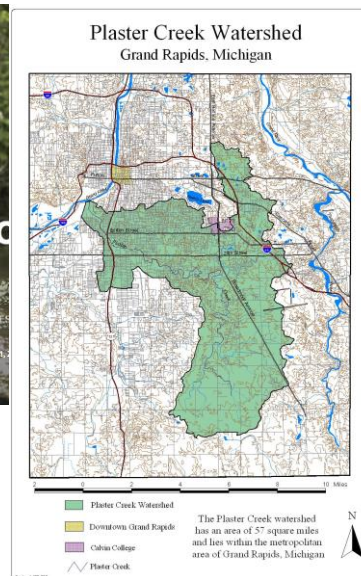
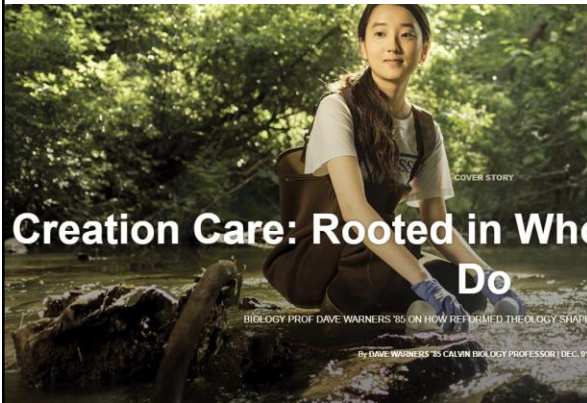


# Effects of Climate Change on Aquatic Ecosystems of the Great Lakes Region



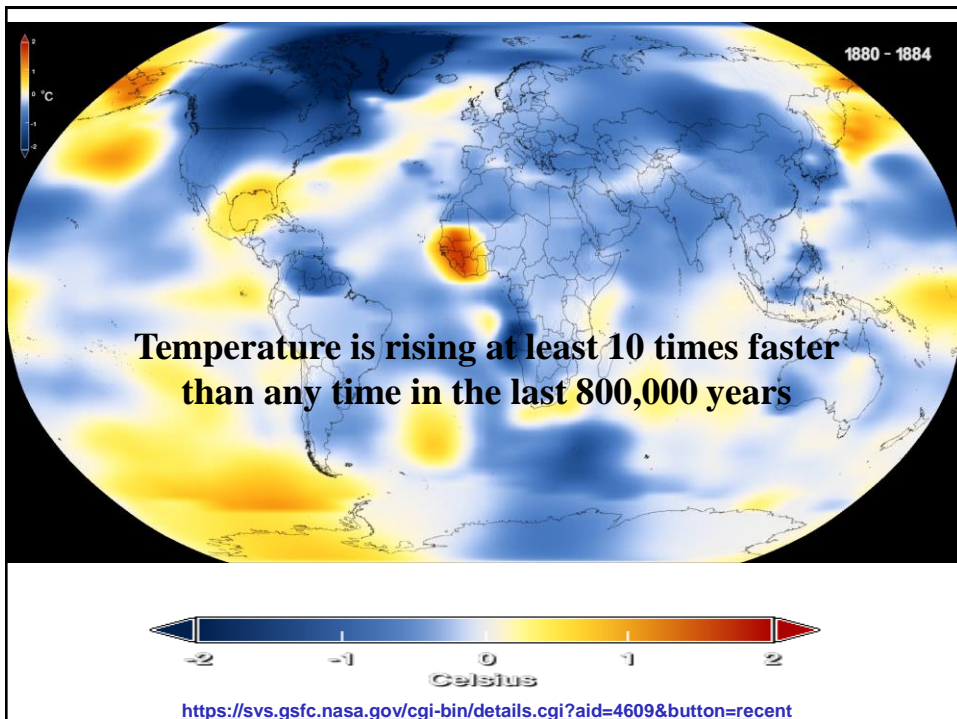
**David Karowe**  
**Department of Biological Sciences**  
**Western Michigan University**

## Calvin College has an exemplary history of environmental stewardship

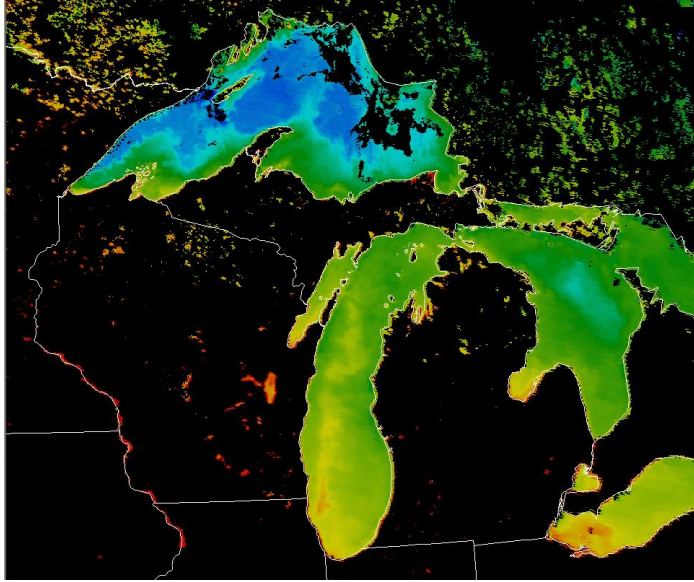


## **This morning, we'll address four questions:**

- 1. Is climate change happening?**
- 2. Are we causing it?**
- 3. Will climate change have adverse impacts on aquatic ecosystems in the Great Lakes Region, including Plaster Creek?**
- 4. How can we reduce those adverse impacts?**

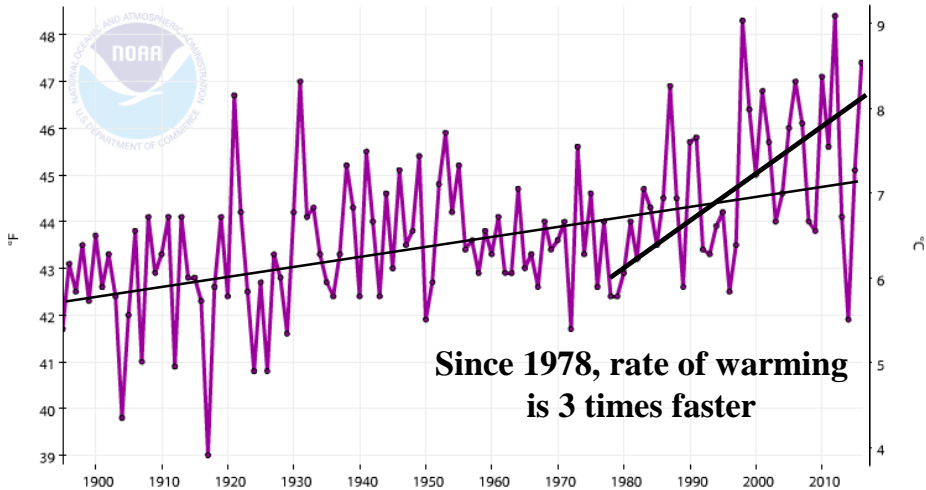


## How has climate been changing in the Great Lakes Region?

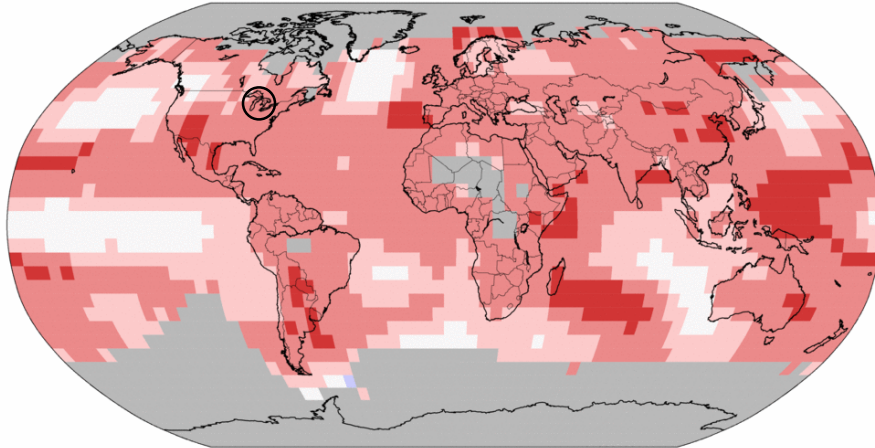


## Since 1900, the Great Lakes Region (GLR) has warmed by ~ 1.0° C

Average annual temperature

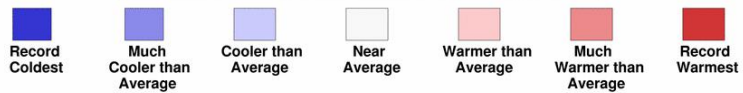
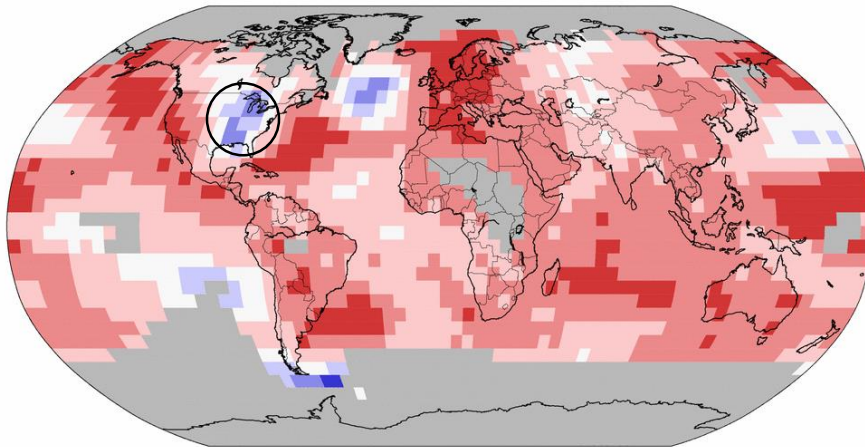


### Globally, 2017 was the 2<sup>nd</sup> hottest year on record (11<sup>th</sup> hottest for Michigan)



Tue Jan 16 07:02:31 EST 2018

### Globally, 2014 is now the 4<sup>th</sup> hottest year on record

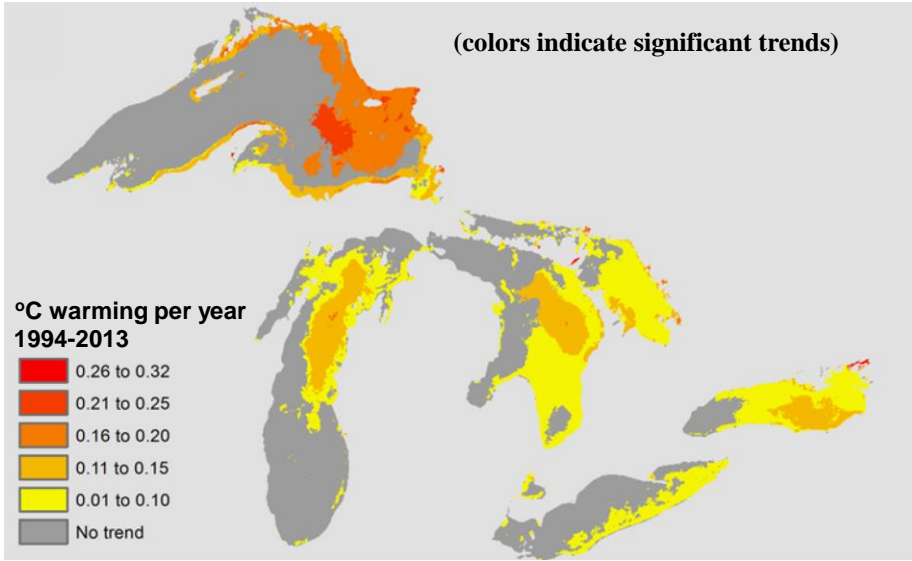


Mon Jan 12 19:34:46 EST 2015

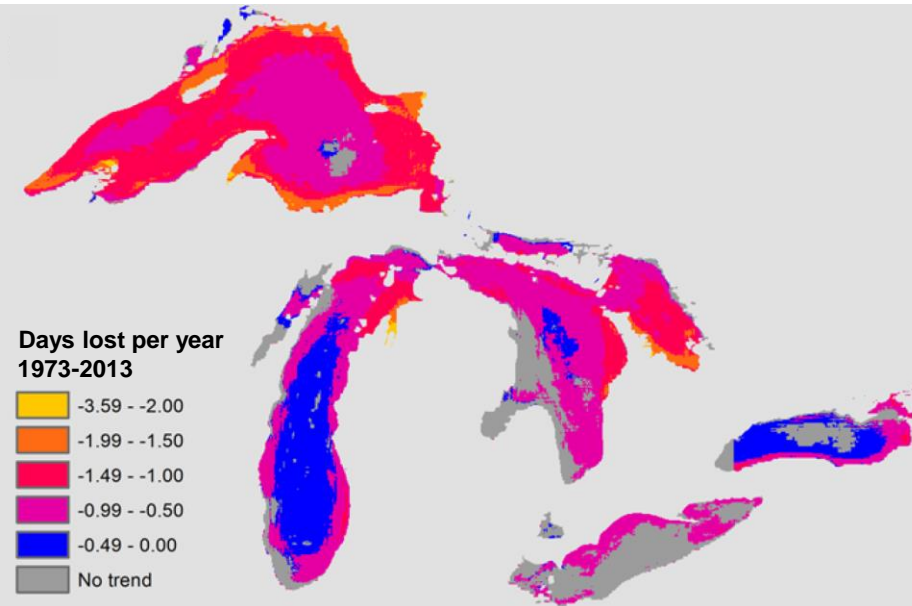
- but 10<sup>th</sup> coolest for Michigan



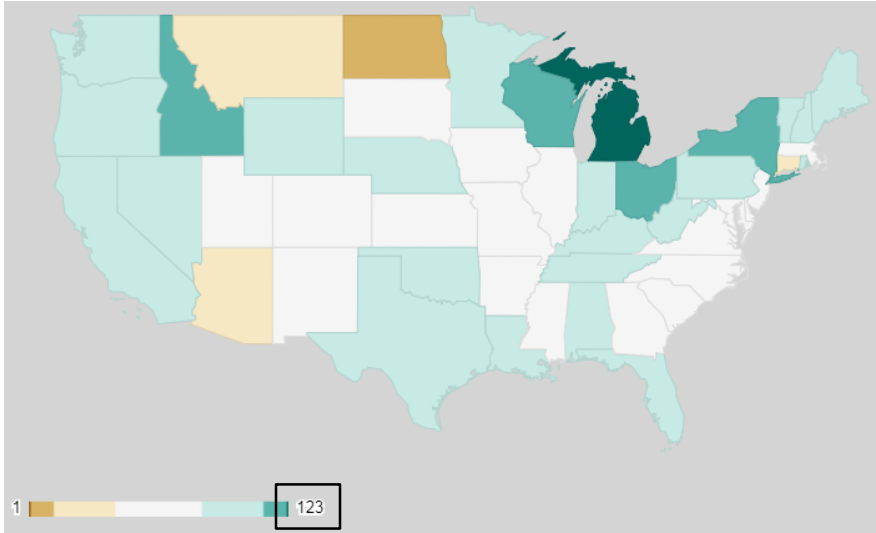
### The Great Lakes have been warming rapidly



### Consequently, ice cover has decreased by 71% since 1973



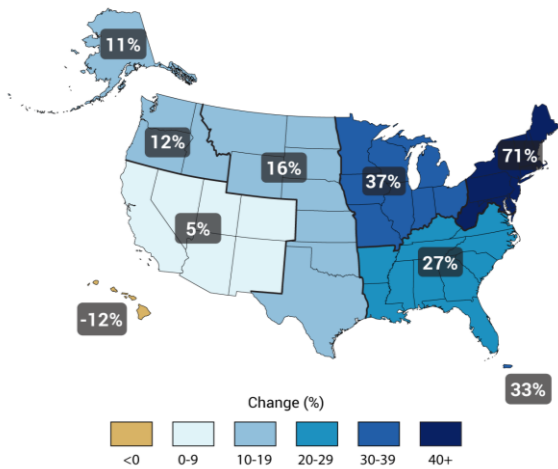
### For Michigan, 2017 was the wettest year on record



### There has been a big increase in extreme precipitation events over the last 60 years



Observed Change in Very Heavy Precipitation Since 1958

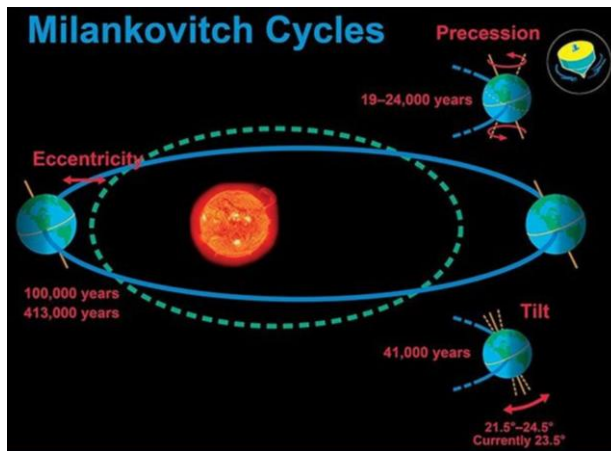
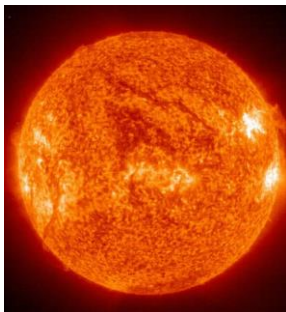
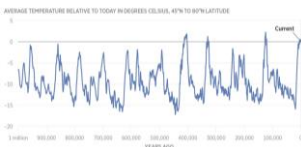


As a result, many areas have had extensive flooding



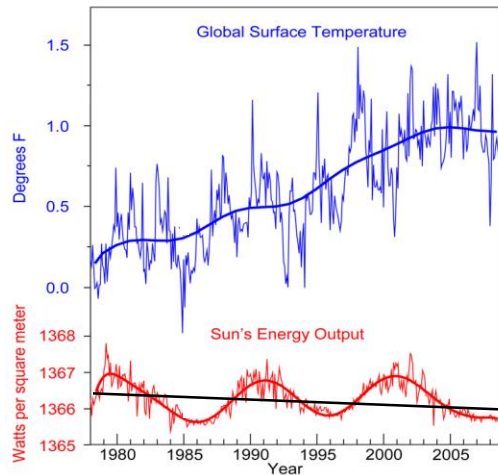
How do we know that today's climate change is not due to "natural factors"?

Until ~1900, all climate change was due to natural factors



*Have we been getting more energy from the sun?*

**For the past 40 years, while Earth has been warming fastest, energy from the sun has been decreasing**



**Over the past century, “natural factors” would have caused a slight cooling of Earth**

**Best estimate: 100% of current warming is due to human activities**

**Fossil fuel burning (CO<sub>2</sub>)**

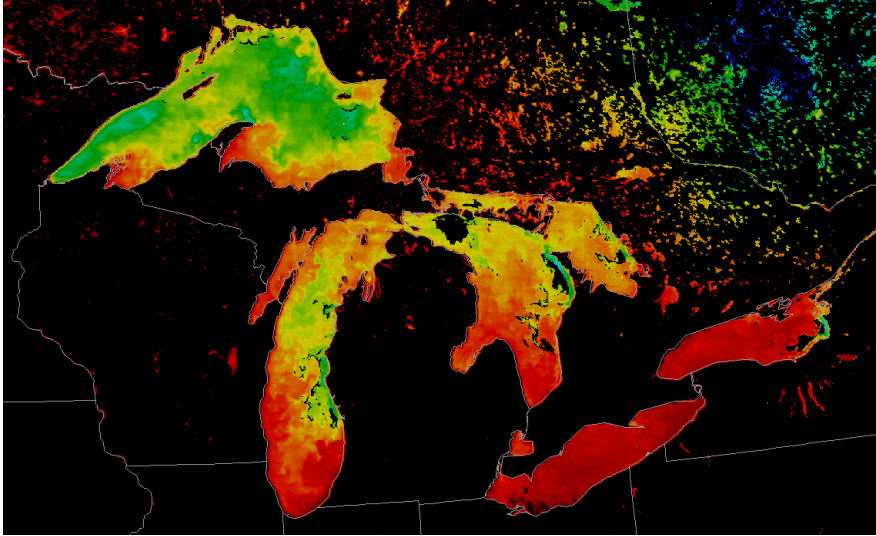


**Deforestation**

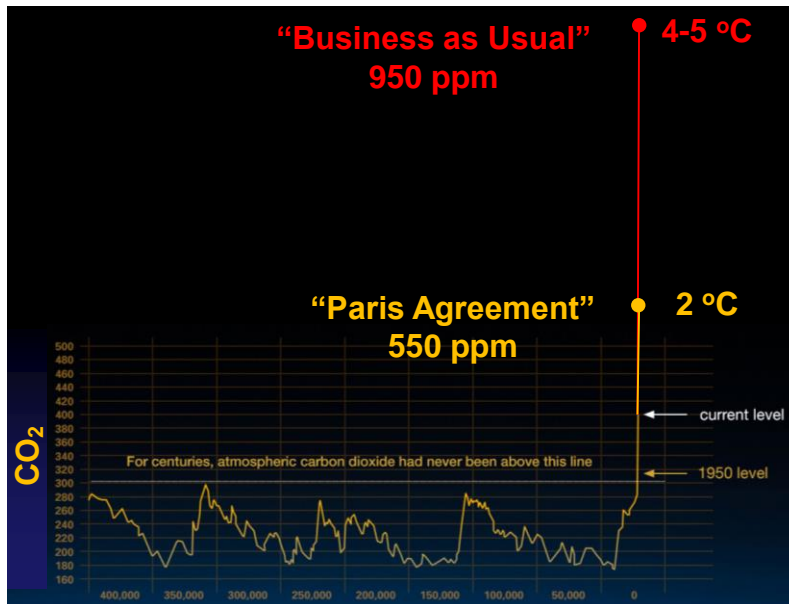




## How will future climate change affect the Great Lakes Region?

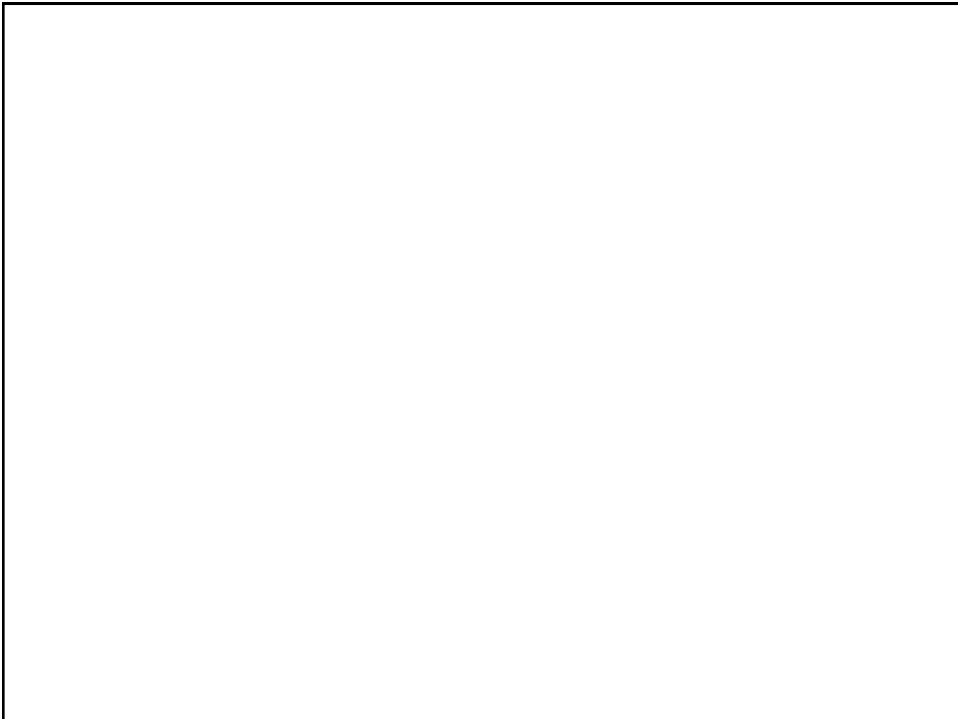


## The magnitude of future warming in the GLR depends on our choices

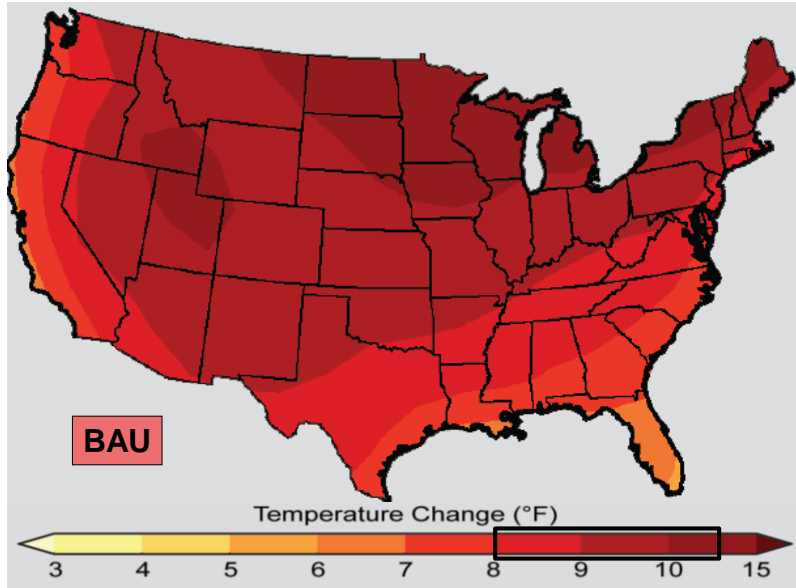


**Would a 5° C temperature rise matter?**

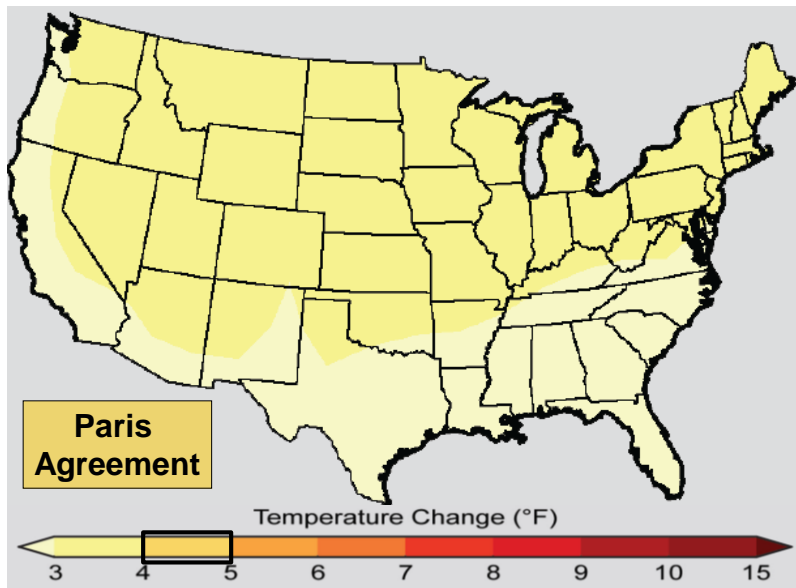
**When Earth was 5° C cooler:**



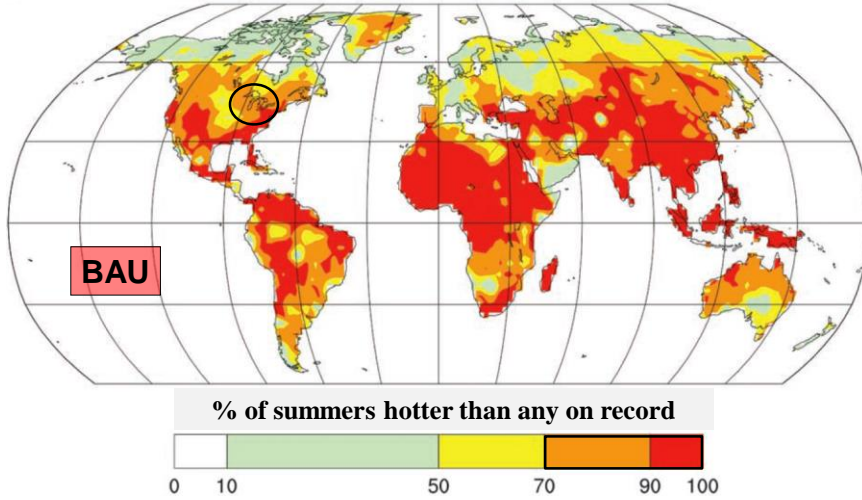
By 2100 under “Business as Usual” (BAU), most of the GLR is predicted to warm by 4.5-6.5° C (8-12° F)



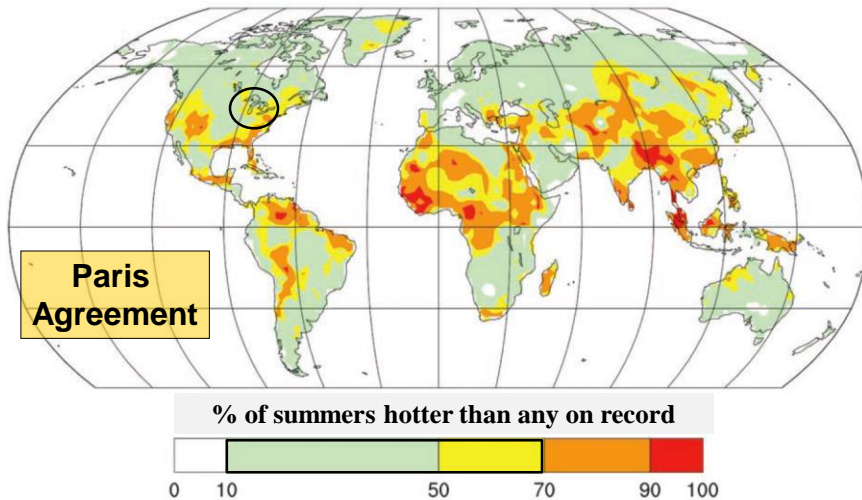
But under the Paris Agreement, most of the GLR is predicted to warm by only 2.2-2.8° C (4-5° F)



**By 2100 under Business as Usual, 70-100% of GLR summers will be hotter than today's record hot summer**

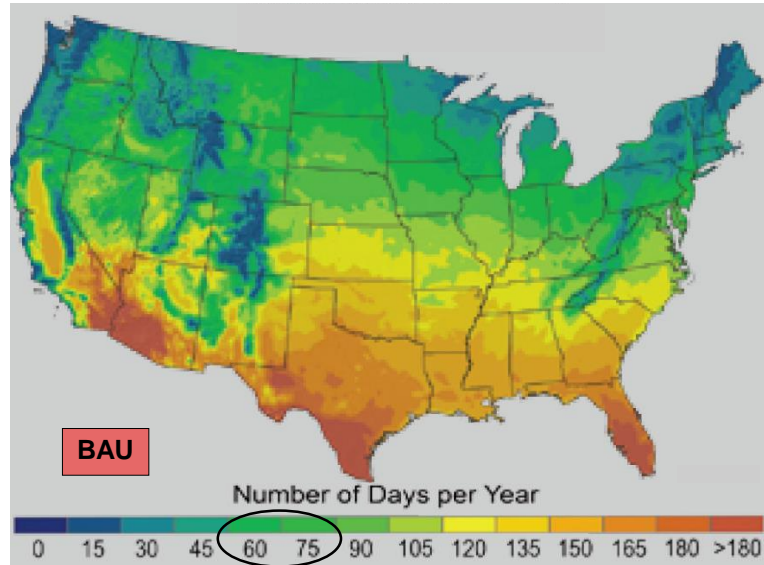


**But under the Paris Agreement, only 10-70% would be hotter than today's record hot summer**

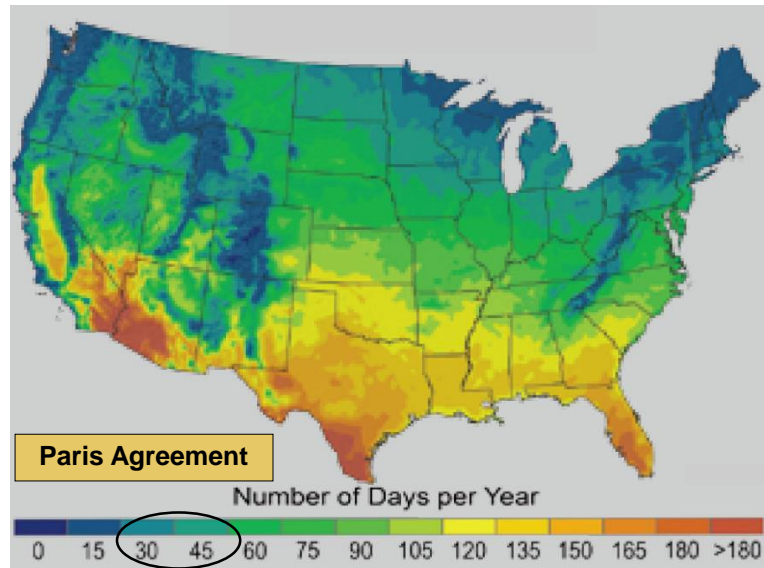




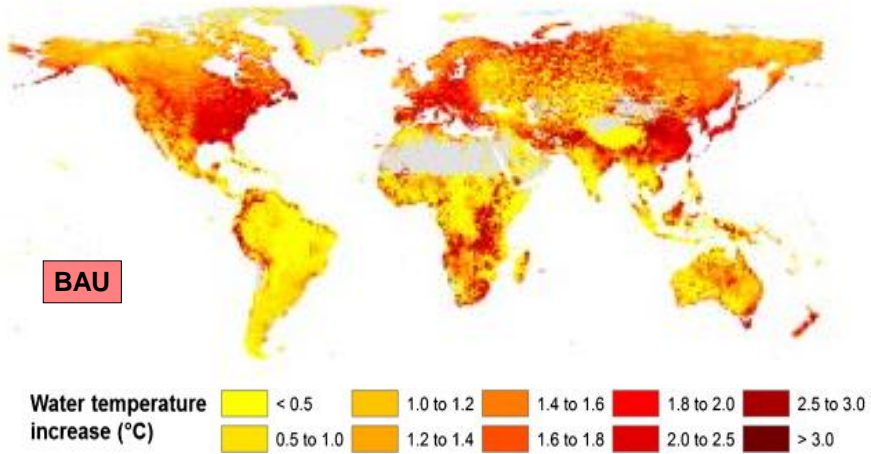
**By 2100 under Business as Usual, southern Michigan is predicted to have 60-75 days per year over 90° F**



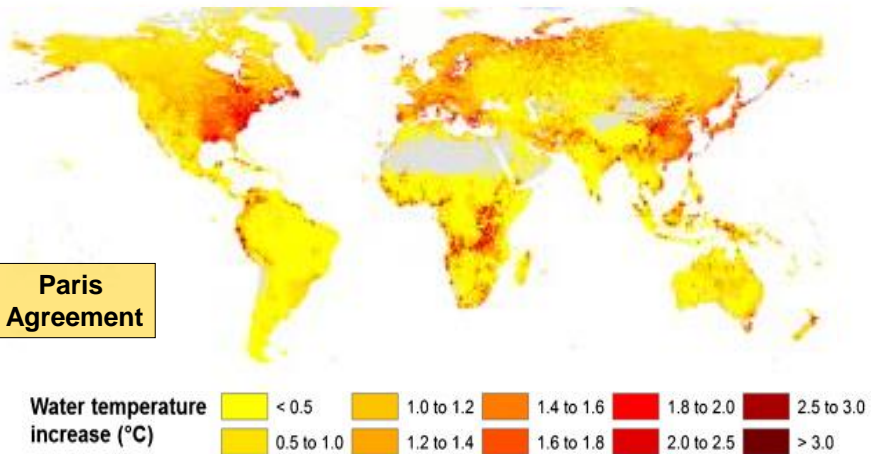
**But under the Paris Agreement, southern Michigan is predicted to have 30-45 days per year over 90° F**



### The Paris Agreement would reduce warming of GLR aquatic ecosystems



### The Paris Agreement would reduce warming of GLR aquatic ecosystems



## Extreme precipitation events are predicted to become more common in the GLR



**How often will today’s “once every 20 years” rain event happen in the future?**

	<b>Business as Usual</b>	<b>Paris Agreement</b>
<b>By 2050:</b>	<b>2.4 times</b>	<b>1.6 times</b>
<b>By 2100:</b>	<b>4 times</b>	<b>2.4 times</b>

## Increased frequency and severity of extreme precipitation events will increase stormwater problems



**Stormwater**

Many of the impairments Plaster Creek faces are caused by stormwater—rain or snowmelt that runs over land instead of soaking into the soil. For an overview of stormwater, visit [Fifteen to the River](#), a collaborative project by the West Michigan Environmental Action Council, the City of Grand Rapids, and other partners. Or, watch our short [slideshow](#) to learn how stormwater affects Plaster Creek in particular.

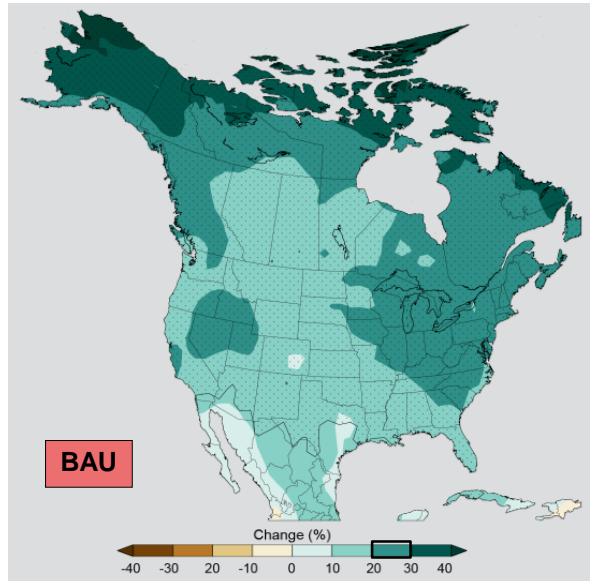
**Priority Pollutants**

Here are the pollutants identified in the [Plaster Creek Watershed Management Plan](#).

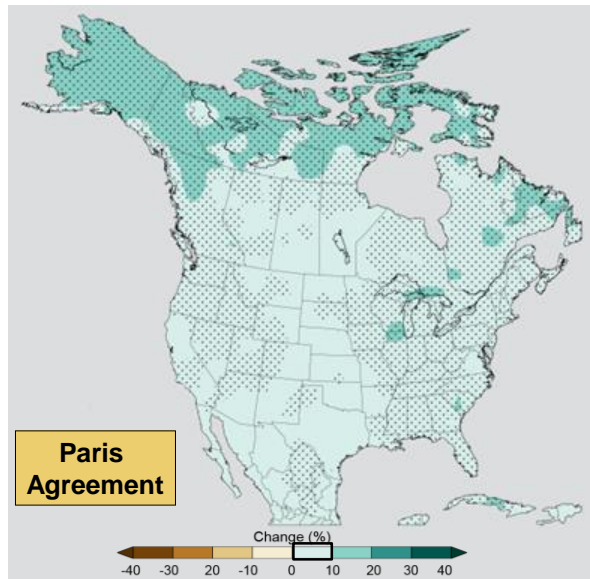
- **Sediment:** Stormwater runoff causes flooding in Plaster Creek, which erodes stream banks and washes sediment into the creek. Sediment can also be introduced into the stream by runoff from agriculture and construction sites. Overabundant sediment in the creek blankets the creekbed and destroys habitat for fish and other aquatic life. It is also carried into the Grand River and Lake Michigan.
- **E. coli contamination:** We know that E. coli contamination is a problem in Plaster Creek, but we don't know how exactly it gets there. Possible sources include dumping pet-waste down storm drains, leaky septic tanks, agricultural sources (livestock, manure), waste from wild animals, and many others. The sources of E. coli are not well understood, but it's clear that stormwater runoff from all parts of the watershed - both urban and rural and everything in between - is making the E. coli problem worse.
- **Nutrient pollution:** Excess nutrients from lawn fertilizers, agricultural outputs, and animal manure can cause algae to bloom, compromising stream quality and degrading ecosystems downstream.
- **Thermal pollution:** Runoff from warm, paved surfaces causes creek temperatures to fluctuate dramatically, making it inhospitable for native fish and other aquatic wildlife.
- **Toxic substances:** The creek is contaminated by untreated urban runoff, road salt, and pesticides. Old industrial sites in the watershed may also be leaching legacy pollutants into the stream.

The root cause of most problems in Plaster Creek is **stormwater runoff**—rain or snow melt that flows over land instead of soaking into the soil.

**By 2100 under Business as Usual, extreme precipitation events in the GLR would also be ~25% stronger**

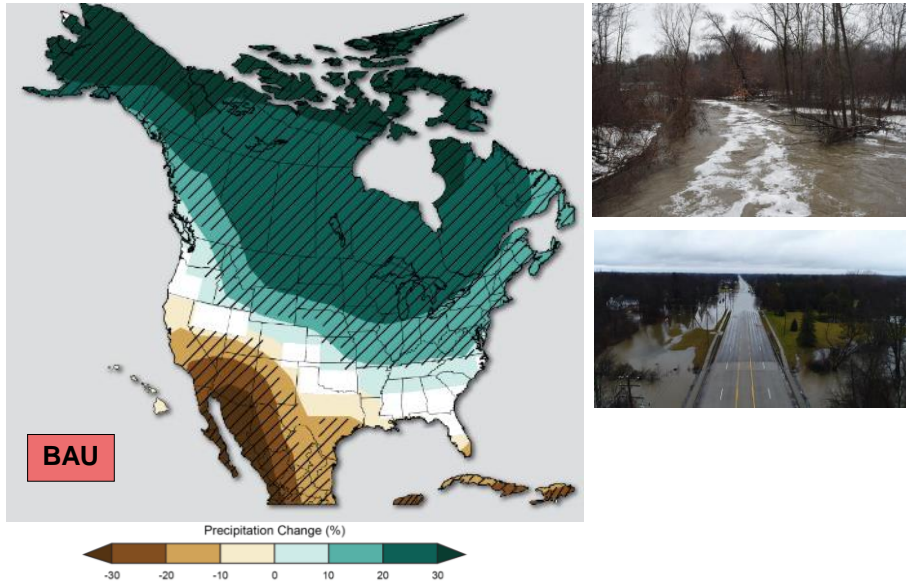


**But under the Paris Agreement, extreme precipitation events in the GLR would be only ~5% stronger**

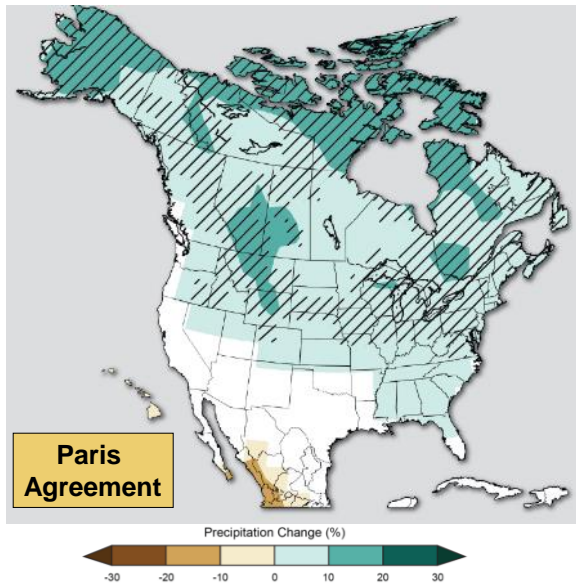




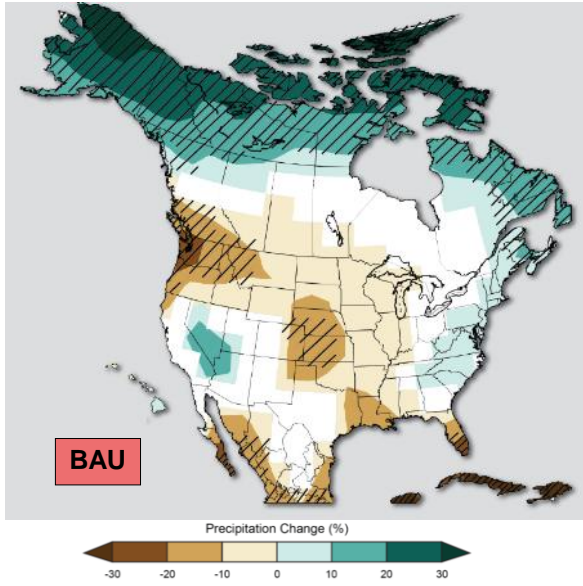
**By 2100 under Business as Usual, spring precipitation in the GLR would increase by ~25%**



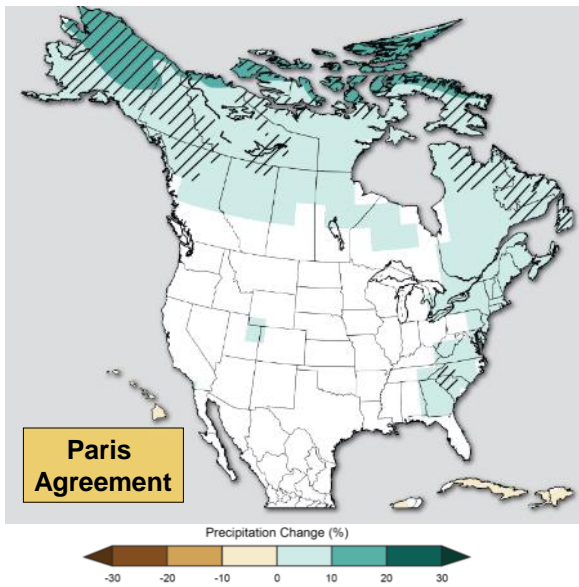
**But under the Paris Agreement, spring precipitation in the GLR would increase by only ~5%**



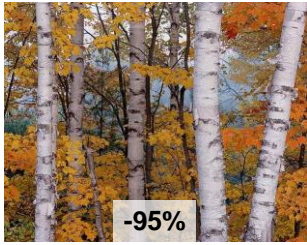
**By 2100 under Business as Usual, summer precipitation in the GLR would decrease by ~5%**



**But under the Paris Agreement, summer precipitation in the GLR would not decrease**



**In Michigan, under BAU, 13 of the 20 most abundant tree species are predicted to decline by at least 50%**



**paper birch**



**both aspen species**



**balsam fir**



**white cedar**

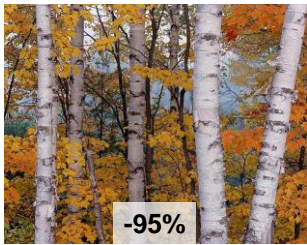


**white pine**

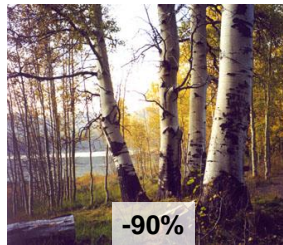


**sugar maple**

**Under the Paris Agreement, 9 of the 20 most abundant tree species are predicted to decline by at least 50%**



**paper birch**



**both aspen species**



**balsam fir**



**white cedar**



**Under BAU, 24 Michigan bird species are predicted to decline by 80-100%**



**Common loon**



**White-throated sparrow**



**Veery**



**Yellow-bellied sapsucker**



**Evening grosbeak**



**Red-breasted nuthatch**



**Magnolia warbler**



**Blackburnian warbler**

**But under the Paris Agreement, only 10 Michigan bird species are predicted to decline by 80-100%**



**Common loon**



**White-throated sparrow**



**Veery**



**Warm-water species will be “climate winners”,  
but cold- and cool-water species will be “climate losers”**

**climate winners**



**carp**



**bluegill**



**catfish**

**climate losers**



**trout**



**whitefish**



**salmon**

**Under Business as Usual, 70% of the Earth’s land surface  
will be at risk of at least moderate biome change**

**Moderate** change  
e.g. boreal forest  
to temperate  
deciduous forest

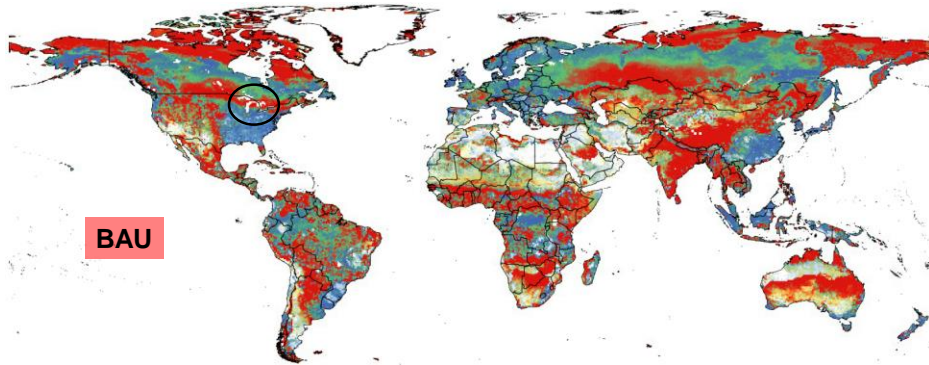


**Major** change  
e.g. tropical  
forest to savanna



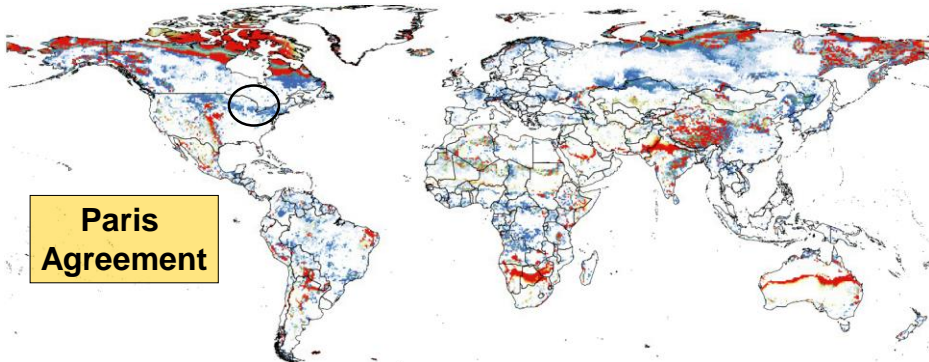
**Under Business as Usual, almost all of the GLR will be at risk of at least moderate biome change**

■ Major change   
 ■ Major/Moderate change   
 ■ Moderate change



**Under the Paris Agreement, much less of the GLR (and only 25% of Earth's land surface) will be at risk of at least moderate biome change**

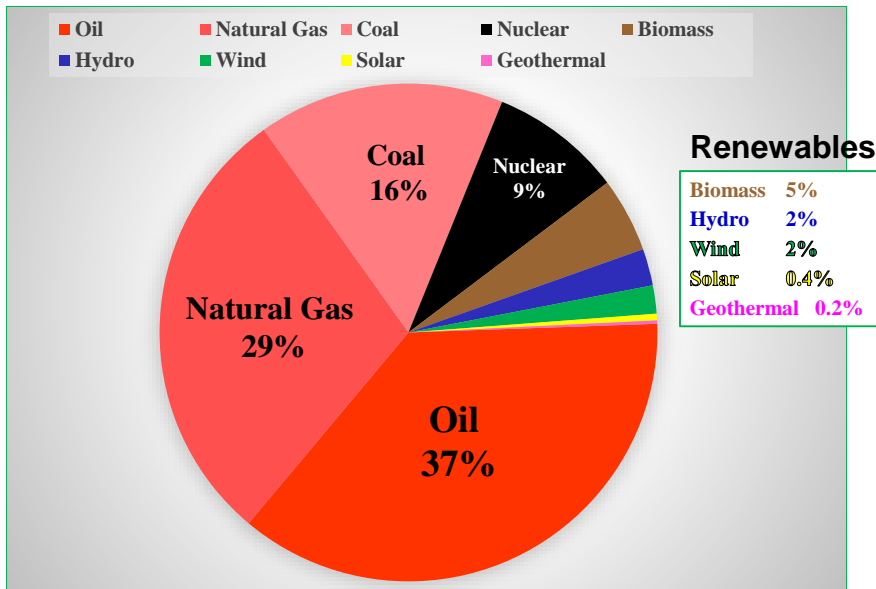
■ Major change   
 ■ Major/Moderate change   
 ■ Moderate change



**The future depends on our choices**  
**With the Paris Agreement, 195 countries pledged**  
**to limit warming to 2° C**

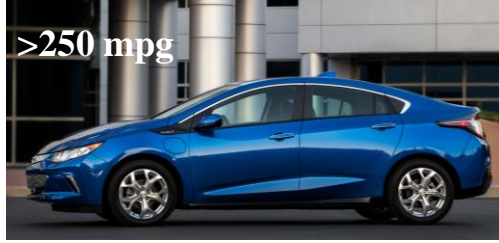


**How do we limit warming to 2° C?**  
**82% of U.S. energy use comes from fossil fuels**



## 1. Choose to use less fossil fuel energy

- practice energy efficiency and conservation



- however, by itself, only delays the outcome

## 2. Choose to generate some of your own green energy





### 3. Choose to demand that our policymakers support smarter energy choices

**Target: 80% of energy from smarter sources by 2040**

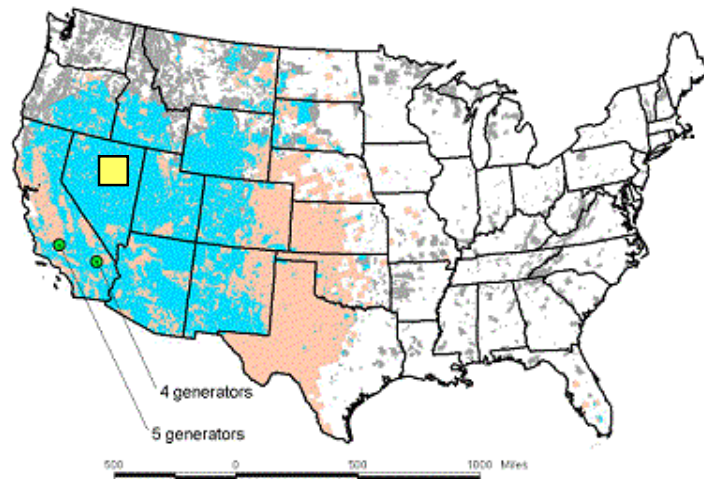


**Potential: 100 times  
total global energy use**



**Potential: 40 times  
total global energy use**

**A solar array less than 100 x 100 miles could provide  
all of U.S. electricity needs today**



**- excess heat captured during the day could be stored  
and used to produce electricity at night**

**4. Choose to talk about climate change causes, consequences, and solutions**

**with friends**



**with ones who think differently**



**with coworkers**



**and especially with youth**

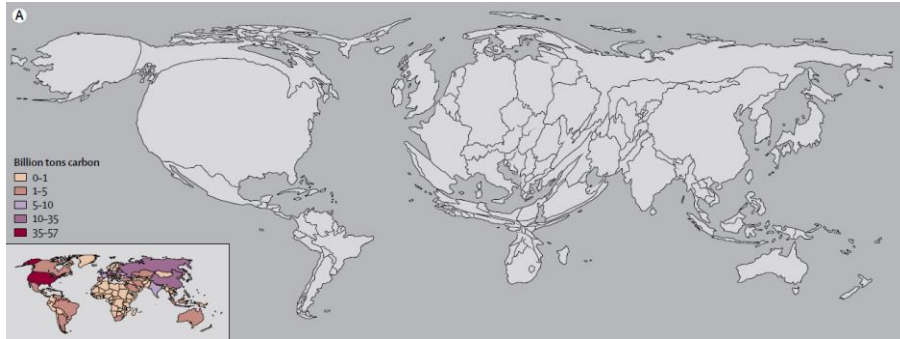


**5. Speak for the moral high ground**



**People in developed countries are causing the problem, but people in developing countries will suffer most of the health effects**

**Countries proportional to CO<sub>2</sub> emissions through 2002:**



**People in developed countries are causing the problem, but people in developing countries will suffer most of the health effects**

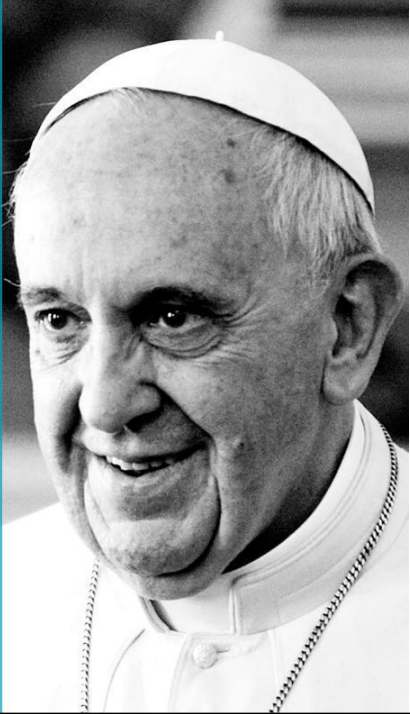
**Countries proportional to climate-related health effects:**





“  
In the face of the emergencies of human-induced climate change, social exclusion, & extreme poverty, we join together to declare that:  
  
Human-induced climate change is a **scientific reality**, and its decisive mitigation is a **moral and religious imperative** for humanity.”

Pontifical Academies of Sciences and Social Sciences



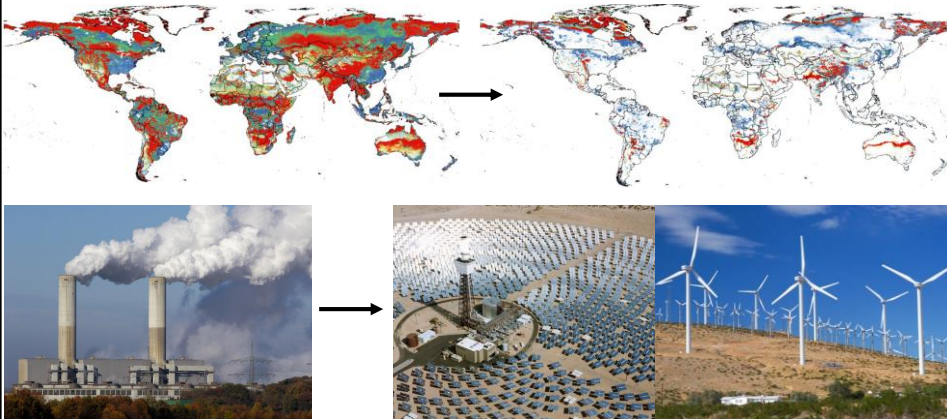
## 6. Choose to join a climate truth organization



## 7. Choose to make climate change a major voting issue



**Bottom line: The Great Lakes Region, like the rest of the planet, would benefit tremendously from limiting warming to 2° C. For a short time, it's still an achievable target, and it's worth fighting for.**





**The future depends on our choices**



**Thank you for listening**