Regional Climate Change Impacts: What Science Tells Us

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https://www.nasa.gov/topics/earth/images/index.html
Geology.com
The world is warming almost everywhere

Source: NASA

https://data.giss.nasa.gov/gistemp/animations/
Sea level is accelerating

http://www.columbia.edu/~mhs119/SeaLevel/
Wuebbles, D.J., Easterling, D.R., Hayhoe, K., Knutson, T., Kopp, R.E., Kossin, J.P.,
Kunkel, K.E., LeGrande, A.N., Mears, C., Sweet, W.V., Taylor, P.C., Vose, R.S., Wehner,
D.J. Dokken, B.C. Stewart, T.K. Maycock (Editors), Climate Science Special Report:
Fourth National Climate Assessment, Volume I. U.S. Global Change Research Program,
Washington, DC, USA, pp. 35–72.
We cannot explain observed warming with natural drivers ...

... but we can with human drivers

The greenhouse effect in three steps

1. Solar radiation warms Earth
2. Earth’s radiation absorbed in atmosphere
3. Atmosphere’s radiation further warms Earth—by 60 °F
The greenhouse effect is well established

1824: Joseph Fourier describes natural greenhouse effect

1858–1861: Funice Foote and John Tyndall identify greenhouse gases

1896: Svante Arrhenius estimates greenhouse effect of fossil fuel CO₂

1938: Guy Callendar documents warming and CO₂ increase
“Many lines of evidence demonstrate that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.”

“For the period extending over the last century, there are no convincing alternative explanations supported by the extent of the observational evidence.”

Fourth National Climate Assessment
Native bees in Northeast US are arriving in spring 10 days earlier than they used to.

Birds in Western PA became smaller by 1.3% on average due to warming from 1961 to 2007


With warming and snowpack reduction, Snowshoe Hare range in Pennsylvania has contracted

Diefenbach et al. (2016), Fourth National Climate Assessment (Lipton et al. 2018)


Photo credit: L. S. Mills research photo by Jaco and Lindsey Barnard, University of Montana Mills Research Lab.
Heavy precipitation is increasing

Change in top 1% of rainiest days from 1958 to 2012

Three possible emissions futures ...

... lead to very different climate futures

Summers in Pennsylvania will feel like those of the Southeast US by mid-century if heat trapping emissions trends continue.
Expect summers to be drier ...

... and winters to be wetter

Percent precipitation change by 2050s

Kunkel et al. (2013)
Expect heavy downpours to continue to increase

Percent change by 2050s in days > 1"

Kunkel et al. (2013)

Projected change in downhill skiing season length by 2090

The wooly adelgid harms the Eastern Hemlock tree (PA state tree)
Warming winters allow the wooly adelgid to do more damage

In Millbrook, NY, warming has led to an earlier larval peak of the blacklegged (deer) tick, the major Lyme disease transmitter.

We have cleaned up our own messes before
“Smog episodes”

October 1948: Pollution from zinc mills in Donora, PA combined with a temperature inversion, leads to 20 deaths

Source: Donora Smog Museum
This is happening much less often than it used to because ...

Median change in US: 1980-2010  Data source: www.epa.gov/airtrends
The Clean Air act reduced emissions and created $170 - $430 billion per year in health benefits—all while energy use went up and costs went down!

Good news: the ozone hole is shrinking!

[Graph showing the decrease in size of the ozone hole over time, with an upward trend from 1970 to 1990, a peak around 2000, and a downward trend from 2010 to 2020.]

NASA image

https://ozonewatch.gsfc.nasa.gov/statistics/annual_data.html
Take-home messages

1. Pennsylvania has followed the global warming trend
2. Impacts are already being felt in multiple ways
3. Human-induced climate change will continue to occur regardless of emissions scenario; further adaptation is necessary.
4. The climate of the mid century and beyond is very sensitive to the emissions scenario.
5. Good science and good policy has gotten us out of environmental messes before
References


