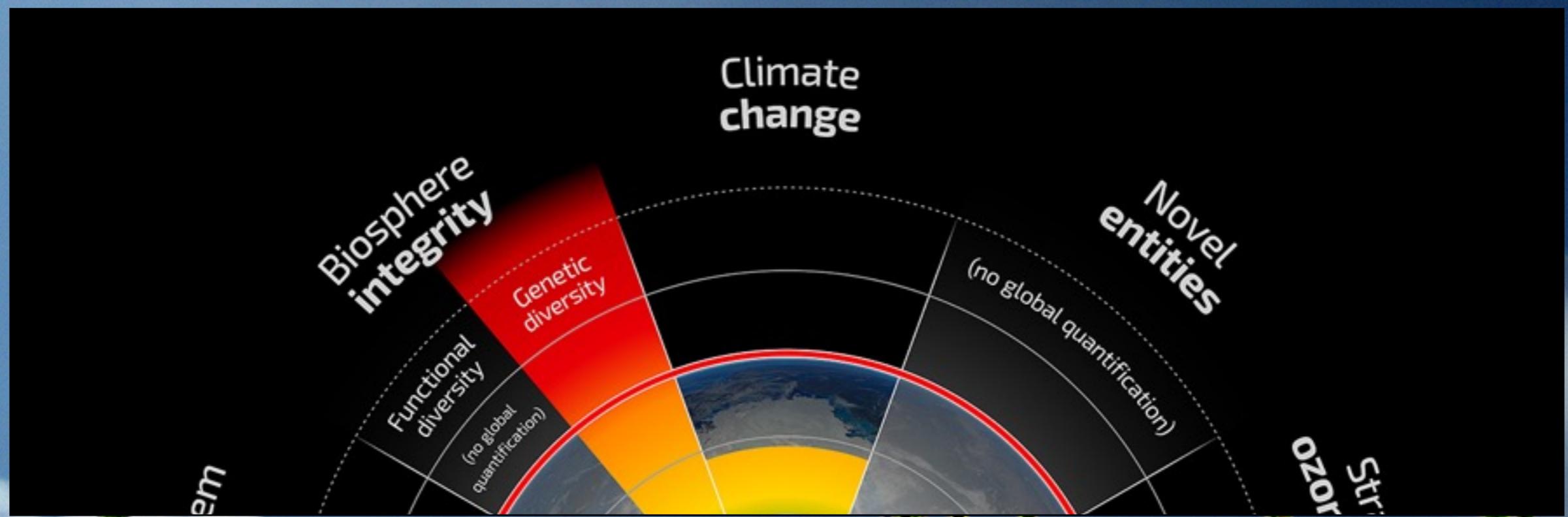
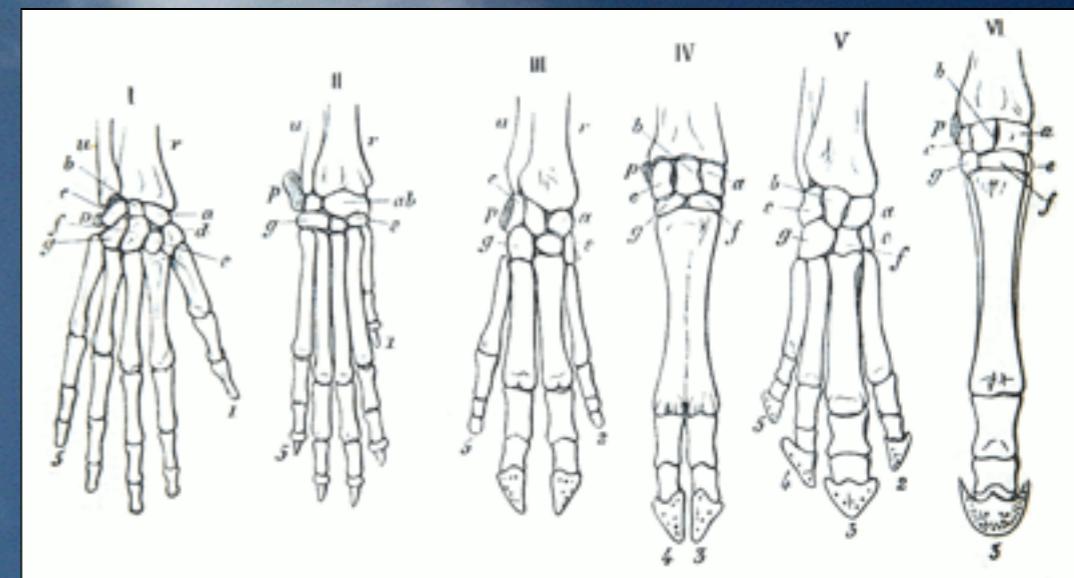
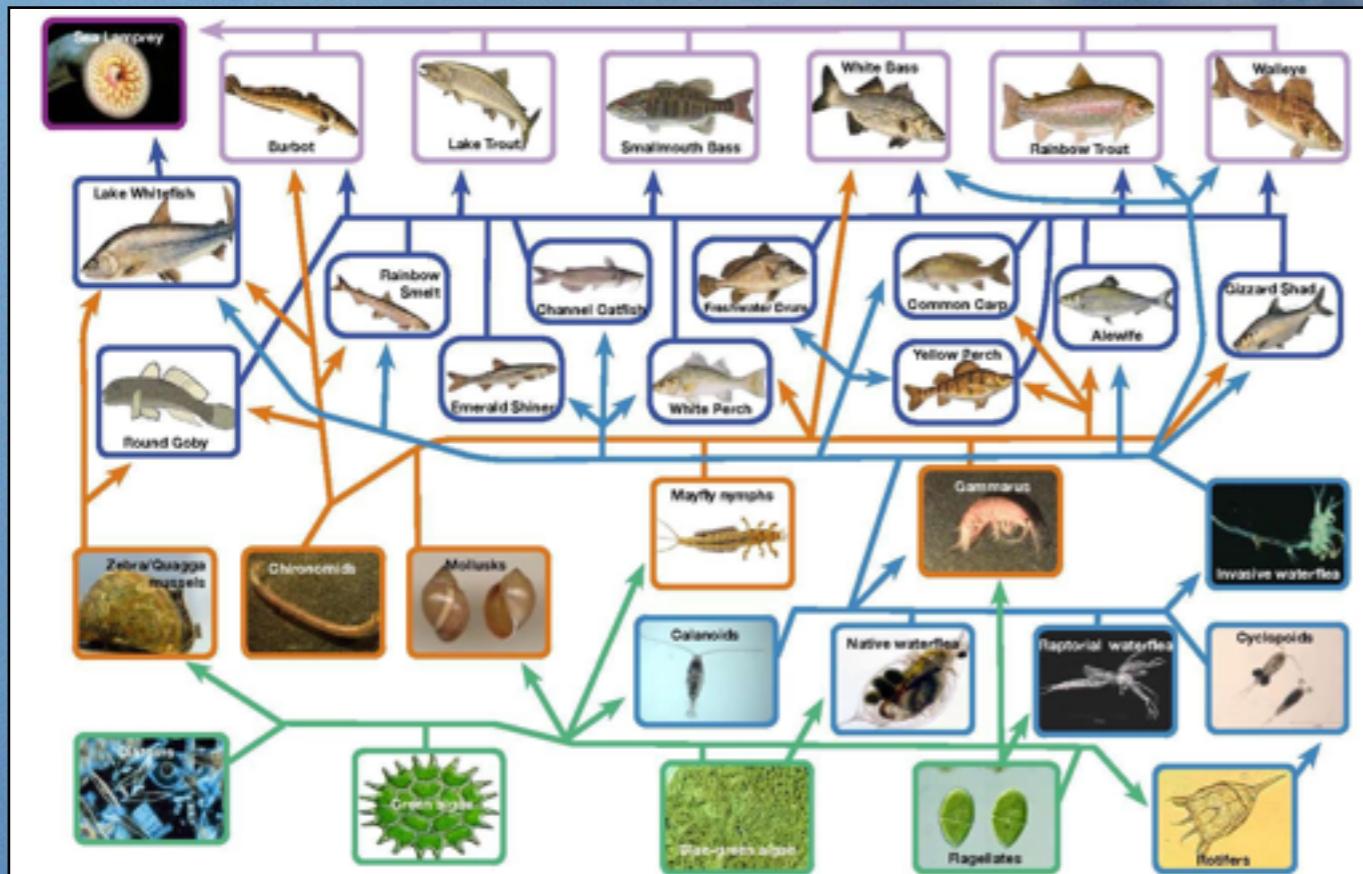


# Pulling Humanity Back Inside the Boundaries

## *How Science Serves Sustainability*



# I am an...



# Ecologist &

# Evolutionary Biologist

# Architecture



# Fine Arts



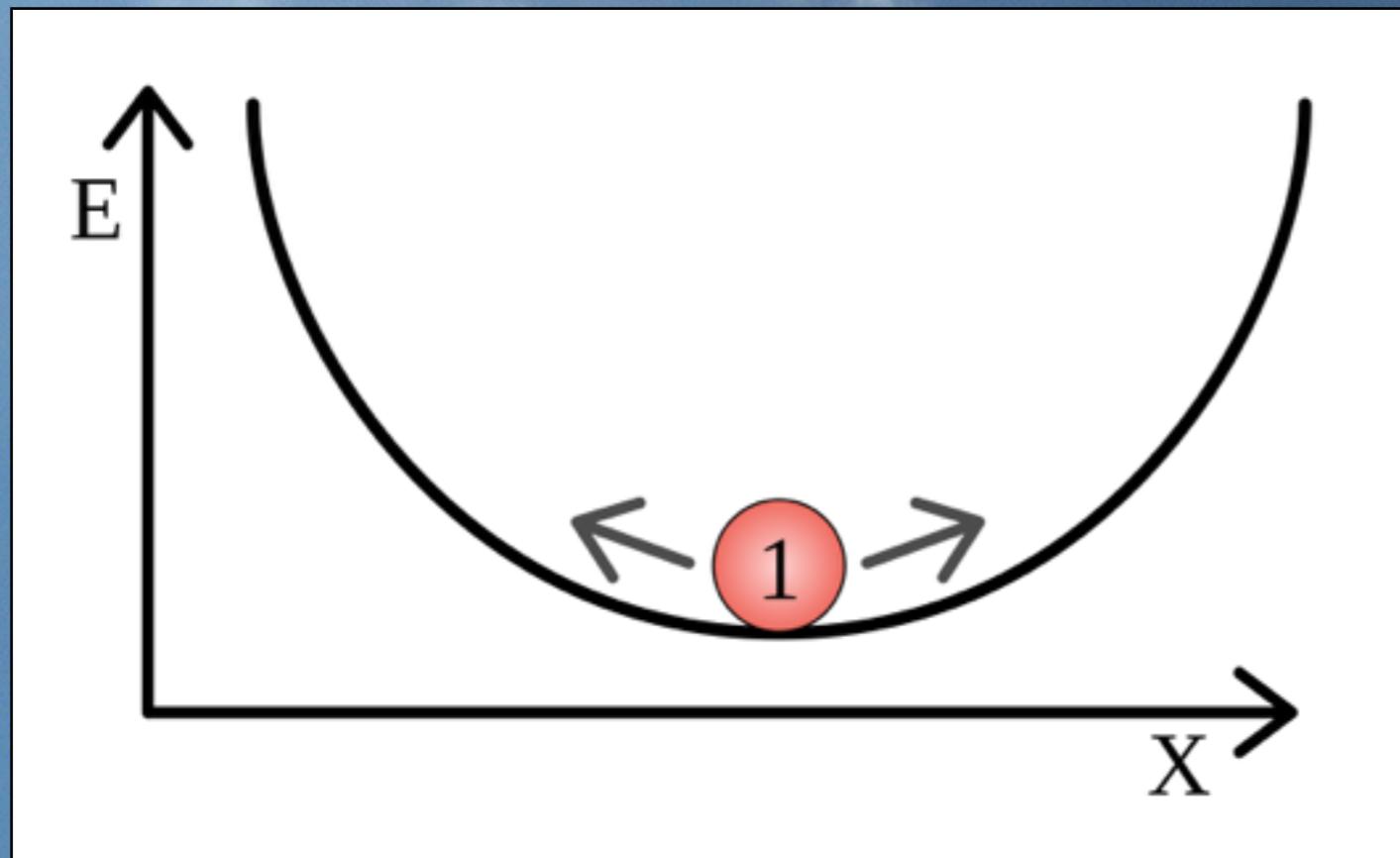
# Design



& other  
creative  
disciplines

*What is  
“sustainability”?*

# Sustainability is about stability:



Source(s): 7, 8

# The three legged stool:



“sustainability”

Environmental  
stability

Economic stability

Social stability

Source(s): 9

# Environmental stability:



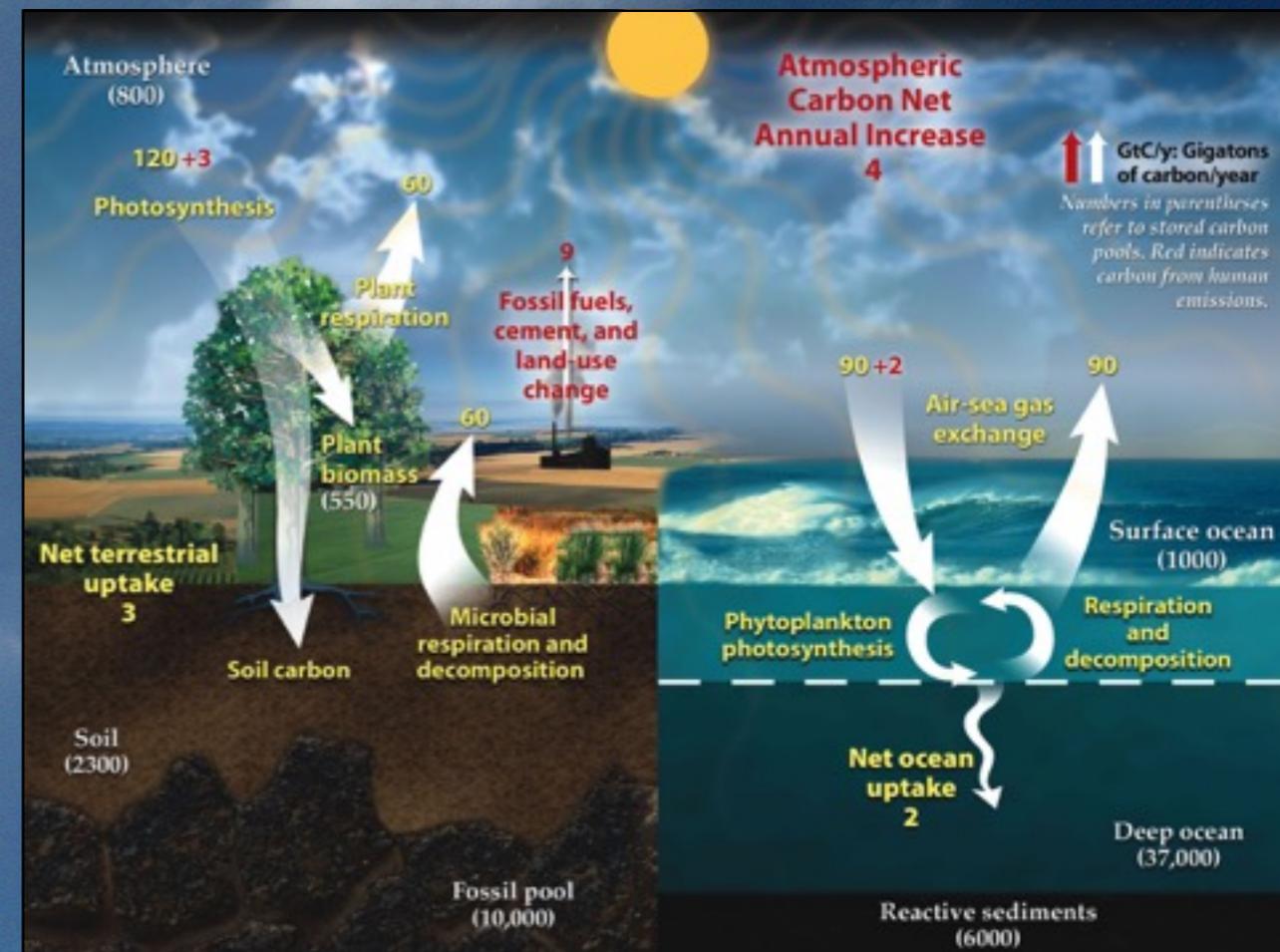
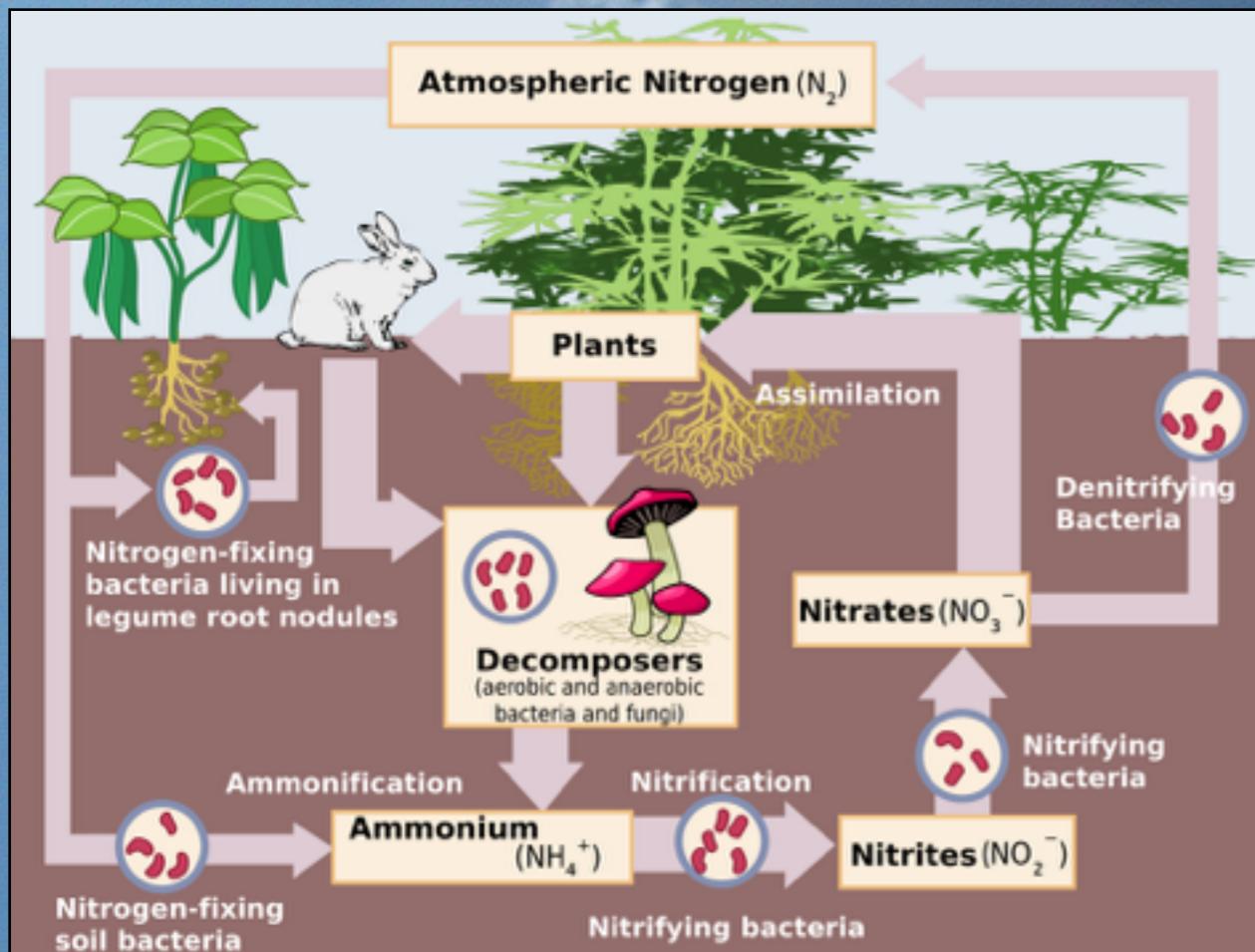
*Will the impact of our environmental exploitation reduce our supply of ecosystem services in the future?*

# What makes nature sustainable?



Source(s): 11

# Overall, nature is a closed system of cycles



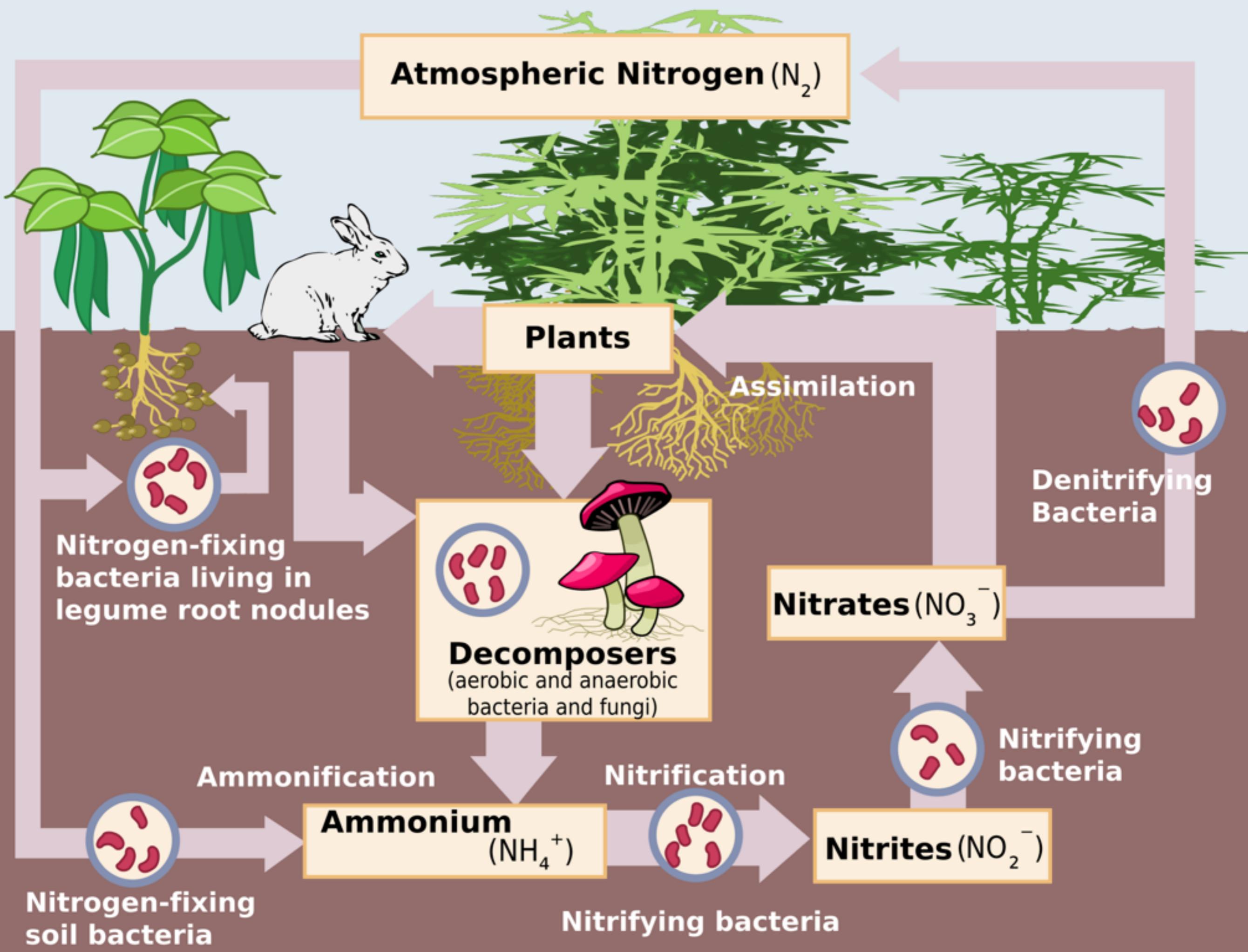
## Nitrogen cycle

## Carbon cycle

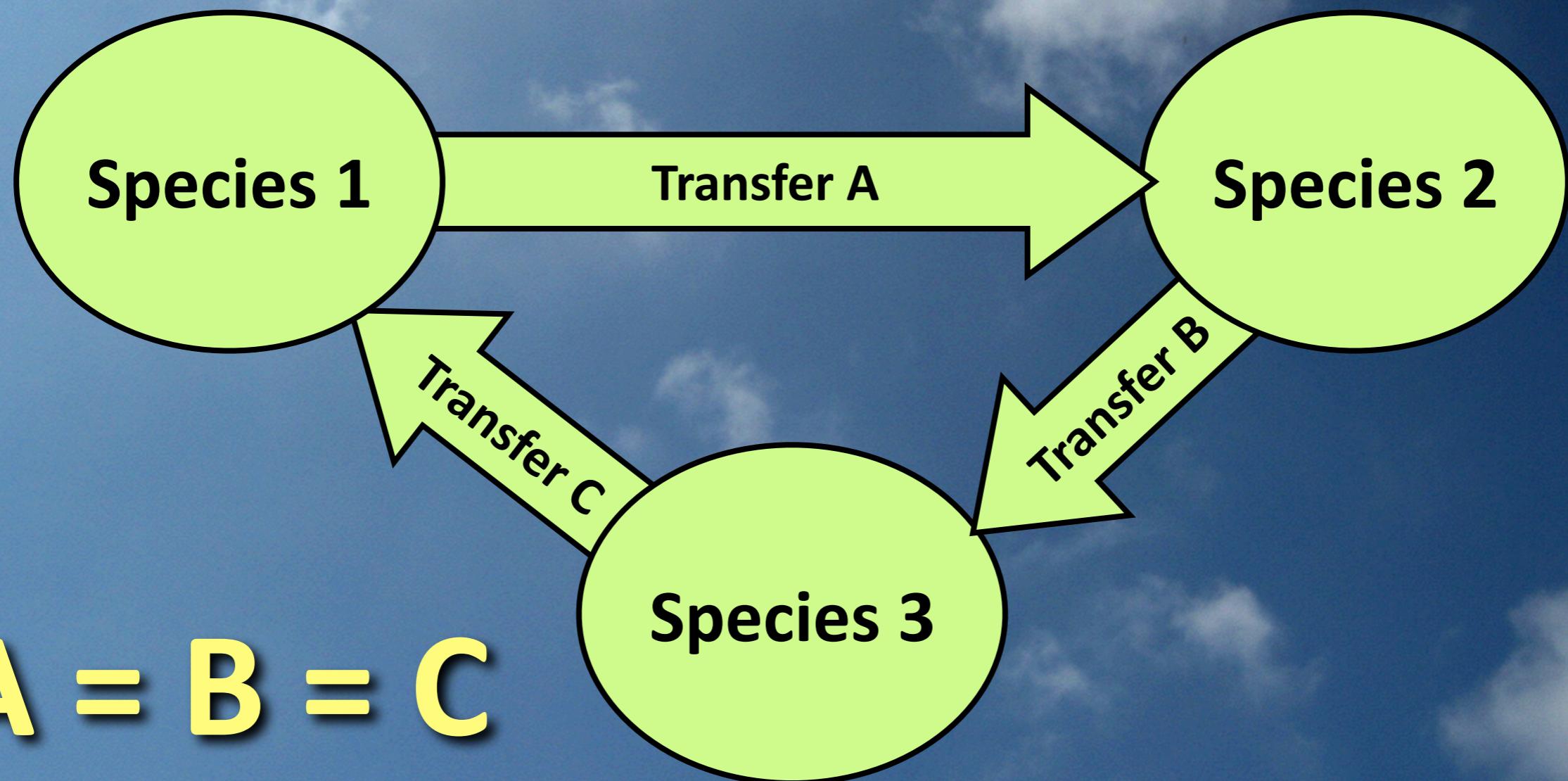
# Balance through evolution



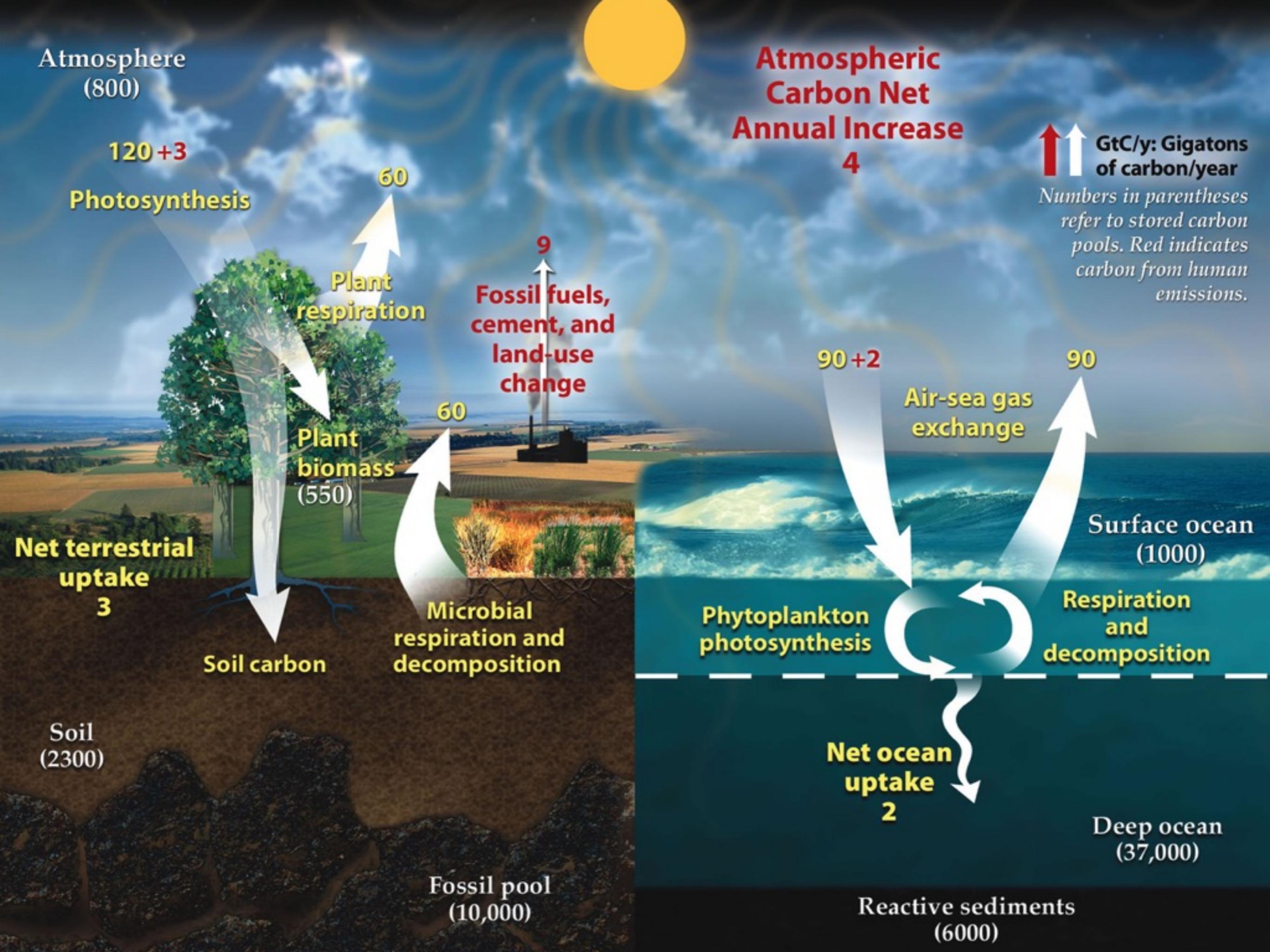
ecological niches don't remain unfilled



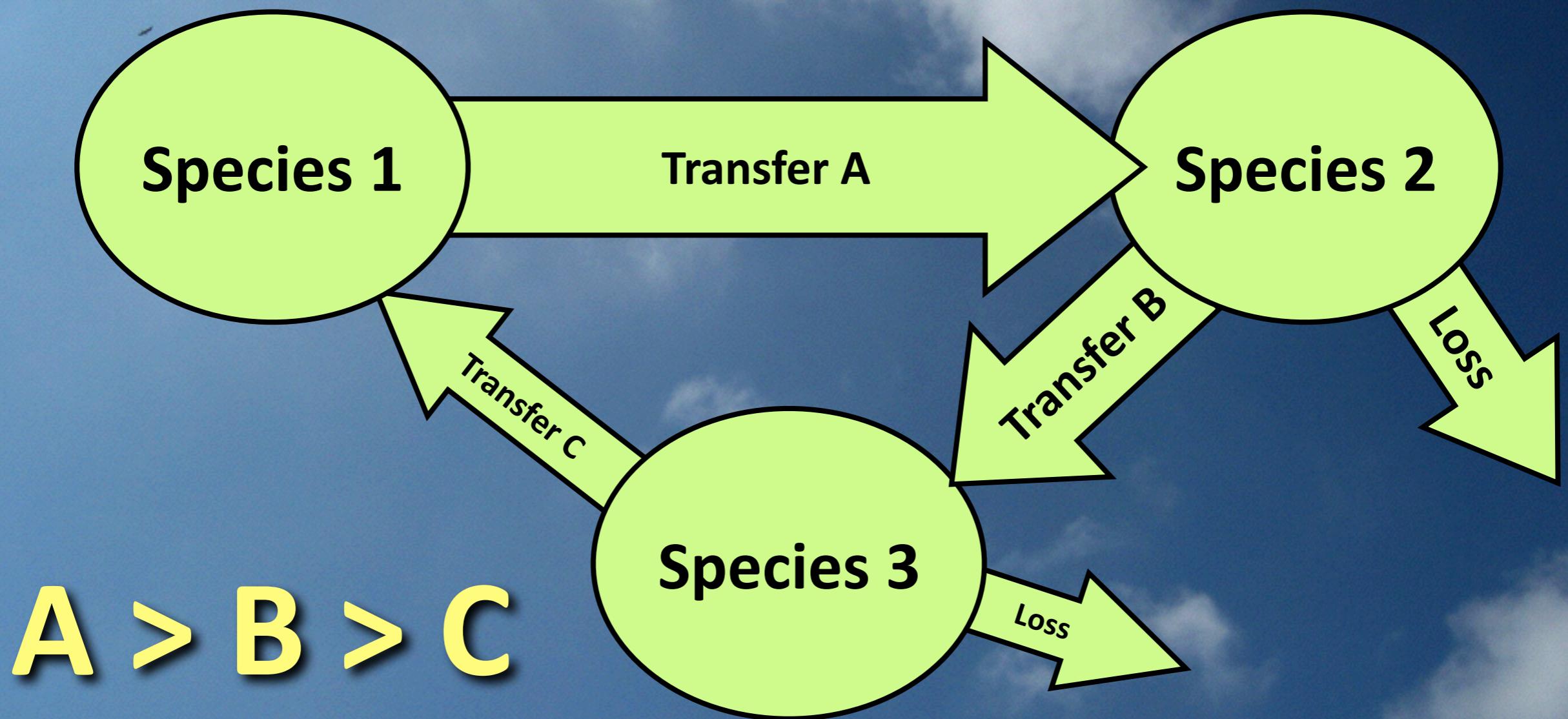
# Cycles are inherently quantitative...



$$A = B = C$$



# Extinction of the unstable?



# Human civilization is unsustainable



# Humans before agriculture



The San



Hunter-Gatherer  
Tribes

Source(s): 21, 22

# Agriculture before fertilizer



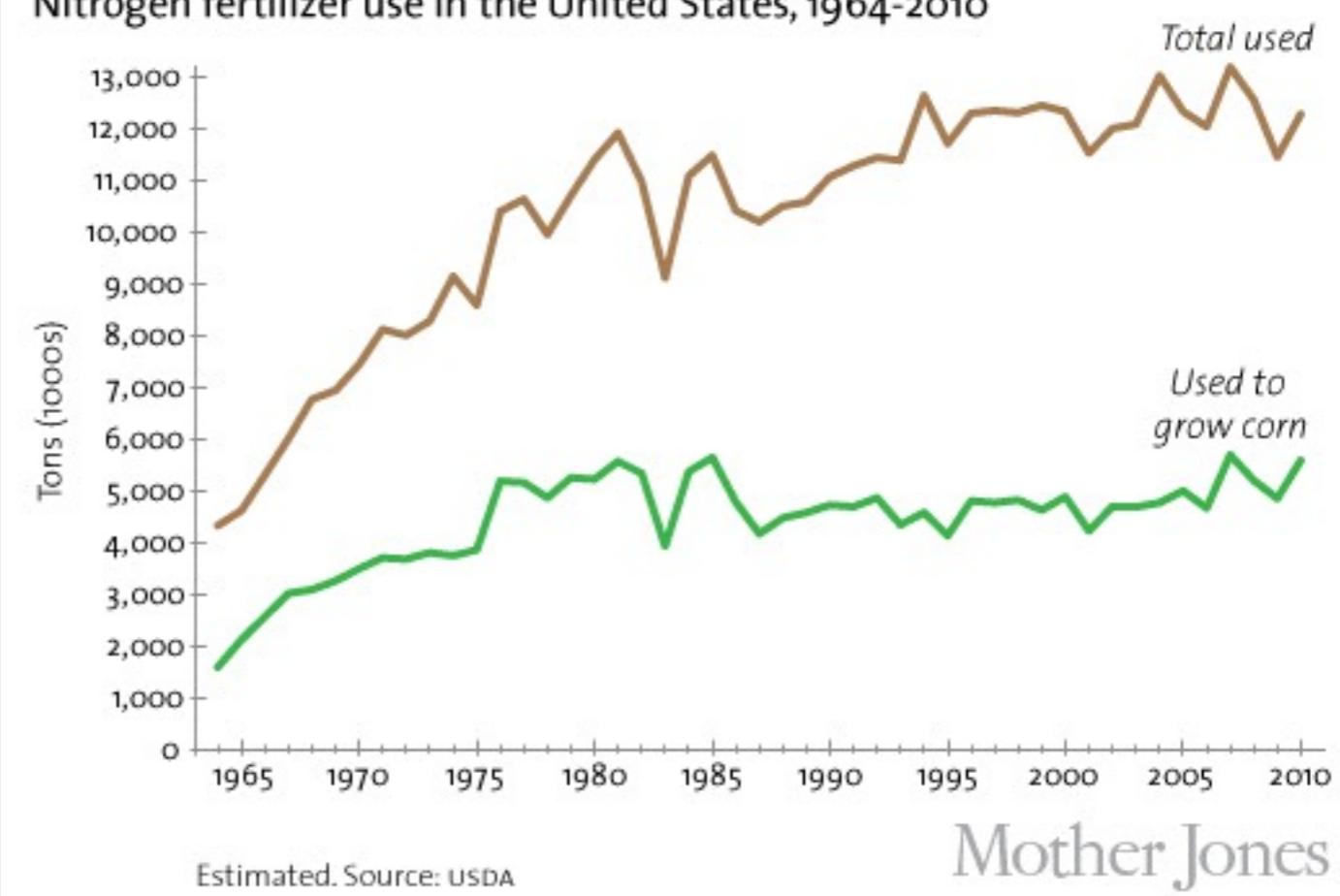
“Swidden” agriculture

Source(s): 23

# Industrial Agriculture



**Growth Spurt**  
Nitrogen fertilizer use in the United States, 1964-2010



Mother Jones

# Industrial Agriculture



Eutrophication  
leads to  
“dead zones”

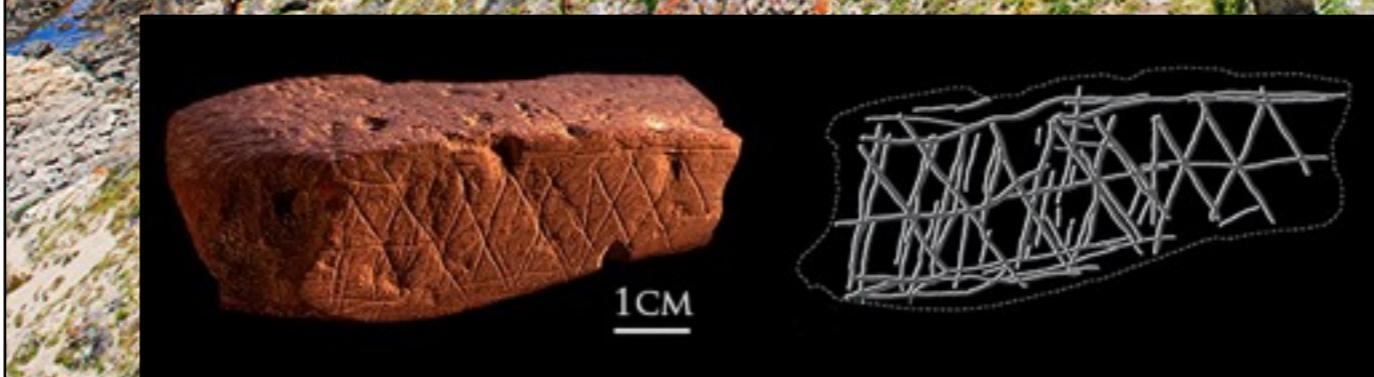
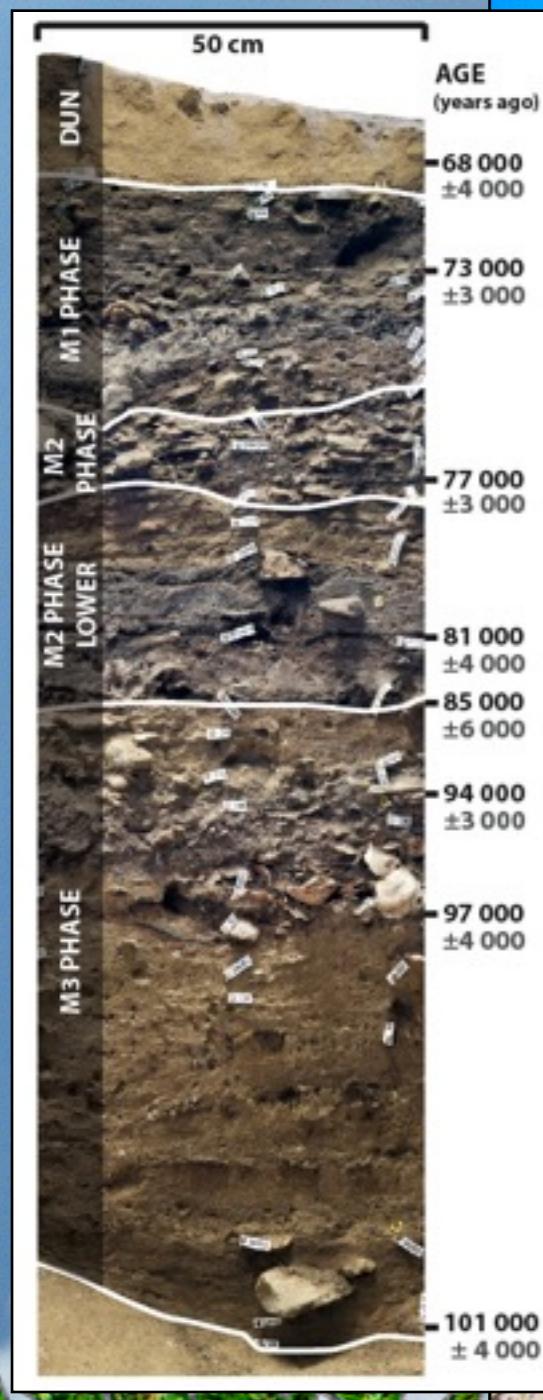
Source(s): 17



# Globally dead zones are linked to affluence

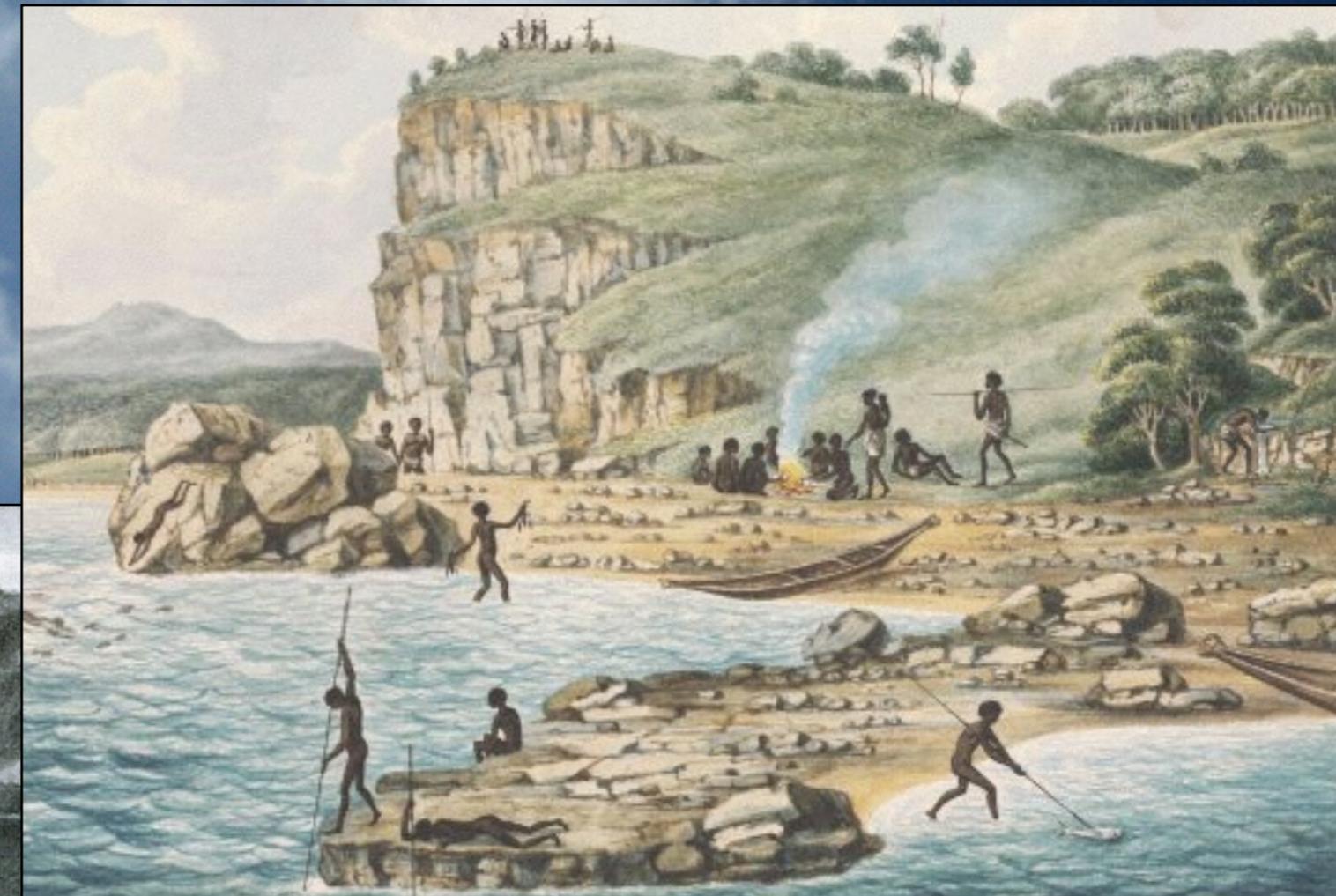
# Humans as fishers

Blombos Cave, South Africa



# Fishing before big boats

Depictions of Aboriginal Australian populations created by Europeans making first contact



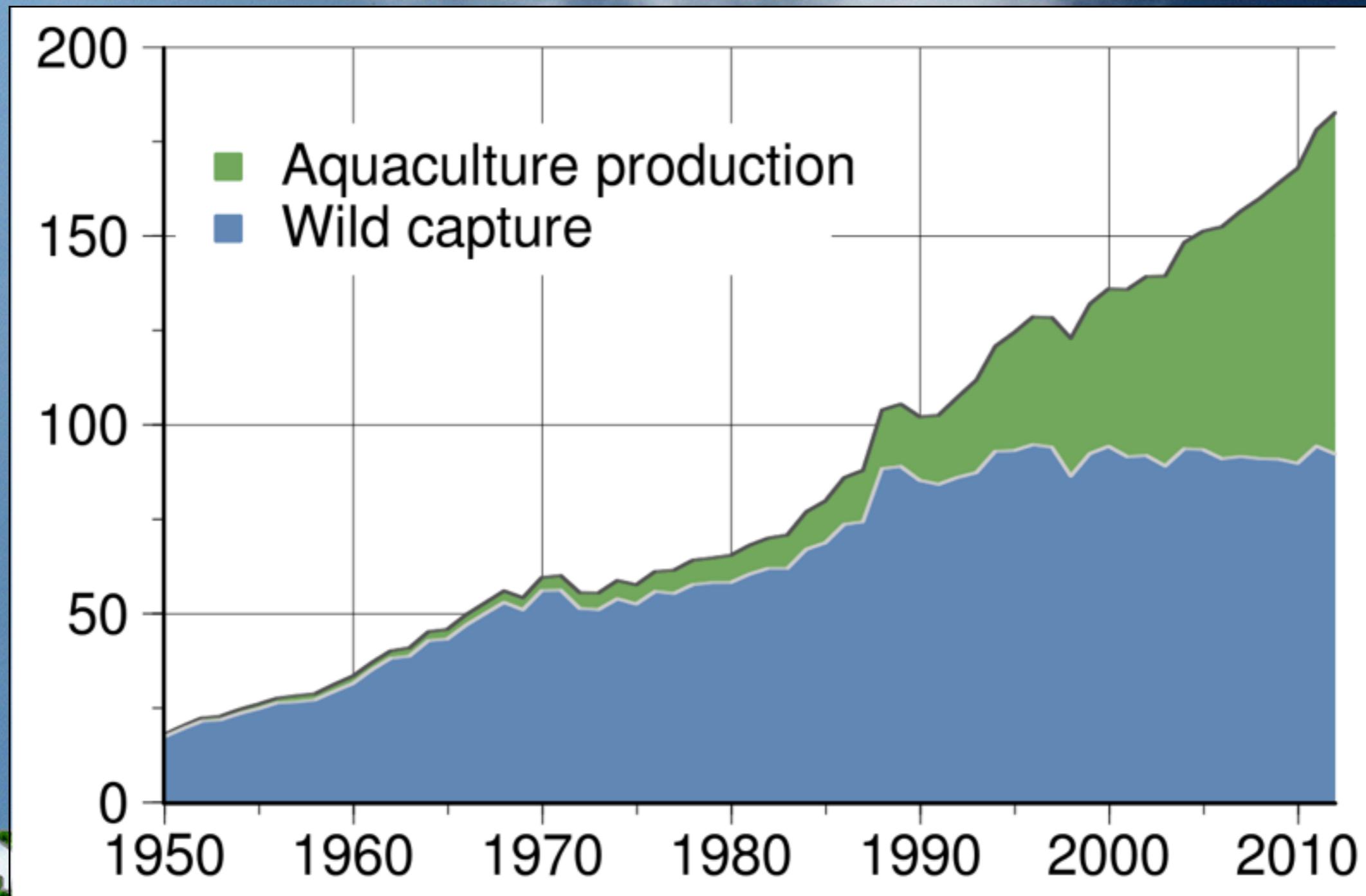
# Industrial Fishing

Catching, processing, and packaging fish at sea



Source(s): 20

# Industrial Fishing



Source(s): 32

# Energy for early humans



*The sun was  
our original  
energy  
source*



# Small energy, small society



Source(s): 36

# Industrial energy



*Our economies rely  
on fossil fuels*

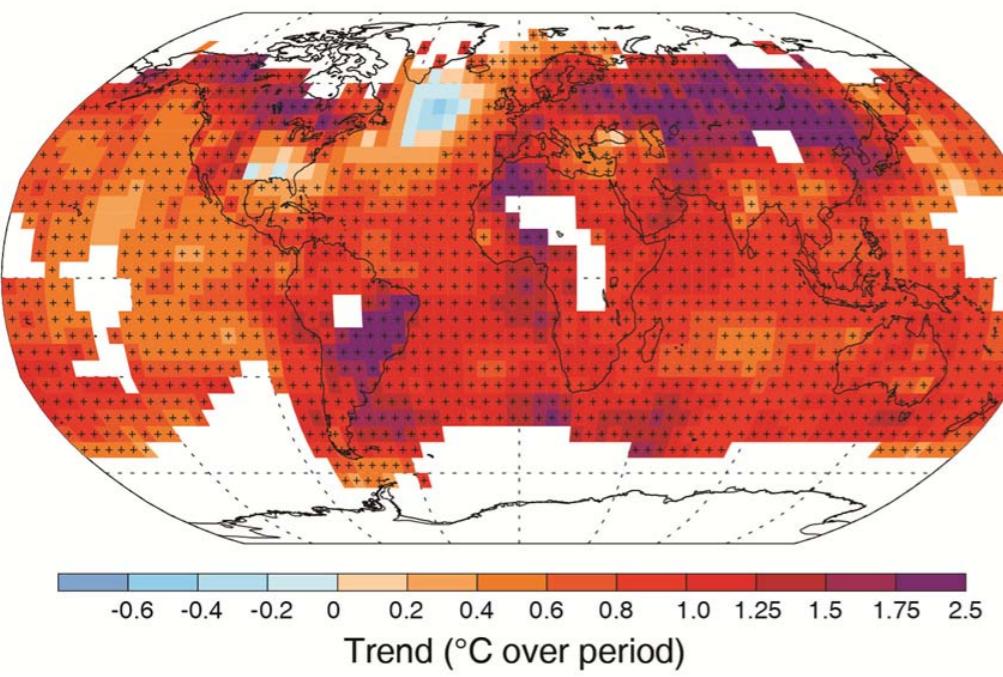


# IPCC Fifth Assessment - 2013

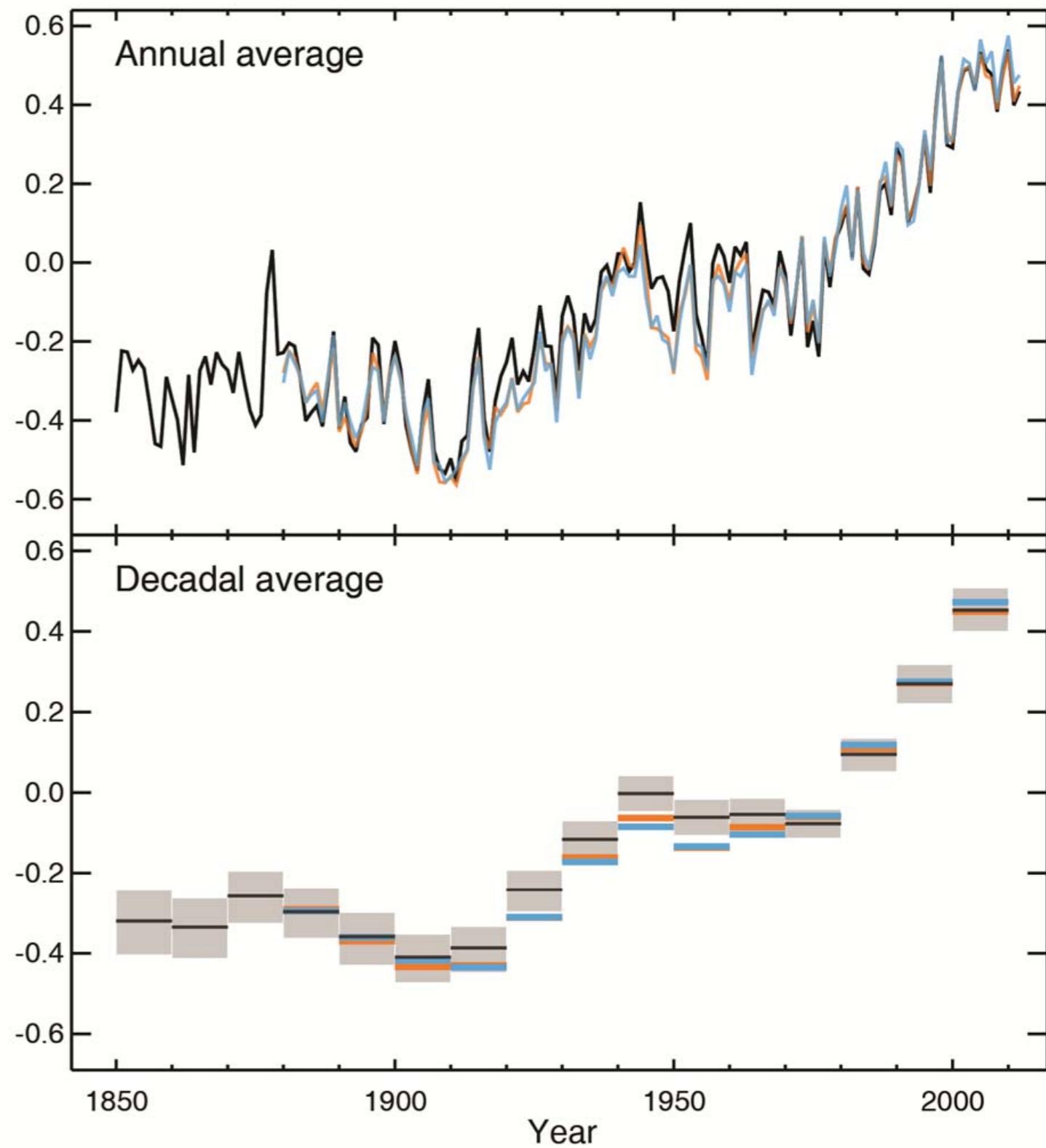
Observed globally averaged combined land and ocean surface temperature anomaly 1850–2012

Source(s): 38, 39

Observed change in average surface temperature 1901–2012



Anomaly ( $^{\circ}\text{C}$ ) relative to 1961–1990



# Energy is everything...

Fertilizer made with natural gas



Gasoline to propel transportation



Coal-produced electricity to power homes & industry



Fishing boats powered by diesel



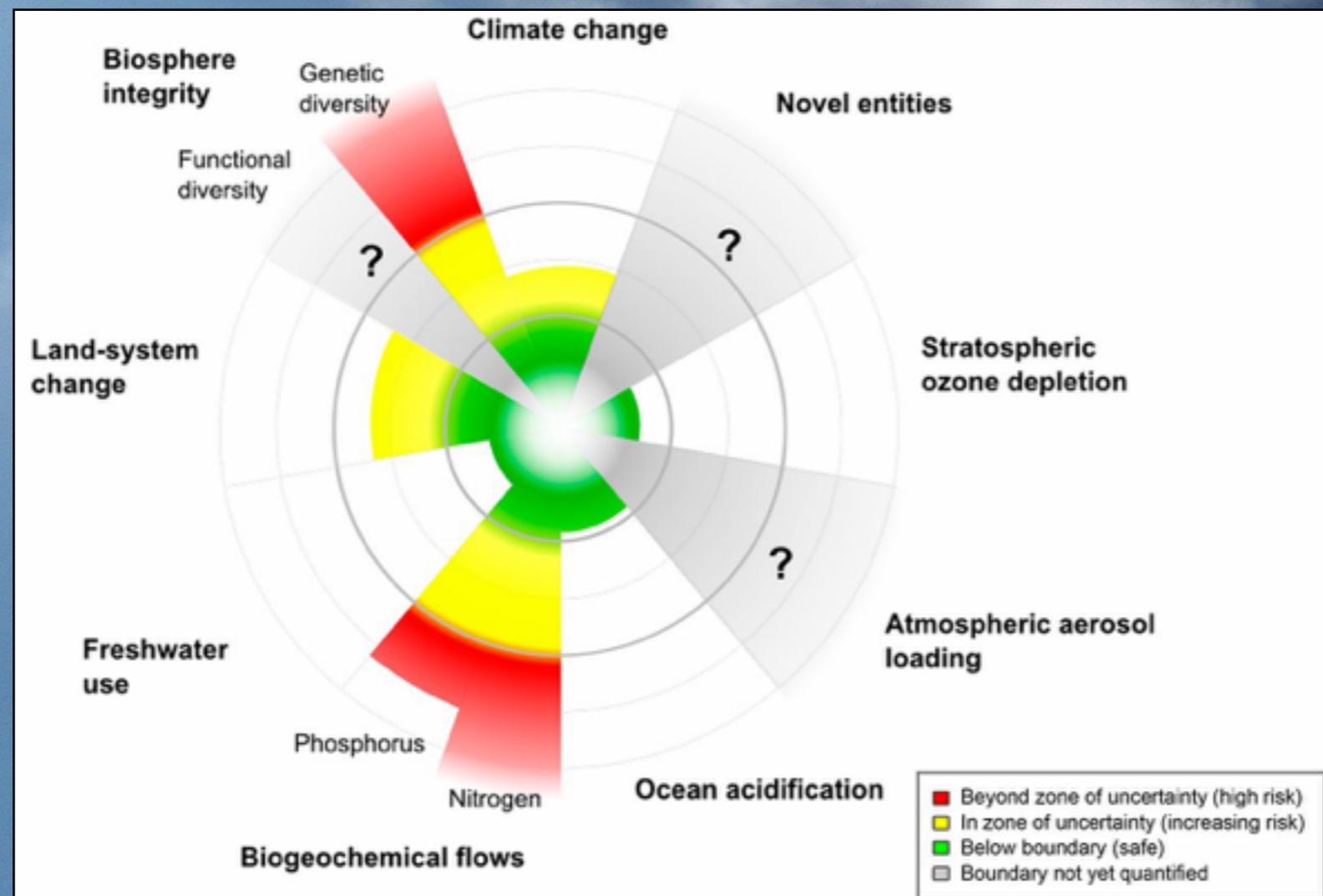
**Answering scientific  
questions is critical  
to creating a  
sustainable society**

*What makes a  
question  
“scientific”?*

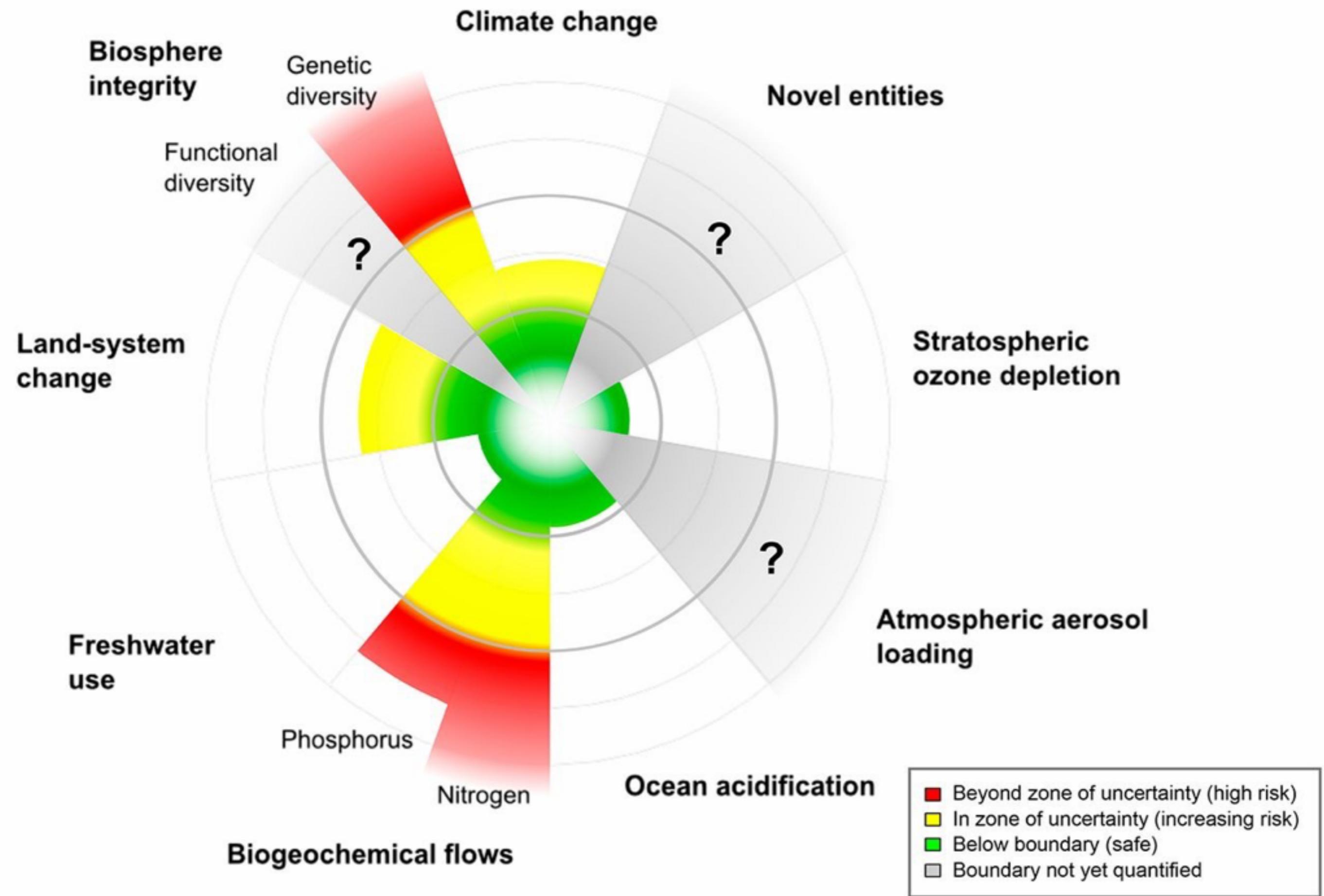
*Scientific question:*  
**What unsustainable impacts are humans creating, and where is our impact greatest?**

# Planetary boundaries

Source(s): 43



*How much human impact can the earth sustain?*



# Biosphere Integrity

Genetic Diversity



Functional Diversity

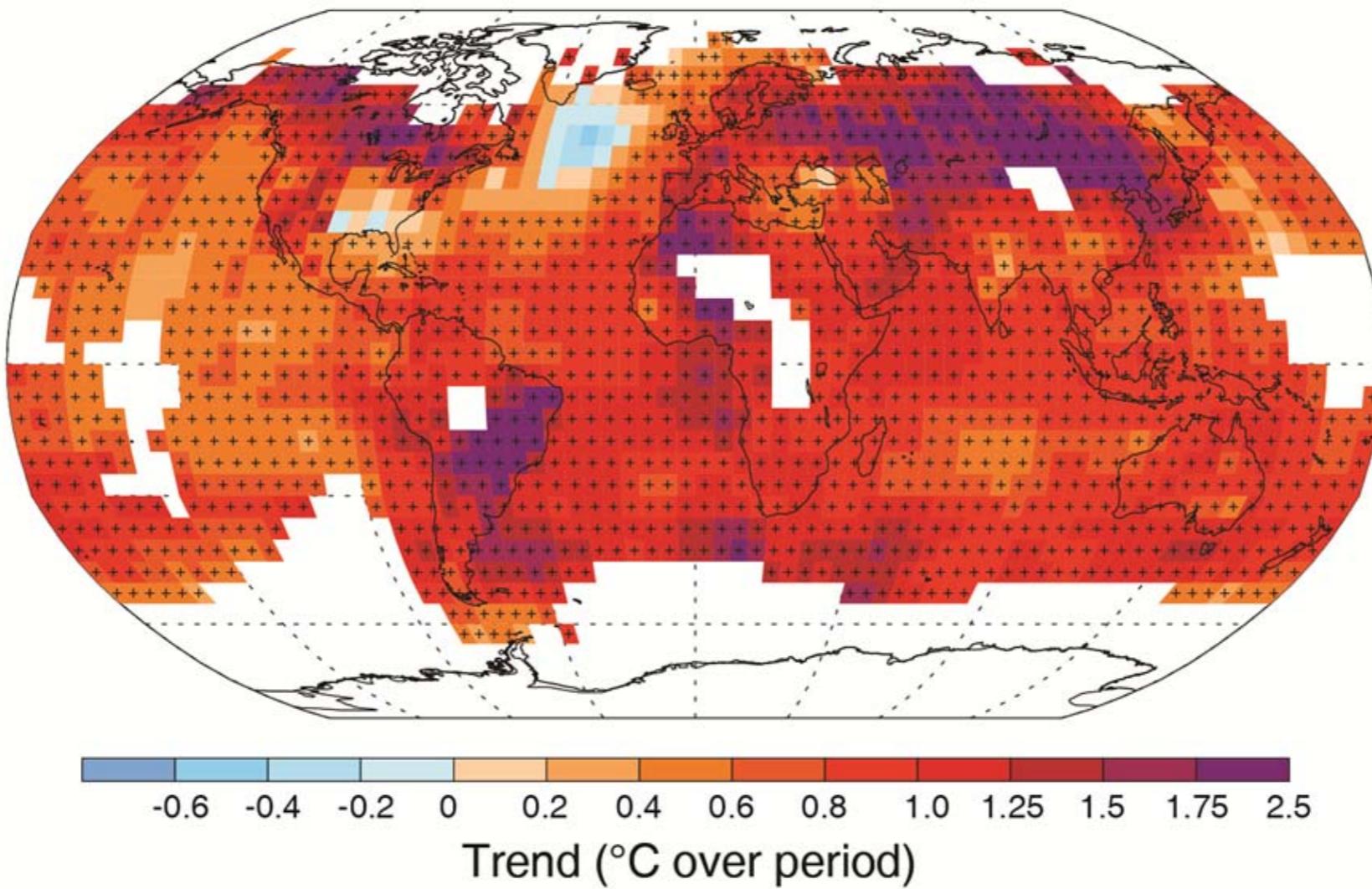


*Status: High Risk*

*Status: Unknown*

# Climate Change

Observed change in average surface temperature 1901–2012



Source(s): 38

Status: Increasing Risk

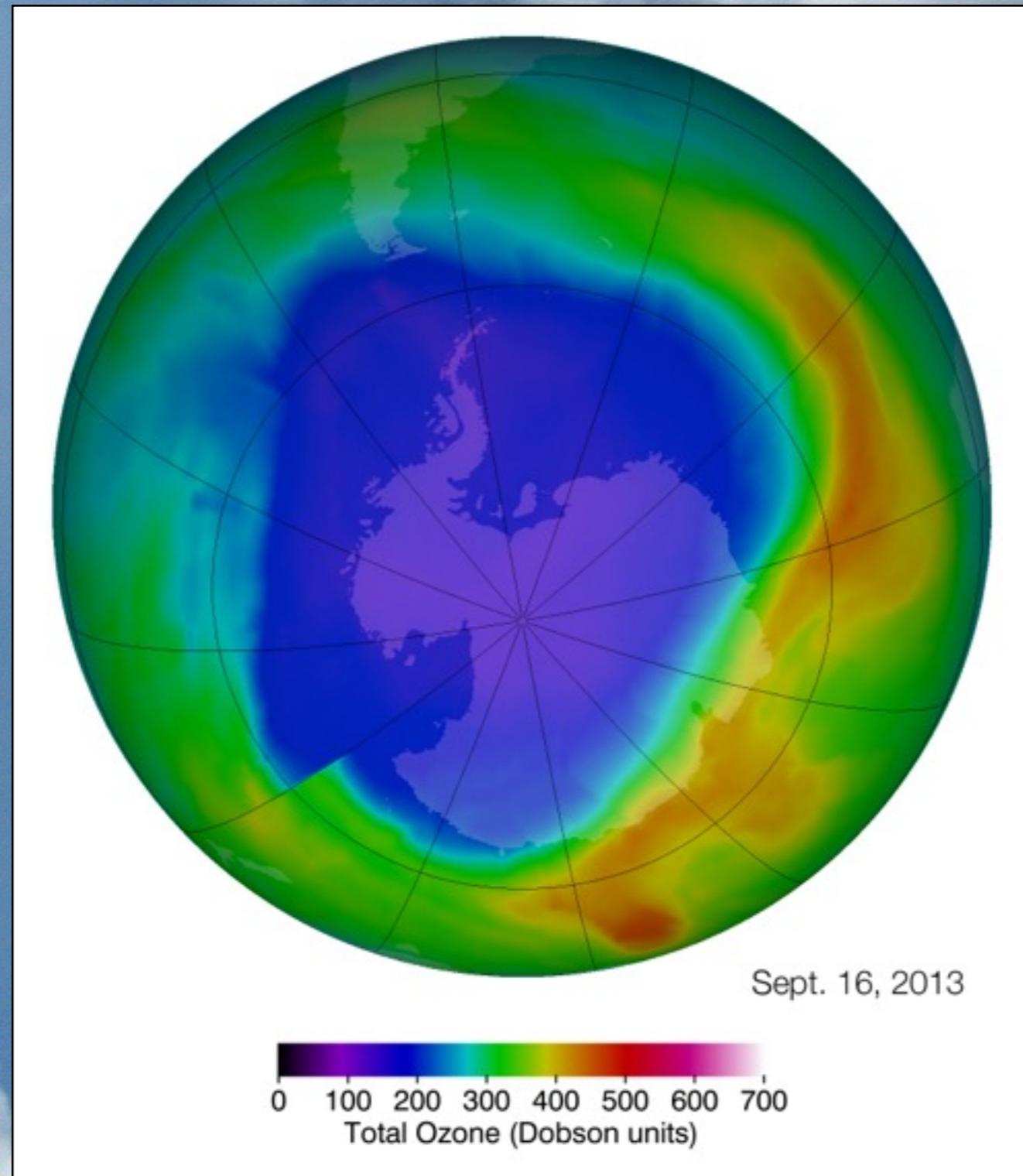
# Novel Entities



Source(s): 46

*Status: Unknown*

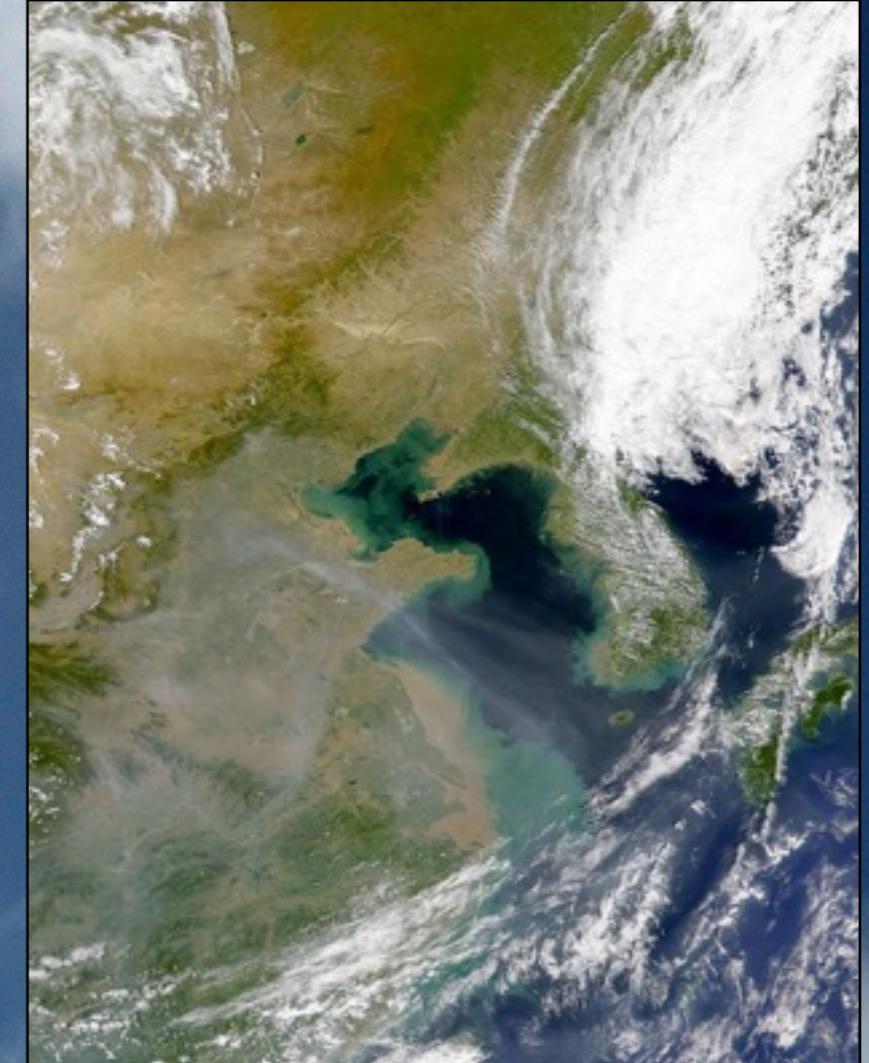
# Stratospheric Ozone Depletion



Status: Safe

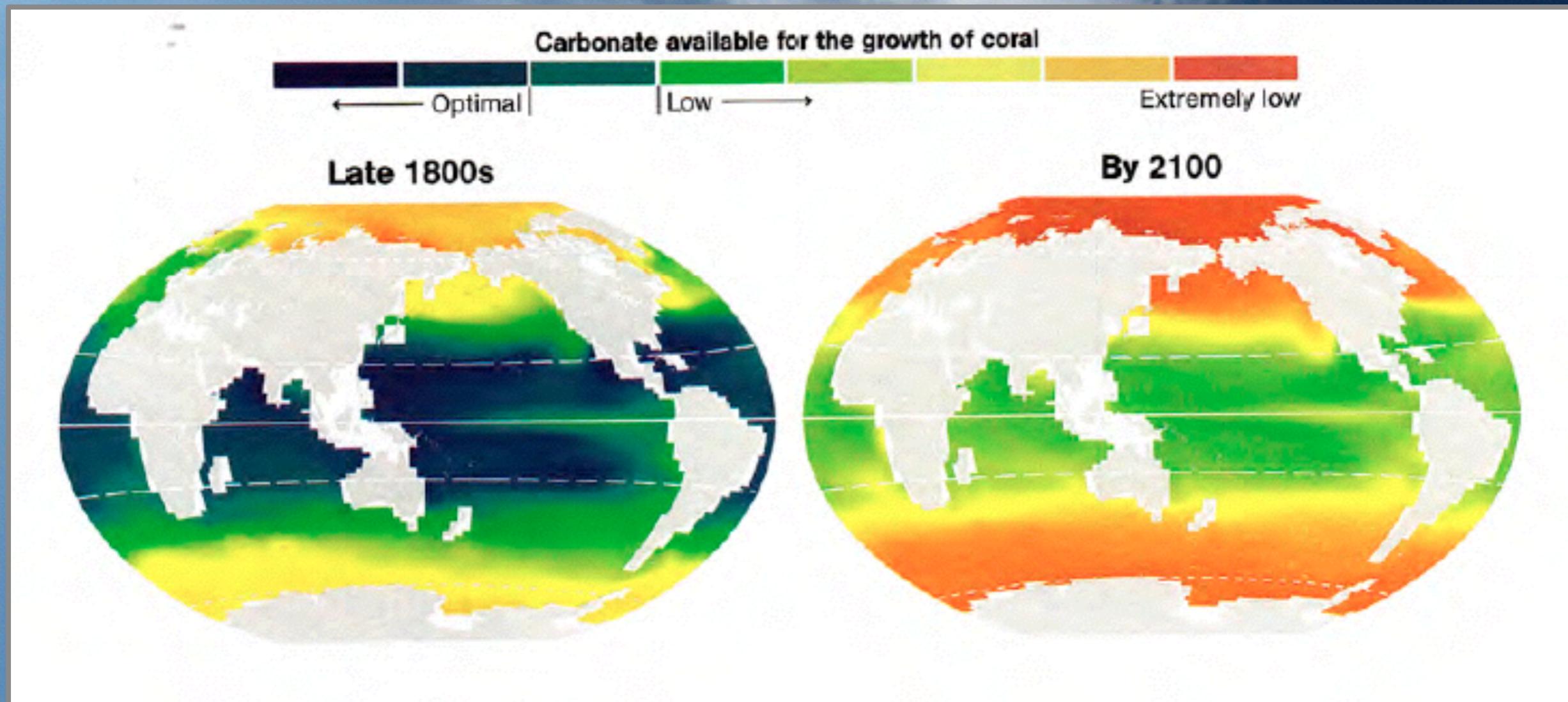
Source(s): 47

# Atmospheric aerosol loading



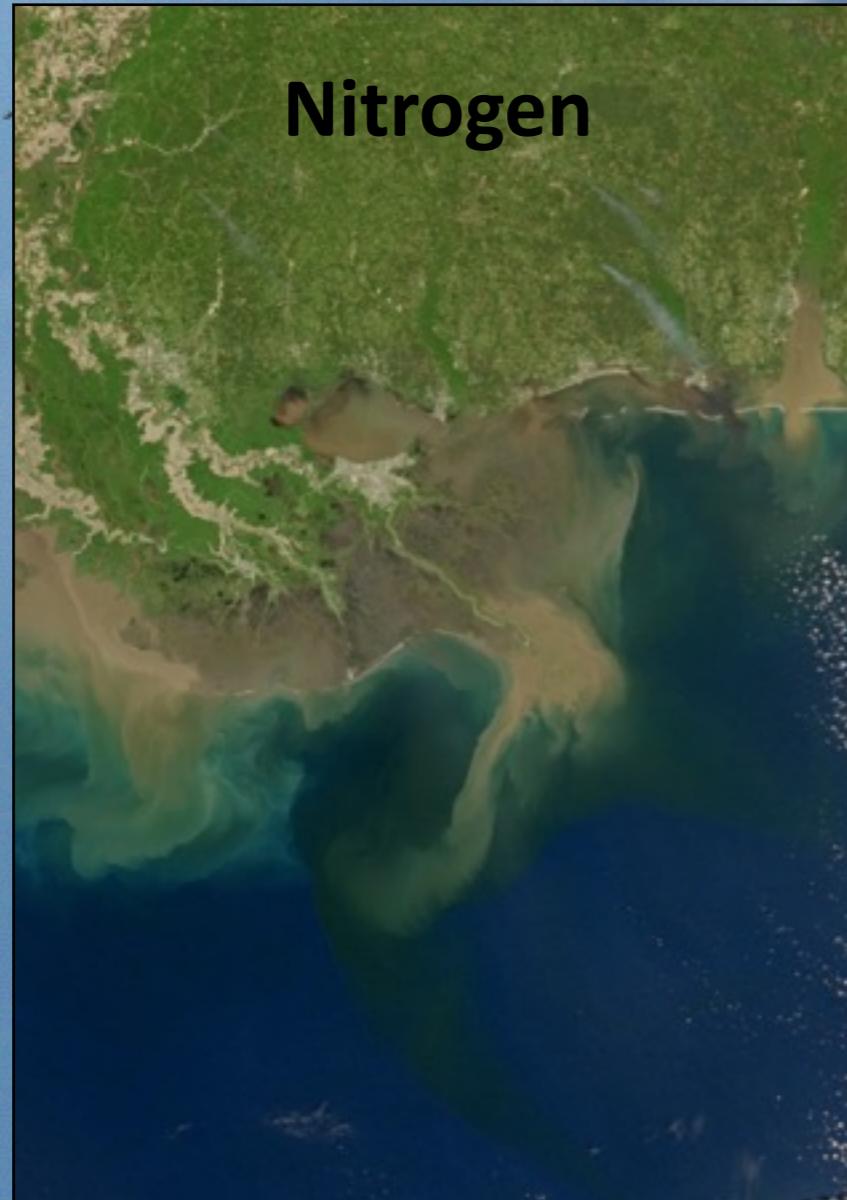
*Status: Unknown*

# Ocean acidification

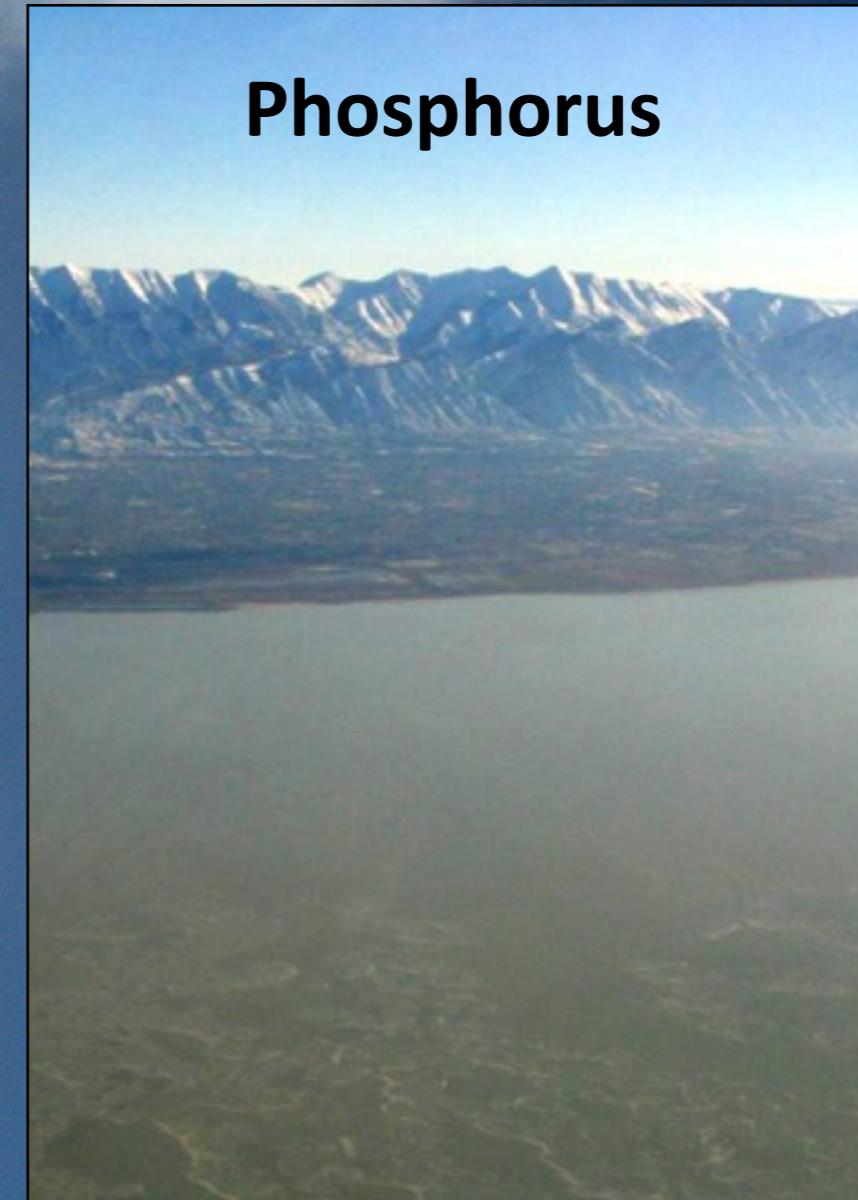


*Status: Marginally Safe*

# Biogeochemical flows



Nitrogen

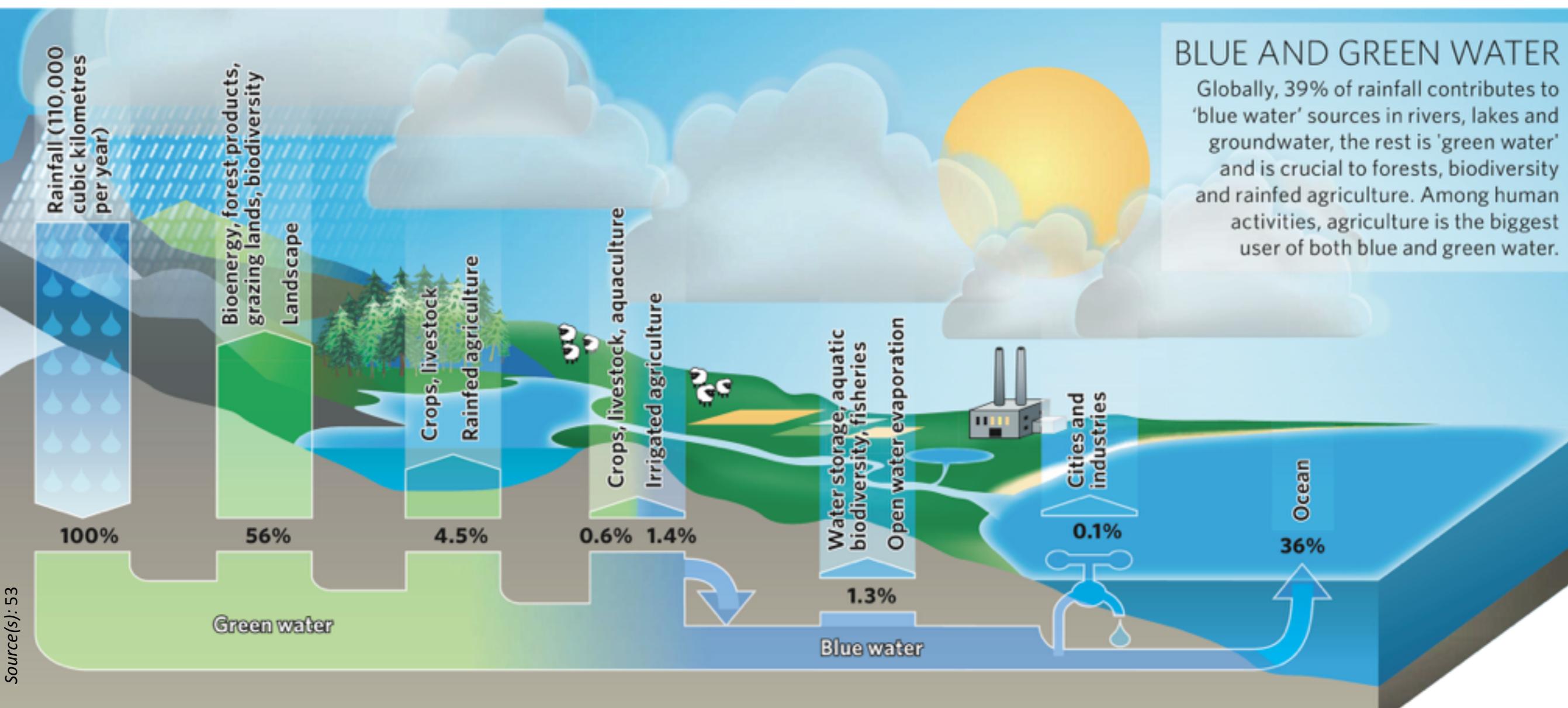


Phosphorus

Status: High Risk

Status: High Risk

# Freshwater use



Source(s): 53

[cxjj.us](http://cxjj.us)

Status: Safe

GMWS March 2016

# Land-use change



Source(s): 54, 55

*Status: Increasing Risk*

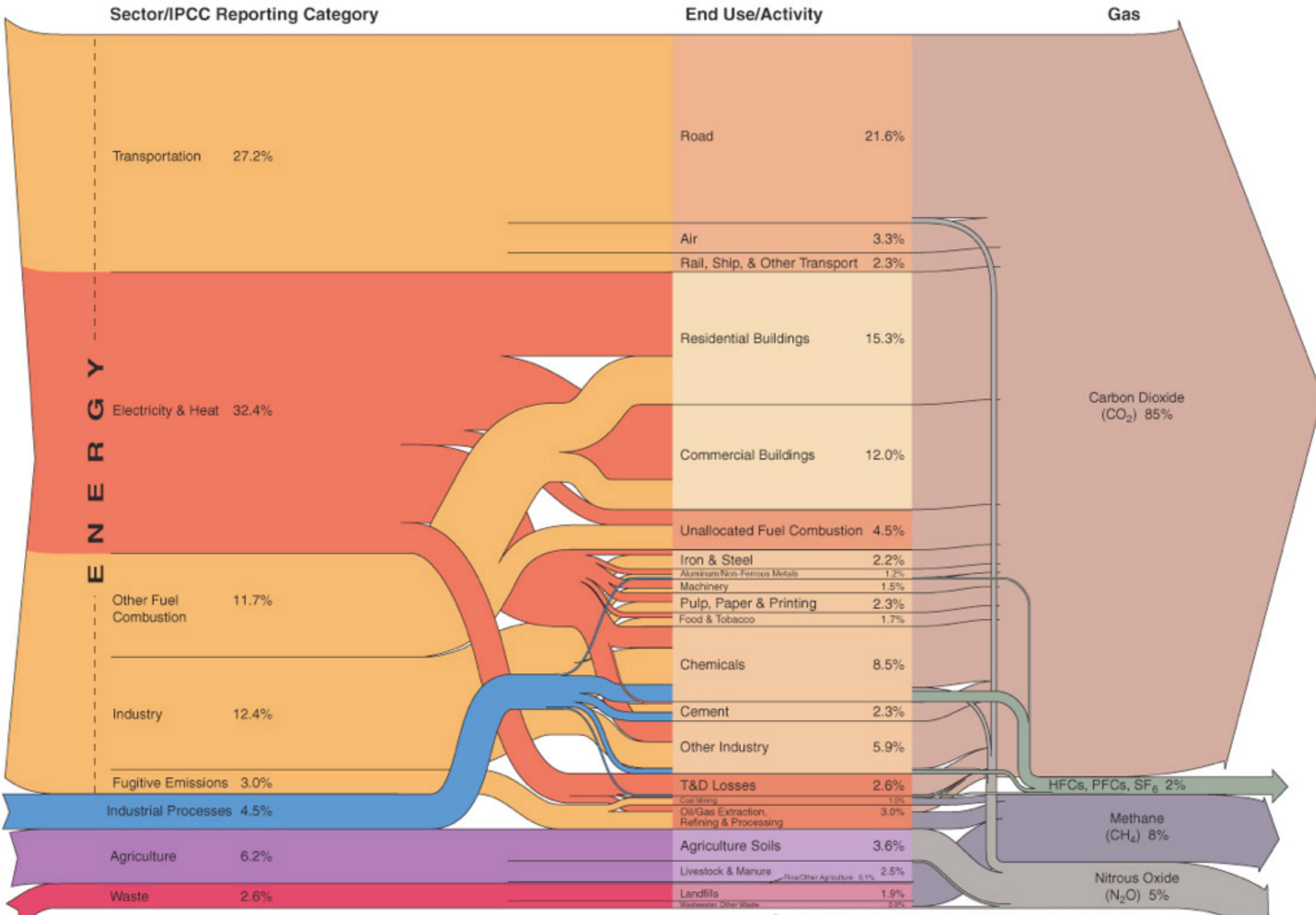
*Identify a sustainable practice and/or technology that might help us stay within one of the planetary boundaries*

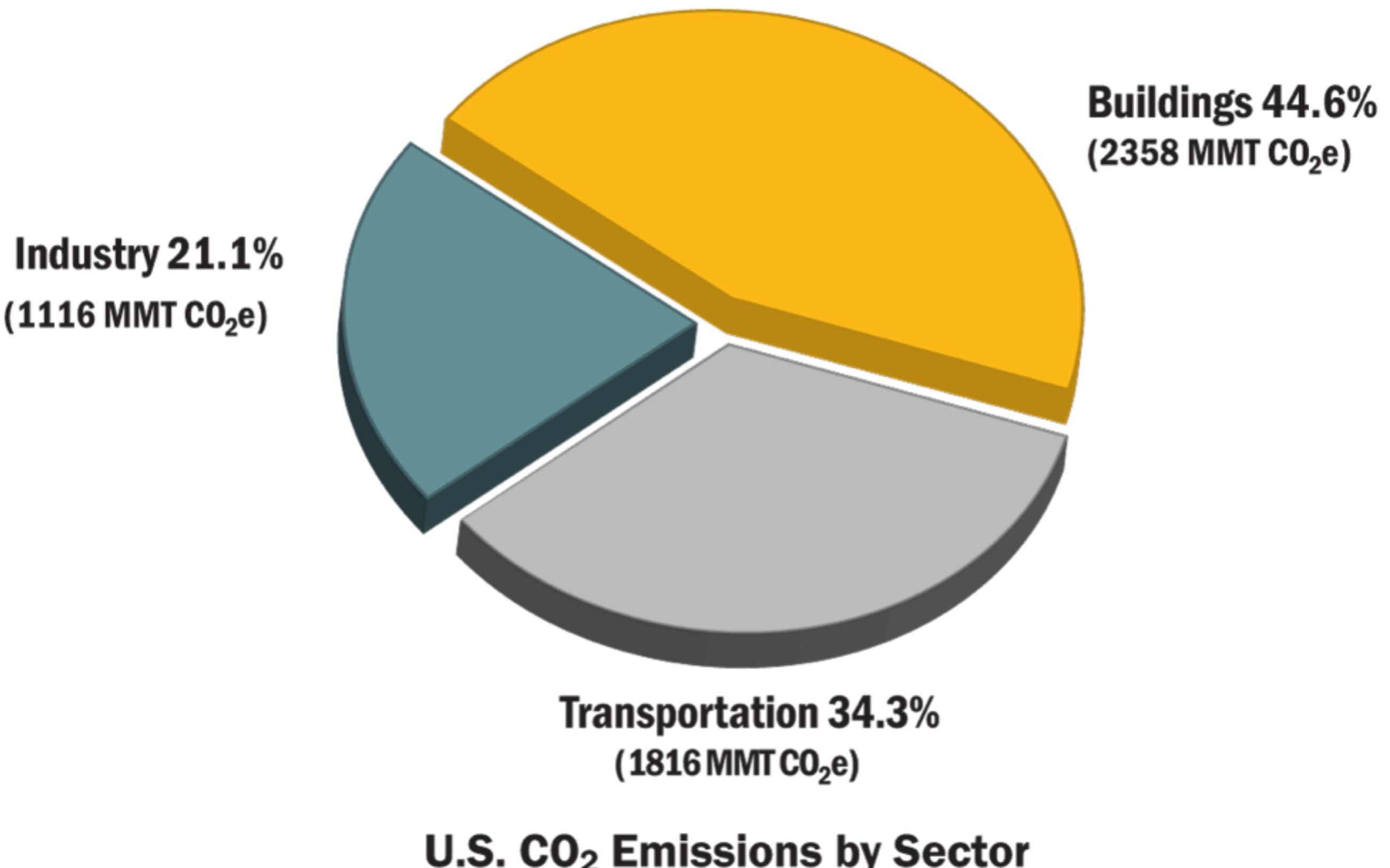
*What scientific  
questions would you  
need to have answers  
to support your choice  
of a sustainable  
technology/practice?*

*Scientific question:*  
**What human activities  
create impact, and  
what activities are the  
most impactful?**

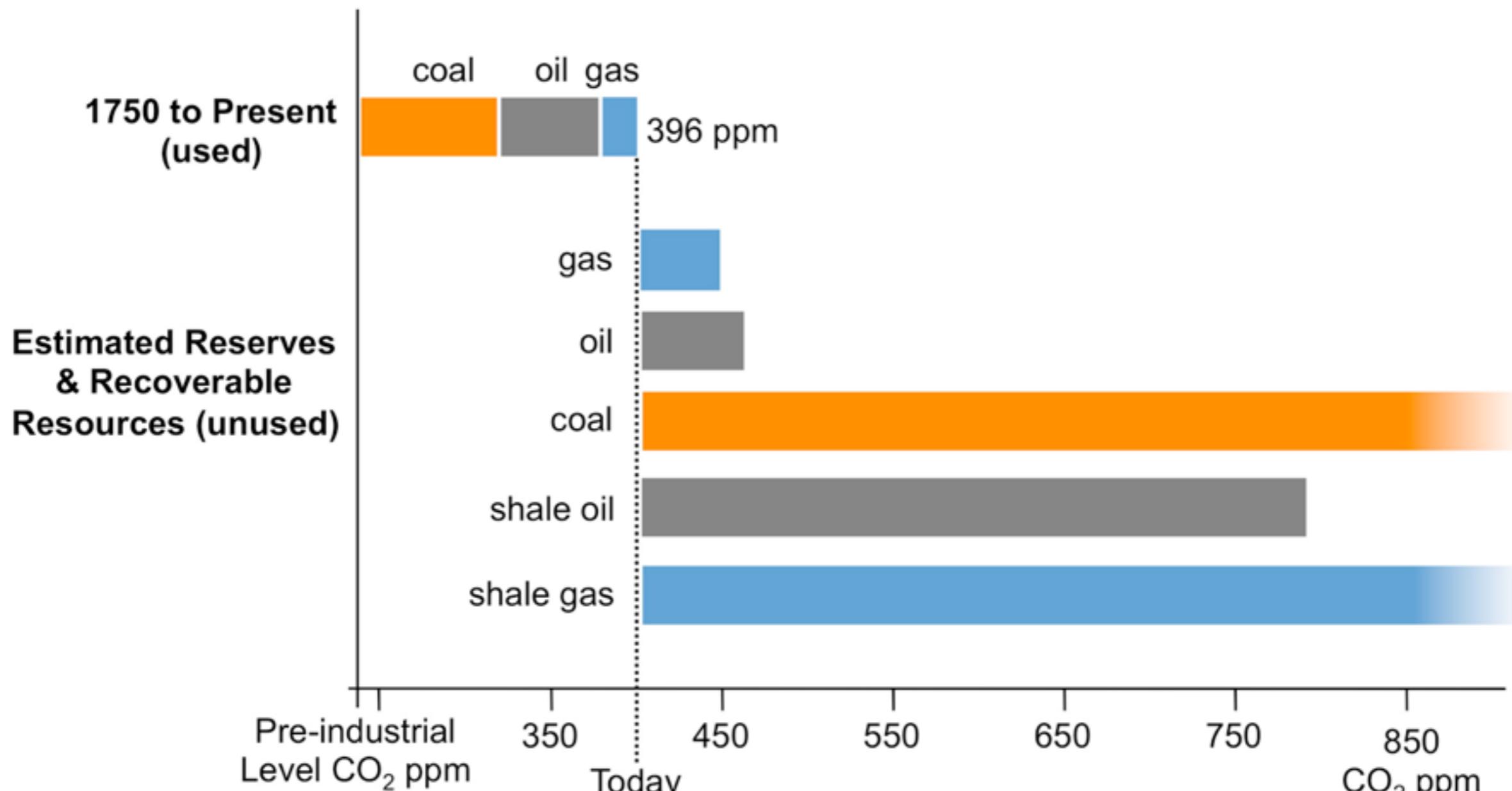
# U.S. GHG Emissions Flow Chart

Source(s): 56





# *How much impact can fossil fuels have?*



## **FOSSIL FUEL RESOURCES & CO<sub>2</sub> EMISSIONS (ppm – atmosphere)**

Source: Architecture 2030

Adapted from J. Hansen et al. 2013: Scientific Case for Avoiding Dangerous Climate Change to Protect Young People and Nature

# Questions or Thoughts?

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10. **Two legged stool image from:** OKPolicy, <http://okpolicy.org/wp-content/uploads/stool.jpg>
11. **Wetlands image from:** Wikimedia Commons, [https://commons.wikimedia.org/wiki/File:Tropical\\_rainforest\\_reflected\\_in\\_a\\_pond\\_in\\_Liberia\\_\(478896627\).jpg](https://commons.wikimedia.org/wiki/File:Tropical_rainforest_reflected_in_a_pond_in_Liberia_(478896627).jpg)
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16. **Fertilizer farm machinery image from:** Mother Jones, <http://www.motherjones.com/tom-philpott/2013/04/history-nitrogen-fertilizer-ammonium-nitrate>
17. **Eutrophication of the Gulf of Mexico image from:** Texas A&M University Galveston, [http://www.marinebiology.edu/Phytoplankton/louisiana\\_delta\\_satimage.jpg](http://www.marinebiology.edu/Phytoplankton/louisiana_delta_satimage.jpg)
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19. **DHL Fuel Tanker Truck image from:** Wikimedia Commons, <https://commons.wikimedia.org/wiki/File:DHL-DK05MFA.jpg>
20. **Industrial Fishing Boat image from:** Wikimedia Commons, [https://commons.wikimedia.org/wiki/File:Kiel\\_\(Ship\\_1973\)\\_-Deutsche\\_Fischfang\\_Union-Cuxhaven\\_2008\\_by-RaBoe\\_01.jpg](https://commons.wikimedia.org/wiki/File:Kiel_(Ship_1973)_-Deutsche_Fischfang_Union-Cuxhaven_2008_by-RaBoe_01.jpg)

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23. **Swidden Agriculture** image from: Wikimedia Commons, [https://commons.wikimedia.org/wiki/File:Swidden\\_agriculture\\_in\\_Yunnan\\_Province\\_uplands.JPG](https://commons.wikimedia.org/wiki/File:Swidden_agriculture_in_Yunnan_Province_uplands.JPG)
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27. **Blombos Cave Stratigraphy** image from: Wikimedia Commons, [https://commons.wikimedia.org/wiki/File:Blombos\\_Cave\\_stratigraphy.jpg](https://commons.wikimedia.org/wiki/File:Blombos_Cave_stratigraphy.jpg)
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30. **Aboriginal fishing village color painting image from:** National Library of Australia, <http://nla.gov.au/nla.pic-an2962715-s17>
31. **Aboriginal net fishing (black & white) image from:** Jane Resture's Oceania, [http://www.janesoceania.com/australia\\_aboriginal\\_traditional\\_society/index1.htm](http://www.janesoceania.com/australia_aboriginal_traditional_society/index1.htm)
32. **Fish Harvest & Aquaculture graph from:** Wikimedia Commons, [https://commons.wikimedia.org/wiki/File:Global\\_total\\_fish\\_harvest.svg](https://commons.wikimedia.org/wiki/File:Global_total_fish_harvest.svg)
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