The Challenge of Climate Change and Biodiversity Loss

David Karowe
Department of Biological Sciences
Western Michigan University

Since 1900, Earth has warmed ~ 0.8°C

12 warmest years in history:
2002-2012, 1998*

Warming is 10-20 times faster than in at least the last 800,000 years
Temperature difference relative to 1950-1980

Precipitation is a very important component of climate
- severe rainstorms have become more common

40% increase in southwest Michigan since 1948
At the same time, much of the world has been experiencing more frequent and stronger droughts.

Palmer Drought Severity Index (PDSI)

1950-1959

-20 -15 -10 -8 -6 -4 -3 -2 -1 -0.5 0 1 2 3 4 6 8 10 15 20

Palmer Drought Severity Index (PDSI)

2000-2009
Climate predictions are coming true in the U.S. In 2011, 10 states had their wettest spring on record.

As a result, there was extensive flooding.
2012 was the warmest year on record for the U.S.

Much of the U.S. has been experiencing severe drought.
Is the U.S. still in drought?

October 15: 55% drought

“Natural variation” cannot explain current warming
Since 1975, while Earth has been warming fastest, solar irradiance has been decreasing

In two major ways, current warming is very different than any warming period in at least the last 800,000 years

1. It’s at least 10-20 times faster
2. It’s happening while solar input is decreasing
Best estimate: ≥ 95% of current warming is due to human activities

Are Americans aware of the cause?

"We’re causing it"

"It’s natural"
Is there any debate among scientists about whether humans are the primary cause of global warming?

“Most of the global warming in recent decades can be attributed to human activities.”

Scientific organizations endorsing this statement:

**United States:**
National Academy of Sciences
American Medical Association
American Association for the Advancement of Science
American Meteorological Society
American Institute of Biological Sciences
American Chemical Society
American Geophysical Union
American Institute of Physics

Geological Society of America
American Academy of Paediatrics
American College of Preventive Medicine
American Public Health Association
National Oceanic and Atmospheric Administration
National Aeronautics and Space Administration
Environmental Protection Agency
National Center for Atmospheric Research
University Corporation for Atmospheric Research
Ecological Society of America
American Society of Agronomy
American Society of Plant Biologists
Association of Ecosystem Research Centers
Botanical Society of America
Crop Science Society of America
Natural Science Collections Alliance
| American Statistical Association |
| Organization of Biological Field Stations |
| American Physical Society |
| Society for Industrial and Applied Mathematics |
| Society of Systematic Biologists |
| Soil Science Society of America |
| Federation of American Scientists |
| National Research Council |
| National Association of Geoscience Teachers |
| American Quaternary Association |
| American Association of Wildlife Veterinarians |
| American Society for Microbiology |
| Society of American Foresters |
| American Astronomical Society |

**Europe:**

| European Academy of Sciences and Arts |
| European Science Foundation |
| European Geosciences Union |
| European Physical Society |
| European Federation of Geologists |
| Royal Society of the United Kingdom |
| Academie des Sciences (France) |
| Deutsche Akademie der Naturforscher (Germany) |
| Accademia dei Lincei (Italy) |
| Royal Irish Academy |
| Royal Swedish Academy of Sciences |
| Royal Academy of Belgium for Sciences and the Arts |
| Royal Meteorological Society |
| British Antarctic Survey |
| United Kingdom Institute of Biology |
Other countries ($\geq 35$):
- Chinese Academy of Sciences
- Science Council of Japan
- Russian Academy of Sciences
- Indian National Science Academy
- Royal Society of New Zealand
- Australian Academy of Sciences
- Australian Medical Association
- Polish Academy of Sciences
- Academia Brasilierea de Ciencias (Brazil)
- Royal Society of Canada
- African Academy of Sciences
- Caribbean Academy of Sciences
- Academy of Sciences of Malaysia
- Indonesian Academy of Sciences
- Academy of Science of South Africa

Scientific organizations holding a dissenting opinion:

Since 2008:
- American Institute of Petroleum Geologists
Are Americans aware of the strength of the scientific consensus?

In fact, 97.5% of climate scientists agree

- "Scientists agree" (97.5%)
- "Scientists don't agree" (2.5%)

Has Earth stopped warming?

This is a deceptive argument that only works with 1998 (the last Super El Nino year) as the starting point.
What does the future hold?

“No fate but what we make”

It depends on our choices

If we remain on our current course, future climate change will be severe

Depending on choices we make, Earth is likely to warm by 2-5°C by 2100

Actual

“Business as usual”

Alternate energy sources
Will a 5° temperature rise matter?
When Earth was 5° cooler:

- current drought indices will longer work properly

Much of the world is likely to experience much more frequent and stronger droughts by the 2060s
Most summers are likely to be hotter than any experienced thus far
Many areas are also predicted to experience “disappearing climates” by 2100

How will climate change affect biodiversity?

It depends on the choices we make
What is the likely future fate of species?

Australian *Banksia* are very dry-adapted species, so will they be “climate winners”?
Typical result: many more climate losers than winners

Under 2° warming with full dispersal: 21 winners 80 losers (5 go extinct)

Under 4° warming with no dispersal: 0 winners 97 losers (24 go extinct)

Under 2° warming, huge losses are predicted for 5,200 African plant species

55% of species go extinct (no dispersal)
40% of species go extinct (full dispersal)
Tree diversity is predicted to decline substantially throughout the U.S. by 2100

By 2080, climate change is predicted to cause the extinction of 20-40% of large African mammals
Even if suitable future habitat exists, species may not be able to get there in time to avoid extinction

This is the worst time in Earth’s history for climate change

Which species are particularly vulnerable?

1. Species that have nowhere to go
2. Species that live in coral reefs
3. Species that live in the tropics
4. Species that have specific timing requirements
Ice-obligate species have nowhere to go

Most, but not all, polar bear populations are predicted to decline dramatically by 2050

- all decline or disappear by 2100

Seals also rely on sea ice, so are highly vulnerable too
In Antarctica, Emperor and Adelie penguins need ice but Chinstrap and Gentoo penguins nest on land.

Scandinavian bird species are predicted to lose 80% of their suitable habitat by 2080. Other high latitude species have nowhere to go.
High altitude species also have nowhere to go.

All of Earth’s 1,009 montane bird species are predicted to be “climate losers”.

[Image of mountainous terrain with trees and bird species]

[Map showing range change with median ranges indicated]
Coral reef species are likely to be particularly vulnerable because both warming and ocean acidification can cause bleaching.

Even 2º warming is likely to cause a massive increase in bleaching events.
Acidification alone may make most or all of the ocean unsuitable for corals

- 650 ppm CO₂ may cause near total loss of coral reefs

Tropical species are vulnerable because they are most likely to experience “disappearing climates”

Where is most of Earth’s biodiversity?
Migrating species are likely to be vulnerable because of their specific timing requirements
- due to loss of synchrony at important stopover sites
- daylength and star patterns vs. temperature

Species that have not been tracking climate change are already declining
- in Thoreau Woods over the last 150 years, major declines for plant species with no timing shift

- European bird species that are not migrating earlier are also declining
Climate change has the potential to cause Earth’s 6th mass extinction

What will climate change mean for Michigan species?
At least 20 common tree species are predicted to decline by 50-100% in Michigan, including:

- black spruce -98%
- paper birch -97%
- aspen -89%
- balsam fir -89%
- sugar maple -67%
- eastern hemlock -66%

20 southern species are predicted to arrive in Michigan:

- loblolly pine
- shortleaf pine
- Virginia pine
- sweetgum
- sugarberry
But forests are more than just trees

32 Michigan bird species predicted to decline by 75-100%

- Common loon
- White-throated sparrow
- Veery
- Yellow-bellied sapsucker
- Evening grosbeak
- Red-breasted nuthatch
- Magnolia warbler
- Blackburnian warbler
15 new species are predicted to arrive in Michigan

- northern bobwhite
- yellow-billed cuckoo
- little blue heron
- cattle egret
- Mississippi kite
- scissor-tailed flycatcher
- painted bunting
- summer tanager

What can I do to minimize climate change?

We can change the future by implementing multiple solutions that already are available
Next time, buy a more fuel-efficient car

- 20 mpg
- 30 mpg
- 34 mpg
- 50 mpg

Weatherize your house: weather-strip, adequately insulate attic, and replace single-pane windows with triple-pane windows
Unfortunately, energy conservation is not a solution - really just delays the outcome

Stop deforestation: great idea, but also not a solution
To limit warming to 2° C, we need to reduce greenhouse gas emissions by 80% by 2050.

This can only happen through aggressive expansion of alternate energy sources.

Globally, we generate only 0.2% of our energy from wind, and only 0.1% from solar.

Global wind potential is >40 times worldwide use.

All 9 highest CO₂-emitting countries could use wind alone.
The “intermittency problem” can be solved easily

*e.g.* Luddington pumped storage plant

Solar energy has even greater potential

Three main technologies:

- solar thermal
- parabolic trough
- photovoltaics

Global potential estimated at up to 100 times current use
A small portion of the Sahara desert could supply all of the world’s electricity

A solar array 100 x 100 miles could provide all of US energy needs today
Again, “intermittency problem” can be solved easily—store excess heat during day, generate electricity at night.

- solar thermal
- parabolic trough

Educate others
Encourage policymakers to make smarter choices

MI 6th District voters will have a clear choice

“… one of the biggest threats to planet Earth on planet Earth.”
LA Times, December 2011

What would Earth gain by these smarter choices?

3.5°C warming

Low Moderate High
Probability of disappearing climate

2°C warming
Bottom Line:

1. We are causing climate to change at an alarming rate.

2. If we continue on our current path, the future is very likely to include unprecedented hardships for the great majority of Earth’s species (including humans).

3. We can change our path by making smarter choices in our own lives and by electing leaders who will also make smarter choices.

Thank you for listening