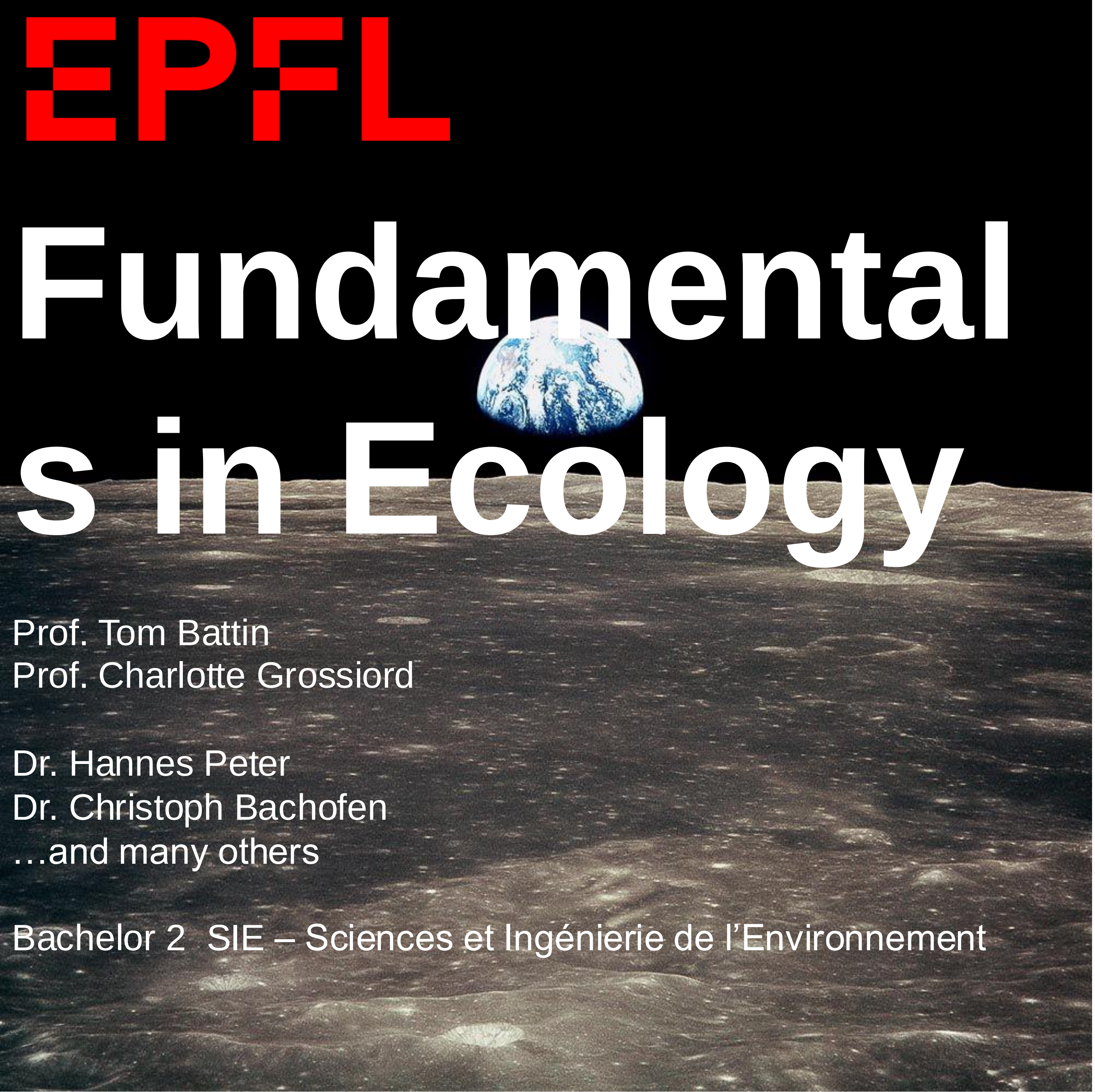
Earthrise
Astronaut William Anders
December 24 1968
Apollo Mission 8

Nature photographer Galen Rowell:
"the most influential environmental photograph ever taken".

‘The image shows our entire world as a small and blue and very finite globe, with our nearest celestial neighbour a desolate presence in the foreground’.

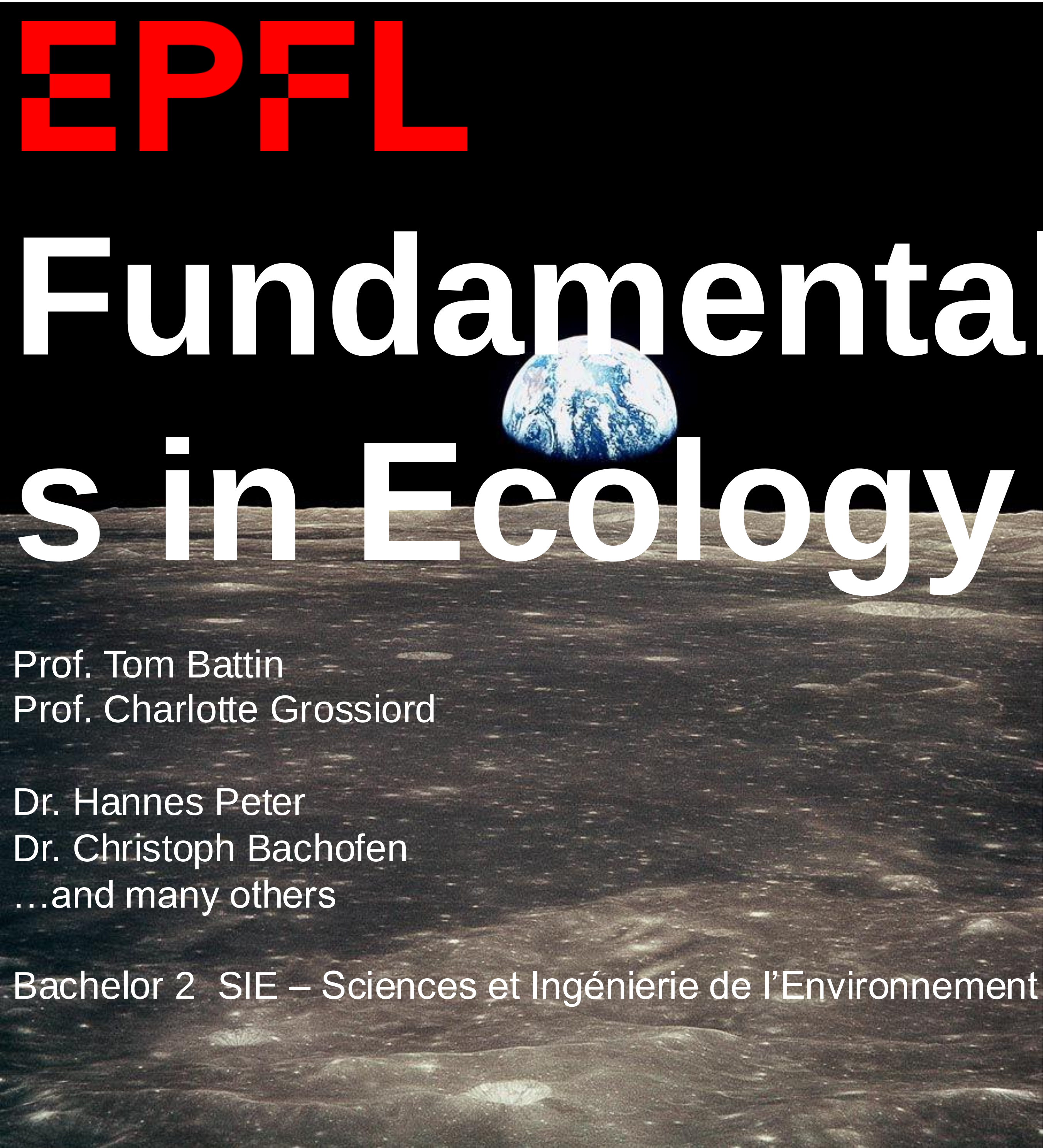


Fundamentals in Ecology

Prof. Tom Battin
Prof. Charlotte Grossiord

Dr. Hannes Peter
Dr. Christoph Bachofen
…and many others

Bachelor 2 SIE – Sciences et Ingénierie de l’Environnement



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Bachelor 2 SIE – Sciences et Ingénierie de l'Environnement

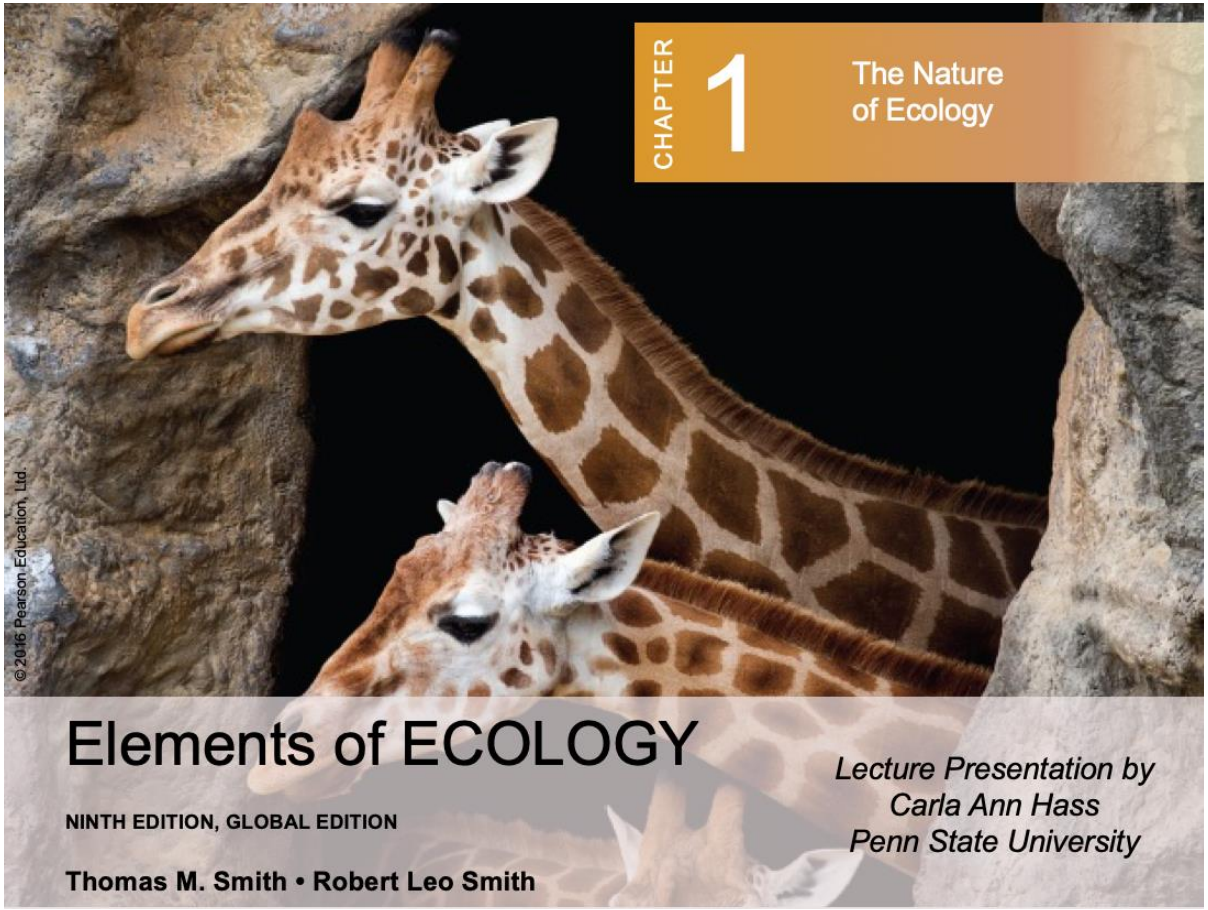
Mandatory course

Class and discussions
Fieldwork and lab work

Written exam (60%)
Practical part (40%)

Library

Located at the Rolex Learning Center, the EPFL Library offers advanced tailored services to EPFL members (students, researchers, teachers). As a public library, collections are available for everyone interested.



Fundamentals of ecology (environment, populations, communities, ecosystems, biogeochemistry)

Examples of applied ecology

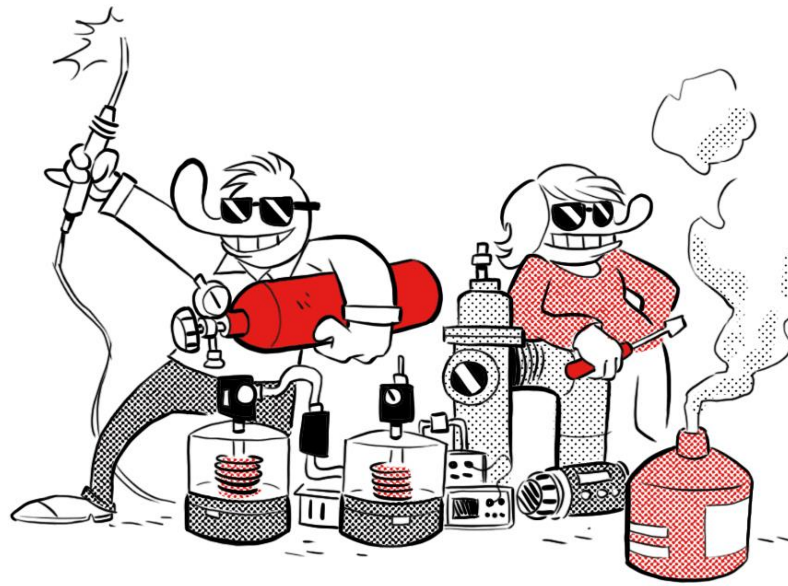
- Prof. Grossiord: Applied ecology, Climate change impacts on terrestrial ecosystems
- Prof. Battin : Climate change impacts on aquatic ecosystems, Restoration ecology

Practical part

Prof. Grossiord
Primary production: plant ecophysiology, photosynthesis

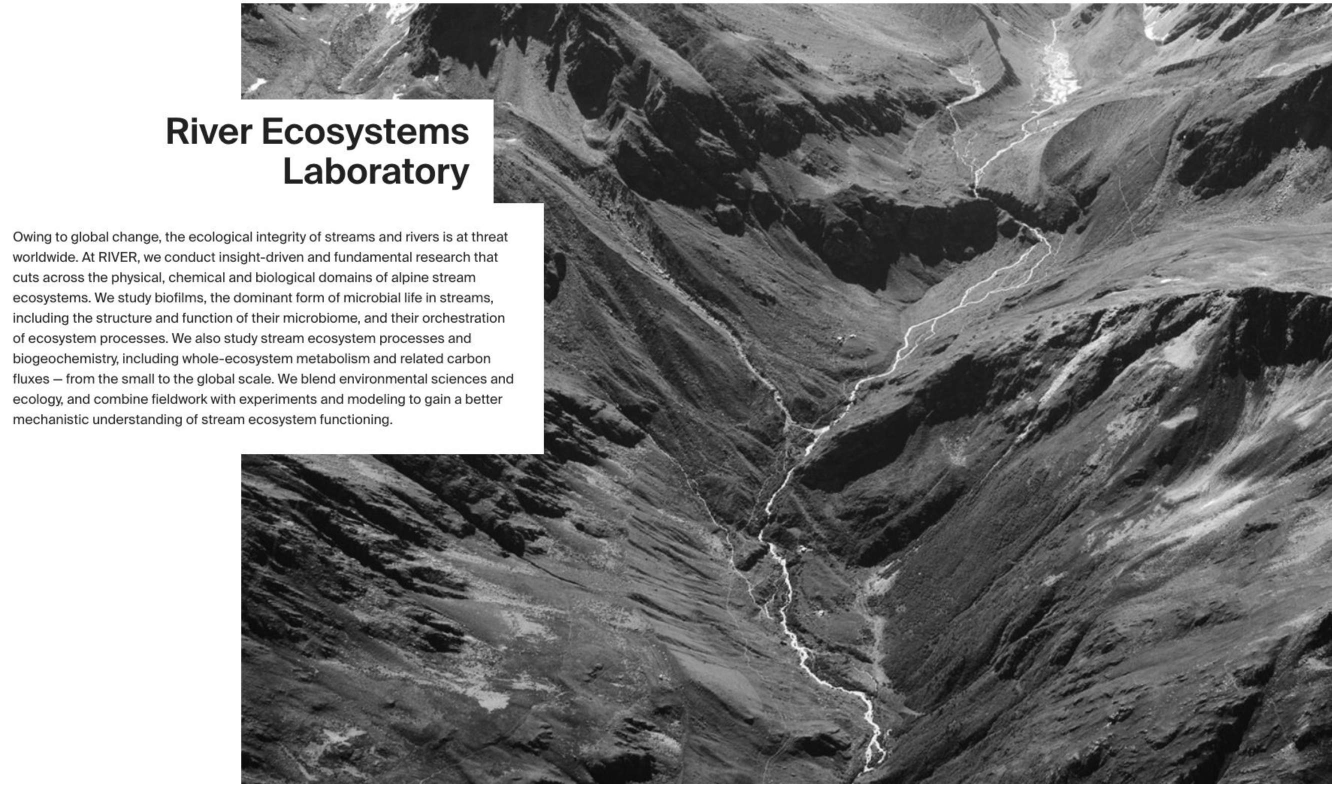
Prof. Battin:
Degradation: leaf litter decomposition

- Primary production (CO_2 assimilation) and decomposition (CO_2 production)
- Major drivers of the carbon and nutrient cycling.



Thursday 22 February @11:15 in GR C0 01

The River Ecosystems Laboratory at EPFL



https://www.epfl.ch/labs/river/

- Ecosystem processes
- Biogeochemistry
- Carbon cycling
- Microbiome structure and functioning
- Ecohydraulics

Lab at ALPOLE, Sion

This year’s plan of the class

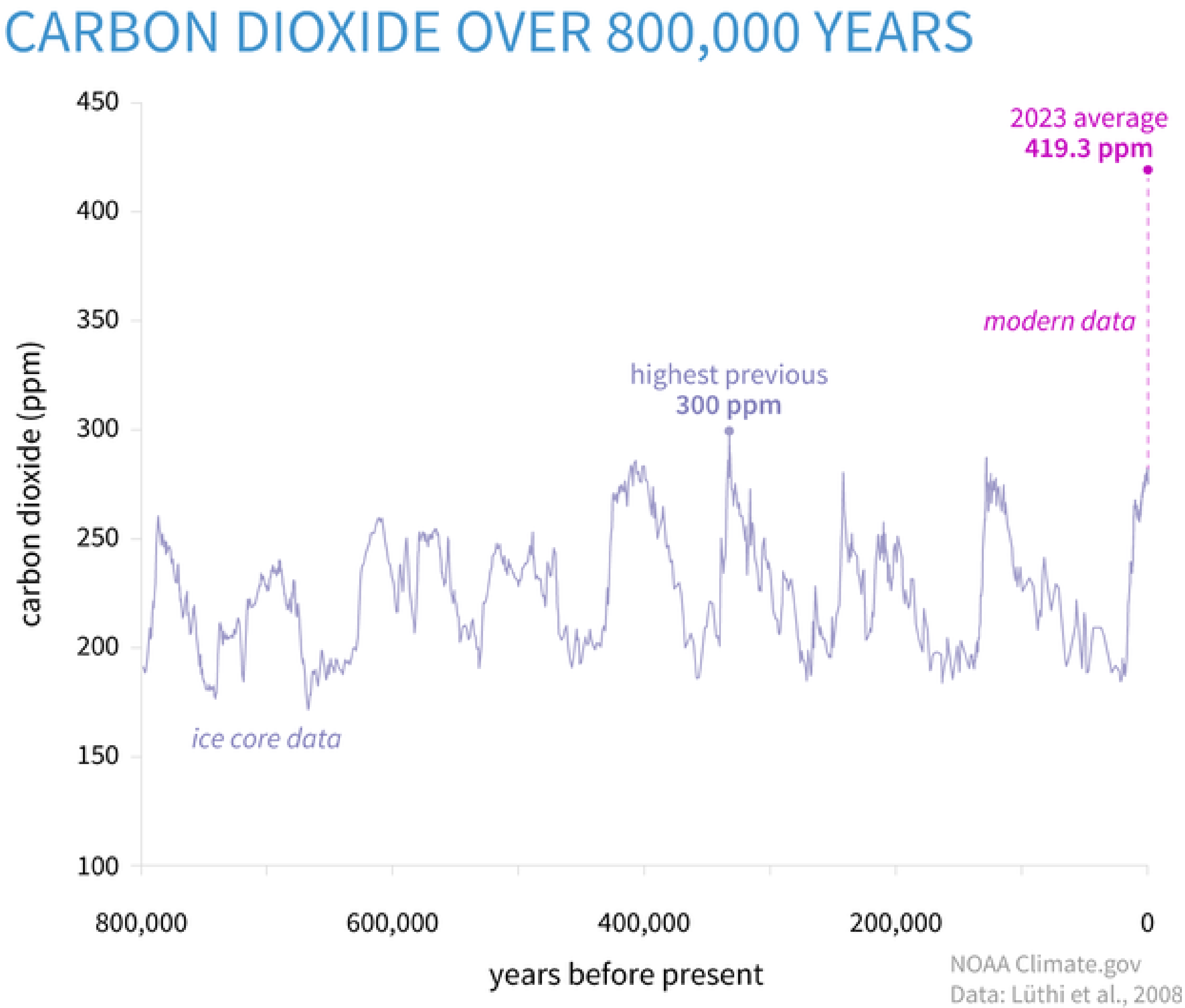
WEDNESDAY - LECTURES - ENV 220			Week	Teacher
19/2/2025	10h15-12h	The nature of ecology (introduction)	1	T. Battin
26/2/2025	10h15-12h	The physical environment	2	T. Battin
03.05.25	10h15-12h	Adaptations to the environment/Physiological ecology	3	C. Grossiord
03.12.25	10h15-12h	Population structure, dynamics, and regulation	4	C. Grossiord
19/3/25	10h15-12h	Community Ecology I	5	C. Bachofen
26/3/2026	10h15-12h	Community Ecology II	6	C. Grossiord
04.02.26	10h15-12h	Ecosystem ecology I	8	T. Battin
04.09.26	10h15-12h	Ecosystem ecology II	9	T. Battin
16/4/2026	10h15-12h	Biodiversity and conservation ecology	10	C. Grossiord
23/4/2025	Easter Holiday			
30/4/2025	ENAC Week			
05.07.24	10h15-12h	Climate Change impacts on terrestrial ecosystems	11	C. Grossiord
14/5/2024	10h15-12h	Climate Change impacts on aquatic ecosystems	12	T. Battin
21/5/2025	10h15-12h	Restoration ecology. Principles of ecosystem restoration, case studies	13	T. Battin
28/5/2025	10h15-12h	Applied ecology. Review and course wrap-up	14	C. Grossiord

Overview of today's class

1. How would basic knowldege in ecology benefit students in environmental engineers?

2. The nature of ecology
   - What is ecology?
   - How does ecological research work?

The carbon cycle and climate change



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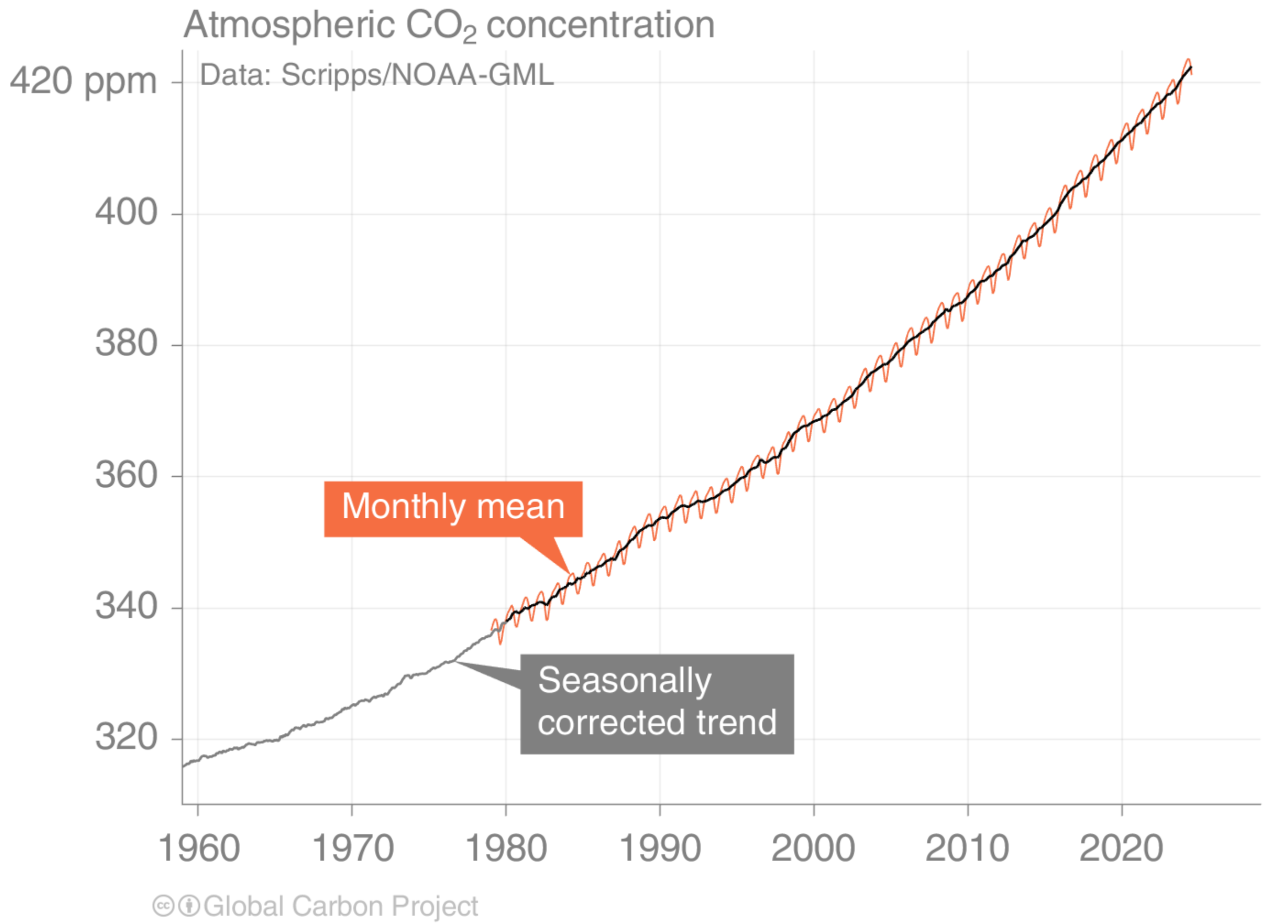
The carbon cycle and climate change

The global CO_2 concentration increased from ~277 ppm in 1750 to 422.5 ppm in 2024 (up 52%)

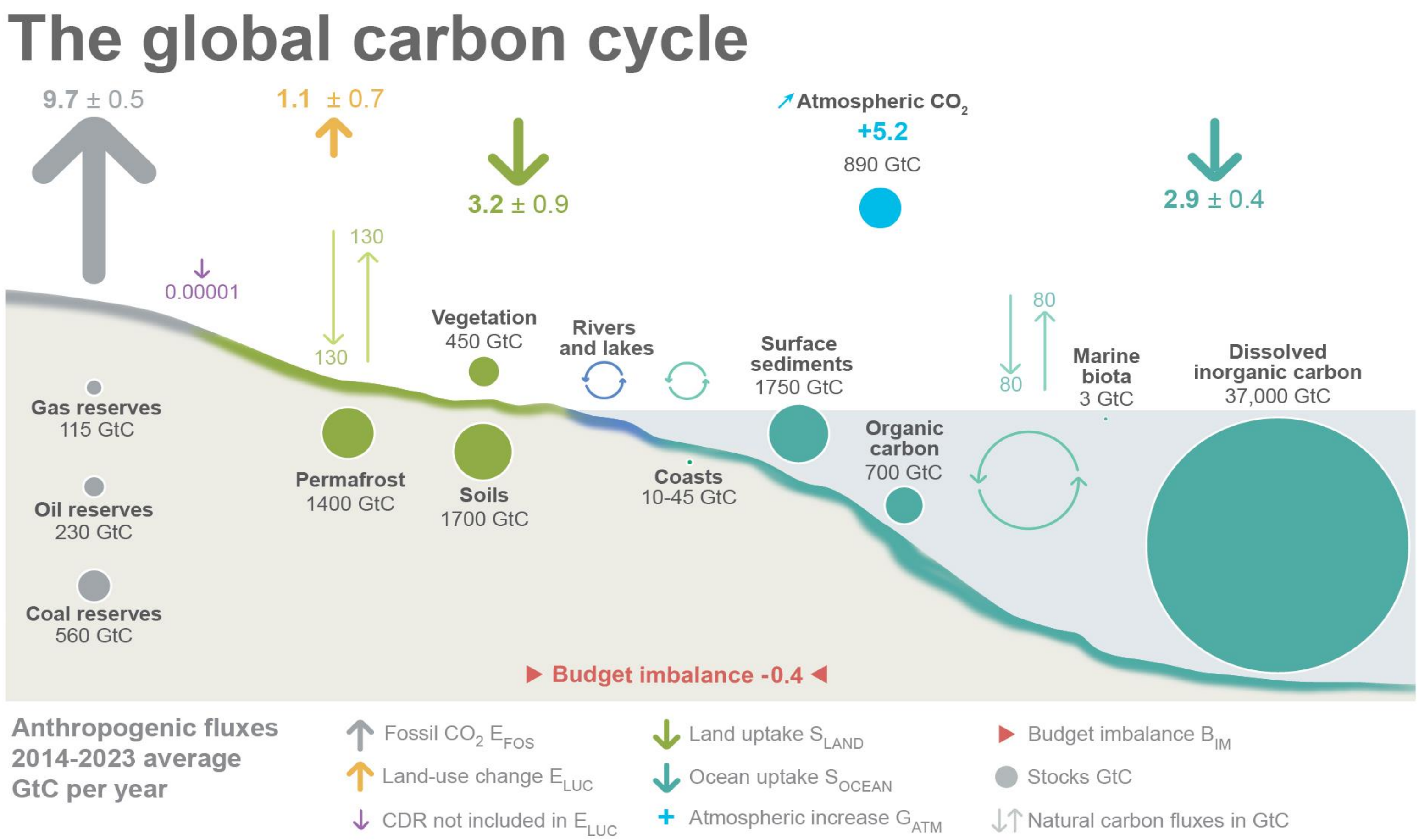


Globally averaged surface atmospheric CO_2 concentration. Data from: NOAA-GML after 1980; the Scripps Institution of Oceanography before 1980

Source: NOAA-GML; Scripps Institution of Oceanography; Friedlingstein et al 2024; Global Carbon Project 2024

The carbon cycle and climate change

Perturbation of the global carbon cycle caused by anthropogenic activities, global annual average for the decade 2014–2023 (GtC/yr)

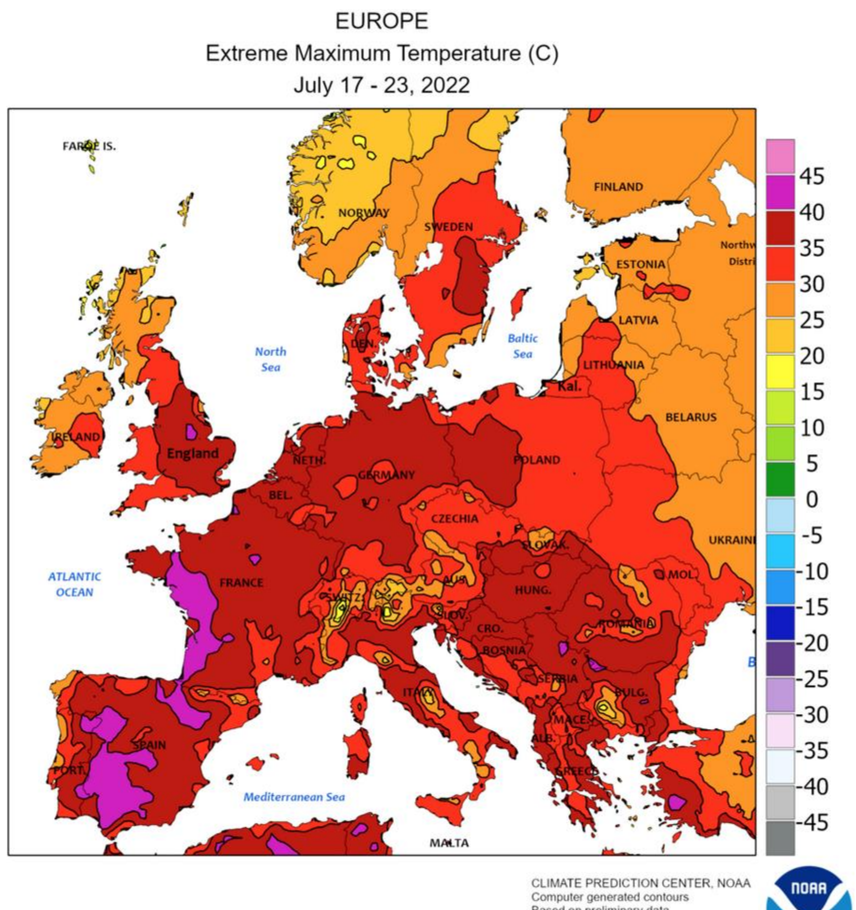


CDR here refers to Carbon Dioxide Removal besides those associated with land-use that are accounted for in the Land-use change estimate.
The budget imbalance is the difference between the estimated emissions and sinks.
Source: NOAA-GML; Friedlingstein et al 2024; Canadell et al 2021 (IPCC AR6 WG1 Chapter 5); Global Carbon Project 2024

Earth is on ‘fire’

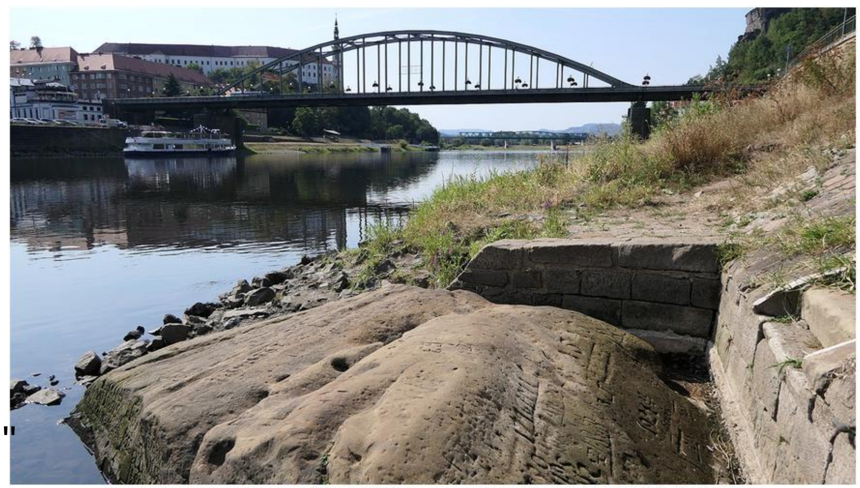
Extreme weather events

Heat waves, droughts, floods



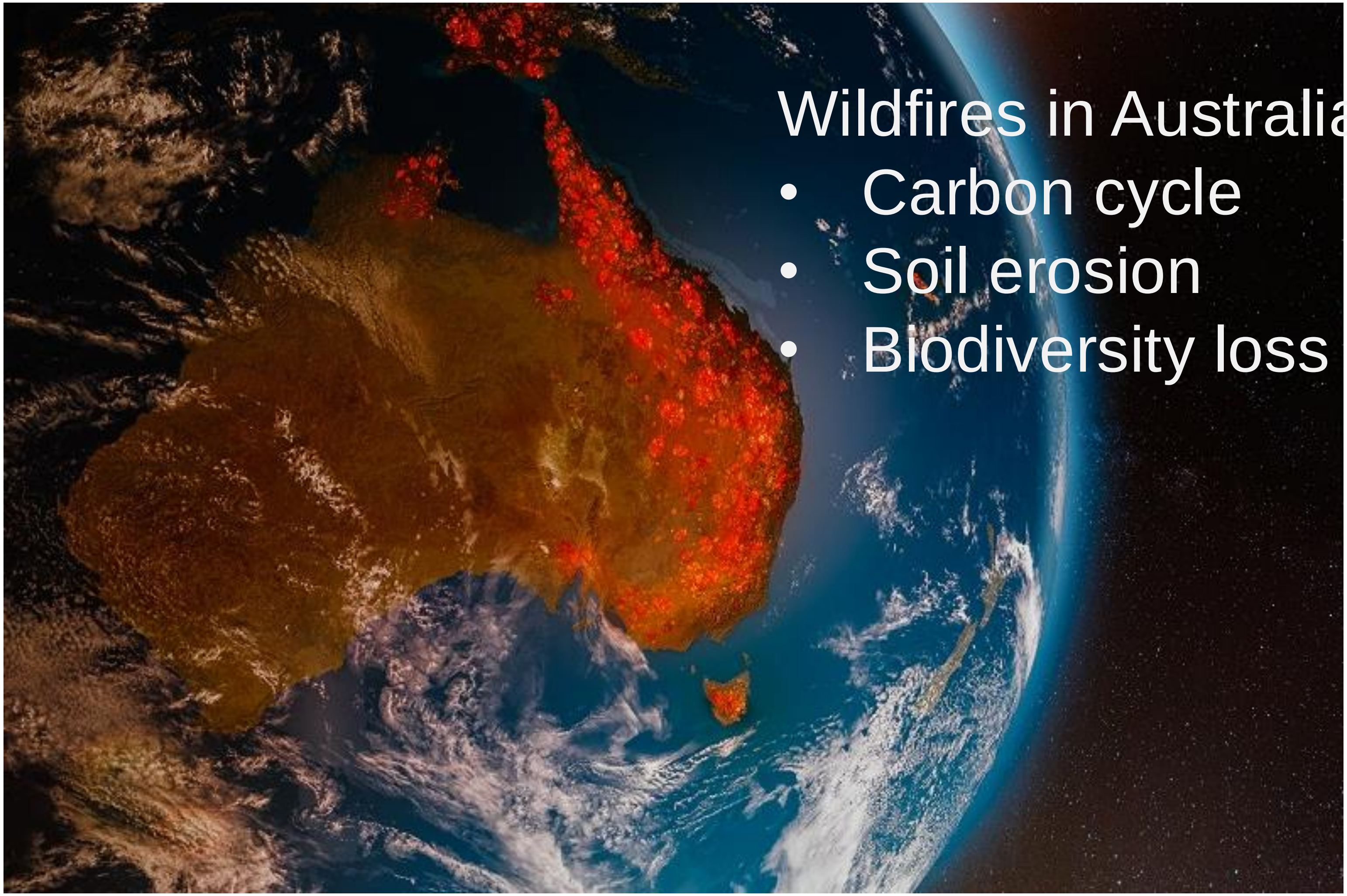
If you see me, then weep,"

"When this goes under, life will become more colorful again."



The drought is revealing "hunger stones" in Germany and the Czech Republic (Credit: Dr. Bernd Gross/CC-BY-SA-3.0/Wikipedia.org)

Earth is on fire



Wildfires in Australia

- Carbon cycle
- Soil erosion
- Biodiversity loss

Biodiversity loss

Swiss significantly underestimate scale of biodiversity crisis in Switzerland

27/05/2022 BY LE NEWS

Switzerland has the highest proportion of threatened species in the OECD, according to Pronatura. However, a clear majority of the population thinks the situation is fine, according to a survey.

A hoopoe bird at risk of extinction © Biosphoto, Dominique Delfino

EPFL

Biodiversity loss

THE CONVERSATION

Academic rigour, journalistic flair

Search analysis, research, academics...

COVID-19 Arts + Culture Business + Economy Cities Education Environment + Energy Health + Medicine Politics + Society Science + Technology

Covid-19 or the pandemic of mistreated biodiversity

April 29, 2020 6.03pm BST

The pangolin, one of the most poached animals in the world, could have served as an intermediate host in the transmission of SARS-CoV-2 to humans. Wahyudi/AFP

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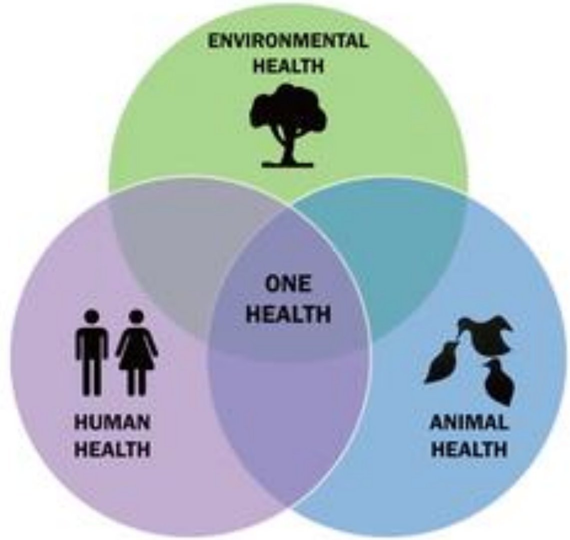
Disclosure statement

The authors do not work for, consult, own shares in or receive funding from any company or organisation that would benefit from this article, and have disclosed no relevant affiliations beyond their academic appointment.

Partners



The 'One Health' initiative seeks to promote optimal health for people, animals and the environment. Wikipedia

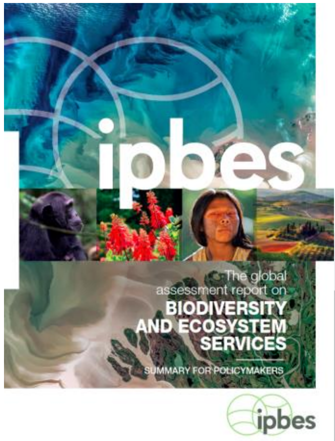
OECD TACKLING CORONAVIRUS (COVID-19) CONTRIBUTING TO A GLOBAL EFFORT

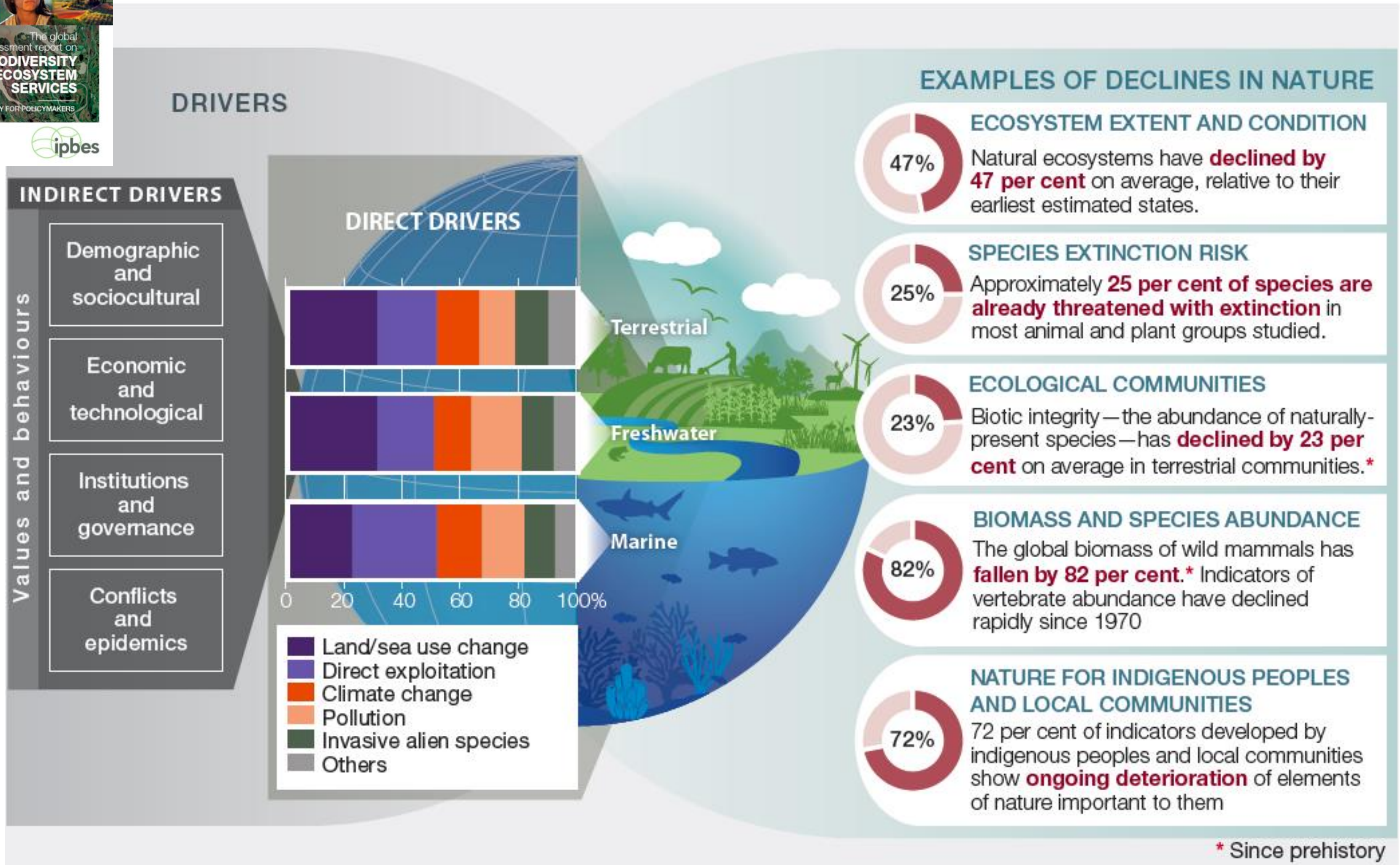
OECD Policy Responses to Coronavirus (COVID-19)

Biodiversity and the economic response to COVID-19: Ensuring a green and resilient recovery

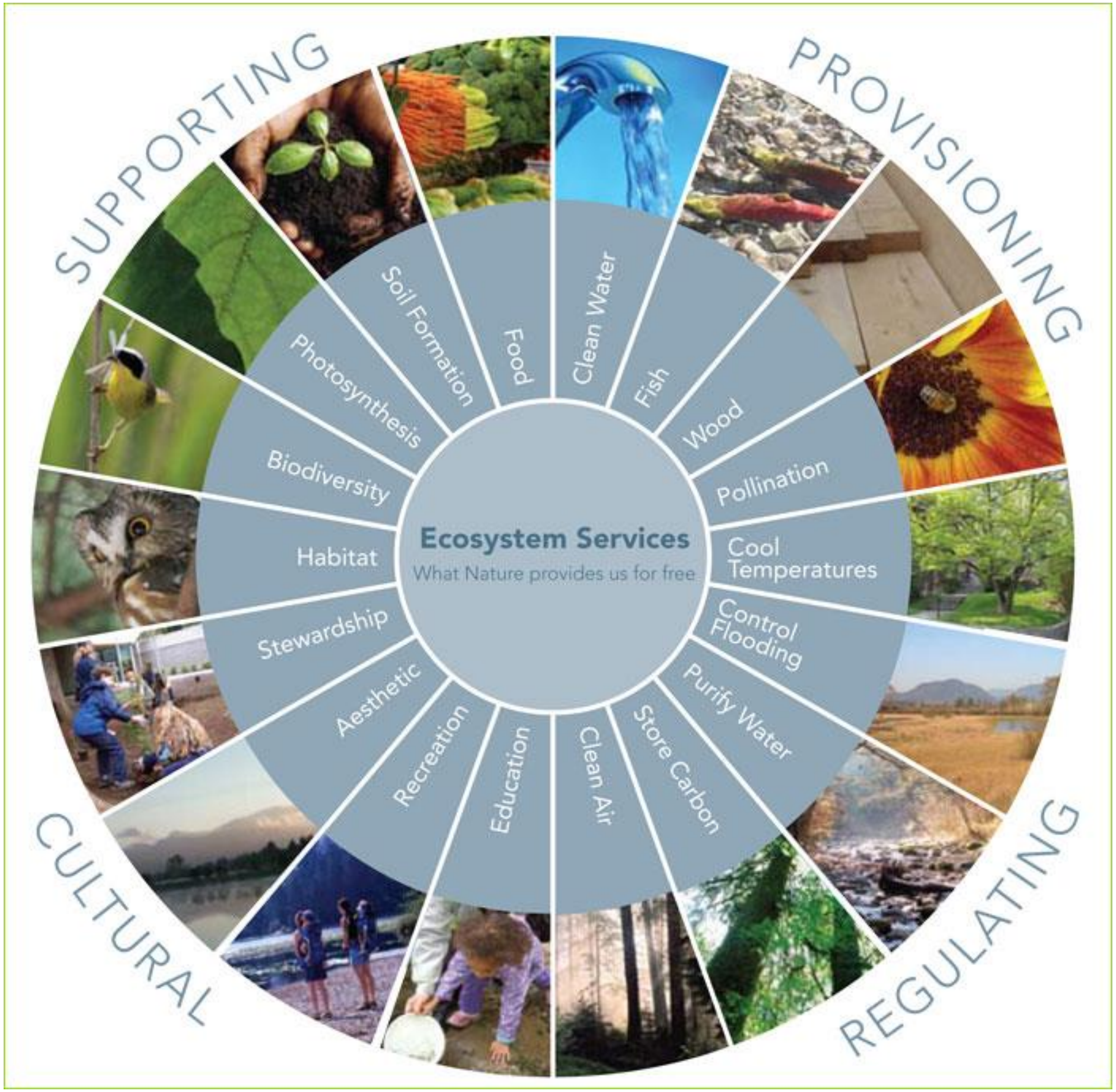
28 September 2020

Deterioration of ecosystems

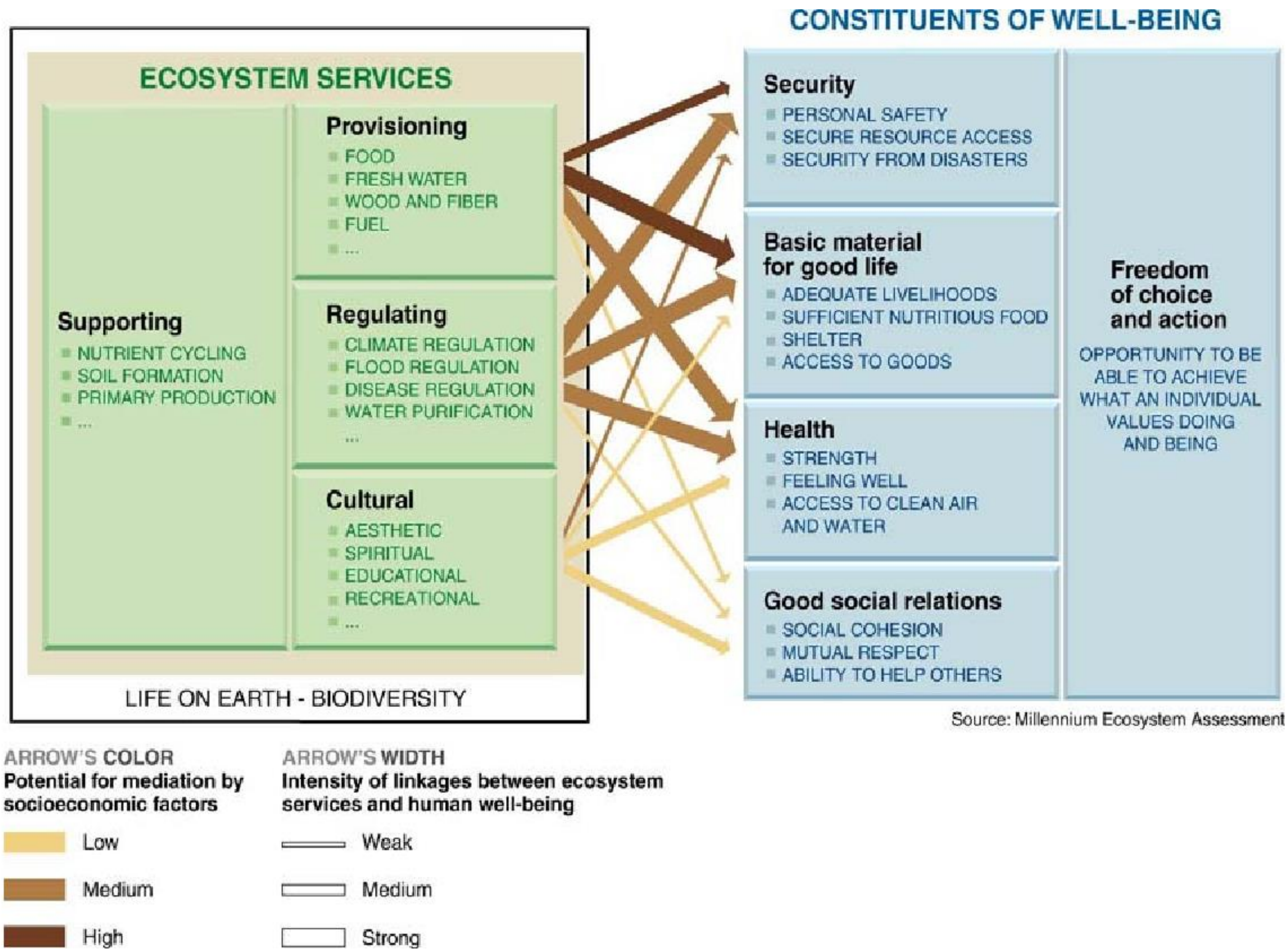




Ecosystem services

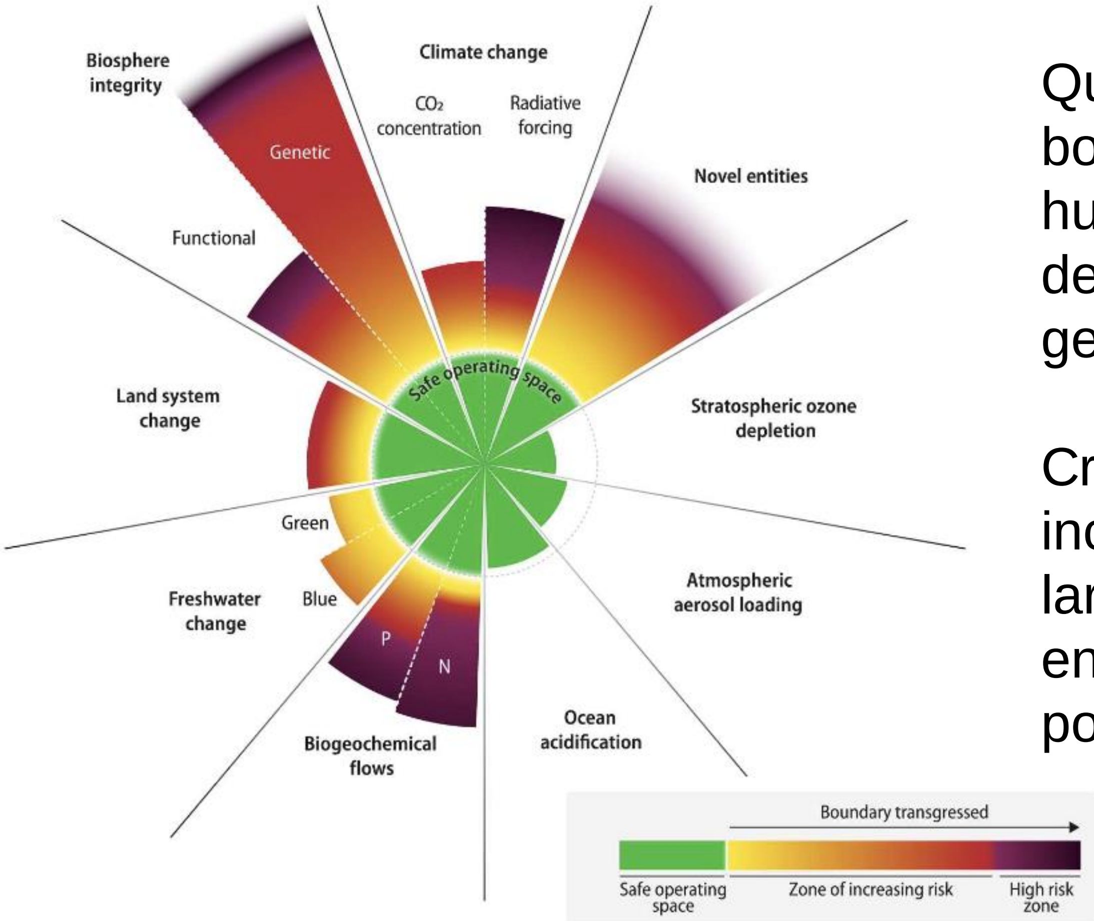


Ecosystem services and wellbeing



Source: Millennium Ecosystem Assessment

Planetary boundaries



Quantitative planetary boundaries within which humanity can continue to develop and thrive for generations to come.

Crossing these boundaries increases the risk of generating large-scale abrupt or irreversible environmental changes –tipping points.

Fig. 1. Current status of control variables for all nine planetary boundaries. Six of the nine boundaries are transgressed. In addition, ocean acidification is approaching its planetary boundary. The green zone is the safe operating space (below the boundary). Yellow to red represents the zone of increasing risk. Purple indicates the high-risk zone where interglacial Earth system conditions are transgressed with high confidence. Values for control variables are normalized so that the origin represents mean Holocene conditions and the planetary boundary (lower end of zone of increasing risk, dotted circle) lies at the same radius for all boundaries (except for the wedges representing green and blue water, see main text). Wedge lengths are scaled logarithmically. The upper edges of the wedges for the novel entities and the genetic diversity component of the biosphere integrity boundaries are blurred either because the upper end of the zone of increasing risk has not yet been quantitatively defined (novel entities) or because the current value is known only with great uncertainty (loss of genetic diversity). Both, however, are well outside of the safe operating space. Transgression of these boundaries reflects unprecedented human disruption of Earth system but is associated with large scientific uncertainties.

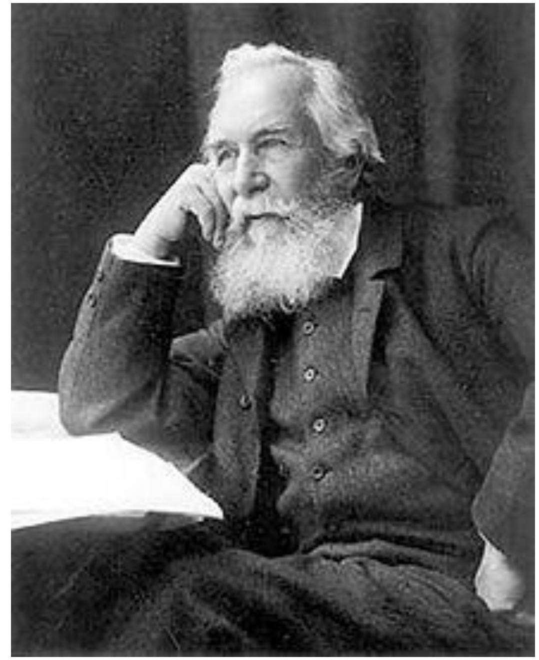
https://www.science.org/doi/epdf/10.1126/sciadv.adh2458

EPFL

A brief history of ecology

Ernst Haeckel 1866

By ecology we mean the body of knowledge concerning the economy of nature—the investigation of the total relations of the animal both to its inorganic and to its organic environment; including above all, its friendly and inimical relations with those animals and plants with which it comes directly or indirectly into contact—in a word, ecology is the study of all those complex interrelations referred to by Darwin as the conditions of the struggle for existence. (translation by Allee, 1949)



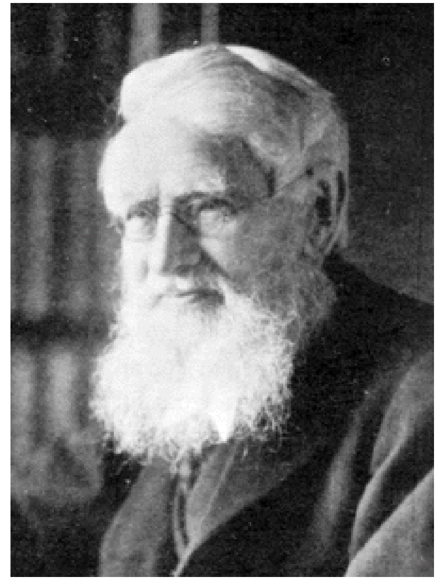
Ecology: οἶκος, "house", or "environment"; -λογία, "study of"

A brief history of ecology

Zoologists, biologists, geographers, anthropologists, naturalists, explorers

Karl Möbius
(1825-1908)

Alexander von Humboldt
(1769-1859)



Alfred R. Wallace
(1823-1913)

Biocenoses: Specific communities composed of different species and occupying a defined space

- Biogeography of animals and plants
- Species are not randomly distributed in space

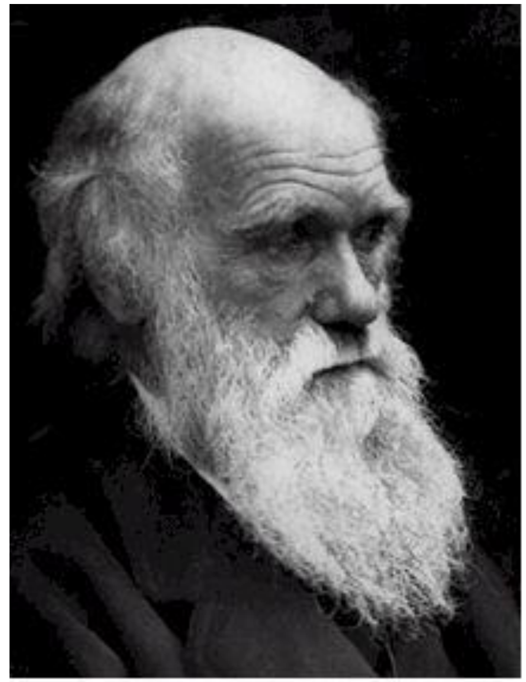
A brief history of ecology

Ecology includes evolutionary aspects

Individuals within a given population show differences

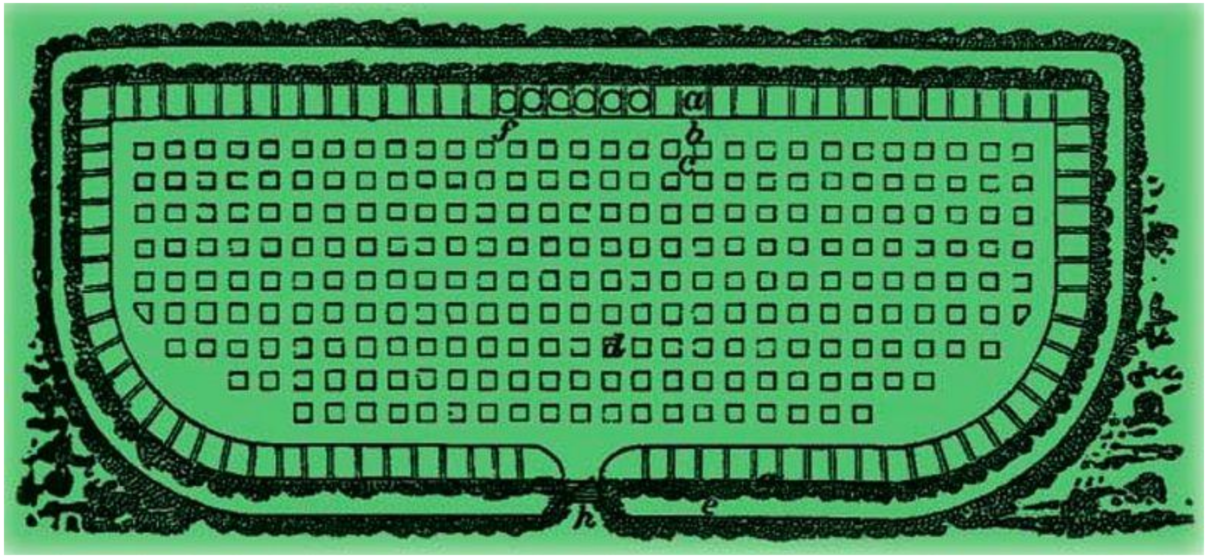
Competition among and between species (populations)

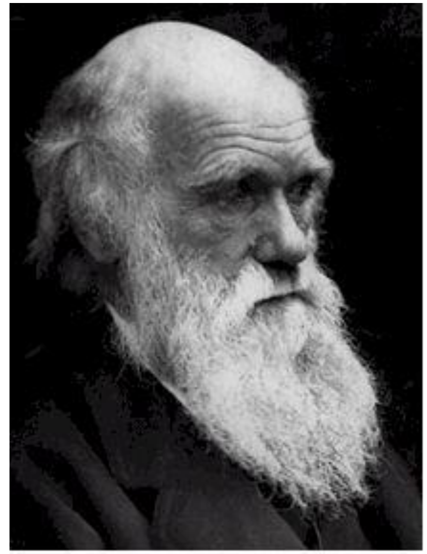
Interactions between individuals and their environment affect their reproductive success (fitness)



Charles Darwin
(1809-1882)

A brief history of ecology





Hortus Gramineus

First large-scale experiment in ecology:

- Relationships between biodiversity and biomass
- See monoculture *versus* polyculture

A brief history of ecology

First systemic approaches

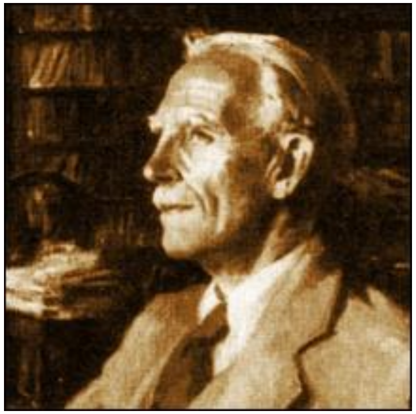
Biosphere and biogeochemistry

Vladimir Vernadsky
(1863-1945)

Lithosphere
Hydrosphere
Biosphere

Eduard Süss
(1831-1914)

A brief history of ecology

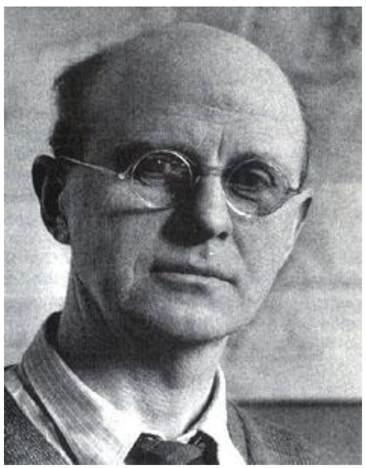


Arthur G. Tansley
(1871 - 1955)

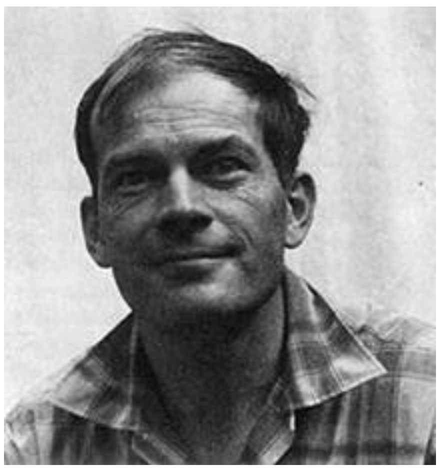
Eugene Odum
(1913-2002)

Ecosystems
Interactions between communities and the environment

Ecosystem ecology
Energy and matter fluxes



Charles Elton
(1900-1991)



Robert MacArthur
(1930-1972)

Food web ecology

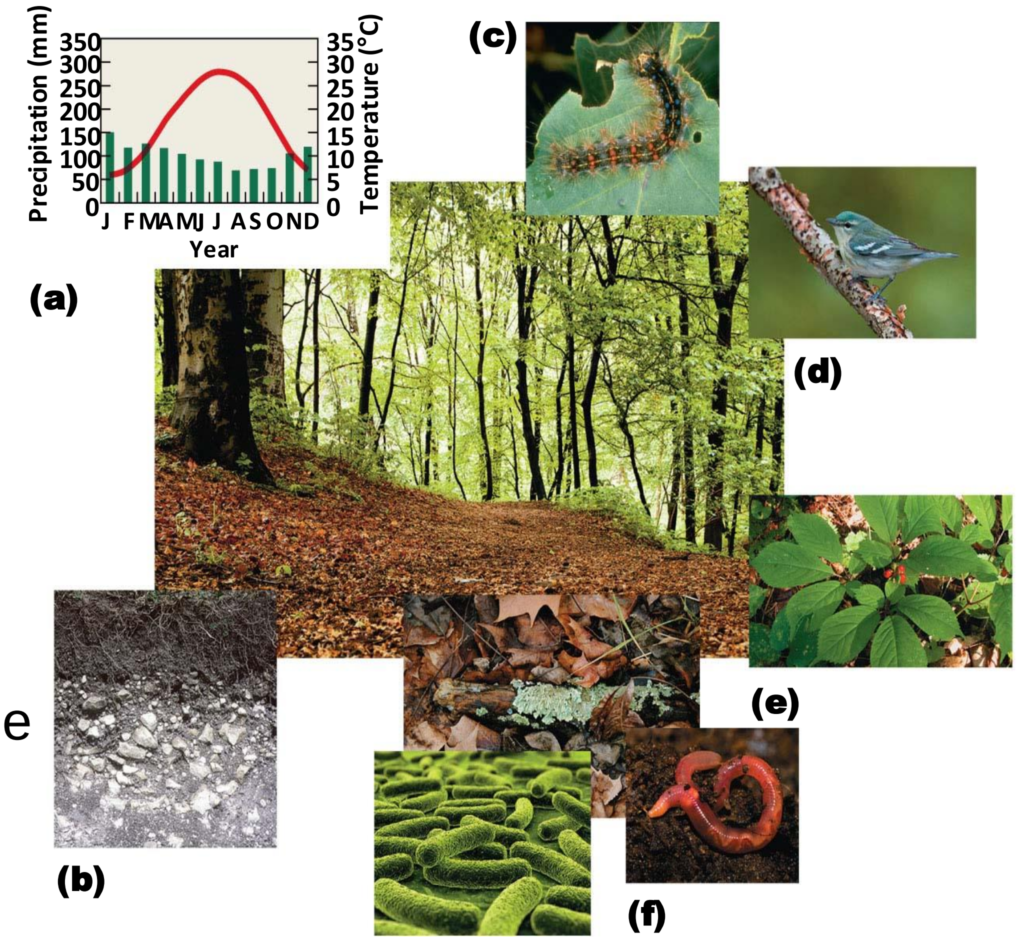
Biogeography

The various facets of ecology

Population ecology
Community ecology
Ecosystem ecology

- Relationships between organisms and their environment
- Interactions between organisms
- Fluxes of energy and nutrients integrate these biotic and abiotic relationships
- Relationship between biodiversity and ecosystem functioning (see Darwin's plot experiments)

Relationships between organisms and their environment



Organisms interact with their environment at many levels

Biotic interactions include predation, competition, parasitism, mutualism etc.

What are key physical and chemical conditions in the environment?

- Physical and chemical conditions include temperature, humidity, concentration of gases, light availability etc.

The numerous organizational levels of ecology

Individual

What characteristics allow the *Echinacea* to survive, grow, and reproduce in the environment of the prairie grasslands of central North America?

Population

Is the population of this species increasing, decreasing, or remaining relatively constant from year to year?

Community

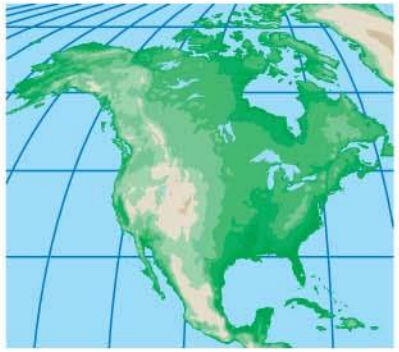
How does this species interact with other species of plants and animals in the prairie community?

Ecosystem

How do yearly variations in rainfall influence the productivity of plants in this prairie grassland ecosystem?

Landscape

How do variations in topography and soils across the landscape influence patterns of species composition and diversity in the different prairie communities?



Biome

What features of geology and regional climate determine the transition from forest to prairie grassland ecosystems in North America?

Biosphere

What is the role of the grassland biome in the global carbon cycle?

The numerous organizational levels of ecology

At each level in the ecosystem hierarchy, different patterns and processes emerge

- Individual – birth and death are discrete events and happen only once
- Population – birth and death are continuous and measured as rates, such as number of births per year
- Community – focus shifts to relative abundance of species (that is, populations) within the community

The numerous organizational levels of ecology

<u>Ecosystem:</u>

Emphasis shifts from populations and communities to the flows of energy and nutrients through both biotic and abiotic components.

Includes questions such as:

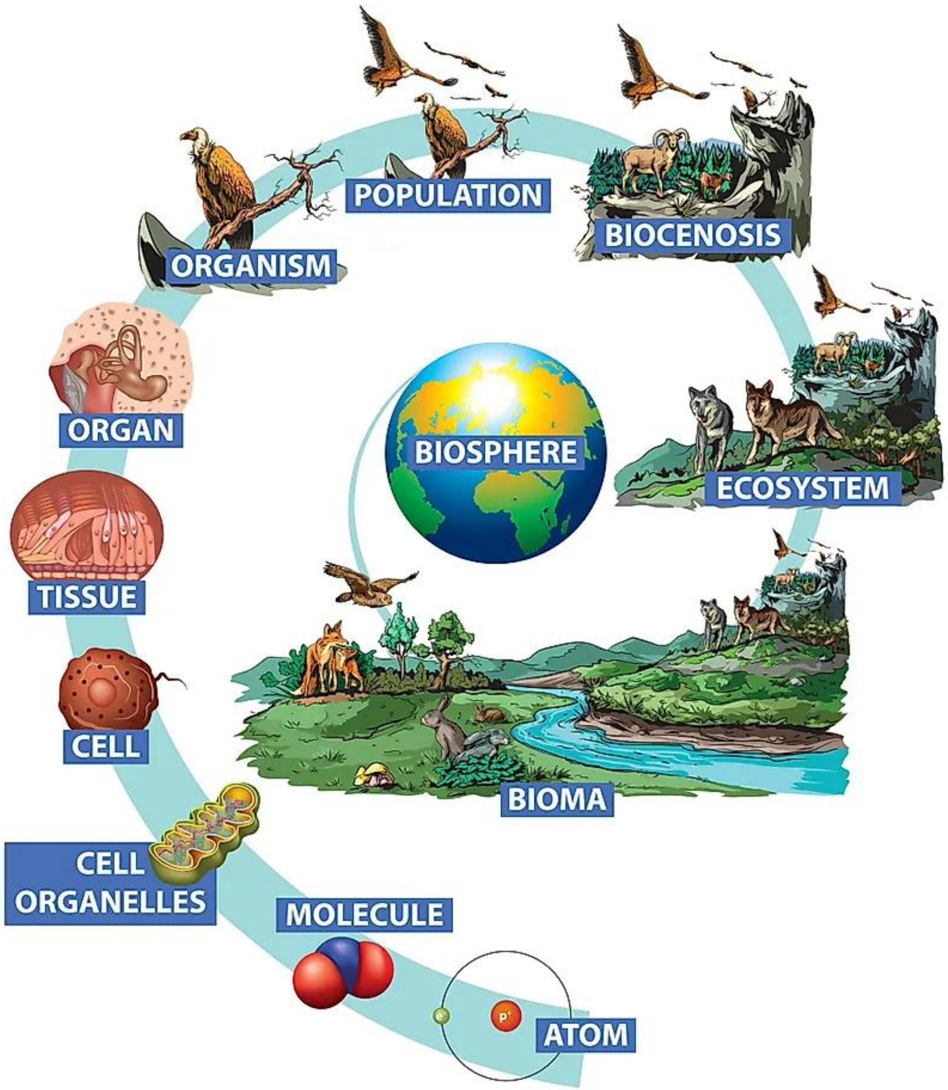
- At what rate are energy and nutrients converted into biomass, including new individuals?
- At what rate are energy and nutrients in organisms broken down, including decomposition after death?

The numerous organizational levels of ecology

<u>Landscape:</u> A patchwork of ecosystems in which spatial patterns are important
- How are energy, nutrients and biodiversity exchanged between ecosystems?
- See fragmentation of landscapes

<u>Global scale:</u> Focus on the distribution of different types of ecosystems or biomes
- How do patterns of biological diversity vary in different biomes?

The numerous organizational levels of ecology

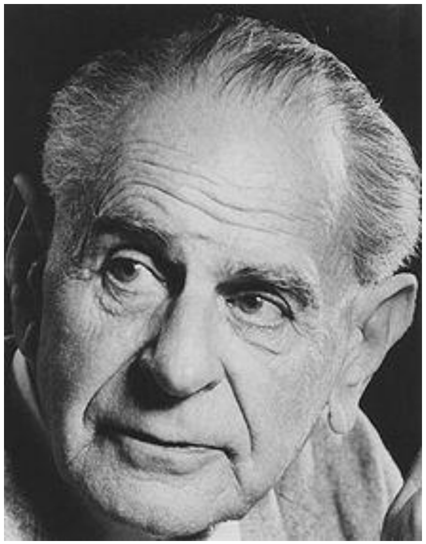


Biosphere: Emphasis on the linkages between ecosystems and other components of Earth, such as the atmosphere, hydrosphere, lithosphere etc.

- How are nutrients and carbon exchanged between the atmosphere, terrestrial and aquatic ecosystems?
- What drives the stability of the biosphere?
- How does the biosphere interact with the climate?

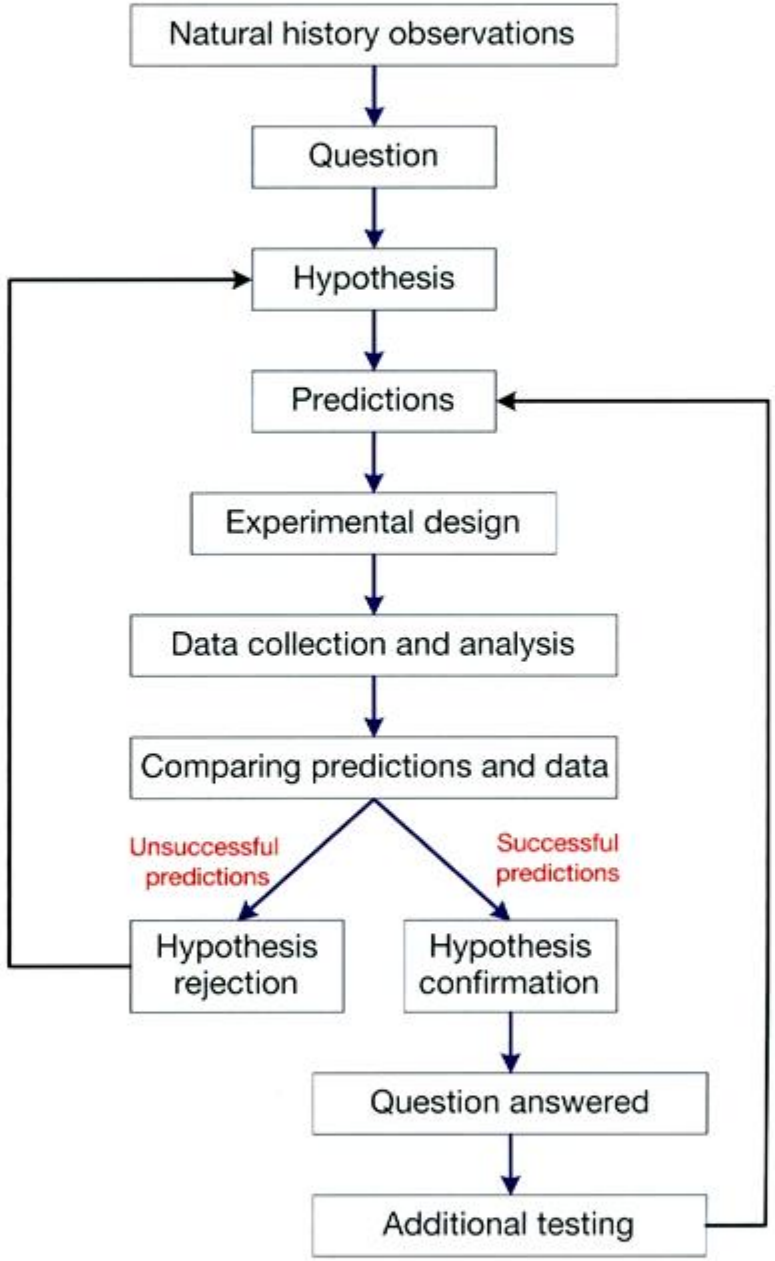
The scientific approach in ecology

Ecology is a relatively young science, still largely conceptual with a relatively poor theoretical basis



Karl Popper

Falsification or verification of an hypothesis leading to a therory (or not)



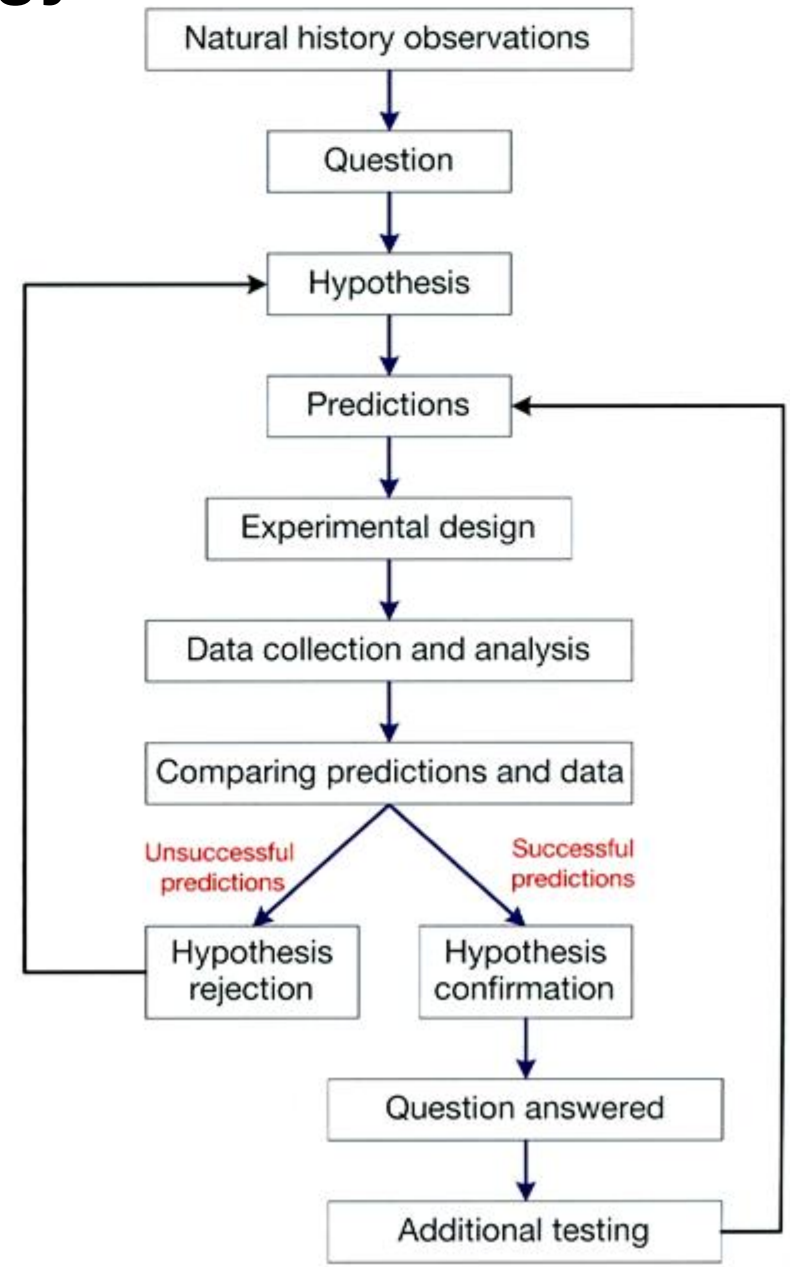
The scientific approach in ecology

The scientific method is a process that begins with an observation, which leads to a question.

Hypothesis: an educated guess about what the answer to the question might be.

Development of a hypothesis is guided by knowledge of the study system.

This is a statement of cause and effect that can be tested



The scientific approach in ecology

Observation: in a North American prairie grassland, the rate at which plant biomass is produced is not random — it varies across the landscape (measured as grams per meter squared (m^2) per year)

Question: What environmental factors drive the observed variation in grassland productivity across the landscape?

The scientific approach in ecology

Hypothesis: The observed variations in the growth and productivity of grasses across the prairie landscape are a result of differences in the availability of soil nitrogen.

Testing: If soil nitrogen is the limiting factor, grass productivity should be greater in areas with higher levels of soil nitrogen than in areas with lower levels.

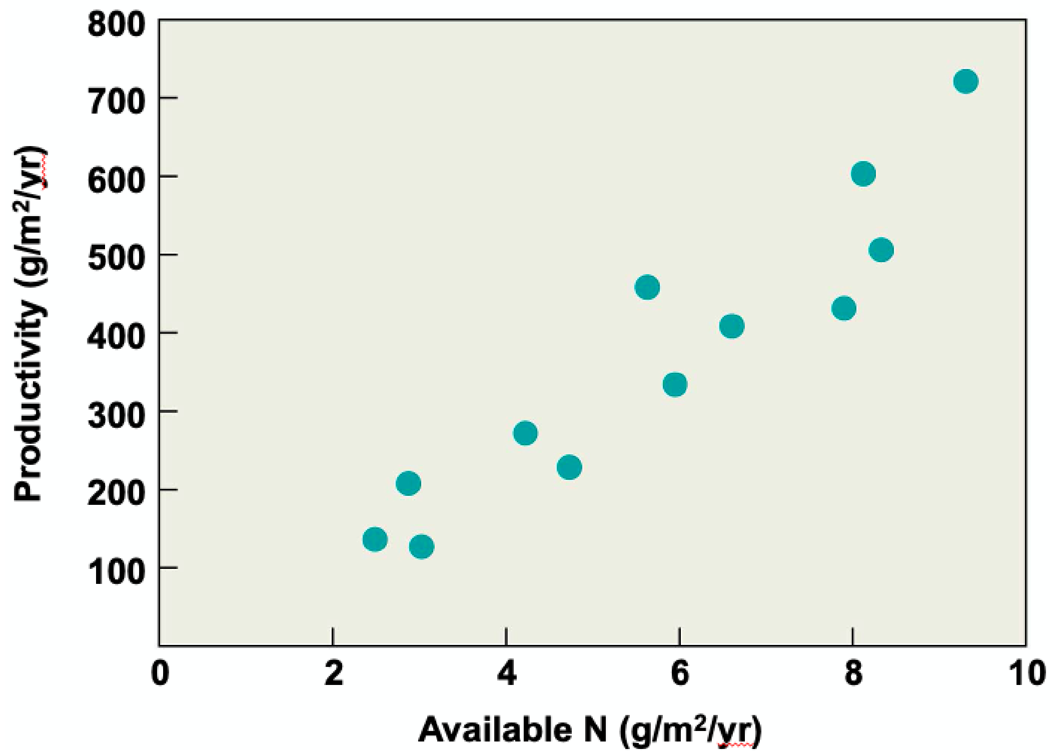
This requires collecting and analyzing data

The scientific approach in ecology

Data to test a hypothesis can be collected in many different ways.

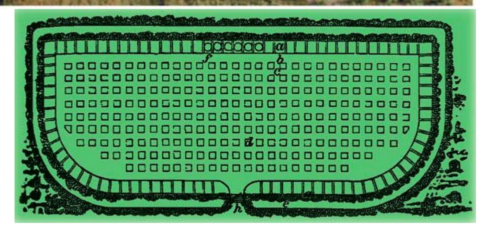
Field study: take samples from different sites in the landscape, then compare nitrogen availability and grass productivity

Productivity increases as available nitrogen increases



The scientific approach in ecology

A field experiment allows the investigator to manipulate one condition in a field setting



Take a single large field, subdivide it into plots and add nitrogen to some plots and not others controlling the independent variable.

Measure plant growth on all of the plots – the dependent variable.

Experimental site must vary minimally in other factors, such as moisture and acidity

The scientific approach in ecology

However, these data do not prove that nitrogen is the only factor influencing plant productivity. Other factors, such as soil moisture or acidity could be responsible for the observed relationship.

What is another way to examine the relationship between grass productivity and available nitrogen?

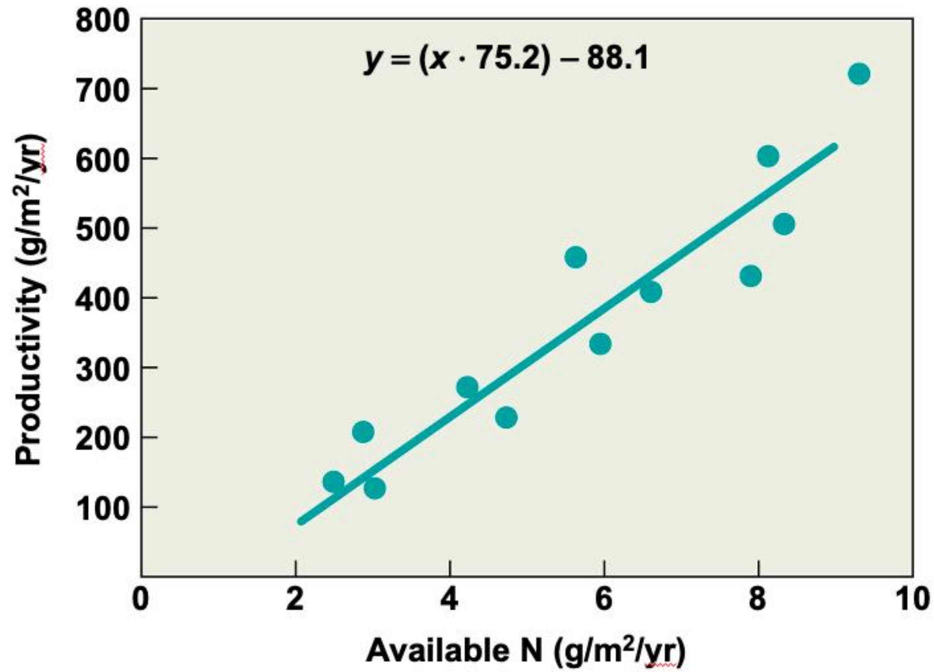
An experiment is a test of the hypothesis under controlled conditions. Unlike the field study, one factor can be examined at a time.

A laboratory experiment allows the investigator greater control over the experimental conditions

The scientific approach in ecology

Models provide a basis for predictions

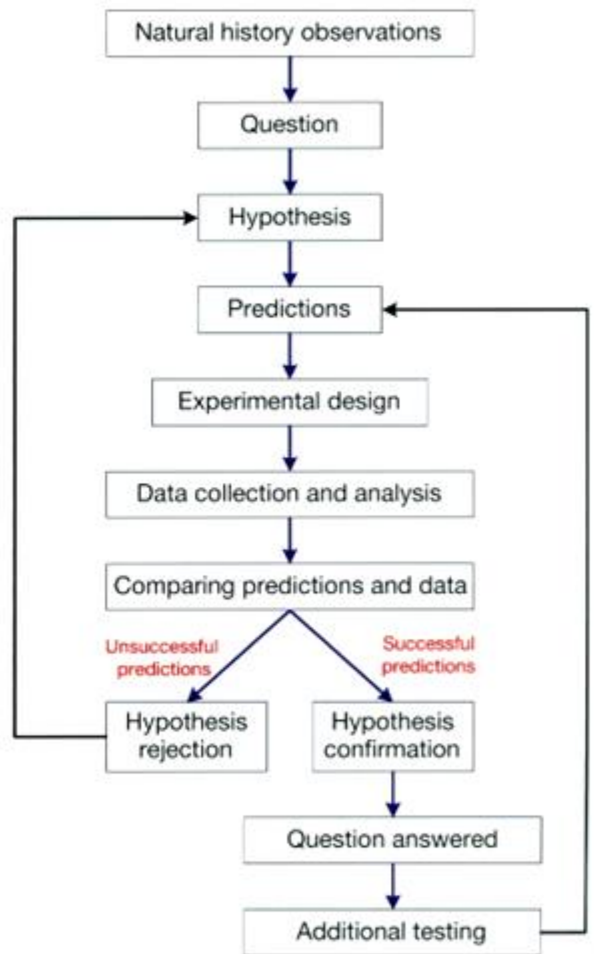
- A model is an abstract, simplified representation of a real system
- Developed from results of observations and experiments
- Qualitative model – grass productivity will increase with increasing nitrogen availability
- Quantitative model – plot data from the field study, then develop a regression equation (statistical model) to predict the amount of grass productivity that will be present per unit of nitrogen in the soil



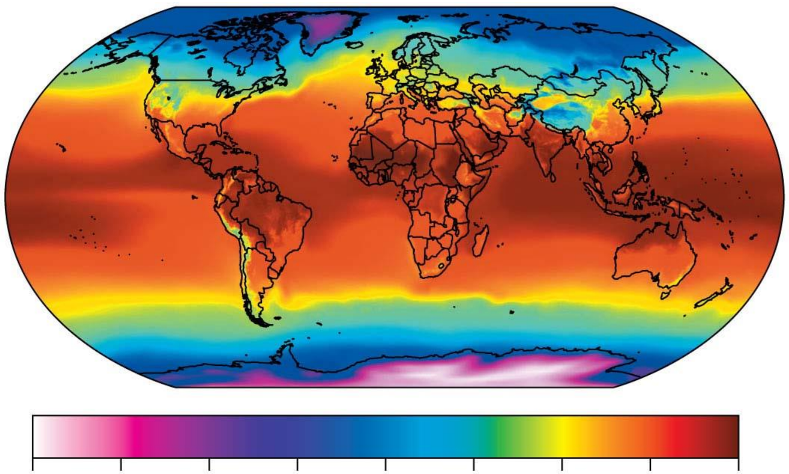
The scientific approach in ecology

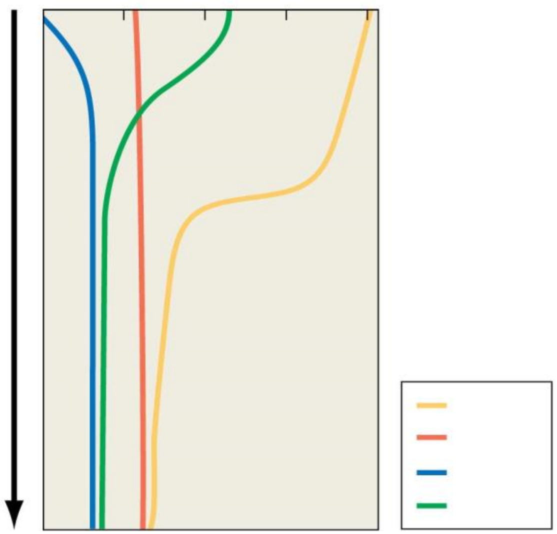
Uncertainty is an inherent feature of ecological science

- The scientific method is a continuous process of testing and correcting explanations to refine our understanding of natural systems.
- Simplify the system being studied in order to establish cause and effect. As a result, only part of the picture is seen.
- Science is a search for evidence that proves our concepts wrong. There is often more than one possible explanation for an observation. Therefore, develop multiple hypotheses and test each one to eliminate those that are not correct.
- Debate is an essential part of the scientific process



Next class
The Physical Environment





- Climate
- Largey-scale patterns of temperature and precipitation

- Aquatic and terrestrial ecosystems
- Commonalities and differences