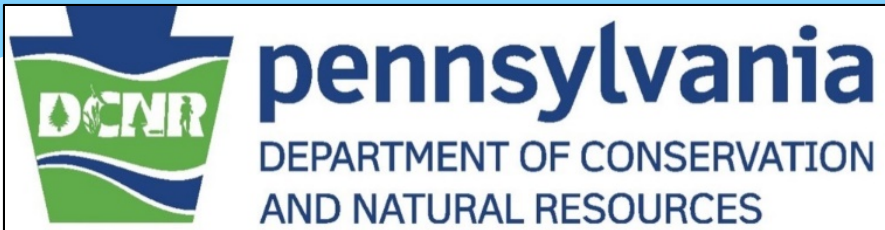


Pennsylvania's Changing Climate

Greg Czarnecki
Director of Applied Climate Science

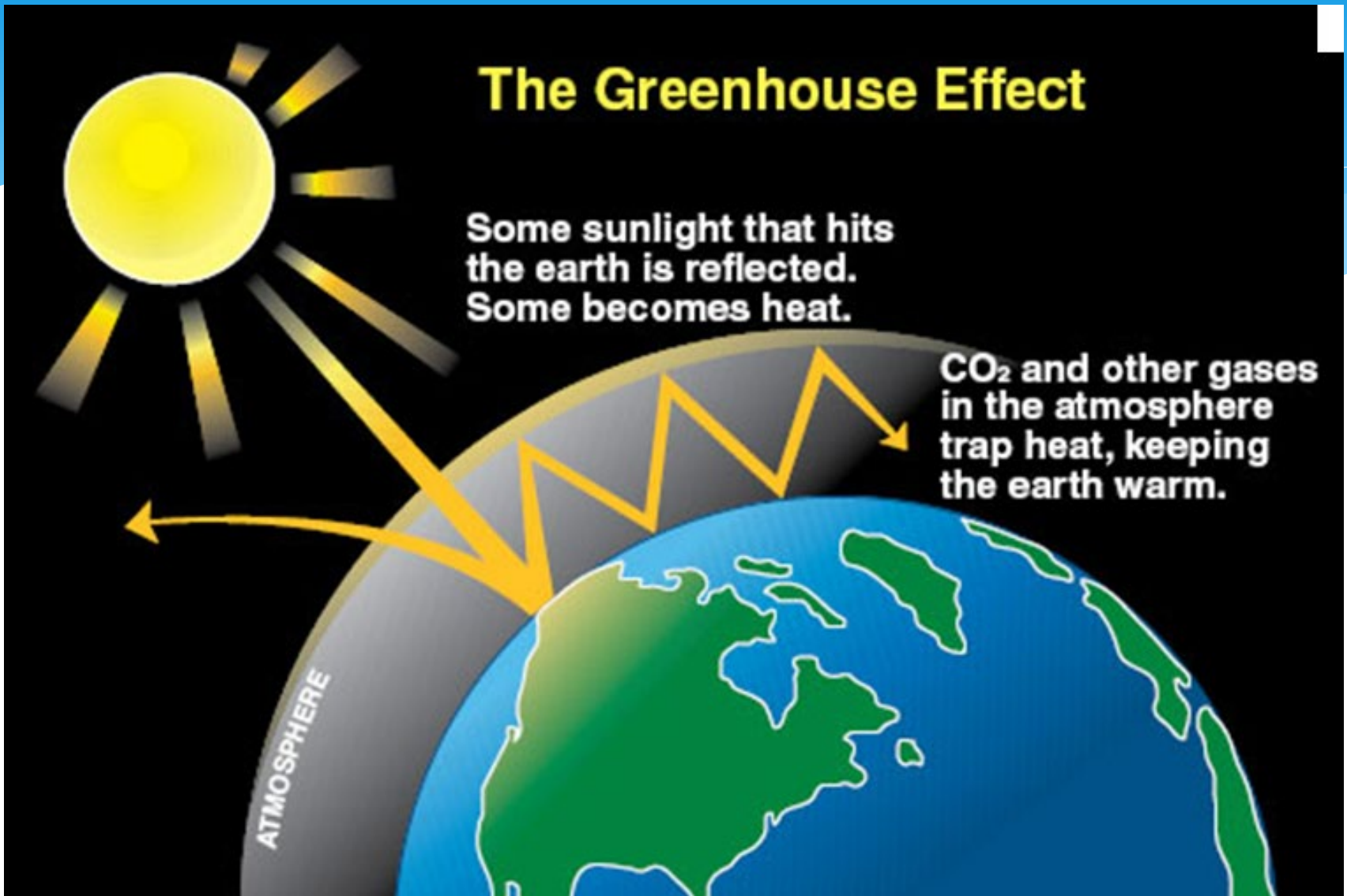


The Greenhouse Effect

Some sunlight that hits the earth is reflected. Some becomes heat.

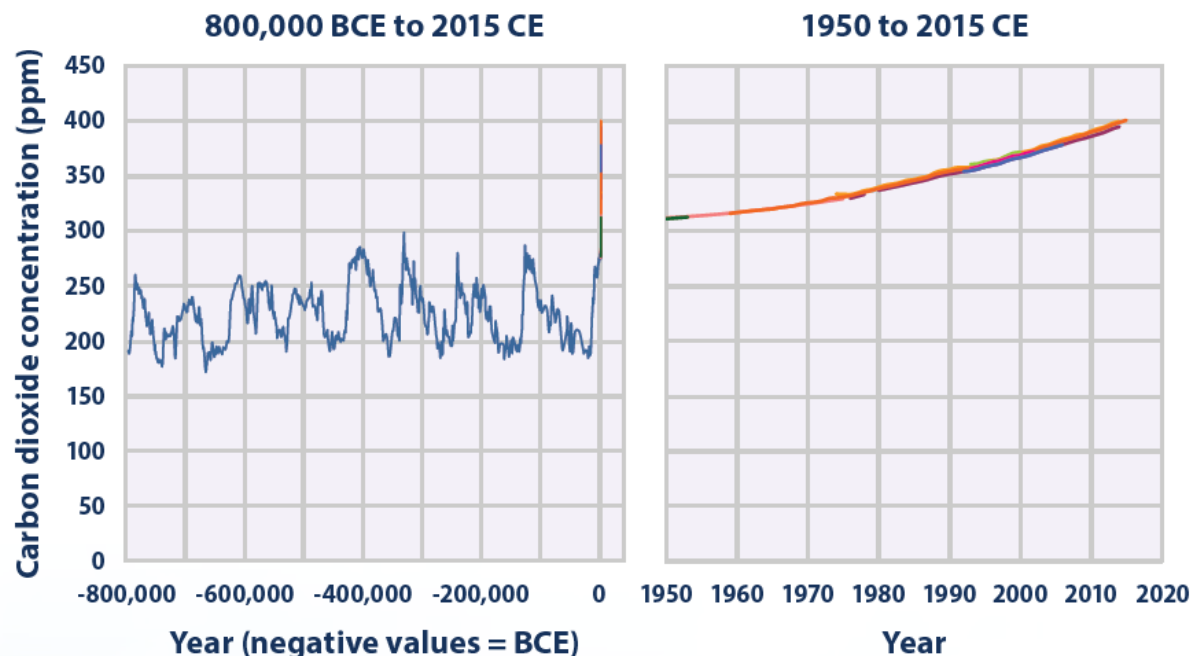
CO₂ and other gases in the atmosphere trap heat, keeping the earth warm.

ATMOSPHERE



WHAT'S HAPPENING

Global Atmospheric Concentrations of Carbon Dioxide Over Time



This figure shows concentrations of carbon dioxide in the atmosphere from hundreds of thousands of years ago through 2015, measured in parts per million (ppm). The data come from a variety of historical ice core studies and recent air monitoring sites around the world. Each line represents a different data source. Data source: Compilation of 10 underlying datasets⁶

- Global atmospheric concentrations of carbon dioxide have risen significantly over the last few hundred years.
- Historical measurements show that the current global atmospheric concentrations of carbon dioxide are unprecedented compared with the past 800,000 years.
- Since the beginning of the industrial era, concentrations of carbon dioxide have increased from an annual average of 280 ppm in the late 1700s to 401 ppm as measured at Mauna Loa in 2015—a 43-percent increase. This increase is due to human activities.⁷

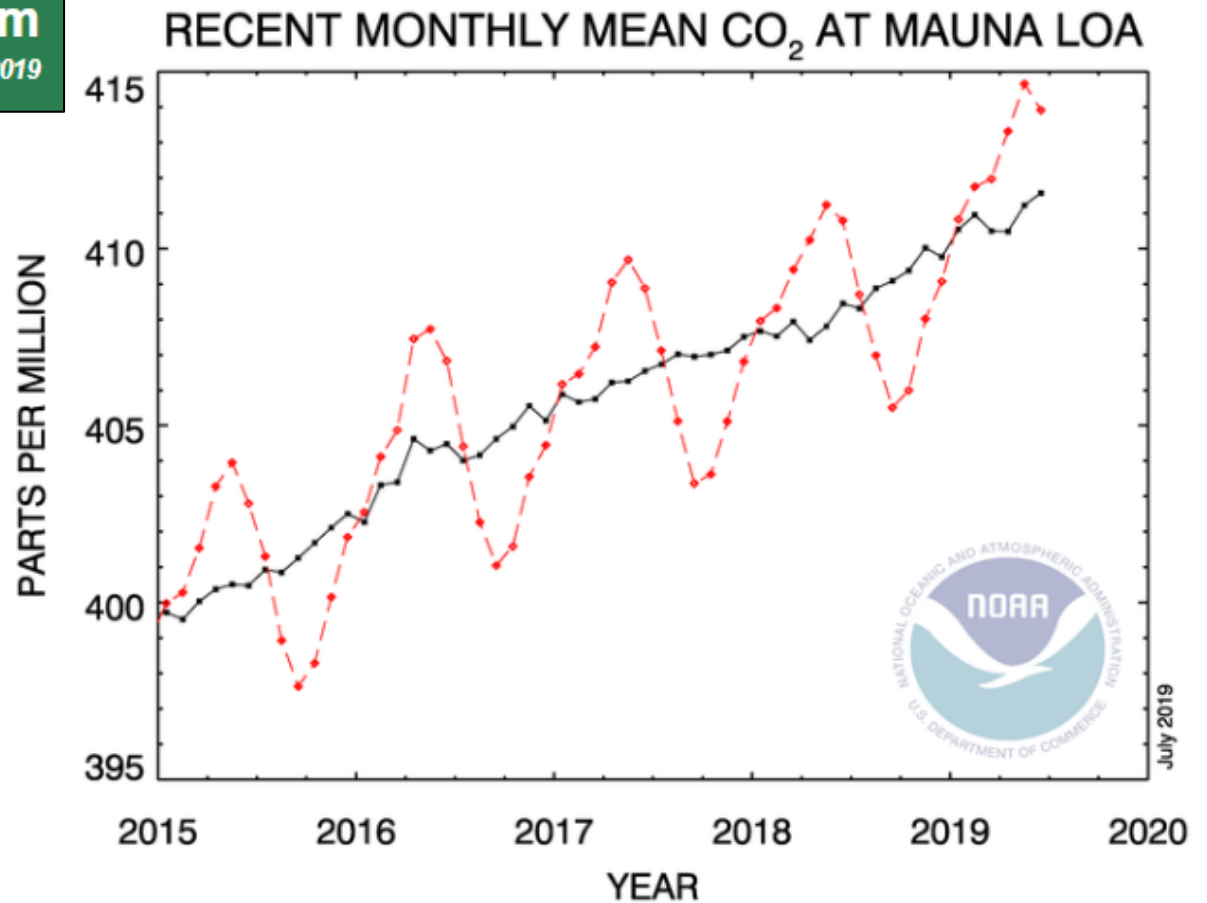
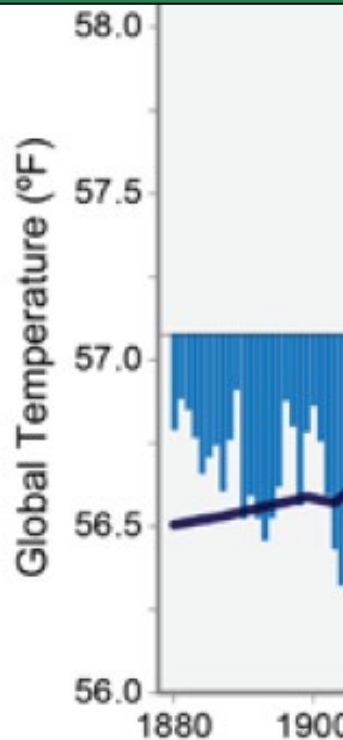
Anthropogenic Climate Change

August 2019: 409.95 ppm

August 2018: 406.99 ppm

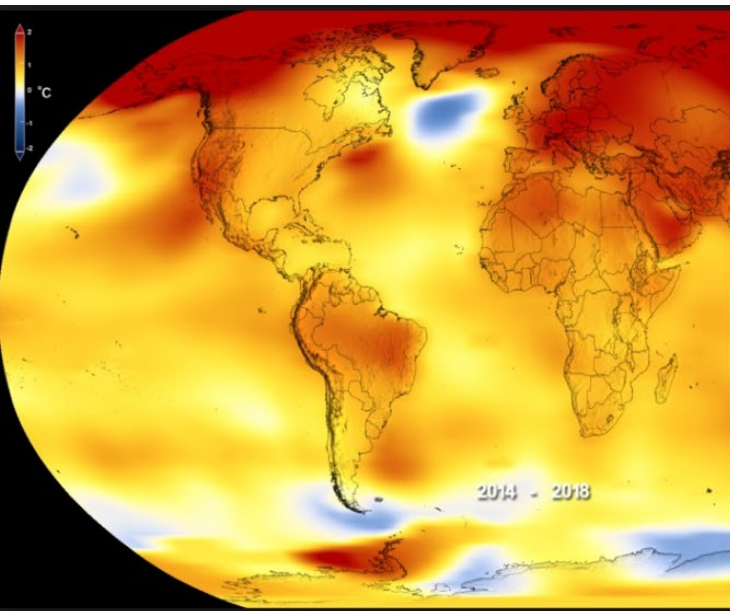
Last updated: September 5, 2019

Temperature and Carbon Dioxide

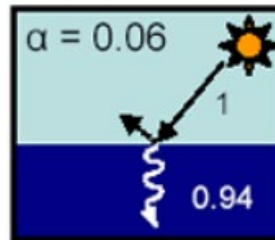


Global Climate Trends

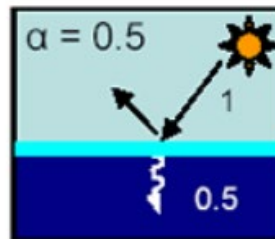
Global Temperature Anomalies



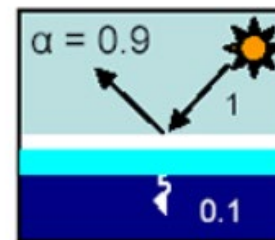
I. Open ocean



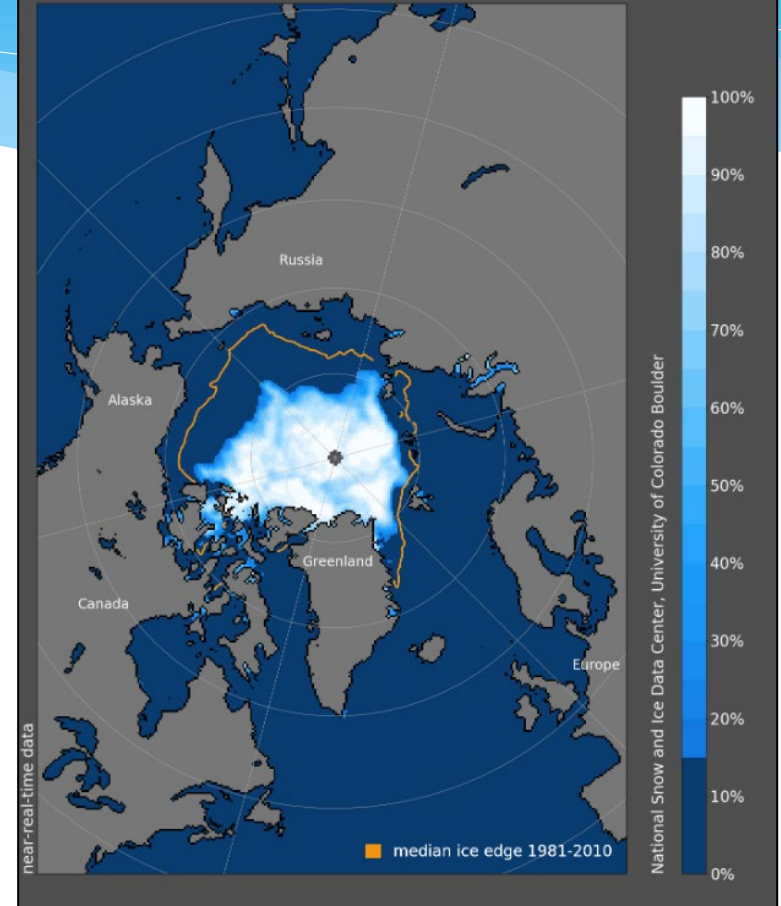
II. Bare ice



III. Ice with snow



Sea Ice Concentration, 17 Sep 2019



What Happens in the Arctic Doesn't Stay in the Arctic!

The Changing Jet Stream

Stable jet stream

A stable jet stream flows on a somewhat straight path.

Wavy jet stream

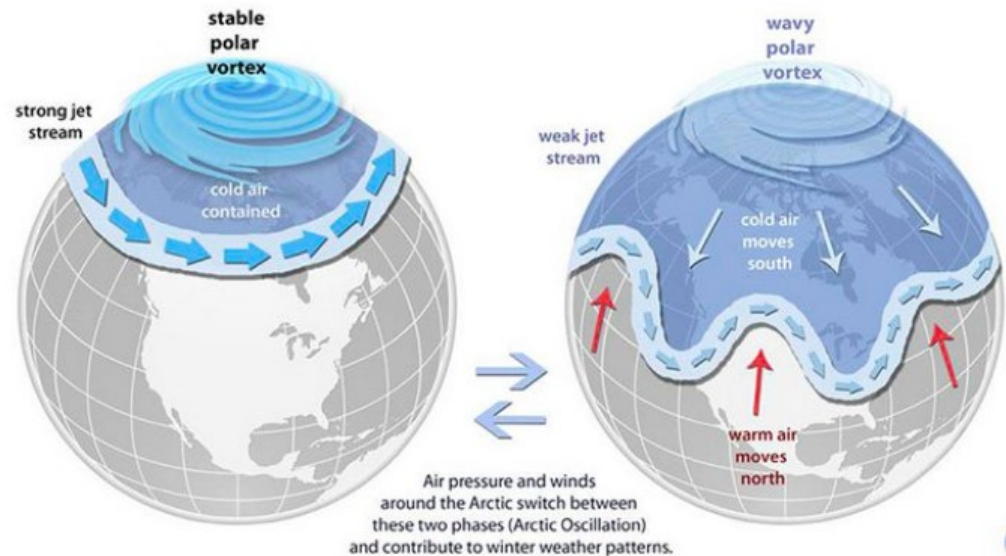
Cold air moves south

A wavy jet stream allows warm air to move north or colder air to sink deeper south.

Warm air moves north

CBC NEWS

SOURCES: NOAA; Scientific American



The science behind the polar vortex.

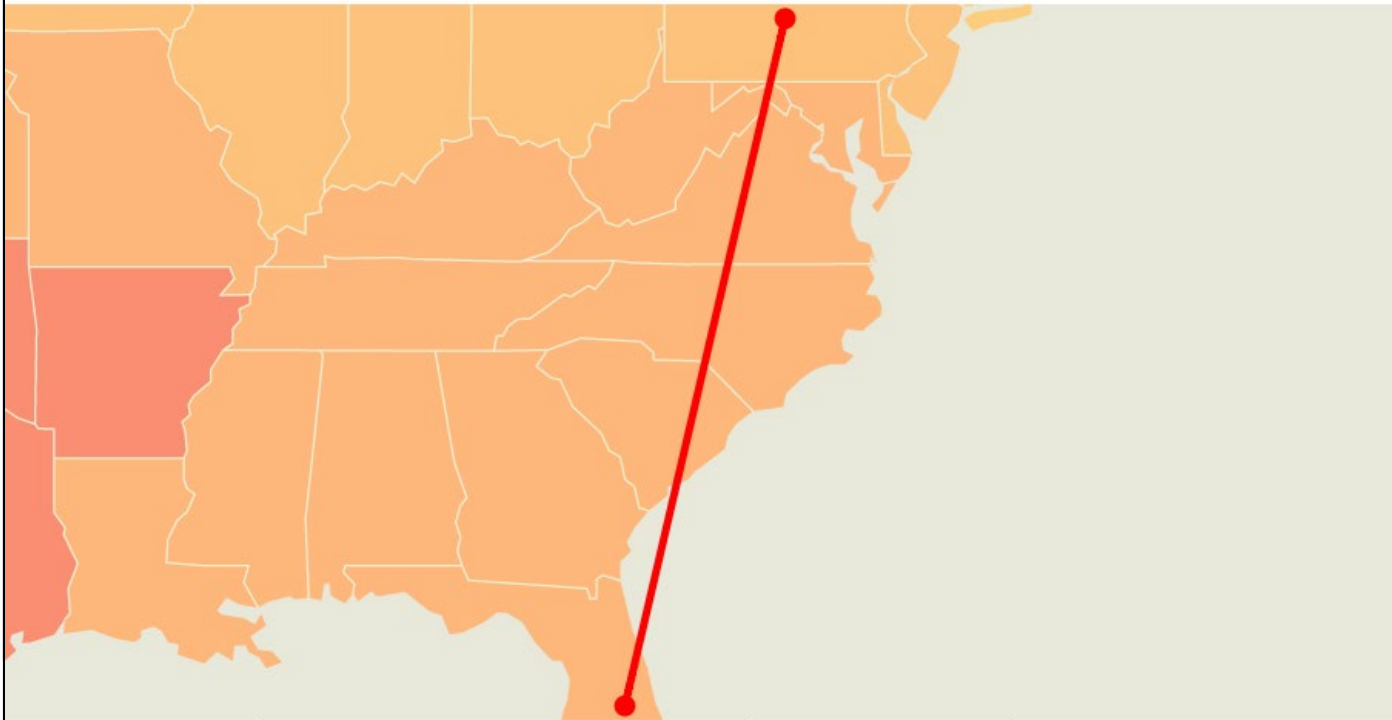
Credit: NOAA

Close

Increasing Temperatures

1 0 0 1 B L I S T E R I N G FUTURE SUMMERS

I live in State College, PA.

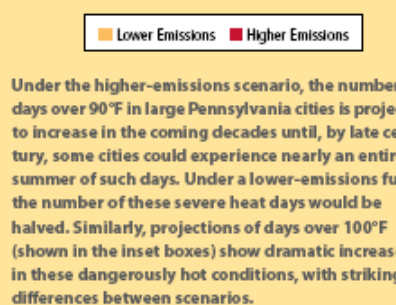
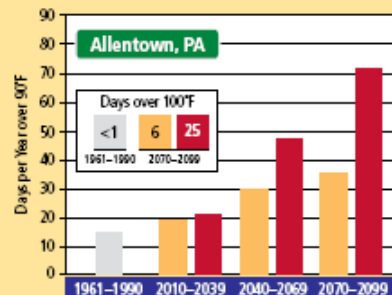
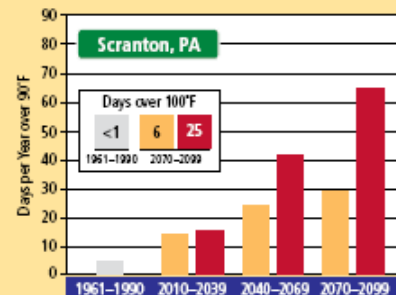
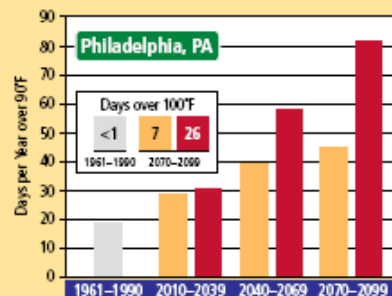
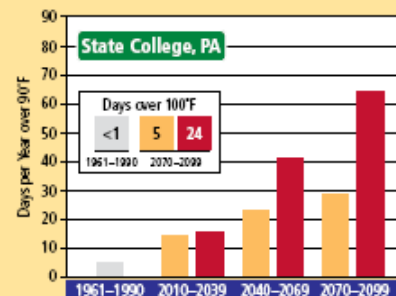
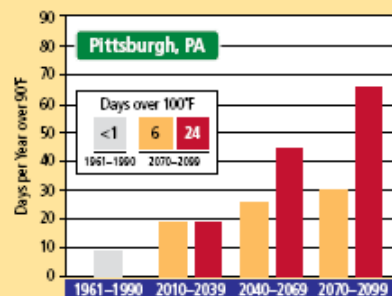
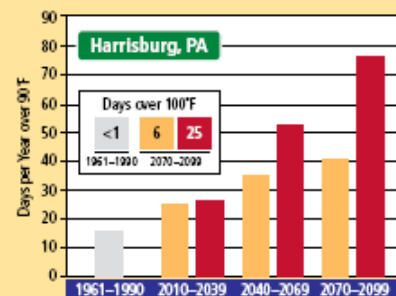


By 2100
summers in

STATE COLLEGE, PA **80.02 °F**

will be like
summers now in

KISSIMMEE, FL **91.11 °F**

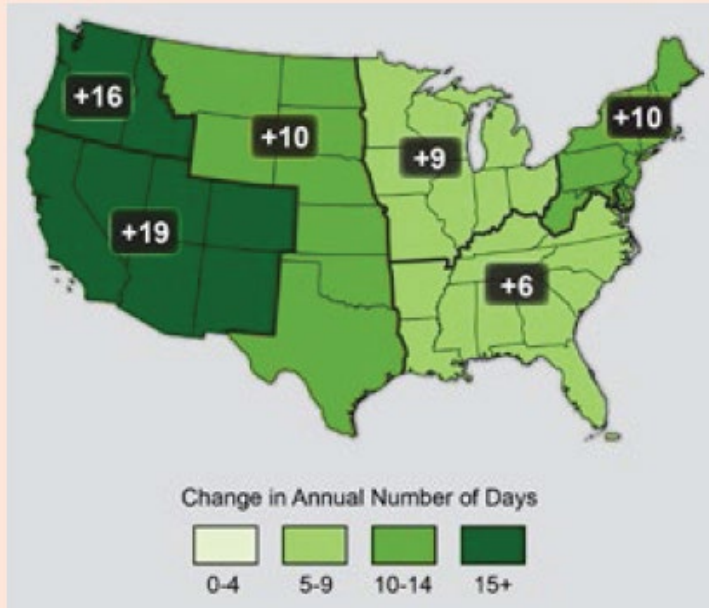


Under the higher-emissions scenario, the number of days over 90°F in large Pennsylvania cities is projected to increase in the coming decades until, by late century, some cities could experience nearly an entire summer of such days. Under a lower-emissions future, the number of these severe heat days would be halved. Similarly, projections of days over 100°F (shown in the inset boxes) show dramatic increases in these dangerously hot conditions, with striking differences between scenarios.

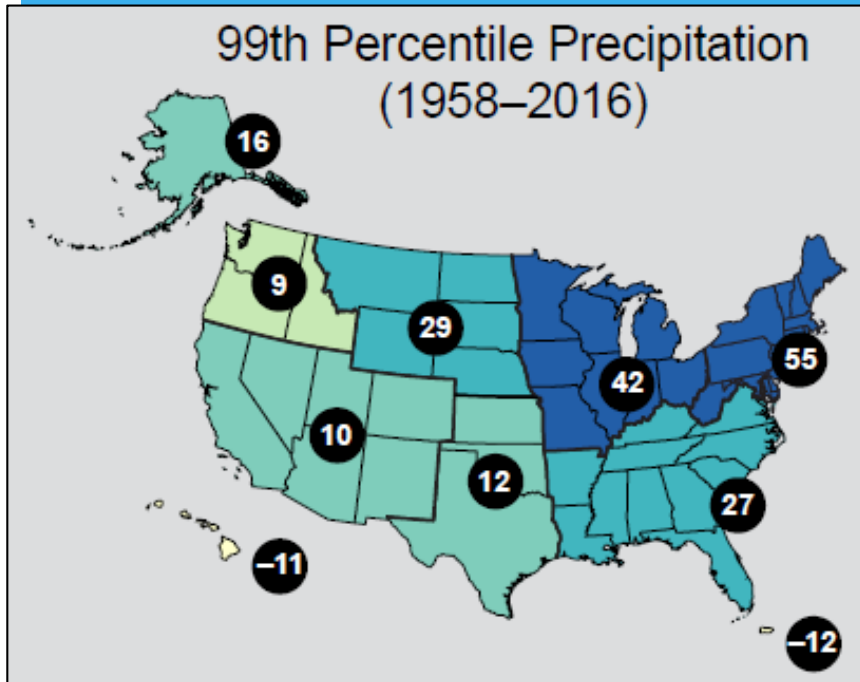
Extreme Heat in PA Cities

Growing Season

Observed Increase in Frost-Free Season Length



Rainfall



Fourth National Climate Assessment

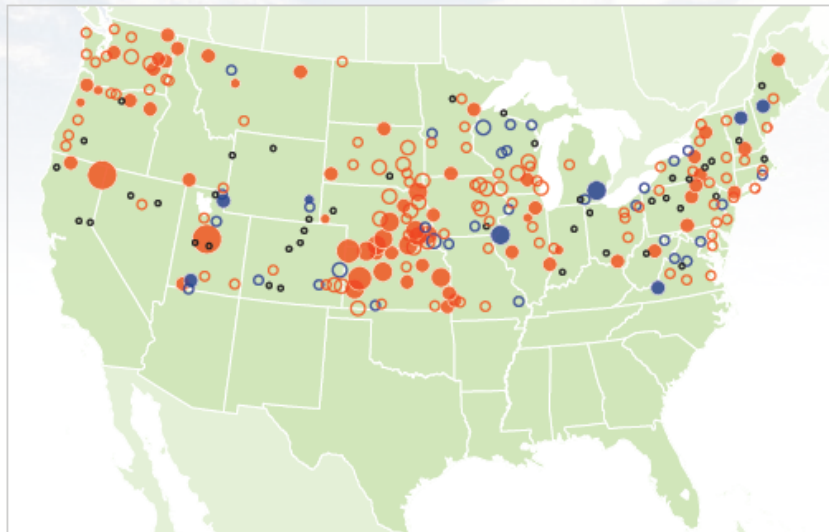


A view of Route 283.

CONTRIBUTED IMAGE/@KURTACEG/TWITTER

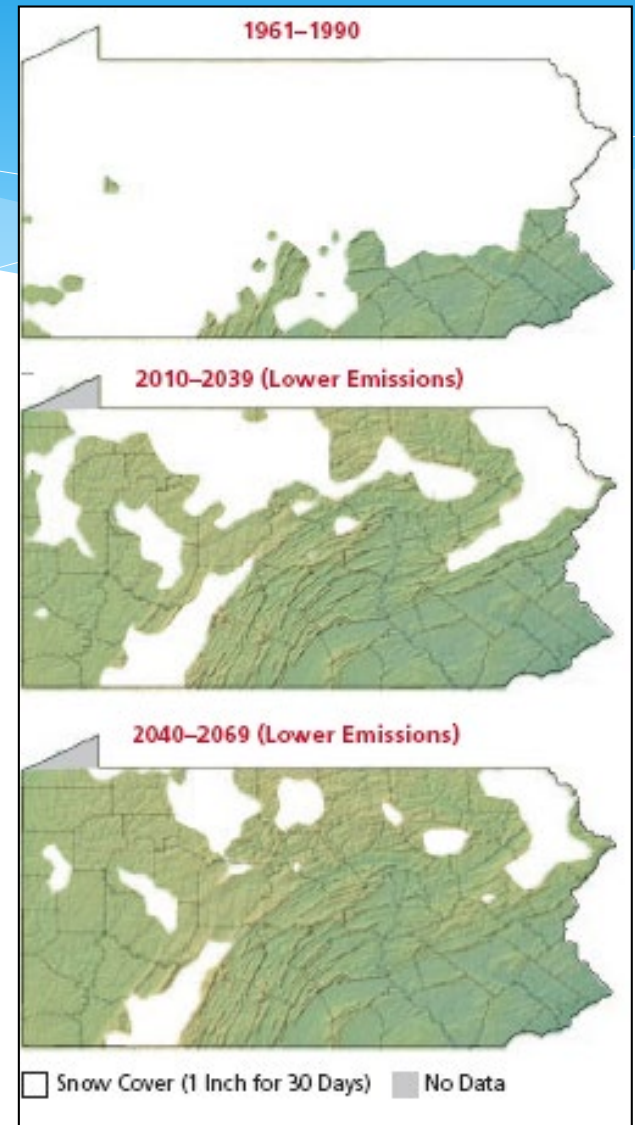
Reduced Snow Cover

Change In Snow-to-Precipitation Ratio In the Contiguous 48 States, 1949–2016



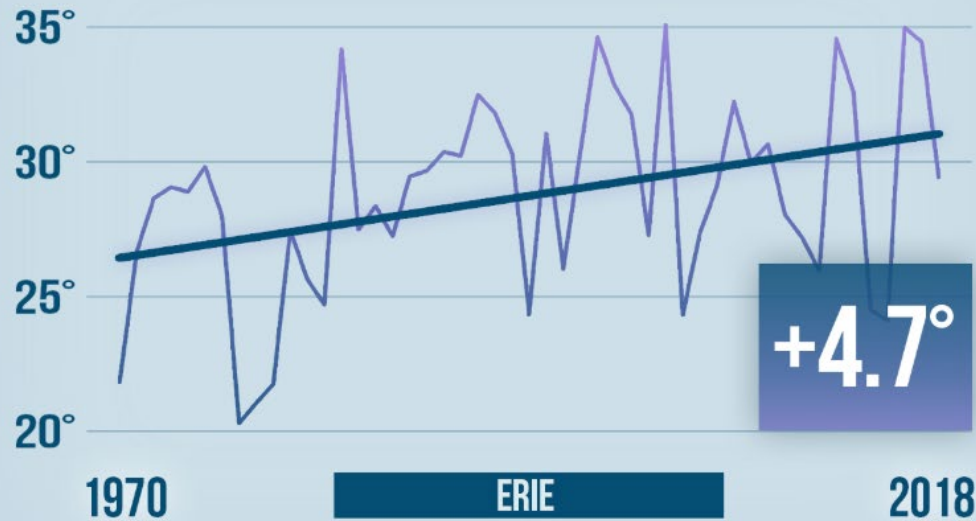
Filled circles represent statistically significant trends.
Open circles represent trends that are not statistically significant.

This figure shows the percentage change in winter snow-to-precipitation ratio from 1949 to 2016 at 246 weather stations in the contiguous 48 states. This ratio measures what percentage of total winter precipitation falls in the form of snow. A decrease (red circle) indicates that more precipitation is falling in the form of rain instead of snow. Solid-color circles represent stations where the trend was statistically significant. Data source: NOAA, 2016⁶



WARMING WINTERS

AVERAGE WINTER TEMPERATURE

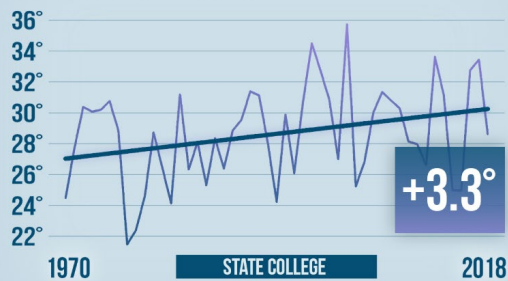


Source: RCC-ACIS.org

CLIMATE CO CENTRAL

WARMING WINTERS

AVERAGE WINTER TEMPERATURE

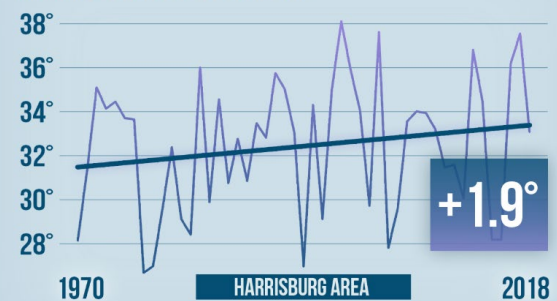


Source: RCC-ACIS.org

CLIMATE CO CENTRAL

WARMING WINTERS

AVERAGE WINTER TEMPERATURE

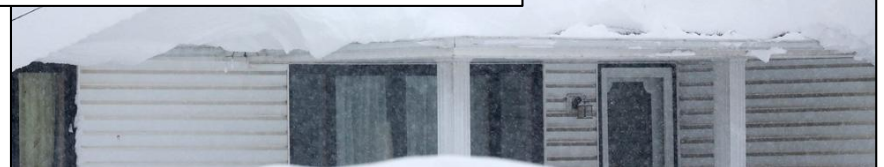
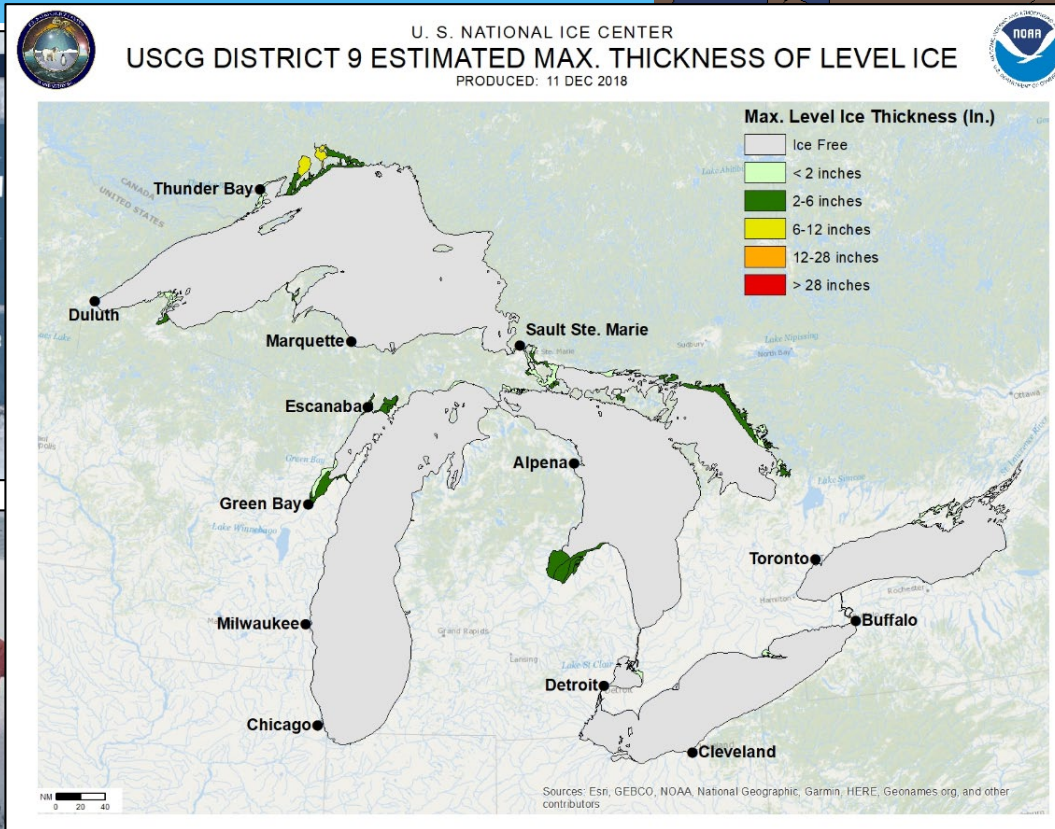
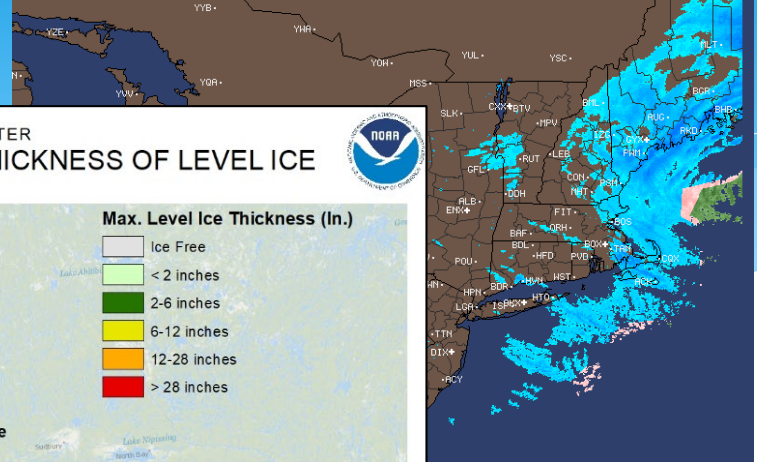


Source: RCC-ACIS.org

CLIMATE CO CENTRAL

Warmer Temperatures = More Lake Effect Snow

12:30 08-DEC-2006 GMT ©Copyright WSI Corporation <http://www.wsi.com>



Invasive Species & Pests



Kudzu is reproducing
in Pennsylvania
(photo from Lebanon
County)



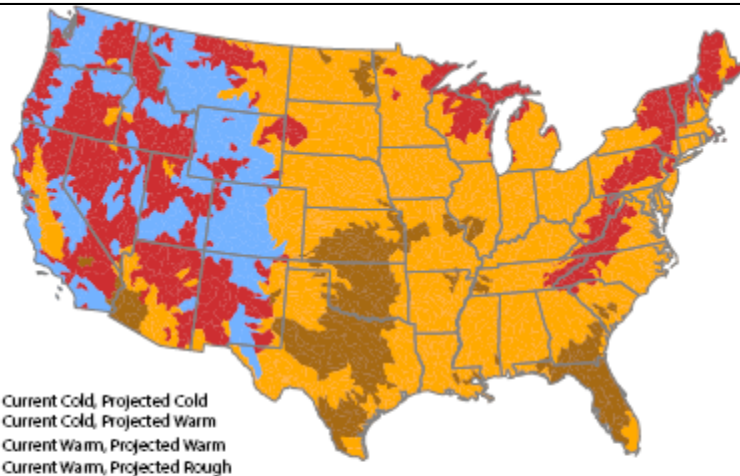
The hemlock wooly adelgid has been
spreading north as winters warm

Most invasives spread and thrive in a changing climate.

Projected Changes in Fish Habitat

GHG emissions continue to increase unchecked

GHG emissions are substantially reduced



COLDWATER FISHERY EXAMPLES



Trout



Salmon

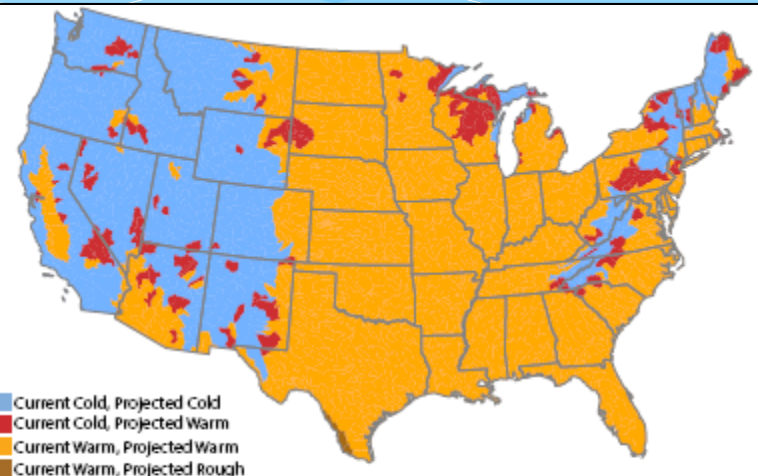


Smallmouth Bass



Shad

WARMWATER FISHERY EXAMPLES



ROUGH FISHERY EXAMPLES



Largemouth Bass



Bluegill



Carp

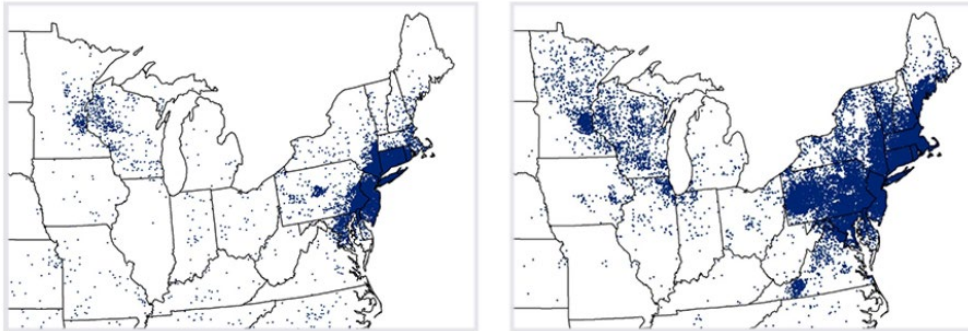


Catfish

Source: U.S. EPA

Human Health Impacts

Reported Lyme Disease Cases in 1996 and 2014



1996

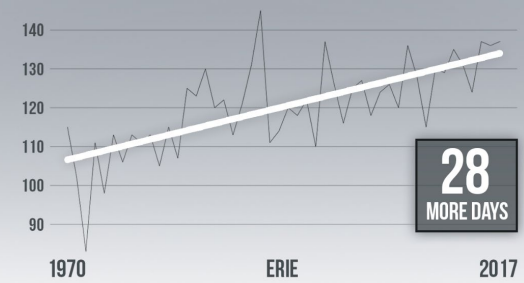
2014

Data source: CDC (Centers for Disease Control and Prevention). 2015. Lyme disease data and statistics. www.cdc.gov/lyme/stats/index.html. Accessed December 2015.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

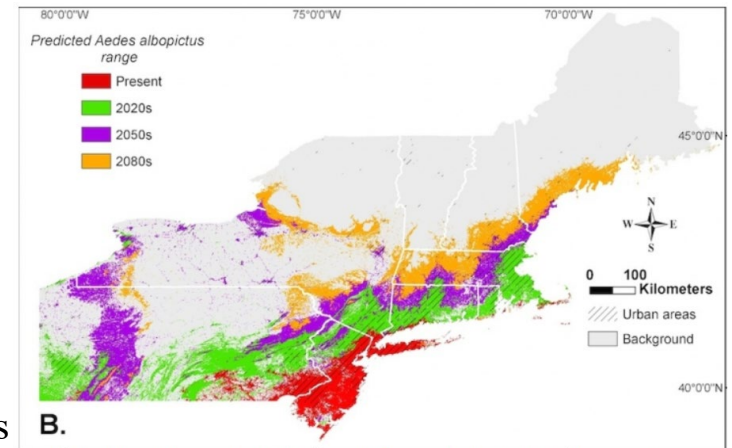
DISEASE DANGER DAYS

Days with transmission risk by mosquitoes



Days with average temp 61°-93° from Mar-Nov
Source: RCC-ACS.org, Mordecai et al. 2017

CLIMATE CENTRAL



Predicted change in the range of the Asian Tiger mosquito with warming from high levels of greenhouse gas emissions.

Vector for:

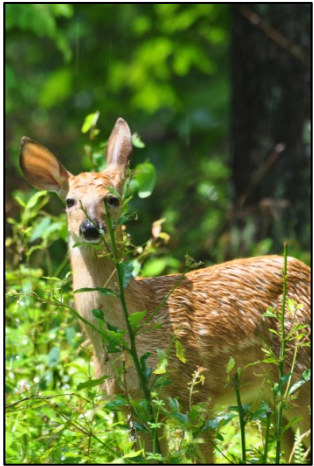
- Zika virus
- Dengue fever
- West Nile virus
- Chikungunya virus



Asian tiger mosquito

How Will Species Respond?

Adapt



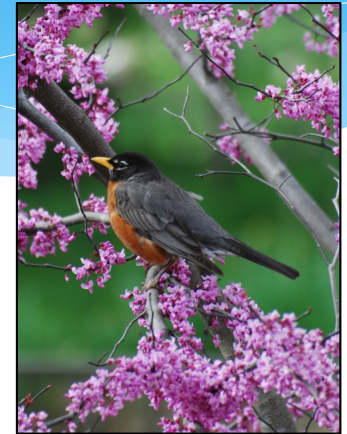
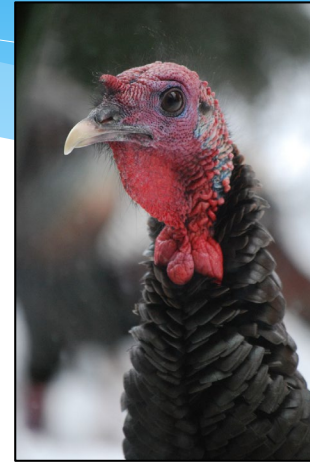
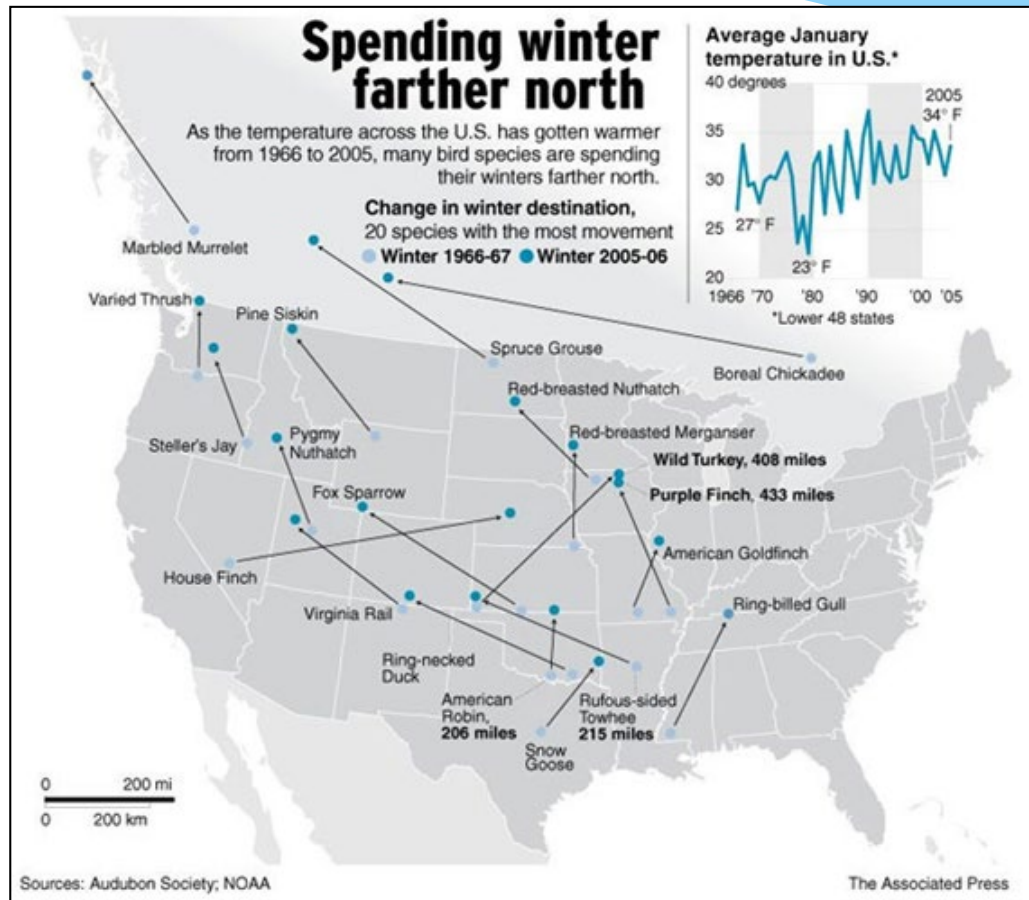
Move



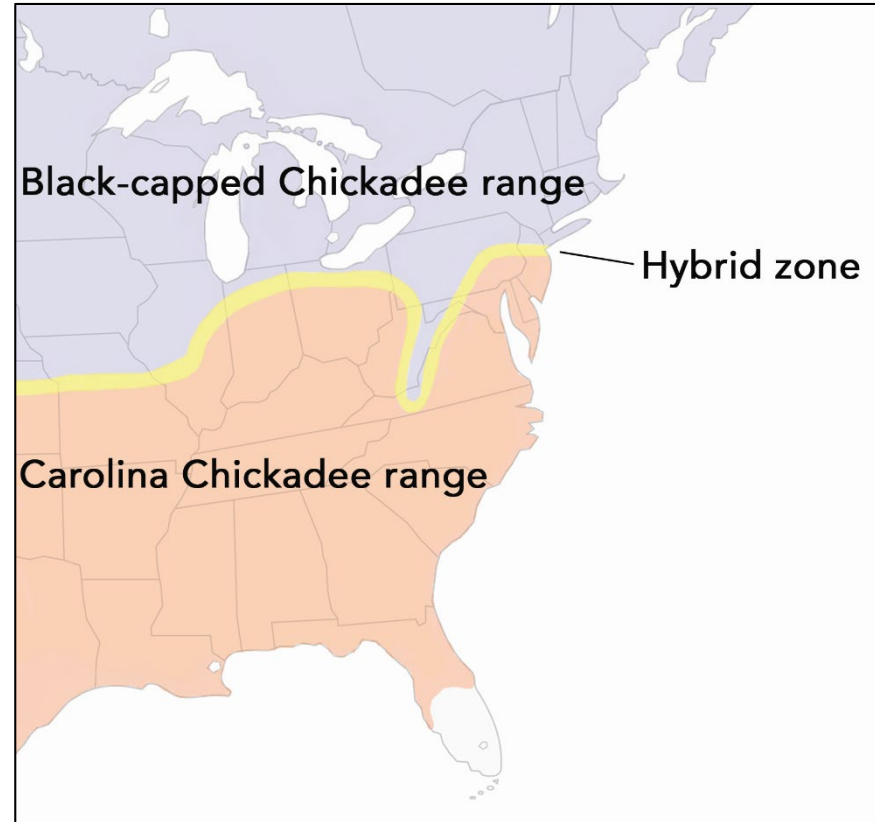
Disappear



Species on the Move

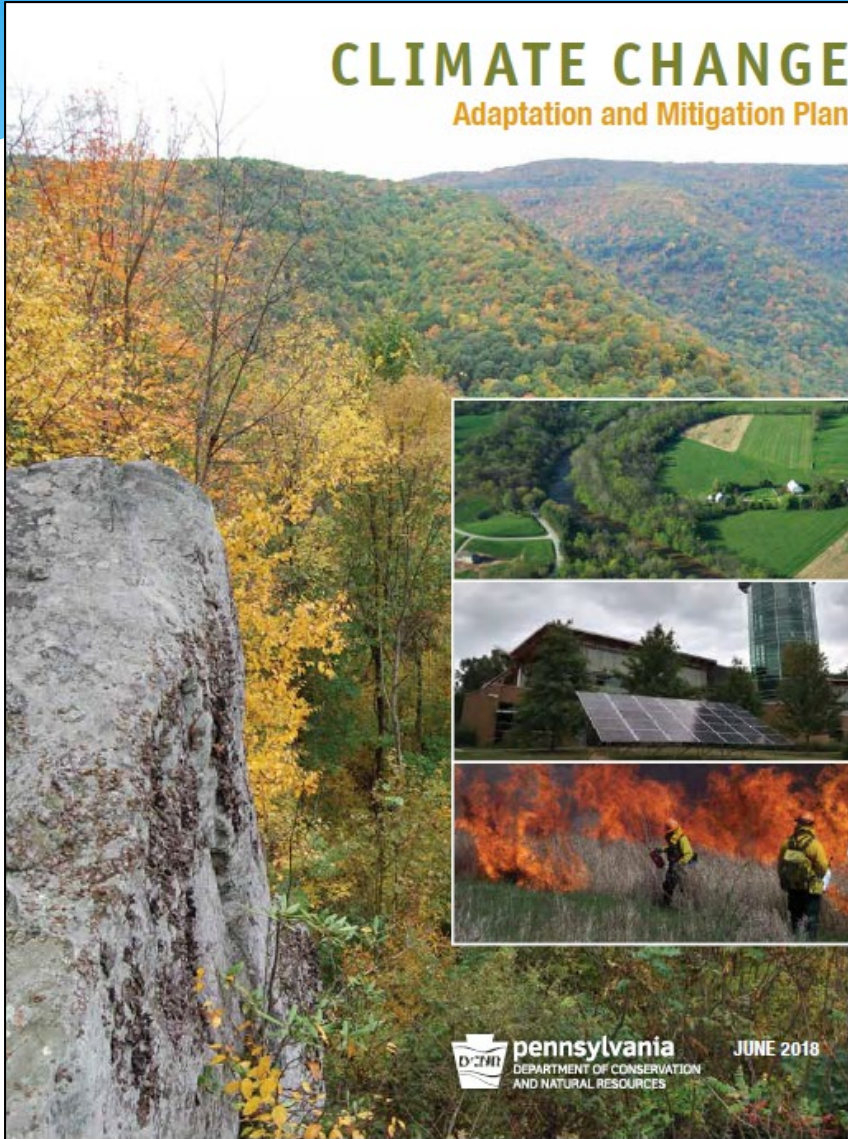


Species on the Move



CLIMATE CHANGE

Adaptation and Mitigation Plan



Questions?