

ENVIRONMENTAL DATA SCIENCE

APPLYING ECOLOGY & DATA SCIENCE FOR A SUSTAINABLE FUTURE



R Studio



Welcome to DATA 399!

Daily Agenda

- Instructor and class introductions
- Syllabus and expectations
- Global change biology

Introductions



Dr. Zechariah Meunier (he/him/his)
Assistant Professor of Data Science

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Office: Ford 305

Office hours: 3-4 pm TR or by appointment

Please call me “Professor Meunier” (min-yay)



LAWRENCE
UNIVERSITY
APPLETON, WISCONSIN

2011–2015

BA in Biology &
Environmental Studies



Epic

2015–2017

Technical Services Analyst for
Radiology Information System



TGH Tampa General Hospital®

MaineHealth

PROMEDICA
TOLEDO HOSPITAL



Oregon State University
College of Science

2017–2023

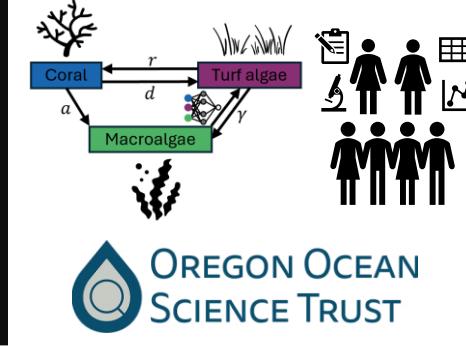
PhD in Integrative Biology,
PhD minor in Statistics



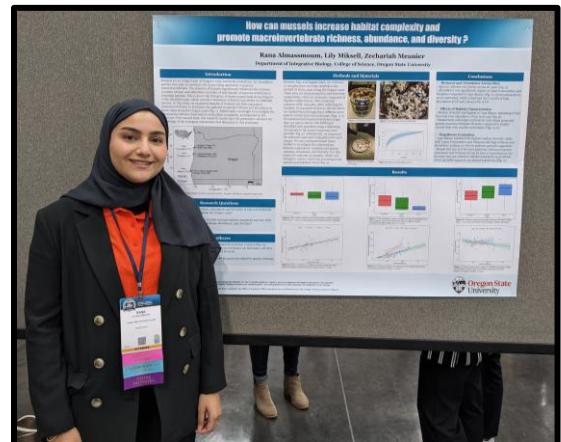
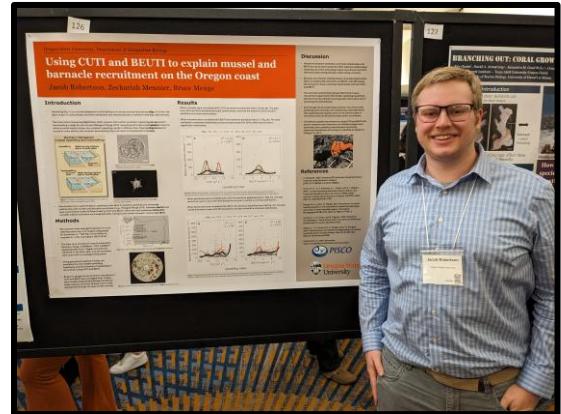
Oregon State University
College of Earth, Ocean,
and Atmospheric Sciences

2023–2025

Postdoctoral Research
Associate & Instructor



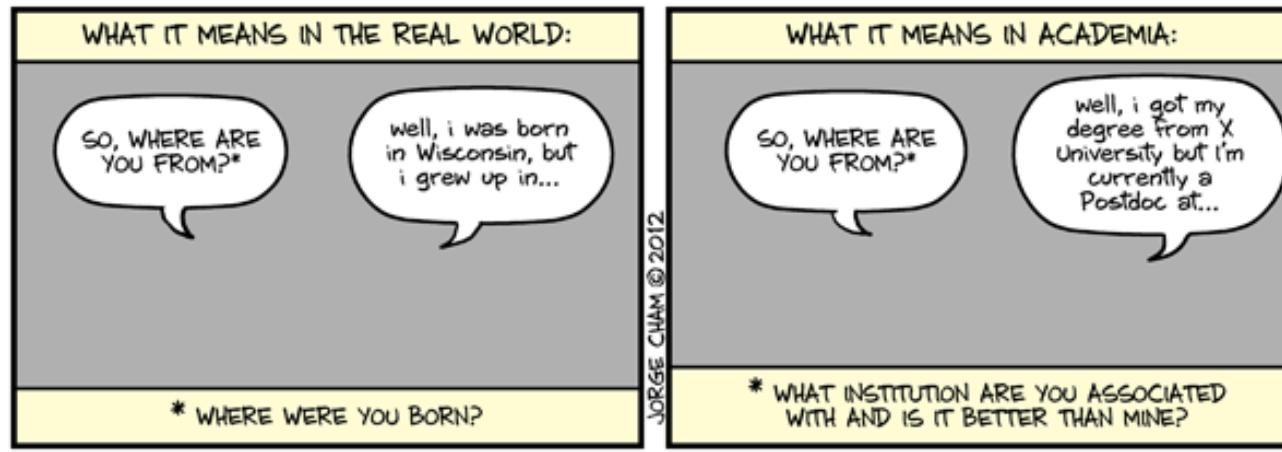
Ecological Data Science Lab



Introductions

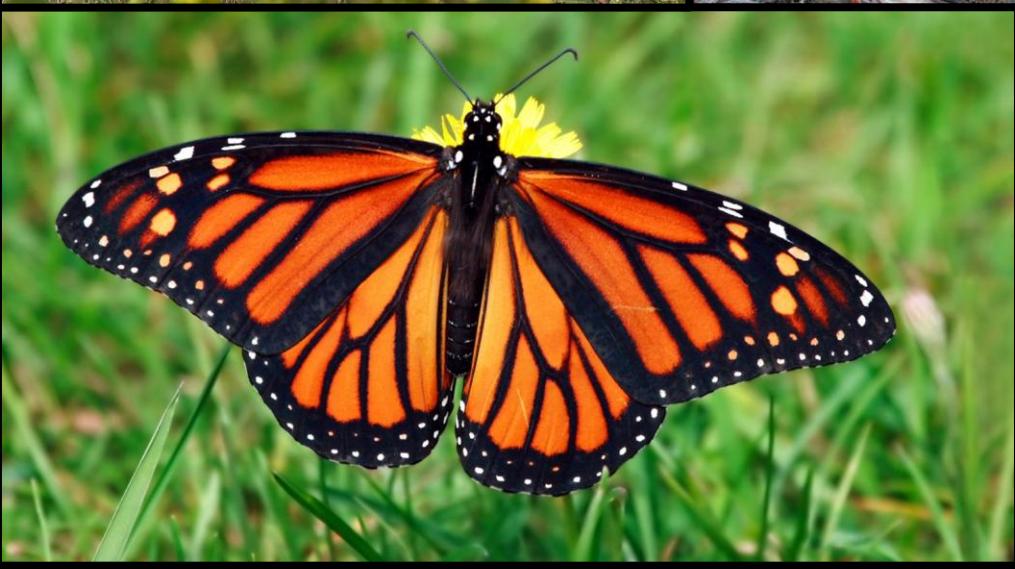
- Preferred name
- Pronouns
- Year in school
- Majors and minors
- What is one fun thing you did over break?
- What do you hope to learn in this class?

"WHERE ARE YOU FROM?"



Syllabus

Time



Week 1 Action Items

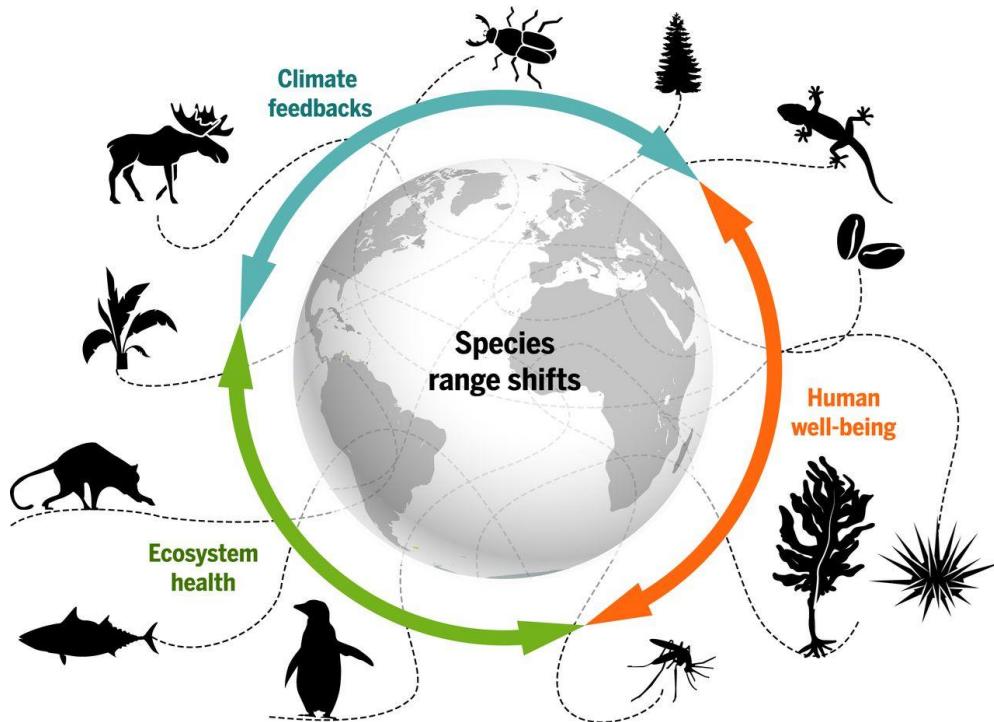
Due this week

- Nothing 😊

Due next week

- GitHub onboarding (1/21)
 - Create a GitHub account
 - Join the course GitHub repository
 - Download GitHub Desktop and clone repository

Global Change Biology



Activity: Think-pair-share

What environmental changes should be included under the umbrella of **global change biology**?

What changes are not part of **global change biology**?

Why is it important to have this distinction?

From the journal

“Global Change Biology exists to promote understanding of the interface between all aspects of **current environmental change that affects a substantial part of the globe and biological systems**. It publishes articles on the impacts of global change on biological systems and solutions.

Studies must concern biological systems, regardless of whether they are aquatic or terrestrial, and managed or natural environments. Both biological responses and feedbacks to change are included, and may be considered at any level of organization from molecular to biome.”

Primary drivers of global environmental change



Climate change



Biodiversity loss and biotic invasion



Eutrophication



Land use and transformation

Climate change: causes



GENERATING POWER



MANUFACTURING GOODS



POWERING BUILDINGS



PRODUCING FOOD



USING TRANSPORTATION



CUTTING DOWN FORESTS

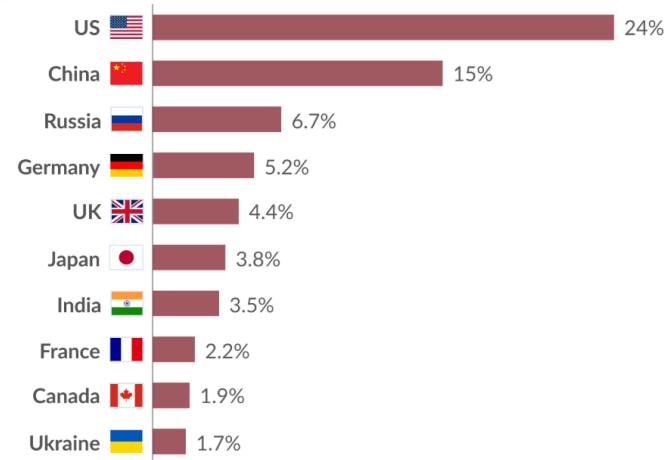


CONSUMING TOO MUCH

Countries that have emitted the most CO₂ emissions to date

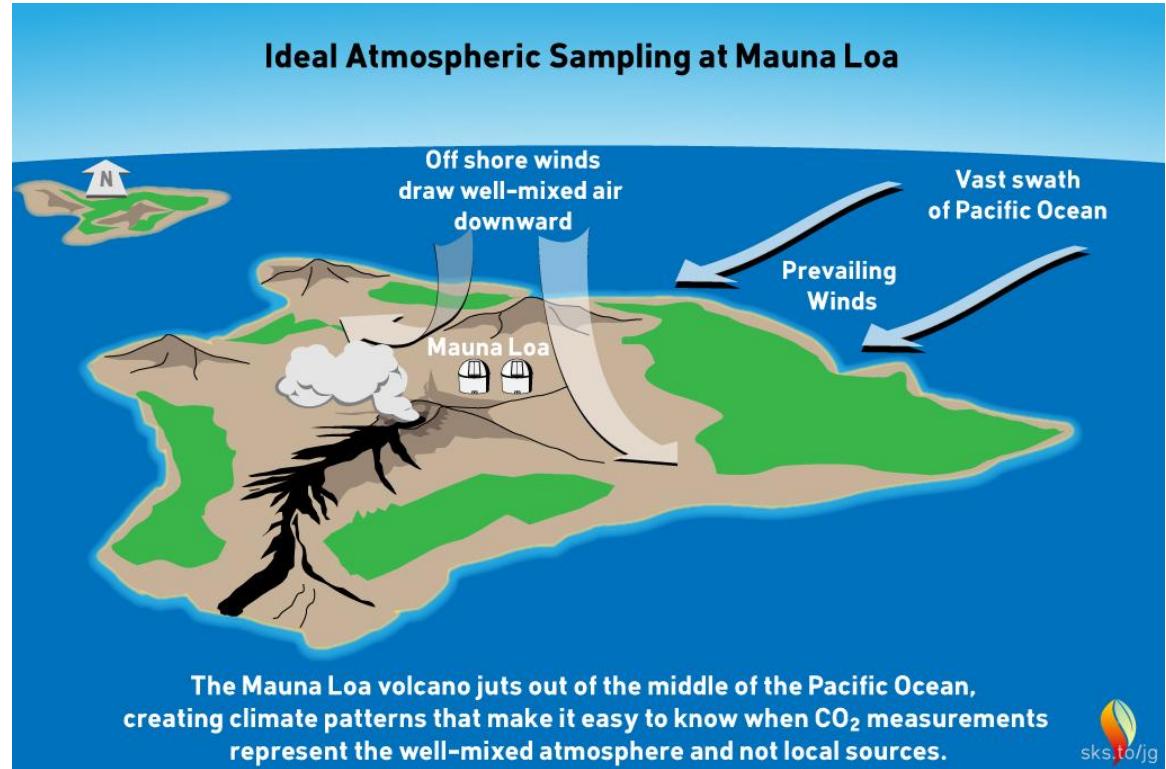
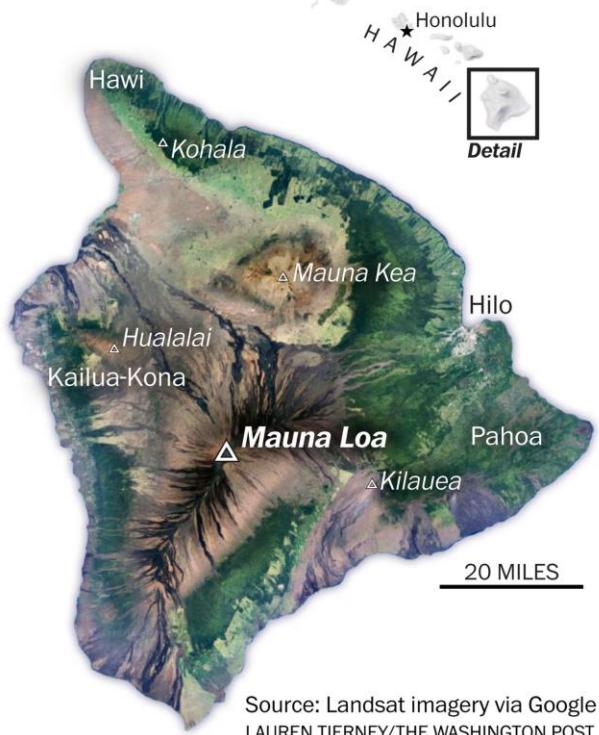
Our World
in Data

Each country's share of global cumulative CO₂ emissions since 1750.
This measures fossil fuel and industry emissions; land use is not included.



Data source: Global Carbon Budget (2024)

CC BY

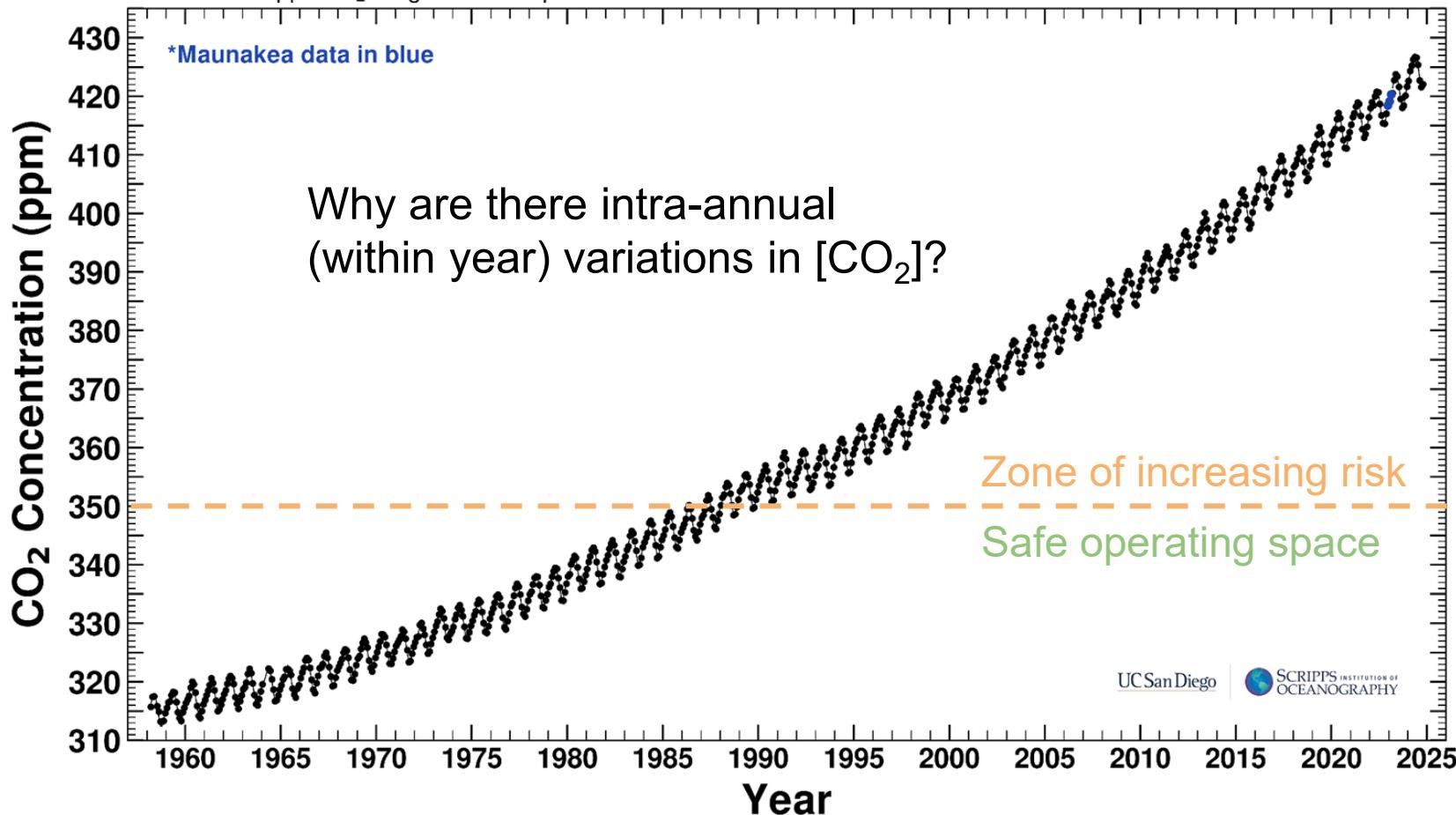


Mauna Loa Observatory, Hawaii*

Monthly Average Carbon Dioxide Concentration

Data from Scripps CO₂ Program Last updated December 2024

High risk (450 ppm)



Climate change: impacts

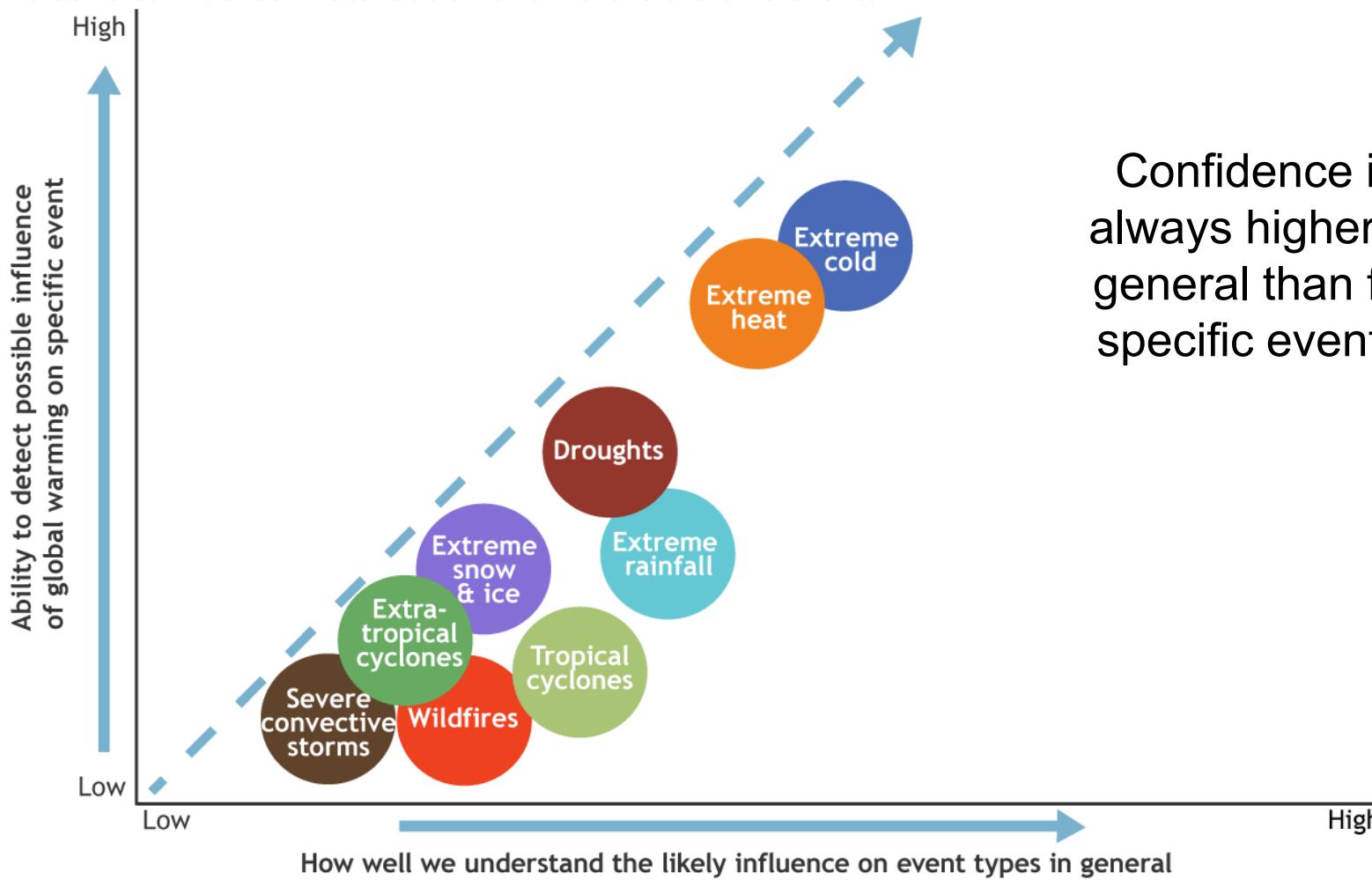
Global warming ≠ climate change, global warming ∈ {climate change impacts}

Changing physical and chemical conditions (e.g., temperature, precipitation, gas concentrations, acidity, nutrient concentrations) affect changes in atmospheric, geologic, oceanographic, and ecological systems

To name a few consequences:

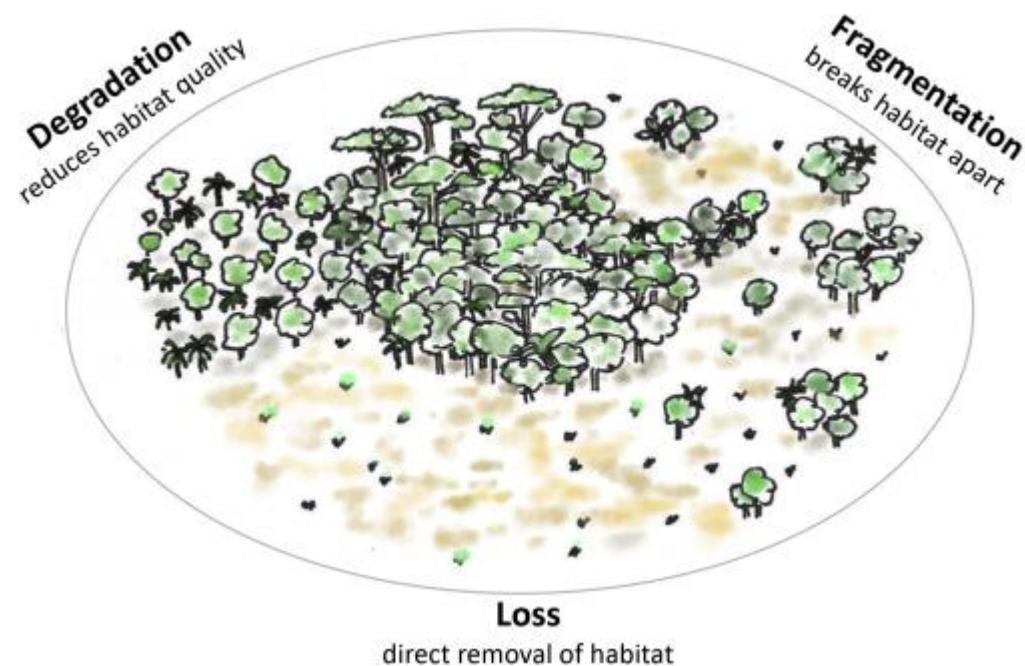
- Ocean acidification
- Hypoxia
- Sea level rise
- Coral bleaching
- Severe tropical storms
- Frequent wildfire
- Species range shifts (latitude, altitude)
- Desertification

Relative confidence in attribution of different extreme events

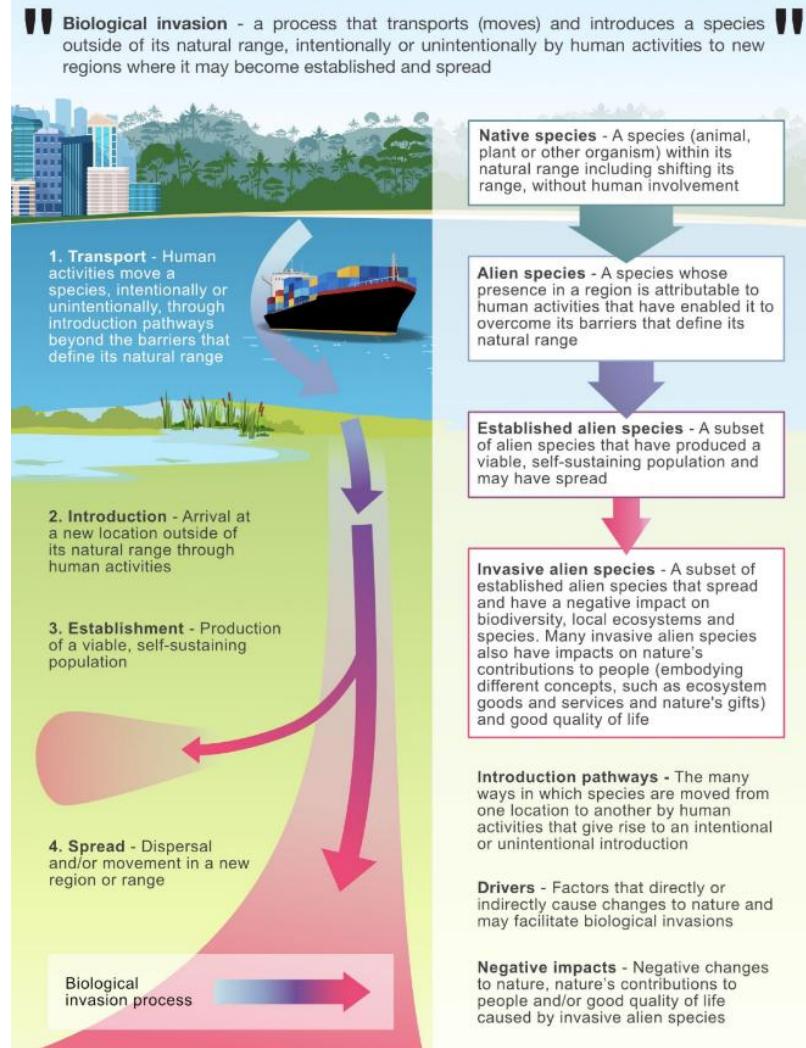


Confidence is always higher in general than for specific events!

Biodiversity loss and biotic invasion: causes

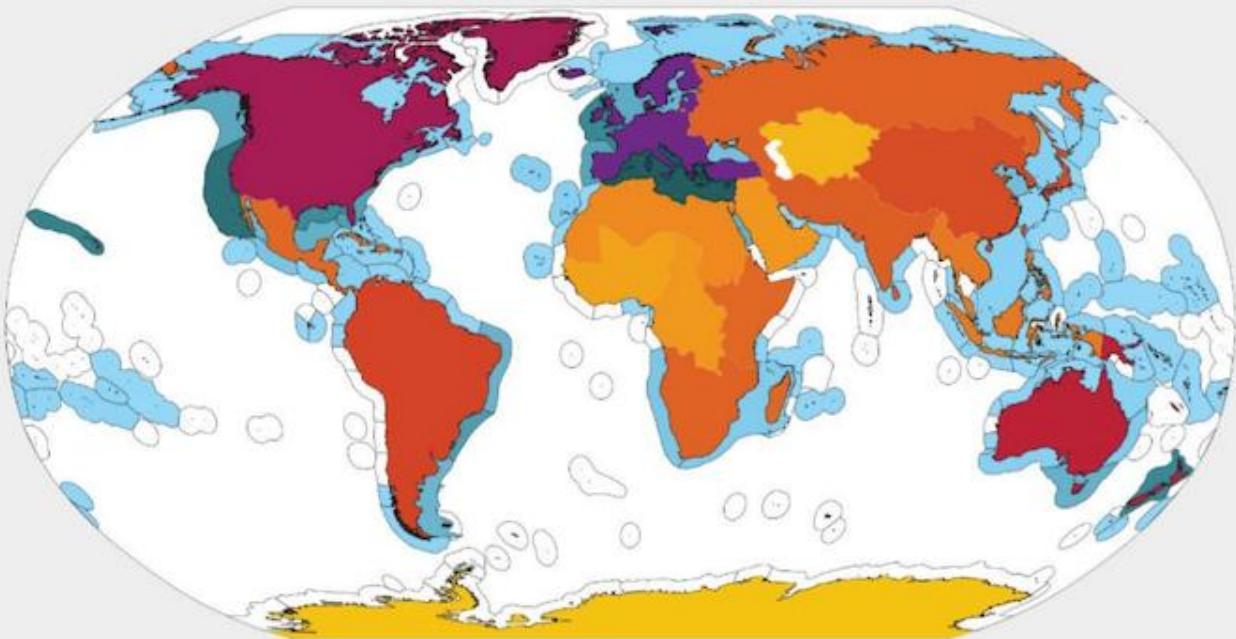


Banks-Leite et al. 2020 *One Earth*



A

Global distribution of established alien species



Established alien marine species

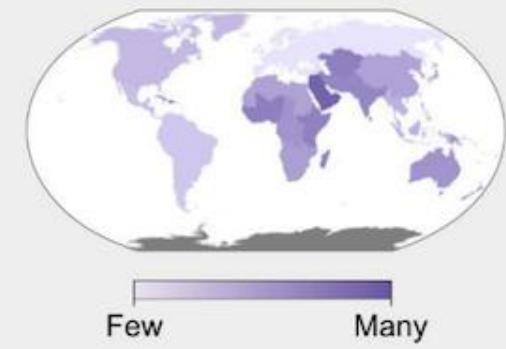


Established alien terrestrial and freshwater species



No data

Distribution of terrestrial data gaps



Environmental trivia

More than 70 species and subspecies of birds have gone extinct on the Hawaiian islands. This represents approximately what percentage of avian extinctions since 1500?

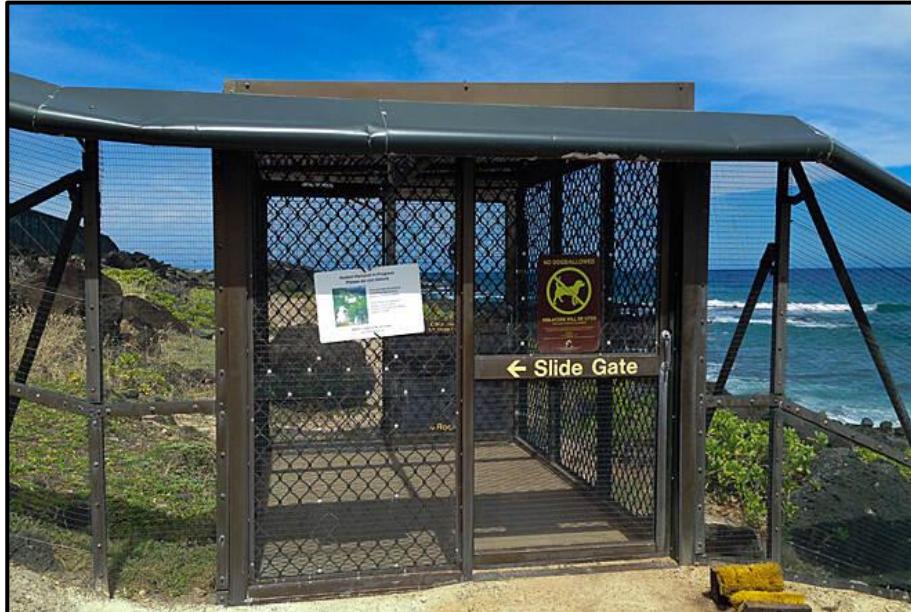
- a) 5%
- b) 15%
- c) 25%
- d) 35%



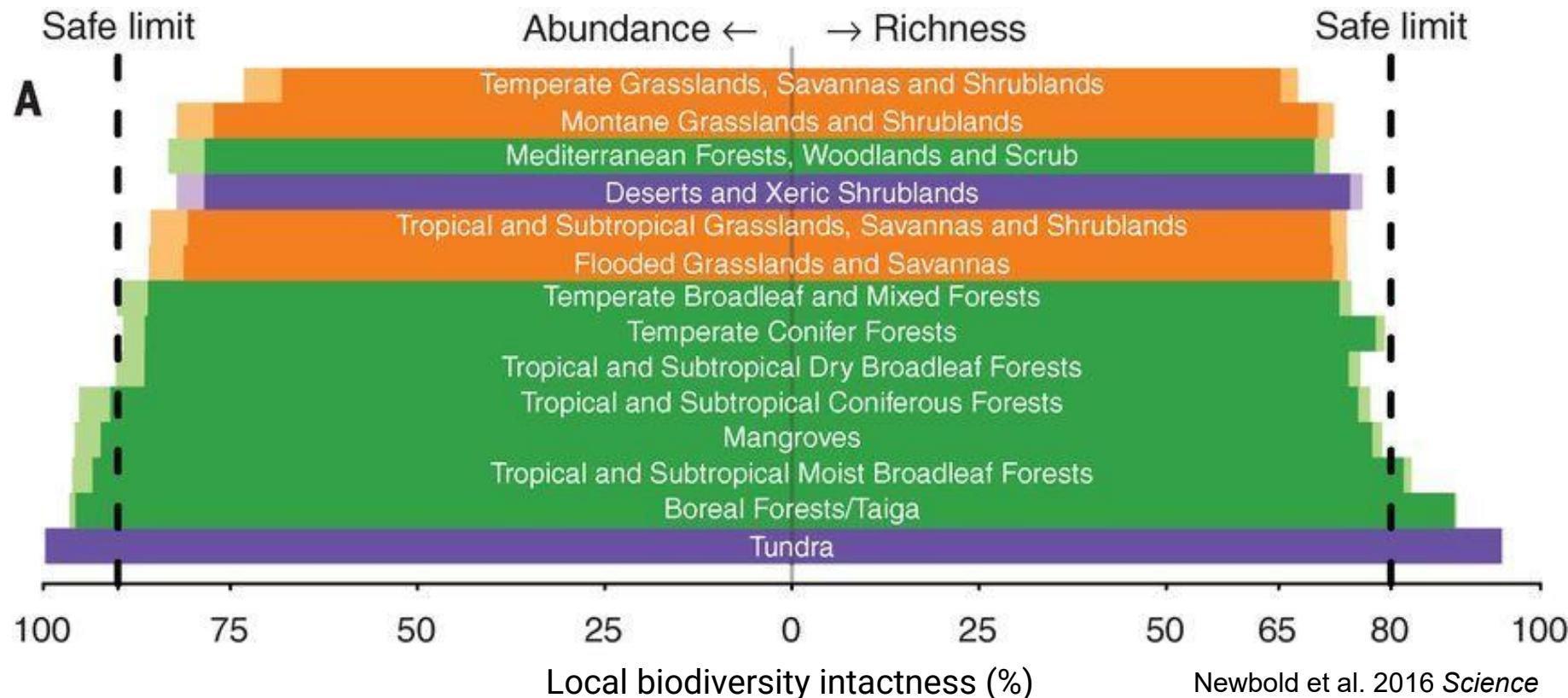
Personal experience birding on O‘ahu



“The Hawaiian Islands are known as both the ‘extinction and invasive species capitals of the world,’”
Jeferson Vizentin-Bugoni



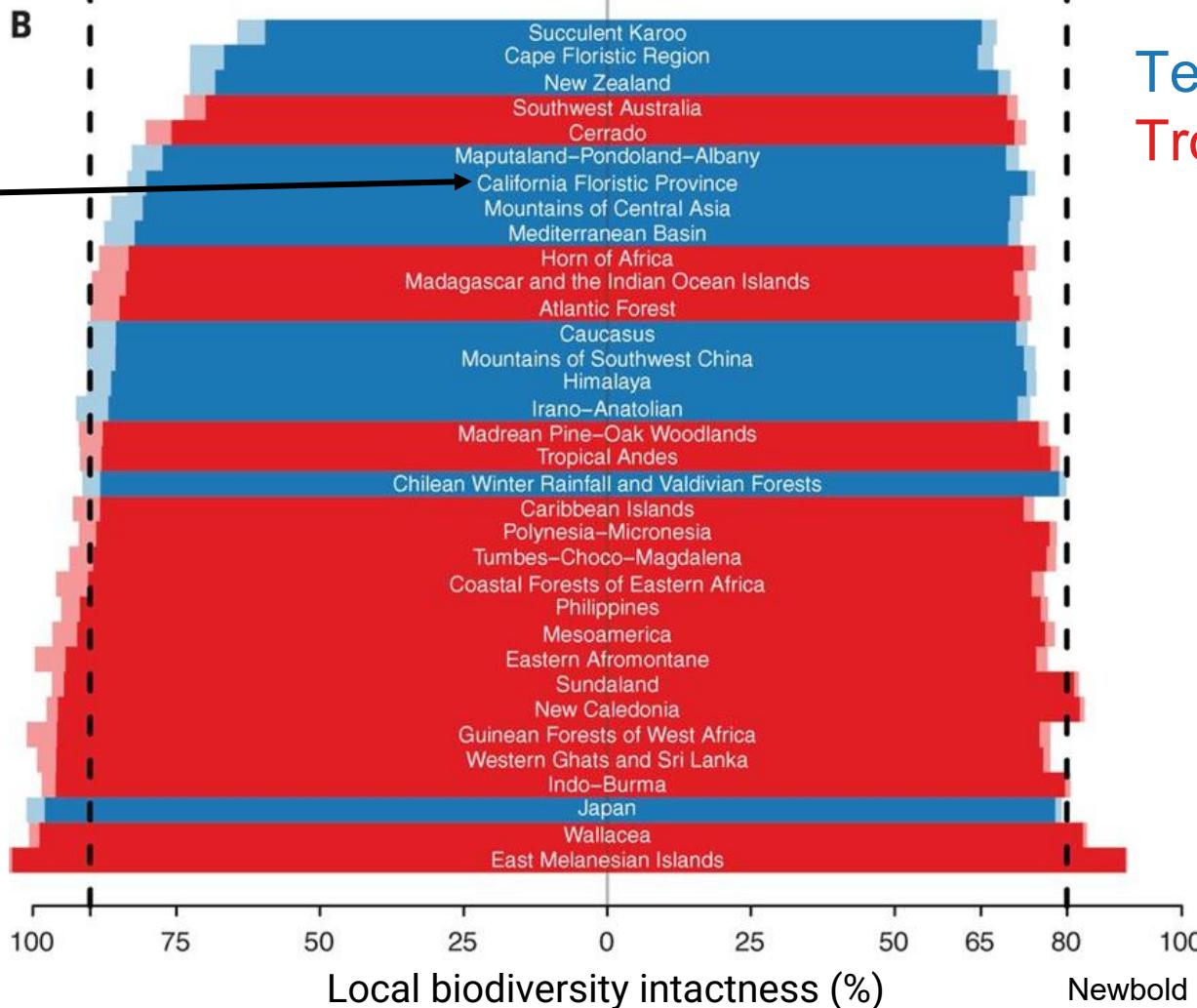
Biodiversity loss and biotic invasion: impacts



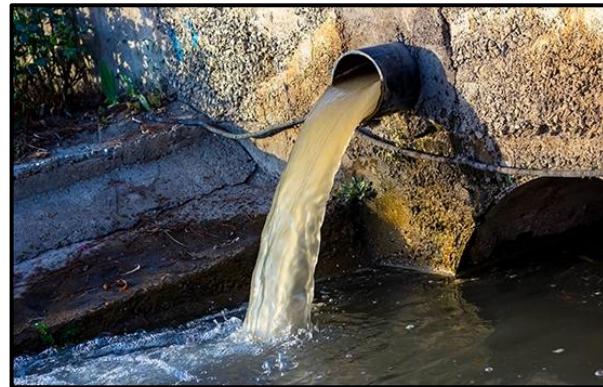
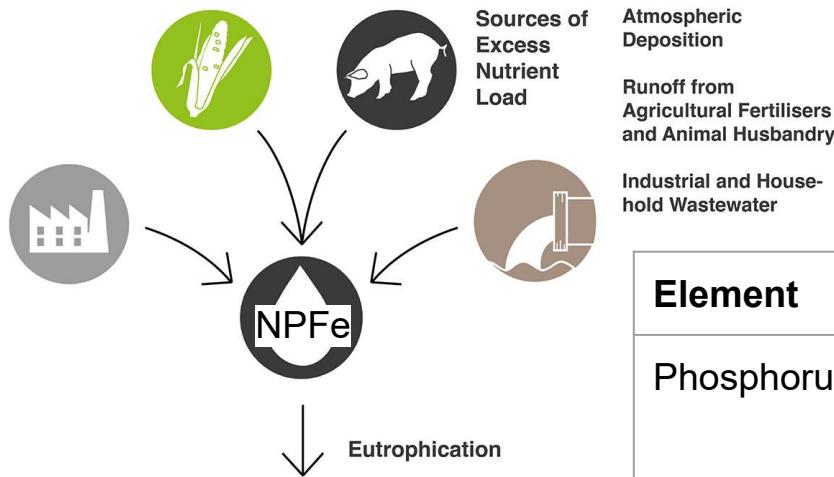


Conservation International (conservation.org) defines 35 biodiversity hotspots — extraordinary places that harbor vast numbers of plant and animal species found nowhere else. All are heavily threatened by habitat loss and degradation, making their conservation crucial to protecting nature for the benefit of all life on Earth.

Temperate
Tropical



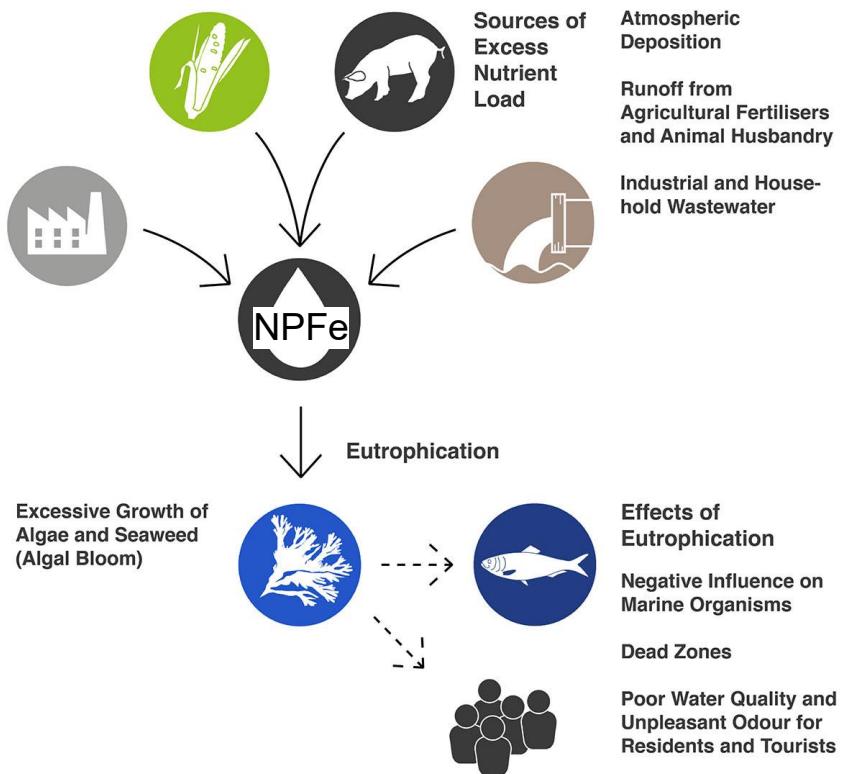
Eutrophication: causes



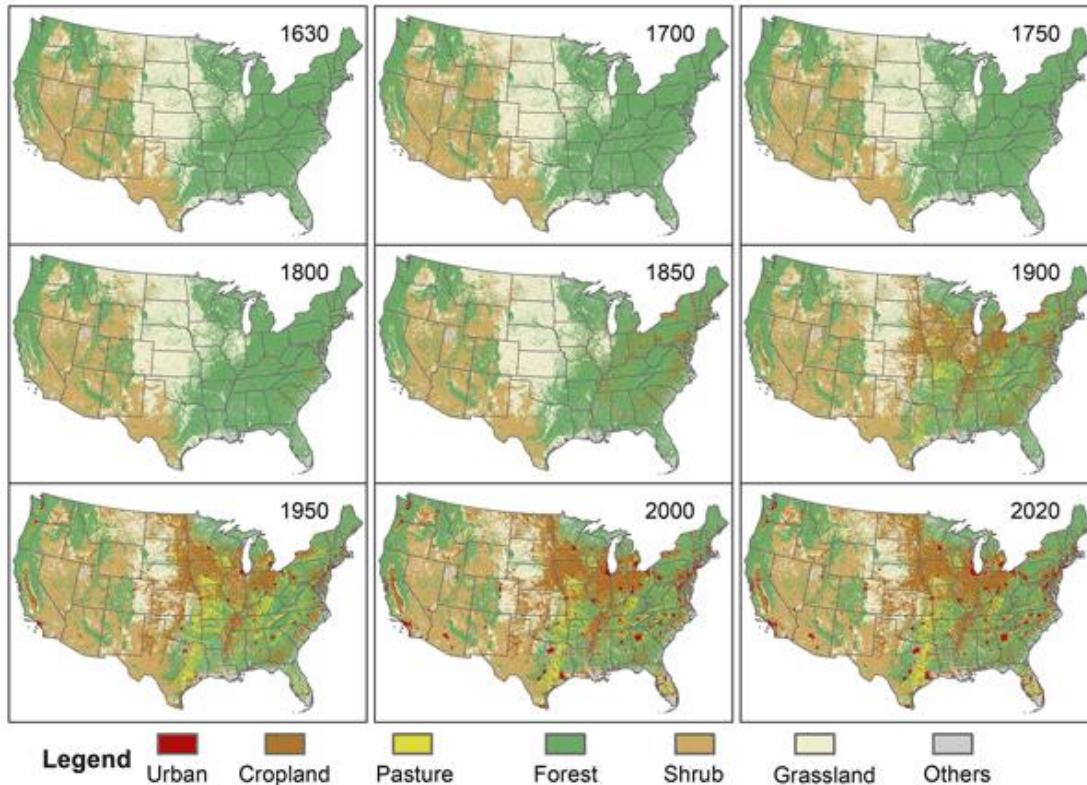
Limiting Nutrients in Aquatic Systems

Element	Freshwater	Marine
Phosphorus	Primary	Secondary but becoming more limiting, especially in the S. Pacific, N. Atlantic, and Indian Oceans
Nitrogen	Secondary	Primary, especially in stratified subtropical gyres and in the summertime Arctic Ocean
Iron	Secondary	Primary, especially in upwelling regions

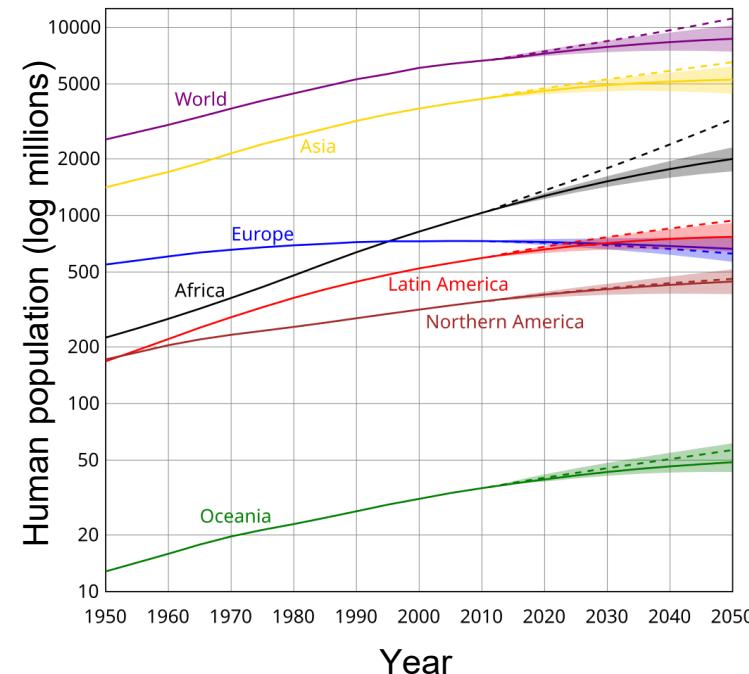
Eutrophication: impacts



Land use and transformation: causes

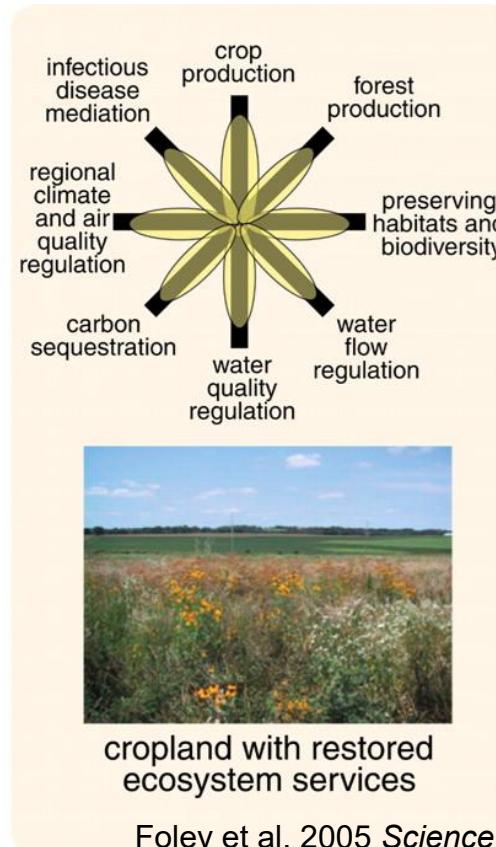
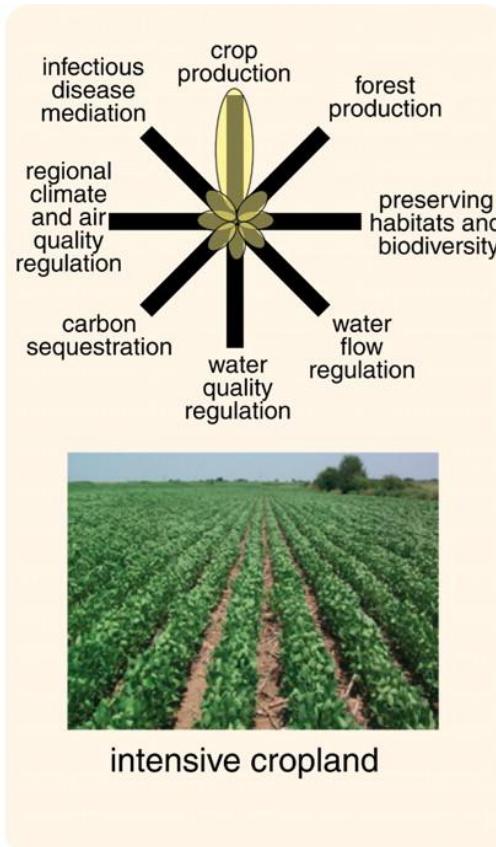
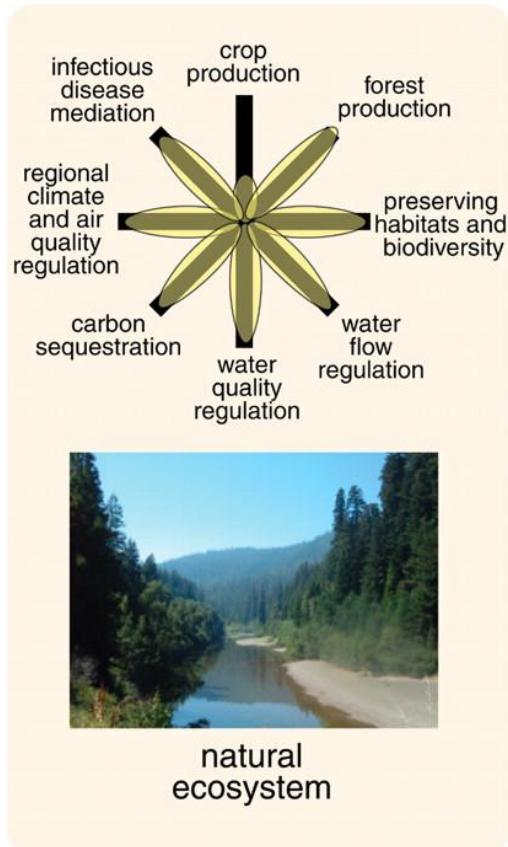


Li et al. 2023 *Earth Syst. Sci. Data*



United Nations 2011

Land use and transformation: impacts



Foley et al. 2005 *Science*

Environmental stressor vs. ecological disturbance

Disturbance – a physical force, agent, or process, either abiotic or biotic, causing a perturbation to an ecological component or system, relative to a specified reference state and/or system

- Often defined by direct loss of biomass (e.g., wildfire burning a prairie)

Stressor – a physical or chemical change that adversely affects organisms' physiologies and may result in mortality

- Loss of biomass is indirect (e.g., drought killing prairie vegetation)

Depending on the relevant time scales, stress and disturbance may be **acute** (short-term) or **chronic** (long-term)

Environmental trivia

Which of the following is not a source of disturbance?

- a) Earthquake
- b) Wildfire
- c) Volcanic eruption
- d) Flash flood
- e) Locust outbreak
- f) Ocean acidification
- g) Slash-and-burn agriculture



Interactions between multiple stressors

Species and ecosystems rarely experience a single stressor or disturbance

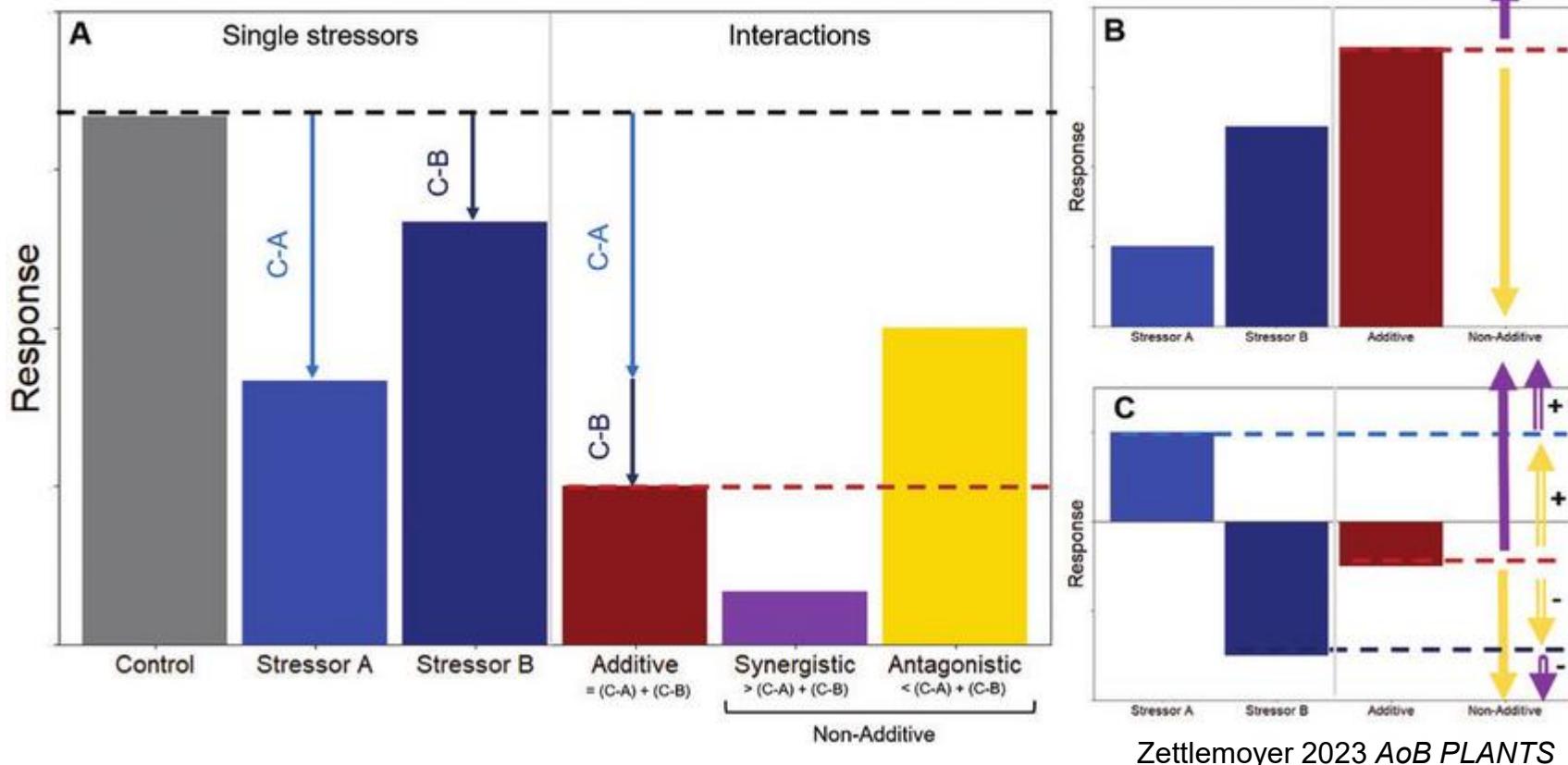
Instead, interactions between stressors A and B can be:

Additive, where the effects of the stressors combined = A+B

Antagonistic, where the effects of the stressors combined < A+B

Synergistic, where the effects of the stressors combined > A+B

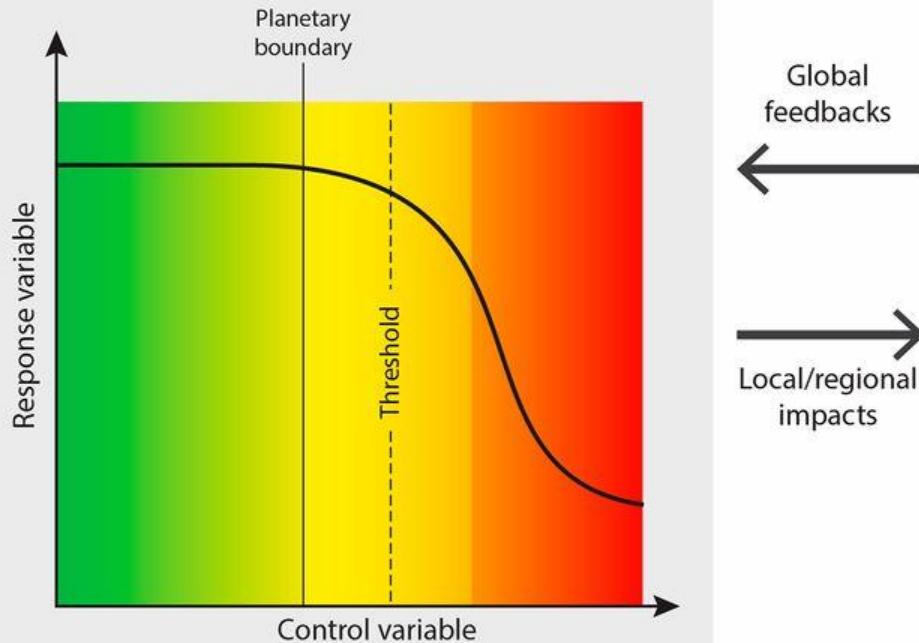
Complicated interactions



Planetary boundaries vs. environmental thresholds

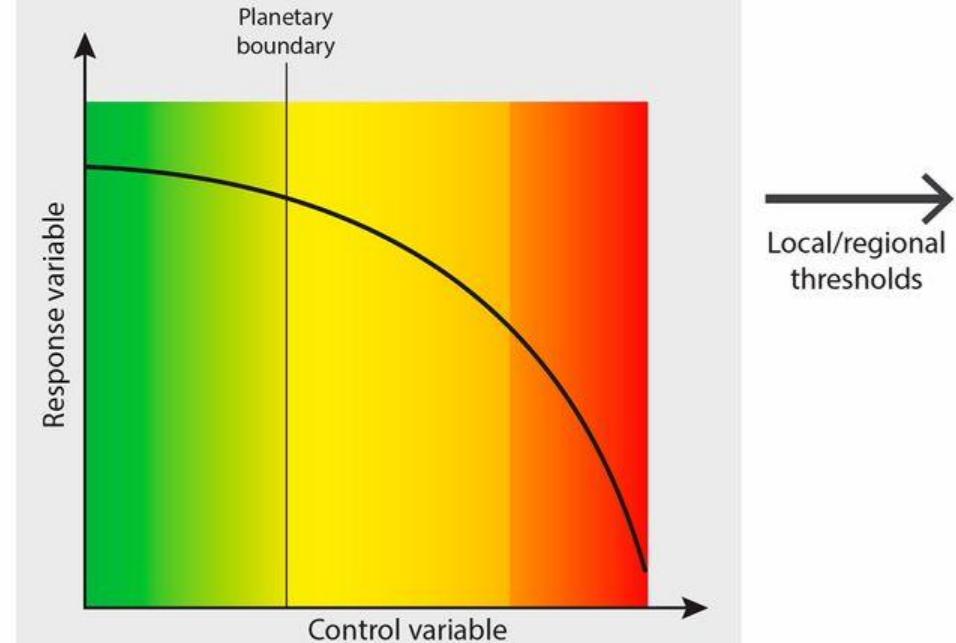
Process X

Globally mixed, with continental/global threshold



Process Y

Heterogeneous, with no continental/global threshold

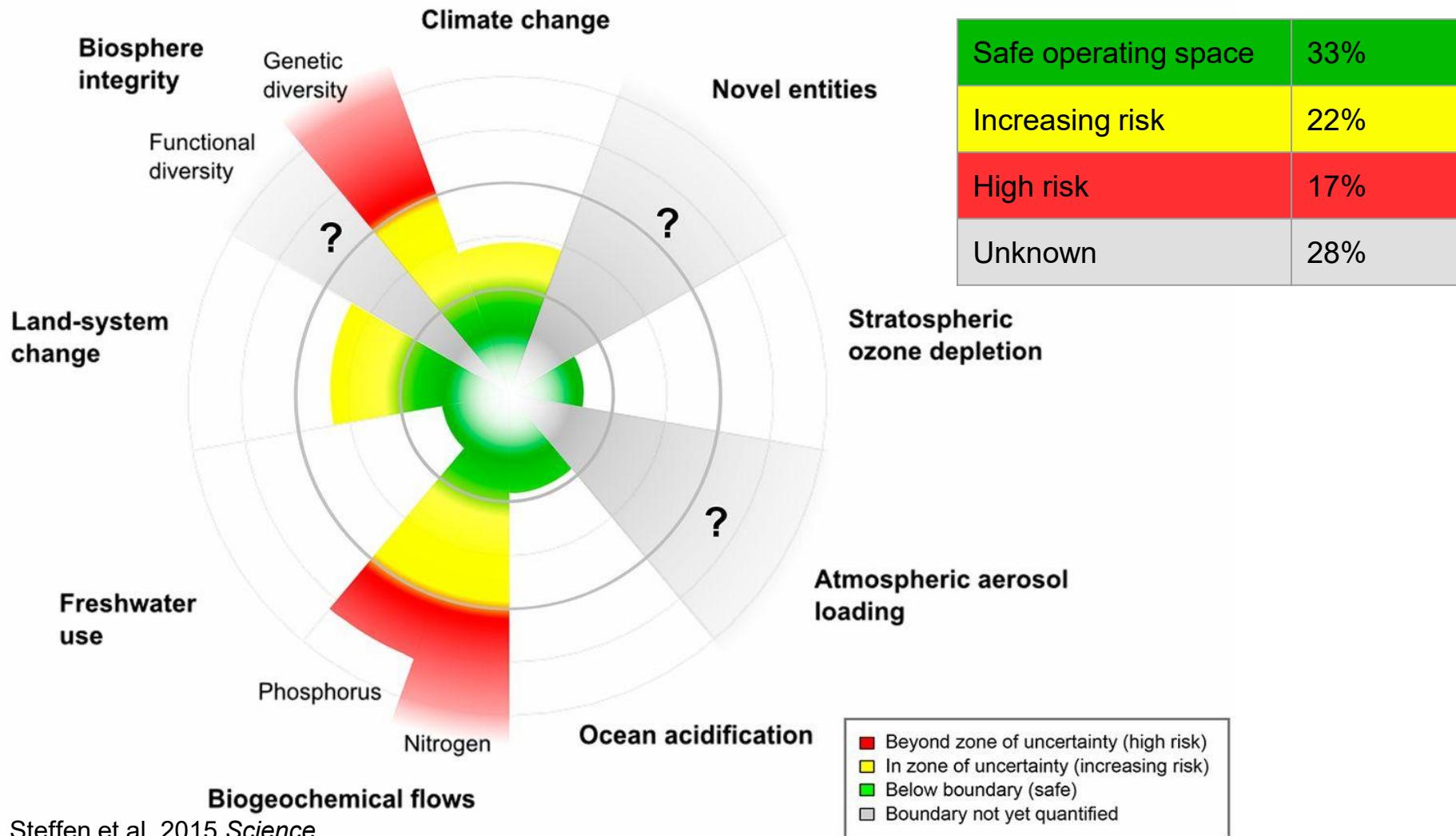


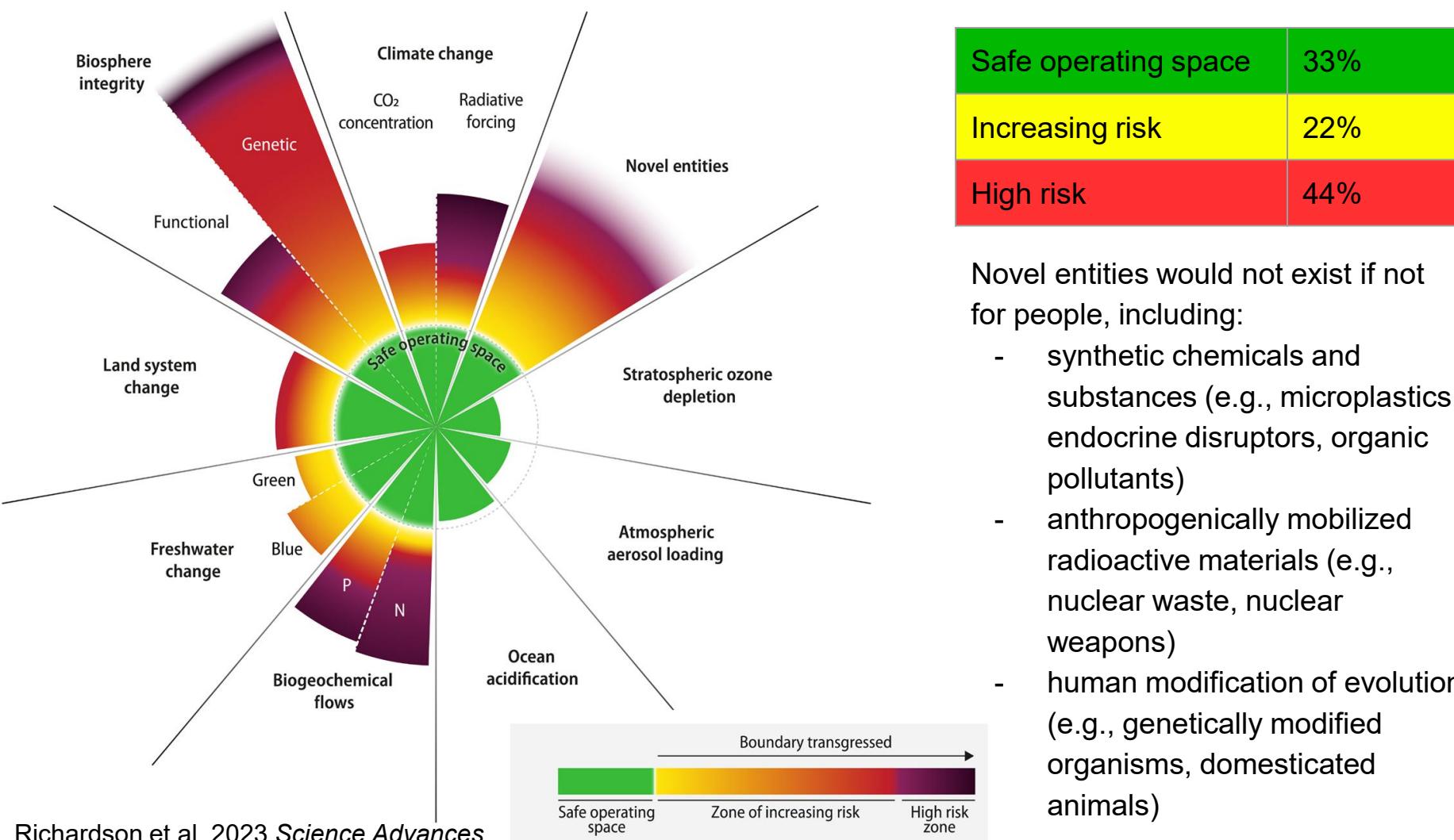
Steffen et al. 2015 *Science*

Safe operating space

Zone of uncertainty: Increasing risk of impacts

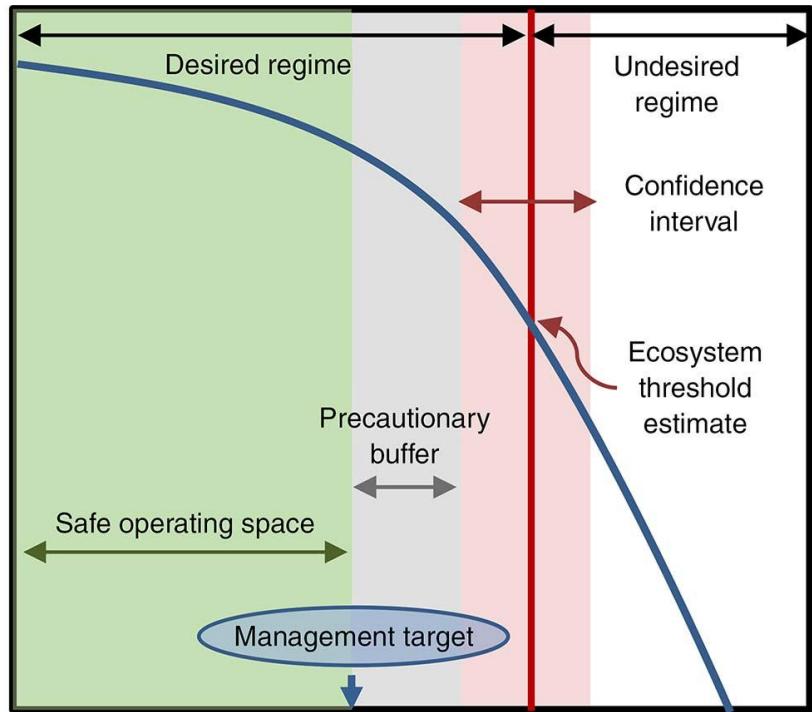
Dangerous level: High risk of serious impacts





Transitions between community states

Ecosystem condition



Selkoe et al. 2015 *Ecosystem Health & Sustainability*



Alternative States
of Ecosystems

Base

Base

Base

Base

New

New

Base

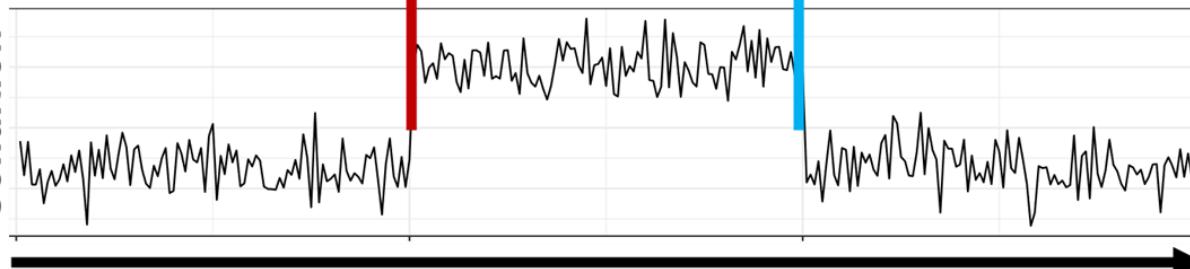
Base

New

Resistance
Resilience
Recovery

Regime shift

Environmental
Condition



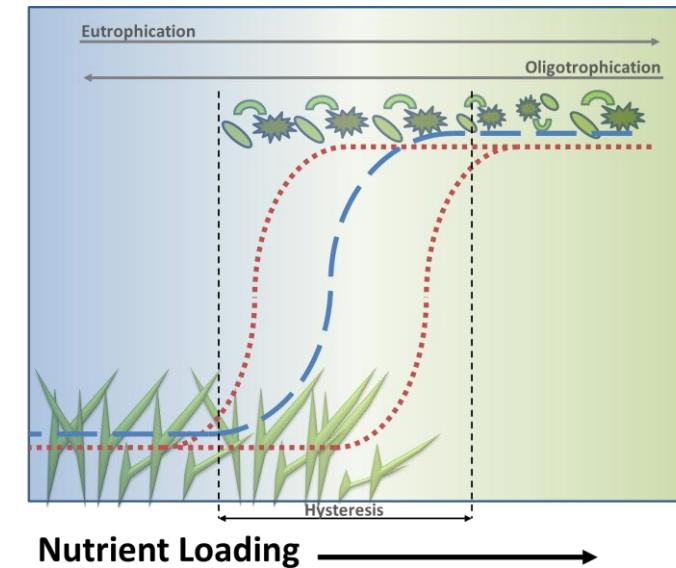
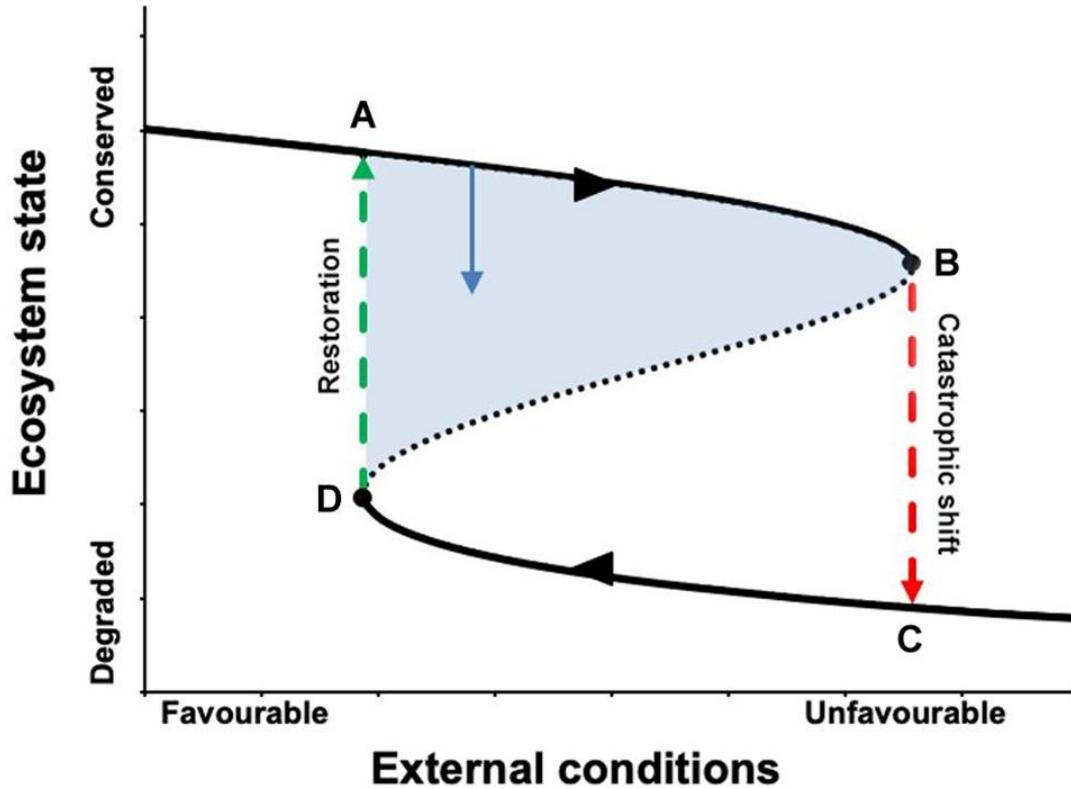
1

2

3

Time

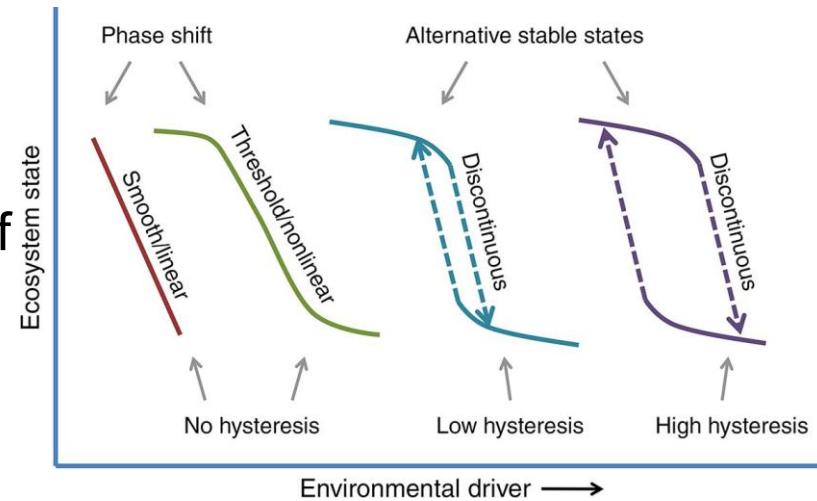
Alternative states and hysteresis



Janssen et al. 2014

Conclusions

- Humans have dramatically altered all aspects of biological systems, from molecules to the biosphere
- Ecosystems can change in a variety of ways: linear/nonlinear, abrupt/slow
- Planetary boundaries exist before tipping points are exceeded
- We are rapidly running out of time before all 9 planetary boundaries are transgressed



Selkoe et al. 2015 *Ecosystem Health & Sustainability*