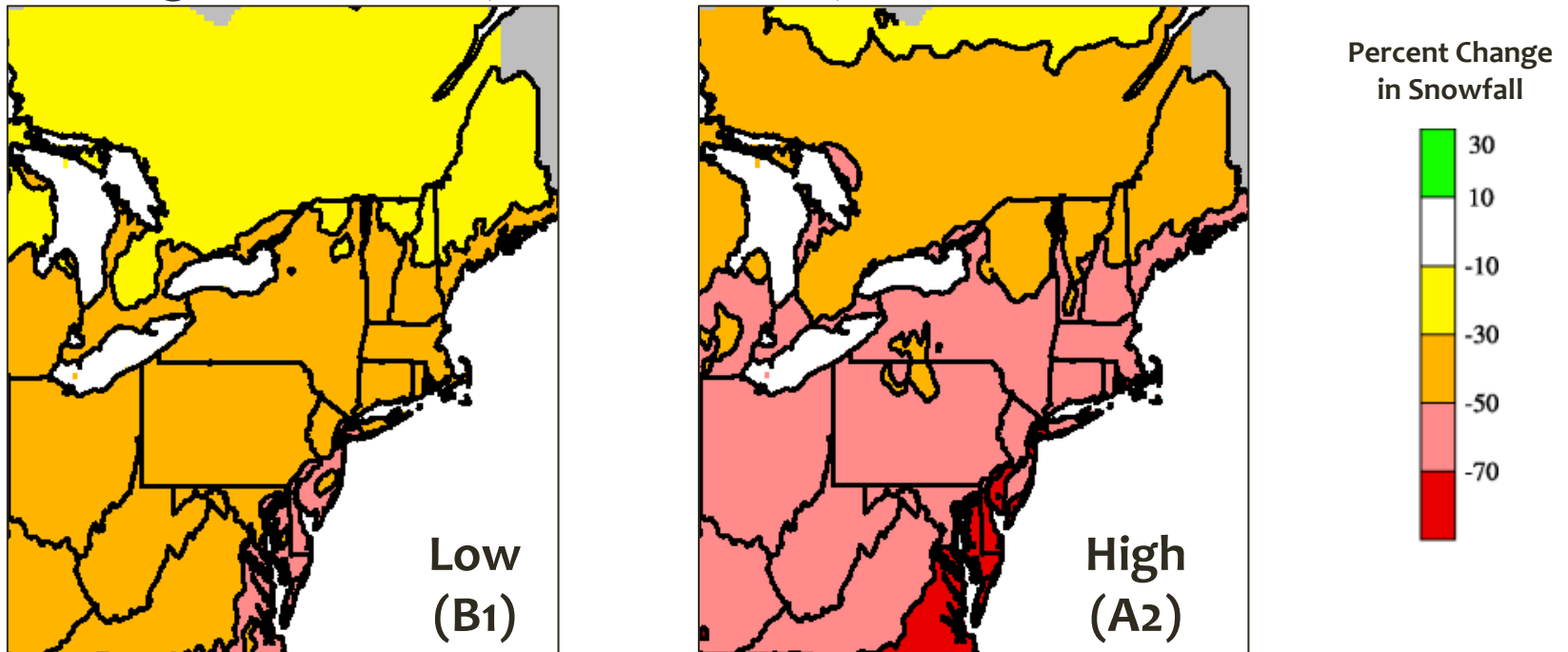
*How could ecosystems be affected?*

# WATER: *Less Snow*

## Projected decreases in snow fall, cover, and depth

- 30-70% decreases in snowfall
- Greatest snowfall decreases in December or January

Percent change in snowfall (late 21<sup>st</sup> century)



# WATER: *Less Snow, but More Rain*

Precipitation is projected to increase = more rain



# WATER: *Less Snow, but More Rain*

Precipitation is projected to increase = more rain

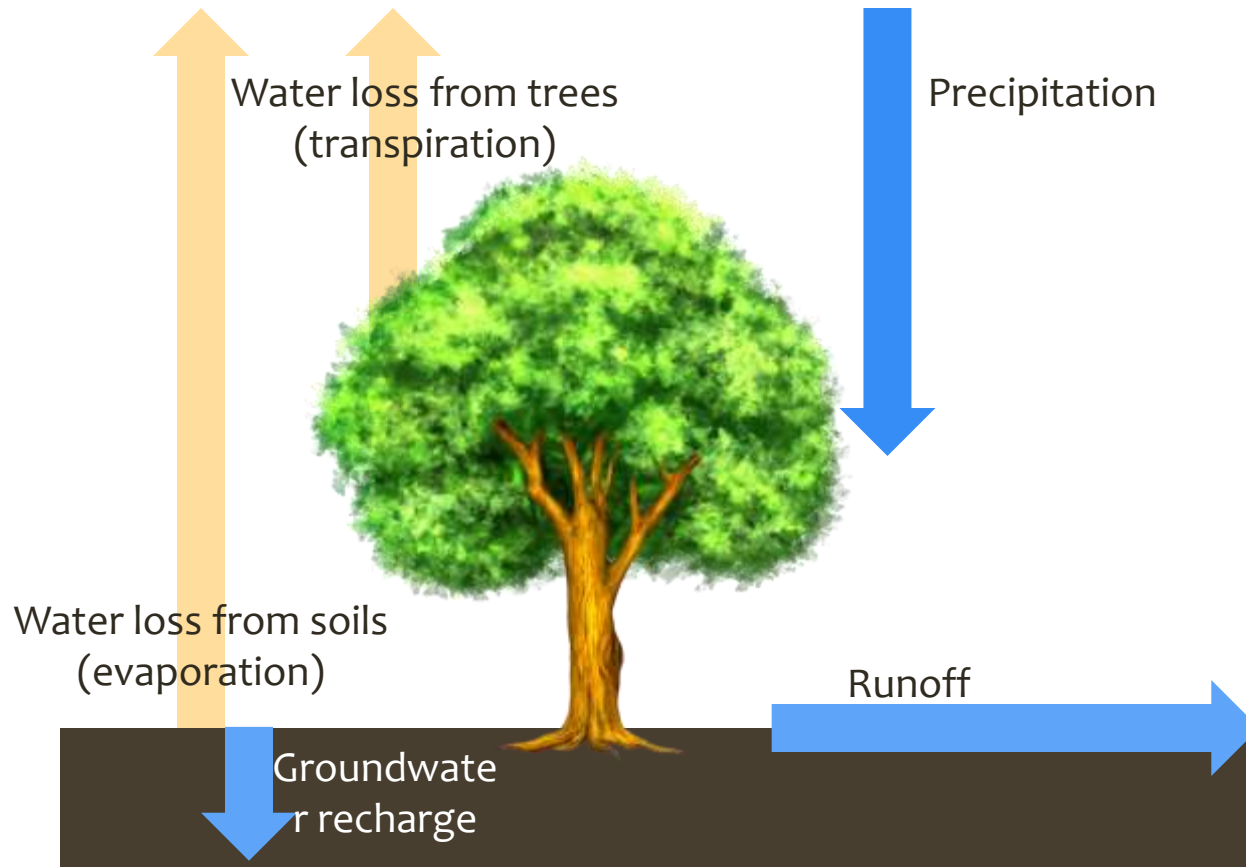
## **Altered streamflow timing and amount**

- Earlier spring peak flows
- Potential increases in flashiness and episodic high flows
- Potential declines in summer seasonal stream flow



# WATER: *Potential for Summer Drought*

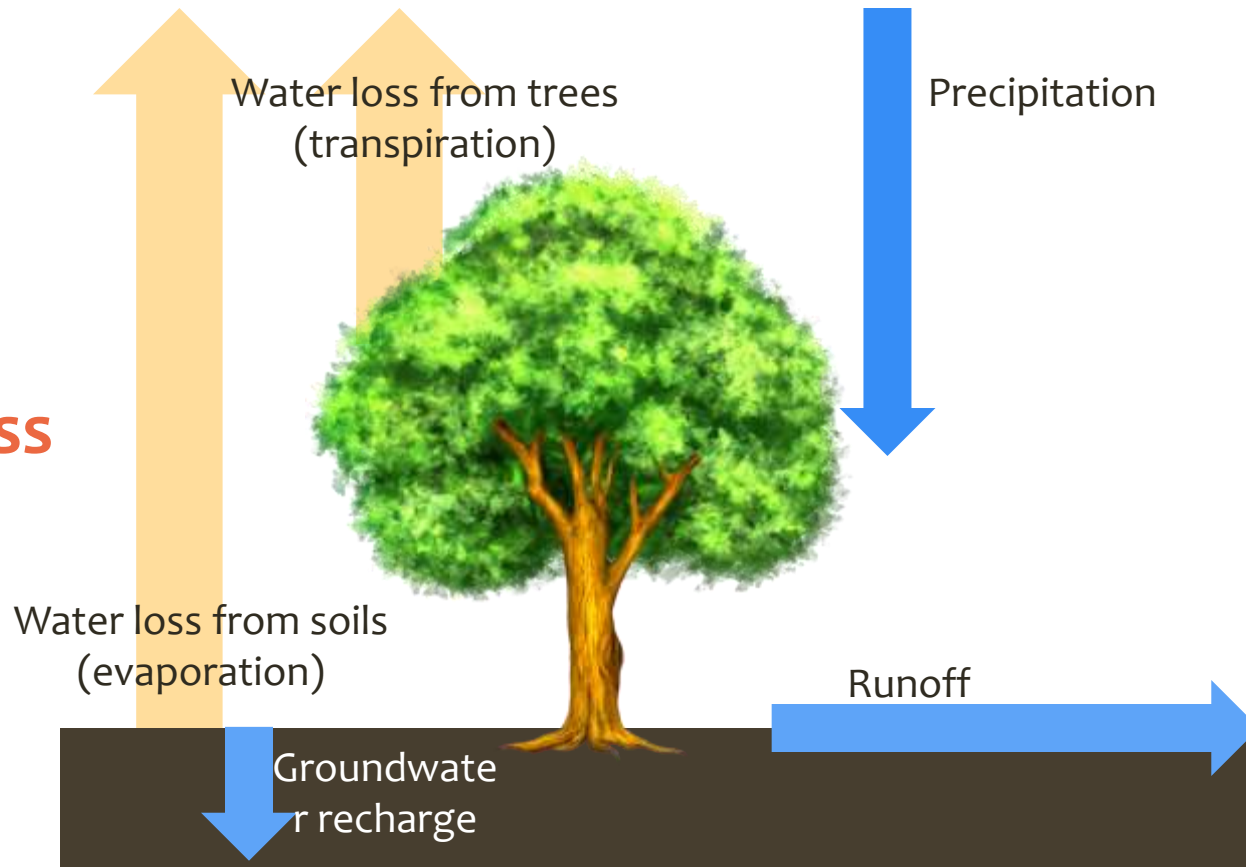
Greater uncertainty about future precipitation, but increased risk of summer moisture stress



# WATER: *Potential for Summer Drought*

Greater uncertainty about future precipitation, but increased risk of summer moisture stress

**Warmer  
temps  
increase  
water loss**





# PLANTS: *Longer Growing Season*

## Warmer temps result in longer growing seasons

- Projected to increase 3-7+ weeks
- Evidence of phenological shifts

## Longer period for plant growth

### Potential risks:

- Early bud break/loss of cold hardening
- Frost damage during spring freezing



# PLANTS: *Changes in Suitable Habitat*

## Habitat based on:

- Temperature
- Precipitation
- Elevation
- Latitude
- Soils
- Slope & Aspect
- Land use
- Competition
- Past management



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## Habitat based on:

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## Climate Change Atlas:

What happens to tree and bird habitat when climate changes?

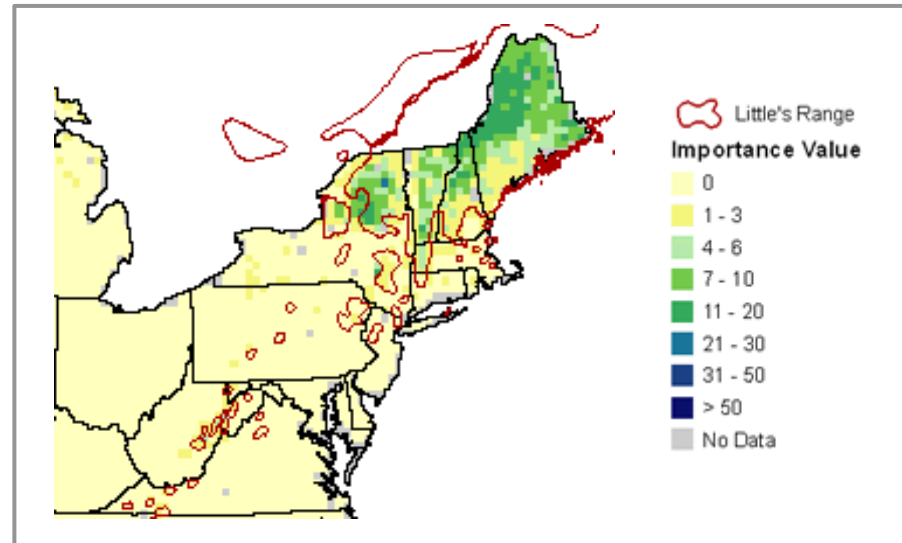
- 134 Trees
- 147 Birds

# PLANTS: *Changes in Suitable Habitat*

## Habitat based on:

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## Red Spruce: Current Habitat (modeled)

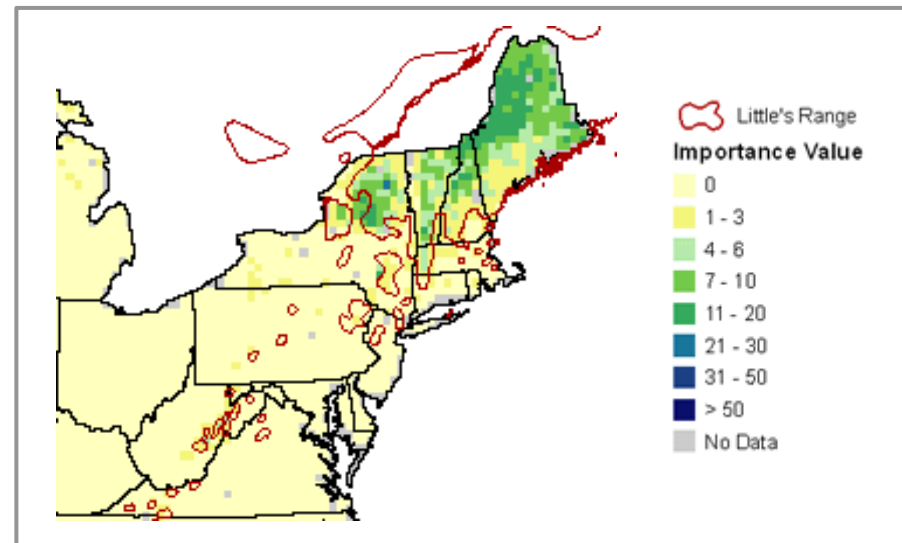


# PLANTS: *Changes in Suitable Habitat*

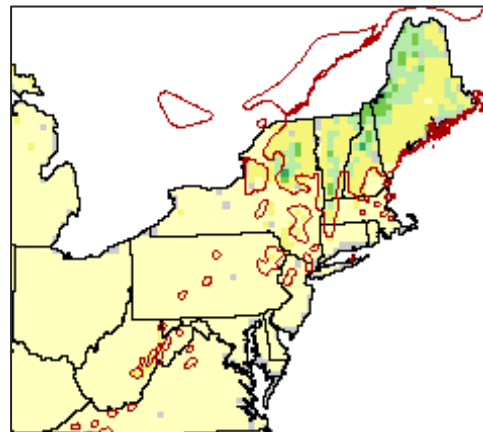
## Habitat based on:

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- *Precipitation*
- Elevation
- Latitude
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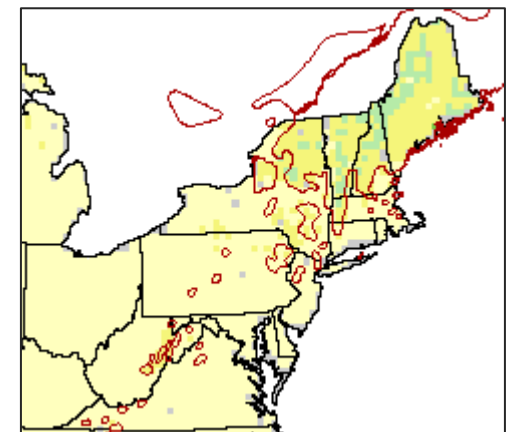
Red Spruce: Current Habitat (modeled)



PCM B1 (Less Change)



GFDL A1FI (More Change)

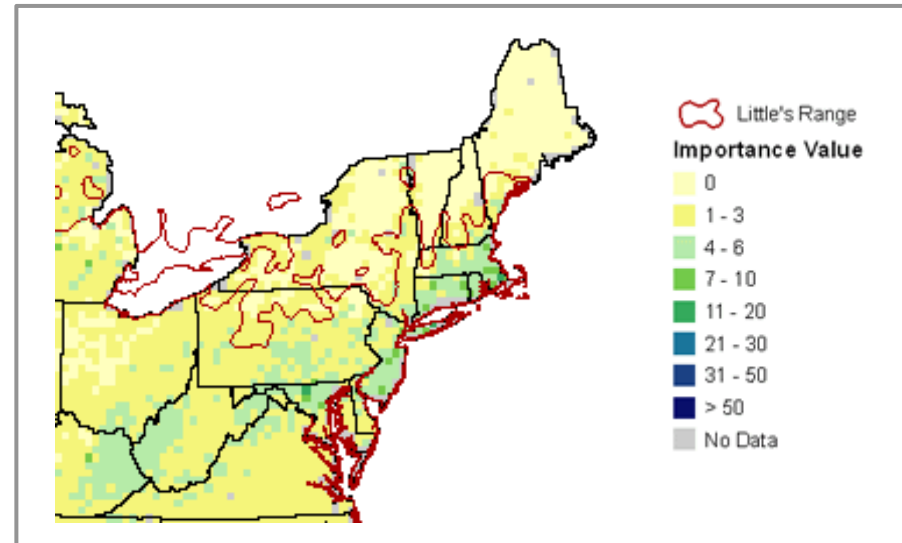


# PLANTS: *Changes in Suitable Habitat*

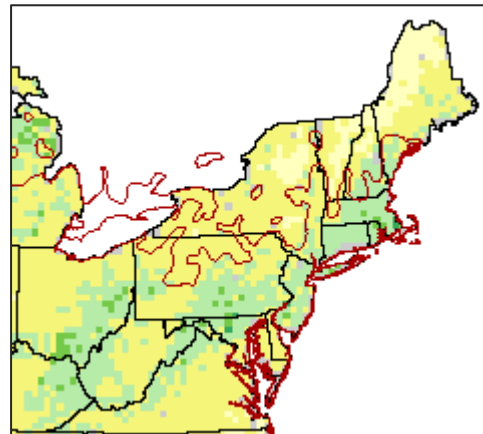
## Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

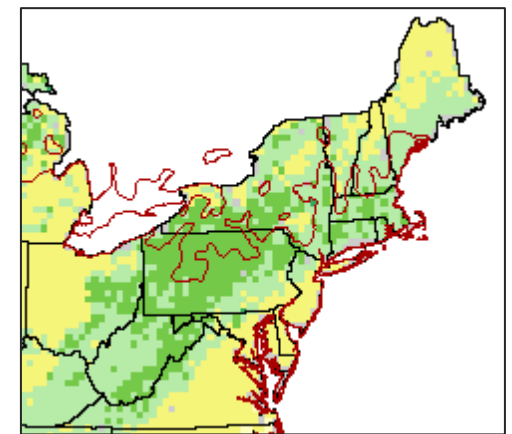
## Black Oak: Current Habitat (modeled)



## PCM B1 (Less Change)



## GFDL A1FI (More Change)



# PLANTS: *Changes in Suitable Habitat*

- Immense lag times
  - Range shifts  $\neq$  instant catastrophic dieback
- Factors causing change will increase over time
  - Temperature
  - Moisture
  - Competition
- Mature and established trees should fare better
  - Developed root system
  - Greater carbohydrate reserves
- Game changers: Disturbance, Land use, ...

# PLANTS: *Invasive Plants*

- Expanded ranges under warmer conditions
- Stress or disturbance from other impacts can affect the potential for invasion or success



Invasives Plants Atlas of New England ([www.eddmaps.org](http://www.eddmaps.org))



# DISTURBANCE: *Extreme Events*

- Heavy precipitation
- Ice storms
- **“Events” are not well modeled**
- Heat waves/droughts
- Wind storms
- Hurricanes



Dan Turner, Cambridge Fire Dept.



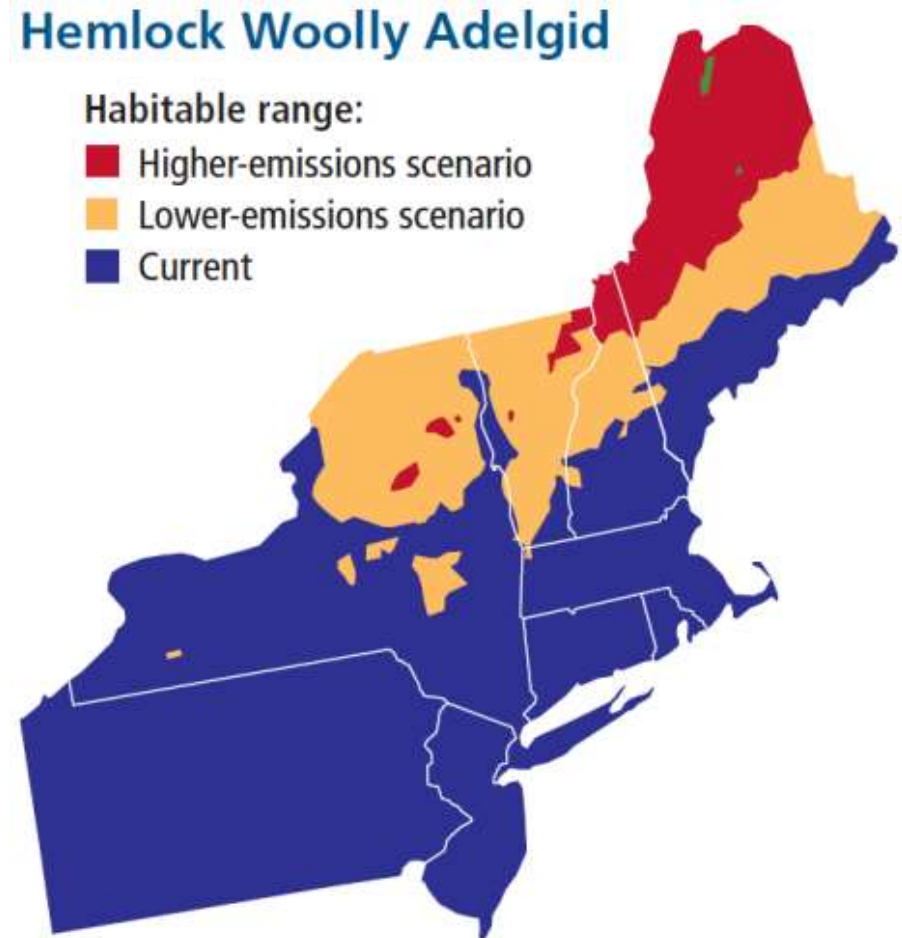
NY DEC



VTRANS/VT ANR

# DISTURBANCE: *Insect Pests & Diseases*

- Stress from other impacts increases susceptibility
- Pests migrating northward
- Decreased probability of cold lethal temperatures
- Accelerated lifecycles



HWA lethal temp: -20 to -30°F

# Climate Change Impacts

- 1) Less Snow, More Rain
- 2) Potential for Summer Drought
- 3) Longer Growing Season
- 4) Changes in Suitable Habitat
- 5) Invasive Plants
- 6) Extreme Events
- 7) Forest Pests and Diseases



*Where do we  
go from here?*

