Climate Change and Trout

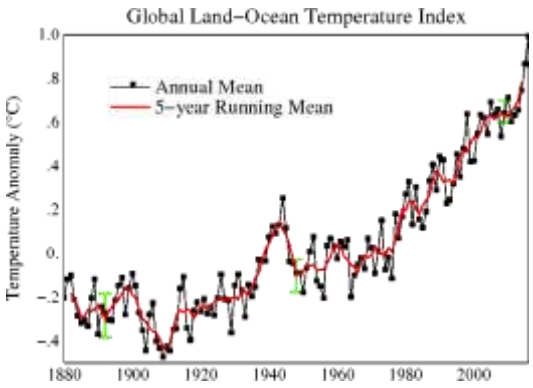
TROUT UNLIMITED

Presentation Goals

- To define climate change and its effect on trout
- To present relevant graphs and data which illustrate the indicators of climate change
- To encourage members and chapters towards efforts to increase stream resiliency to climate change

What is Climate Change?

- Changes in measures of climate, such as temperature
- Global warming is one aspect of climate change

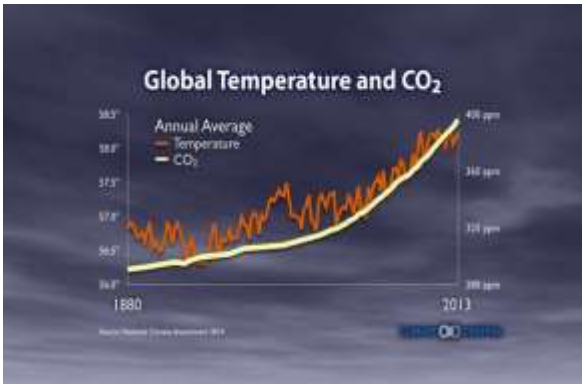


Source of information can be found in a report by the EPA, 25 university and non-government organizations and 4 other government organizations. The title of the report is Climate Change Indications in the US, 2016. The data clearly show the increase in earth's temperature beginning with the start of the industrial revolution. The term temperature anomaly means a departure from a long-term average. A positive anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value.

What causes this warming trend?

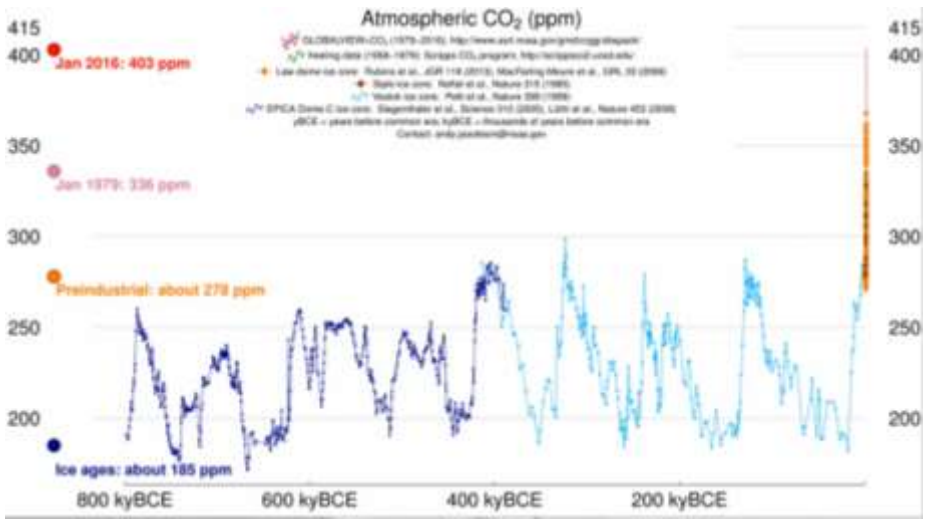
- Increased levels of Greenhouse Gases* are correlated with temperature increases

*CO2, CH4, NOx and ozone



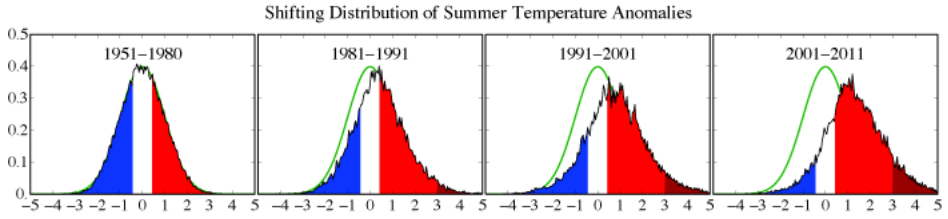
Increases in greenhouse gas emissions due to burning fossil fuels in power plants, factories and vehicles are thought to be major contributors to the recent rise in CO2 and temperatures. Prior to the industrial revolution, the contribution to greenhouse gases were mainly from natural sources. More recently, all the greenhouse gases are increasing more rapidly due to human activities. That temperature is rising is evidenced recently by each new year being called the hottest on record (2016 was the hottest). CO2 = carbon dioxide; CH4 = methane; NOx = nitrogen oxides. CO2 concentrations have increased roughly from 300 to 400 ppm over the last 130 years, and global average temperatures have increased at the same rate over this period. Both temperatures and CO2 levels are displayed on the y-axis.

Atmospheric CO_2 over 800,000 years



The influences on atmospheric CO_2 over the 800,000 years of recorded history (largely from volcanic inputs during tectonic shifts and the wobble of the Earth's axis) compared to the changes during the brief blip of Industrial times (the orange). Long-term estimates of atmospheric CO2 are from ice core studies.
Data source: https://www.esrl.noaa.gov/gmd/ccgg/trends/history.html And note this is actually a fantastic short video that puts this post-industrial impact in stunning scale.

Temperature Anomalies



Northern hemisphere temperatures show a decrease in cooler days (blue) and an increase in hotter days (red) over the past 50 years.

The first graph shows a normal distribution of days that are typical (white) and those cooler (blue) or hotter (red). That is real data over a 30 year period. Moving left to right one sees a dramatic increase in days that are hotter than normal. From 2001 to 2011 note the low number of cooler and typical days. Observed summer temperature anomalies over global land during the first decade of the 21st century averaged about 75% in the "hot category". This means that summers will have "red" temperatures 75% of the time compared with 33% of the time during 1951-1980. Extremely hot outliers already occur more frequently than unusually cold seasons.

Other Climate Change Indicators

- Warming and acidification of the oceans
- Increased storm intensities
- Flooding in some areas; drought elsewhere
- Forest drying leads to more wildfires
- Increases in some invasive species
- Early snow melt-off

EPA has identified these indicators of climate changes.

The Oceanic Connection

- Rising temperatures melt icecaps
- Higher ocean levels obliterate coastal areas
- The surface water increases in temperature
- This leads to higher absorption of CO2 which is converted to carbonic acid
- Acidification is causing changes in species abundance and composition

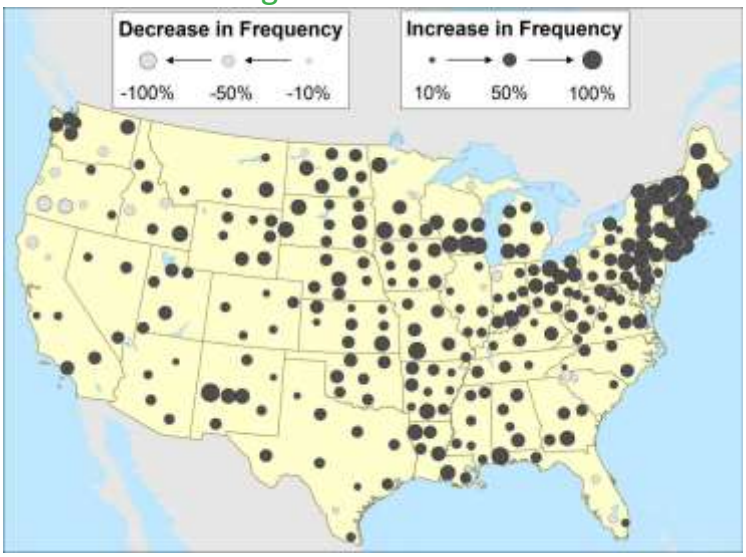
Coral and plankton species cannot form shells as the pH of the ocean decreases (acid increases). Many species depend on coral or plankton so wider effects on ocean ecology results as pH lowers. A 2017 UN study found damage in 21 of 29 reefs on the UNESCO organization's list of World Heritage Sites, including Australia's Great Barrier Reef. Coral reefs could be one of the first ecosystems to become casualties of rapid climate change.

Increased Storm Intensities

- Warmer oceans lead to more evaporation
- Increased water vapor and higher temperatures lead to more frequent and stronger storms
- Results in more flooding and damage
- More severe hurricanes and tornados

The frequency of heavy downpours is expected to continue to increase as the century progresses. Summer thunderstorms that drop up to 6 inches of rain in a local area can be devastating to trout streams. The Summer 2017 issue of the Atlantic Salmon Journal recounts the high water and massive flooding that affected much of Eastern Canada (and parts of BC) this past spring (2017). The record flows affected all aspects of the Atlantic Salmon world. Infrastructure such as roads, fishing access points and buildings were damaged.

Increasing large storms: largest storm at each station increased average of 10% from 1948 - 2012



This slide uses a 65 year history to show the sites where the largest storm at each weather station increased vs. decreased in frequency. The largest dark circles indicate where the largest storms increased in frequency by 100%. The dark circles cover most of the Northeast and Mid-Atlantic States. Sites with decreased frequencies of large storms are mostly in the Pacific Northwest.

Forest Fires

- Drier forests are prone to fires
- After fires, unstable land is eroded during rainfall events
- Increased siltation in streams limits benthic populations
- Siltation affects spawning success for trout

Forests in arid regions or with invasive species causing tree death are more subject to wildfires. After a major fire, when heavy rains do occur, there is nothing left to absorb water and so the water rushes off slopes carrying soil into streams. Mud and silt clog the stream bottoms where benthic organisms live and this silt can also affect the development of trout eggs after spawning.

Floods after fires

- Big Wood River one year later, after rain event
- July 2013 Beaver Creek fire, Sun Valley, ID
- Decreased snowpack after fire failed to remove post-fire silt
- Aquatic life and fishing both seen to decrease

Photo: Carmen Northern

After forest fires the exposed earth is unstable and rain events can greatly erode the land and put mud into rivers, as seen above.

Snowmelt and Trout

- Glaciers are receding as temperatures rise
- Early melting of snow means warmer streams in summer
- Trout require low water temperatures for reproduction

Muir Glacier
Glacier Bay N.P., Alaska

1950 **2004**

One graphic example of how glaciers are melting as the global temperature increases

Increases in Invasive Species

- Lyme disease is a bacterial disease transmitted by ticks
- Increased temperatures have widened the range of Lyme Disease and ticks affecting wildlife
- Wooly Adelgid affecting Hemlocks
- Pine Bark Beetle killing pine trees

Lyme disease is just one example of the spread of invasives. The Pine Bark Beetle explosion out west is directly related to climate change as is the wooly adelgid infestation. The ticks are moving north and may have reached Alaska. Moose in Maine have been dying off due to heavy tick predators.

Regional Changes

- Source: Third National Climate Assessment (2014)

  GlobalChange.gov

  US Global Change Research Program

This section of the presentation shows how climate effects may differ by US region. The country is divided into six regions to present this information. Regions are by no means homogeneous though. The information presented in the next slide are based on predictive modeling of future conditions. One of the important inputs to these simulations are estimates of future greenhouse gas emission quantities. Two emission scenarios are evaluated: Scenario A2—where GHG emissions continue to increase, and Scenario B1—where global emissions are reduced substantially.

There are two emissions scenarios used to develop estimates of future year impacts (A2—emissions continue to increase, and B1—global emissions are reduced substantially).

A2=high population growth, low economic growth, relatively slow technology improvements and infusion.
B1=lower population growth, higher economic development, a shift to low-emitting efficient energy technologies

Regional Model Projections for Low and High Emission Scenarios

Key Indicators 2071-99 vs. 1971-2000	Mean Annual Temperature (degrees F)	Summer Precipitation	# of Days Above 90F (2055)
Northeast	+4 to +9 F	-5 to +6 %	+13 days
Southeast	+3 to +8 F	-22 to +10 %	+31 days
Midwest	+4 to +10 F	-22 to +7 %	+19 days
Great Plains	+3 to +9 F	-27 to +5 %	+20 days
Southwest	+4 to +9 F	-13 to +3 %	+24 days
Northwest	+3 to +8 F	-34 to -4 %	+4 days

This table illustrates what is predicted if we do not curb greenhouse gas emissions. Increased temperatures in all regions are seen and changes in precipitation, both high and low. Note the increased number of hot days in all regions. The middle columns provide mean temperature and summer precipitation estimates for the last 30 years of this century compared with a 1971-2000 reference period. The estimates of the increase in the number of days with temperatures above 90F are for 2055 (versus the same reference period).

Note that the mean annual temperature and summer precipitation estimates are for 2071-2099, while the number of days above 90F estimates are for 2055 (versus the base 1971-2000 period). Consider the implications of the Southwestern US having 24 more days with 90F plus temperatures.

Regional changes like those above could be particularly severe for the SW where a hot and dry area becomes even hotter and drier.

Projected Coldwater Losses Due to Climate Change

- Recent studies*project major habitat losses by 2100 for trout waters
- Coldwater habitat will decline by 50%
- High altitude western watersheds and some Appalachian streams may still be trout water
- Models predict large economic losses to regions where coldwater fisheries decline

*R. Jones et al., Mitig. Adapt. Strateg Glob. Change (2013) 18:731–758
S. Wenger et. al. Proc. Nat. Acad. Sci. (2011) **108,** 14175-14180

This study shows that as greenhouse gases increase under different modeling scenarios, coldwater habitat will decline 50%. Warmwater fisheries will replace those lost watersheds and fishermen will have to travel further with more expense to fish for coldwater species.

What has TU been doing?

- **Mitigating the effects of climate change**
- **Adaptation efforts**
  - **Protect the best watersheds**
  - **Restore mainstem, riparian and floodplain habitats**
  - **Reconnecting mainstems to tributaries**
- **Goal: Making streams more resilient to climate change**

See the Fall 2016 issue of Trout magazine for more information.

Long Mountain Brook culvert replacement

Before – September 22, 2008 (looking upstream)
6' diameter pipe; 1.2' drop

After – September 29, 2008 (looking upstream)
22' x 8' embedded aluminum box

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One of the climate adaptation strategies that TU has been pursuing is replacing culverts that restrict water flow during high water events. Culverts like the one on the left restrict normal downstream flows and can act as dams during floods. Culverts like the one on the right are much less restrictive.

Slide Brook culvert remediation

May 12—26, 2010

Before – July 20, 2006 (looking upstream)
6’ diameter pipe; 3.4’ drop

After – May 26, 2010 (looking upstream)
42’ clear span; pre-manufactured steel bridge

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Here is an another culvert replacement example where a pre-manufactured steel bridge replaced an aging pipe.

What can you do?

- Get involved in stream improvement projects
  - Tree plantings to shade streams
  - Channel improvements creating deeper pools
  - Culvert replacement to allow trout to access headwaters
- Advocate for reduced use of fossil fuels
- Reduce your carbon footprint

Sources of Information

- Climate Change Indicators in the United States EPA, 4th Edition, 2016
- Third National Climate Assessment (2014)

  www.GlobalChange.gov

  US Global Change Research Program of the National Academy of Sciences
- The New Climate Dice: Public Perception of Climate Change, by James Hansen, Makiko Sato, Reto Ruedy, Proc. Natl Acad. Sci, 2012
- Trout Unlimited's Scientific Staff

Another useful reference to read is the most recent IPCC Summary Report to Policymakers. This report is short and has information in a form that is relevant to policymakers around the globe.

In addition, the NCA 2014 report has a FAQ section in an appendix that answers many common questions about climate change.