Laurea in Ingegneria per l'Ambiente ed il Territorio

CAMBIAMENTI CLIMATICI E ADATTAMENTI NEGLI ECOSISTEMI E NELLE SOCIETÀ

Docenti

Salvatore Pappalardo
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Supporto didattico
Edoardo Crescini

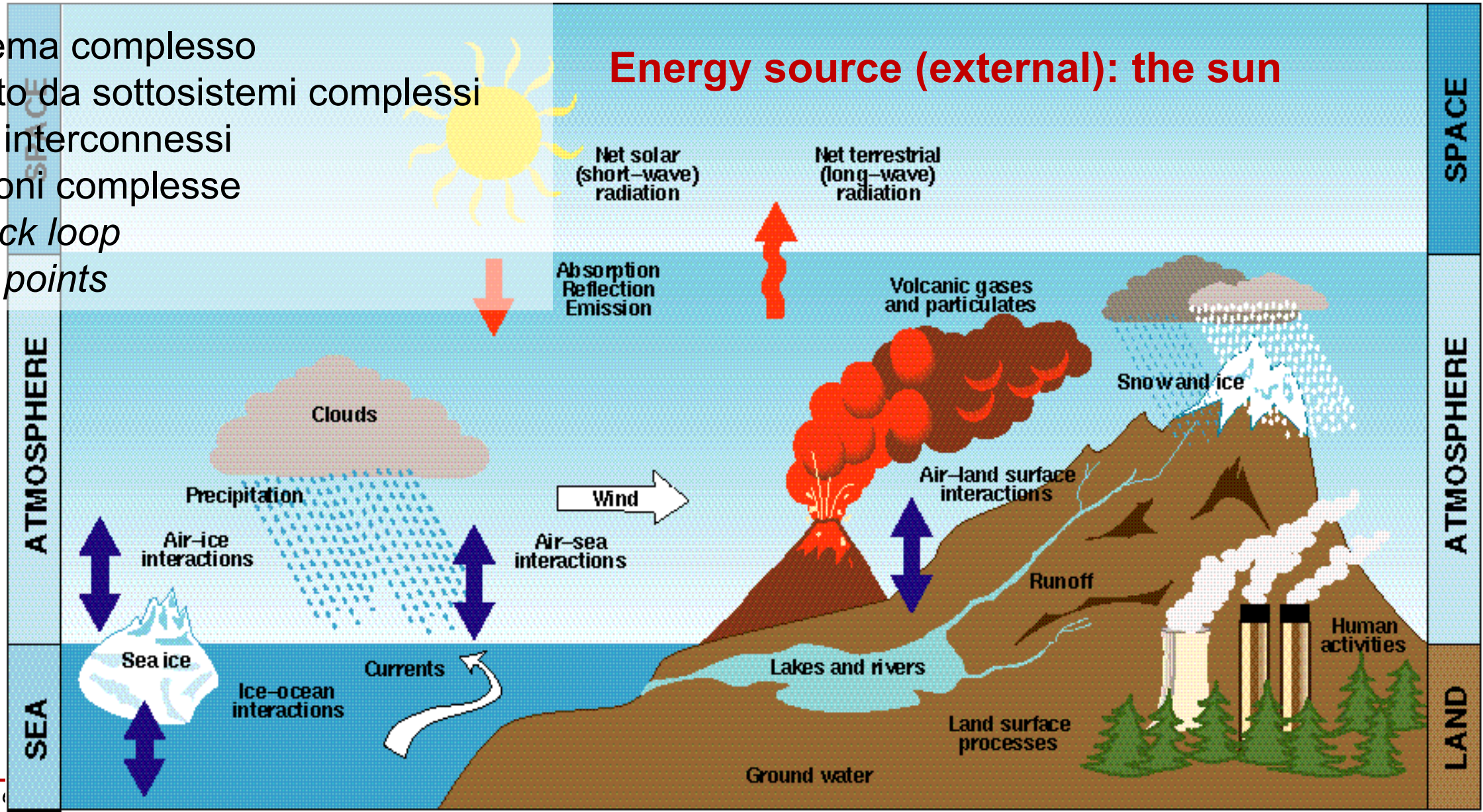
- 6 CFU
- 48 ore
- 102 ore di studio individuale

Outline

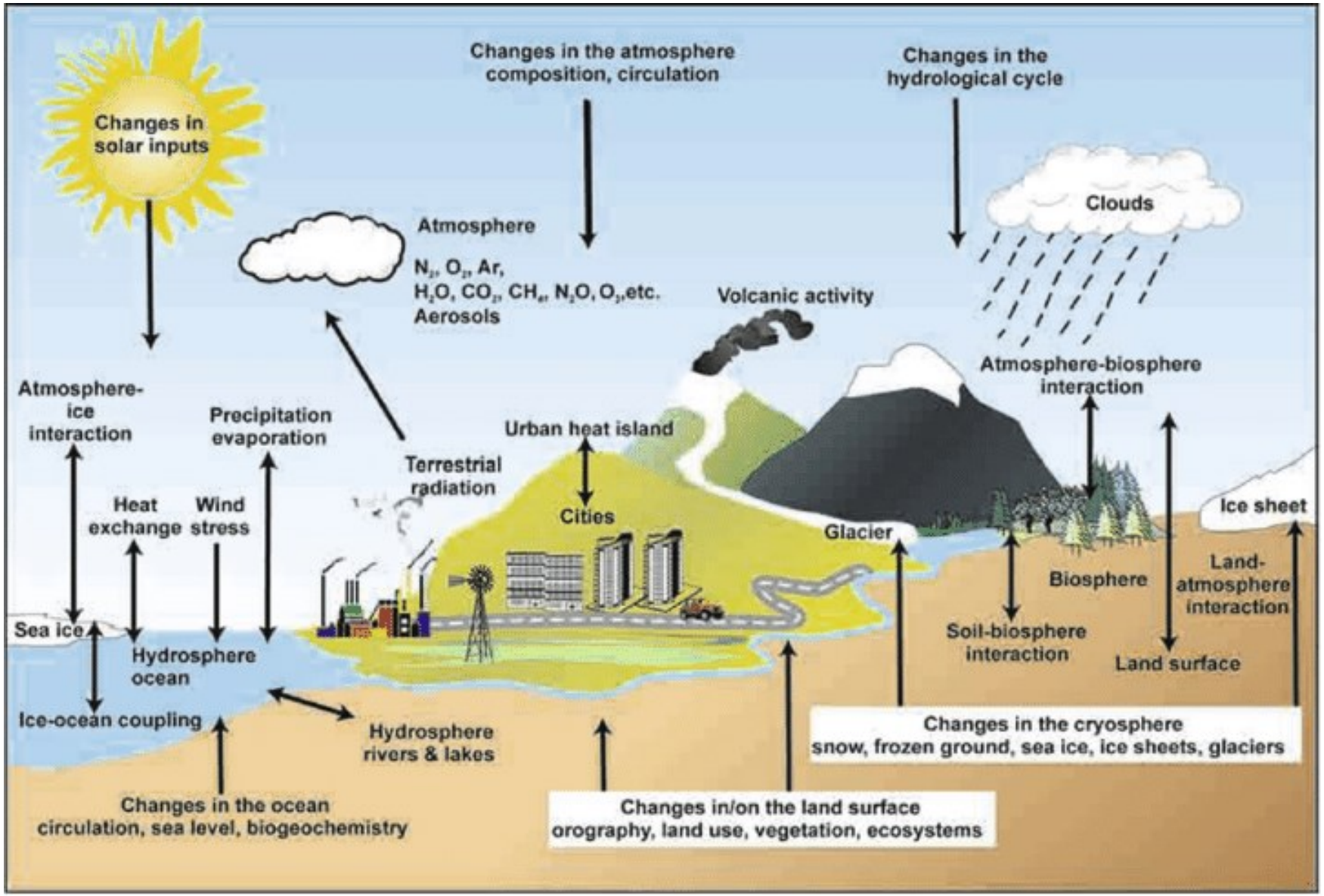
- Sistema climatico
- Interazioni tra clima ed ecosistemi
- Biomi e clima
- Classificazione dei climi

Il clima:

- Un sistema complesso
- Costituito da sottosistemi complessi
- Sistemi interconnessi
- Interazioni complesse
- *Feedback loop*
- *Tipping points*



Sistema climatico



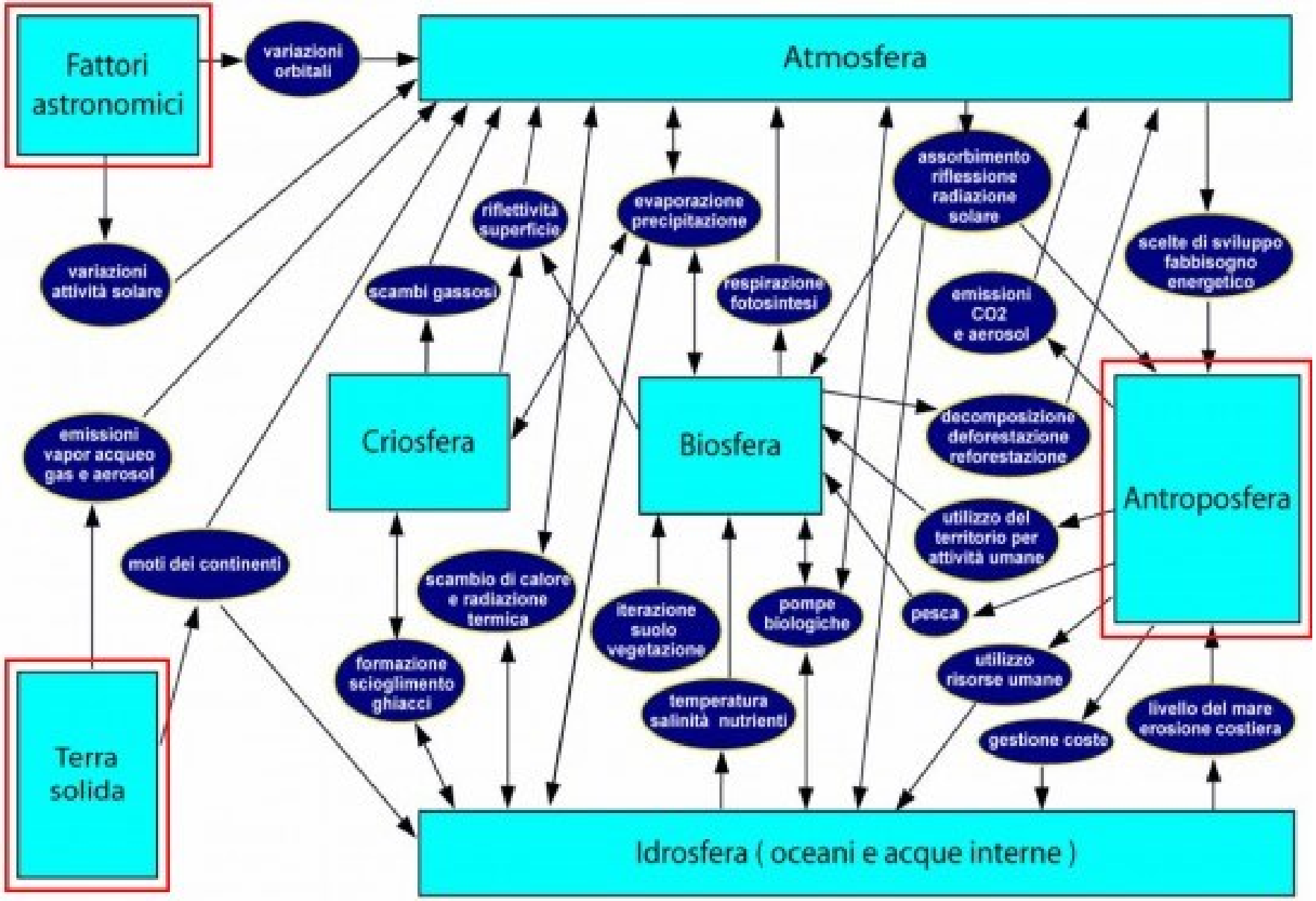
- **Atmosfera**
(involucro gassoso; molto veloce)

- **Idrosfera**
(Oceani, mari, laghi, fiumi)
(veloce/lento)

- **Criosfera**
(Neve, ghiacciai e ghiaccio terrestre e marino)
(veloce/lento)

- **Biosfera**
(Mondo animale e vegetale)
(veloce/lento)

- **Litosfera**
(Terra solida)(molto lento)



SISTEMA CLIMATICO

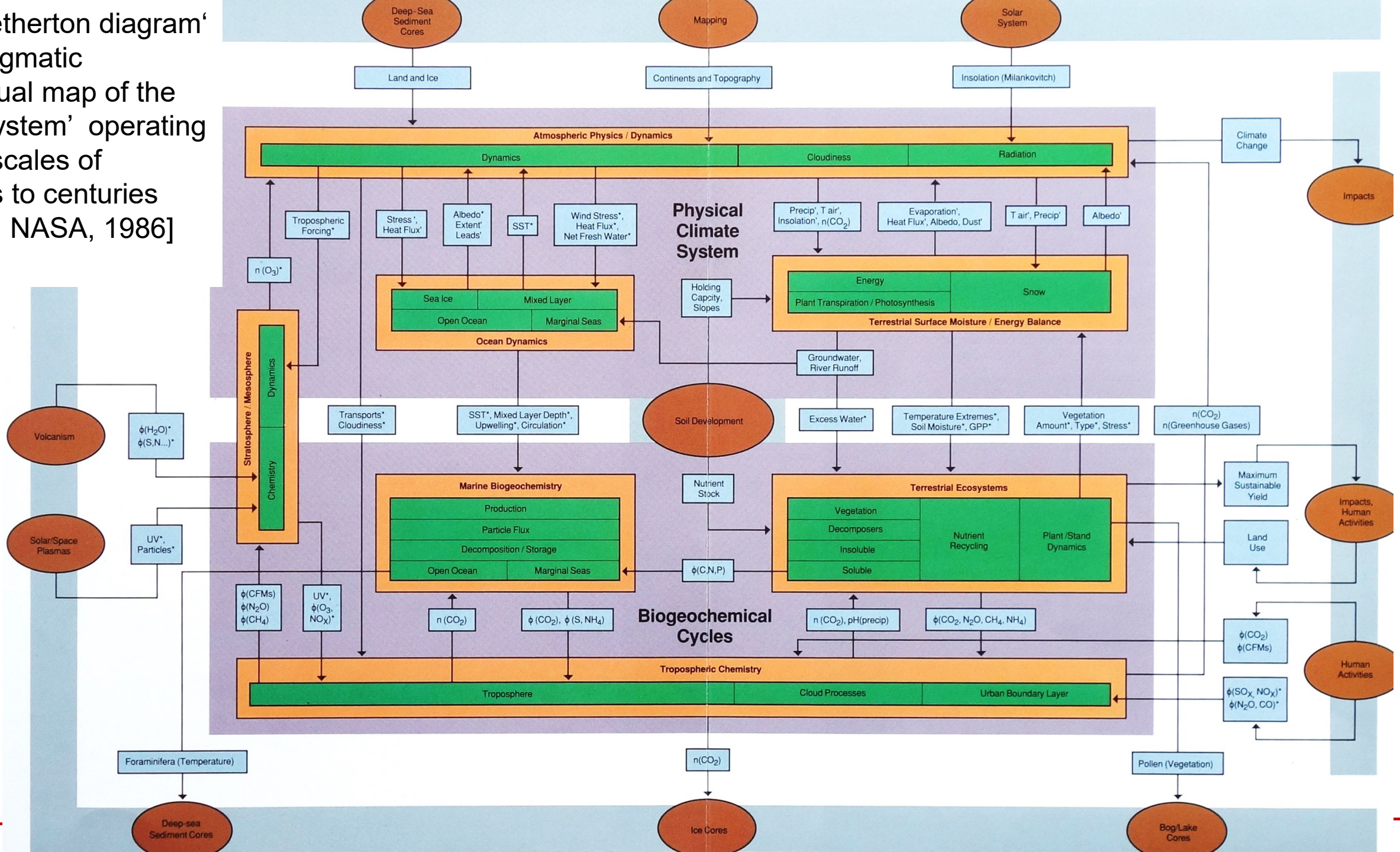
Sottoinsiemi

Fenomeni/processi

Ogni cambiamento nei sottosistemi influisce sugli altri sottosistemi tramite uno o più processi ed eventualmente, tornare al primo sottosistema.

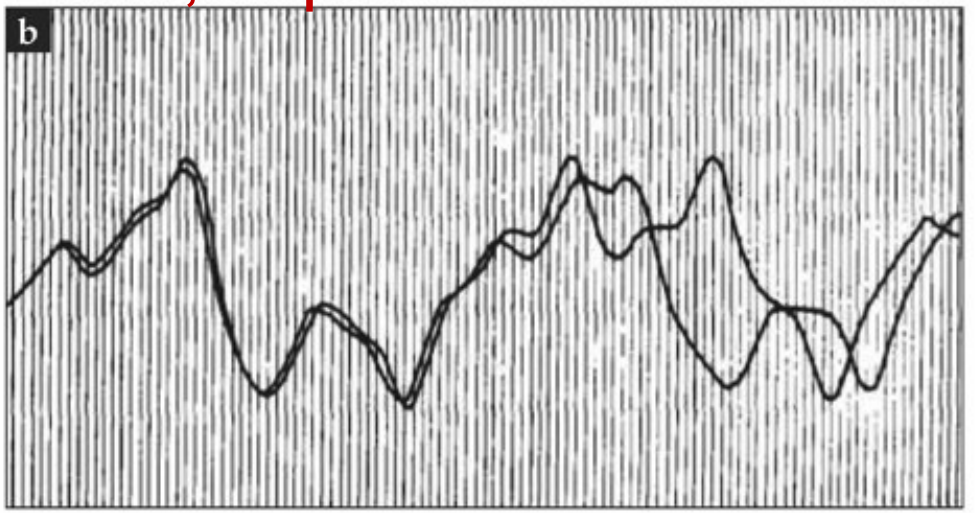
Non esiste una causalità lineare
Ma possono crearsi catene circolari di causalità
(Cassardo, 2022 Polito)

The 'Bretherton diagram' a paradigmatic conceptual map of the 'Earth system' operating on timescales of decades to centuries [Source: NASA, 1986]



Sistema meteo-climatico, complessità, imprevedibilità

- Imprevedibilità delle evoluzioni dei sistemi complessi
- Caratteristica di un sistema complesso è la sensibilità alle condizioni iniziali
- Piccole variazioni delle condizioni iniziali possono rendere imprevedibile l'evoluzione del sistema



https://www.wetterzentrale.de/de/show_diagrams.php?model=gfs&var=2&geoid=72880&lid=ENS&bw=1

- Sistemi complessi, sistemi caotici

"Does the Flap of a Butterfly's Wings in Brazil Set Off a Tornado in Texas?"

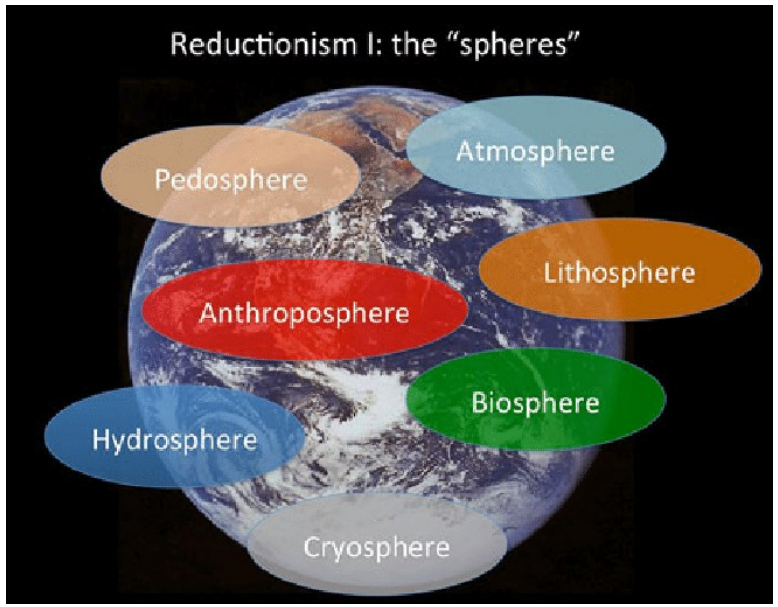
Computer memory 6 decimali, per "risparmiare" approssimazione a 3: **.506127**; **.506.**

https://www.technologyreview.com/2011/02/22/196987/when-the-butterfly-effect-took-flight/

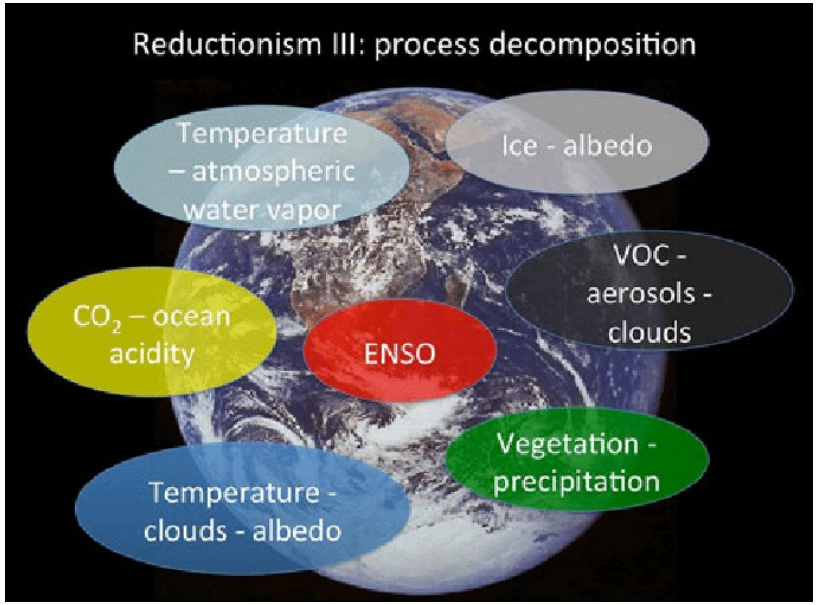
https://news.mit.edu/2008/obit-lorenz-0416

(Ed Lorenz 1917-2008)

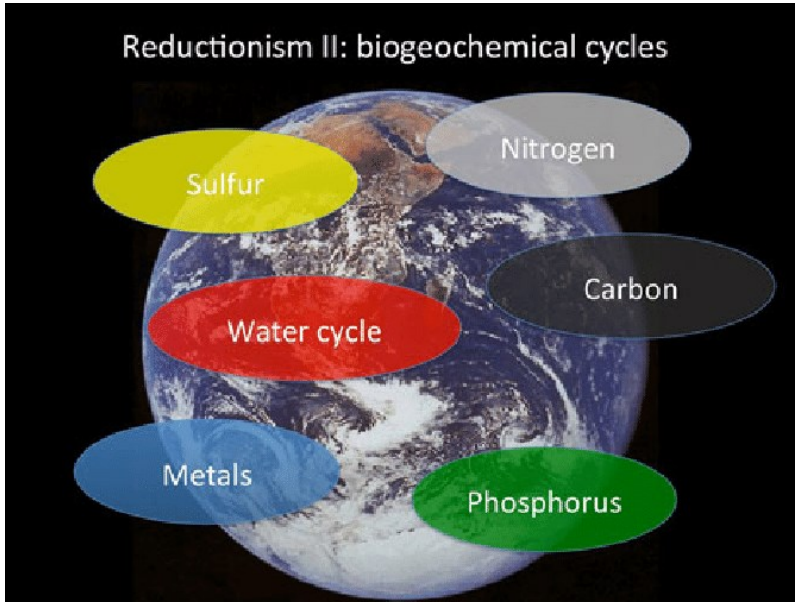
Studiare il clima: dal riduzionismo alla complessità



Separazione in sottosfere (modelli)



Analisi dei processi di feedback



Trasformazione di cicli biogeochimici

- Trattare ogni sottosistema separatamente e descriverlo (tipico dei modelli)
- Semplificare o non considerare le interazioni tra i sottosistemi

***Reduced Complexity Models* (RCMs)**

sistema climatico: definizioni e approcci

GARP (Global Atmosphere Research Programme, WMO) 1975:
“composto dall'atmosfera, dall'idrosfera, dalla criosfera, dalla superficie terrestre e dalla biosfera”

FCCC (Framework Convention on Climate Change, UN) 1992:

“la totalità dell'atmosfera, dell'idrosfera, della biosfera e della geosfera e le **loro interazioni**”

IPCC AR5 (2013)

"il **sistema dinamico altamente complesso** è costituito da cinque componenti principali: l'atmosfera, l'idrosfera, la criosfera, la litosfera e la biosfera, e le **interazioni** tra loro"

Sistema climatico
Sistemi ecologici (ecosistemi)

Sistemi ecologici (ecosistemi)

…sono sistema termodinamicamente aperti

Sono unità funzionali che comprendono **le comunità biologiche** (tutti gli organismi che vivono, si riproducono ed interagiscono in una determinata area) **– biocenosi** – e le componenti ambientali non viventi (**abiotiche**)

Pignatti 2004

Un complesso dinamico di piante, animali e comunità di micro-organismi e dell'ambiente abiotico circostante come unità funzionale **(MA, 2005)**

Componenti

comunità biotica, abiotica, i flussi di energia e le interazioni

- Meccanismi di feedback
- Capacità di auto-organizzazione
- Memoria
- Resilienza
- Incertezza

Sistemi ecologici (ecosistemi)

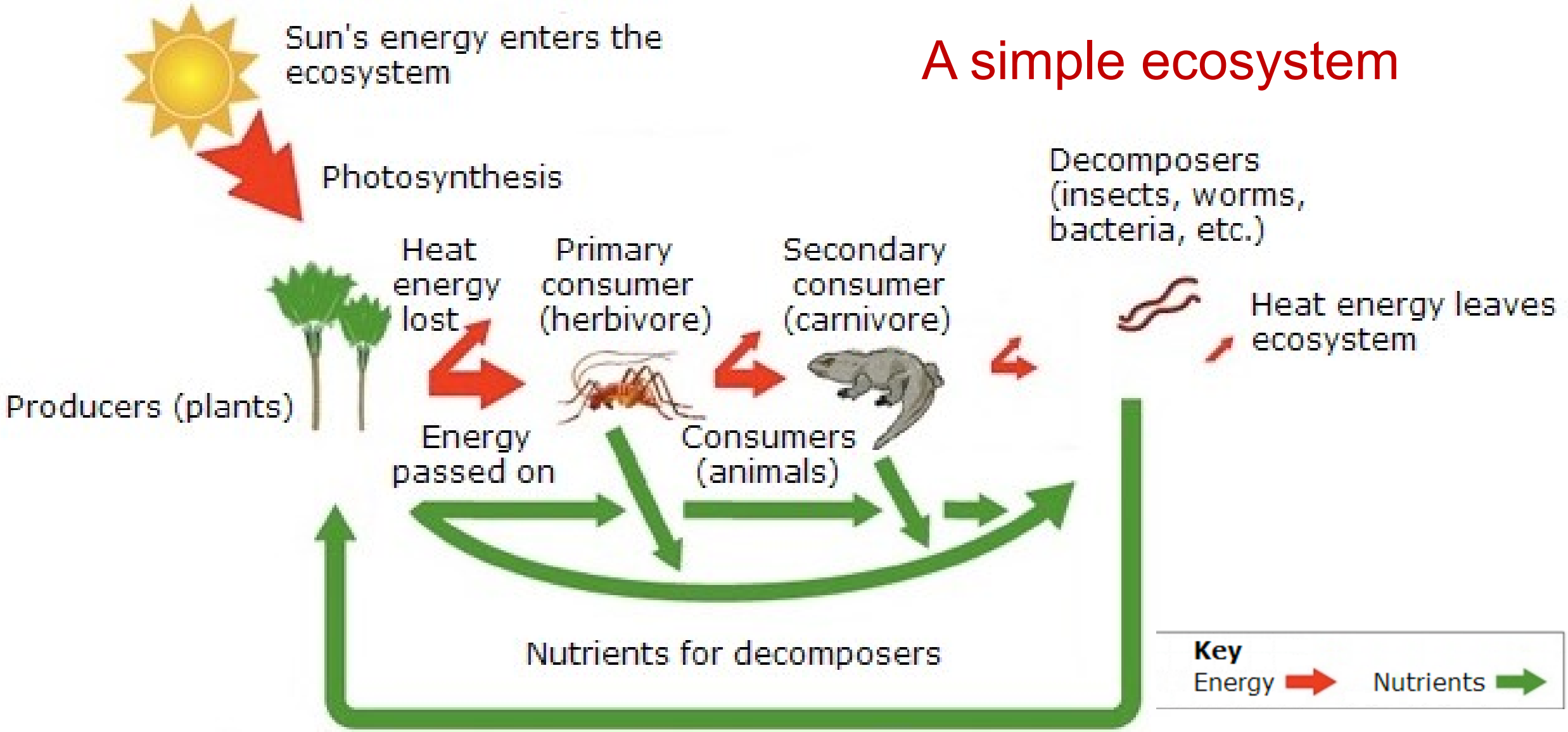
Unità ambientale eterotipica risultante dall'integrazione di una collettività di specie differenti (biocenosi) con l'ambiente dove essa vive (biotopo)

Ecosistema = biocenosi (1) + biotopo (2)

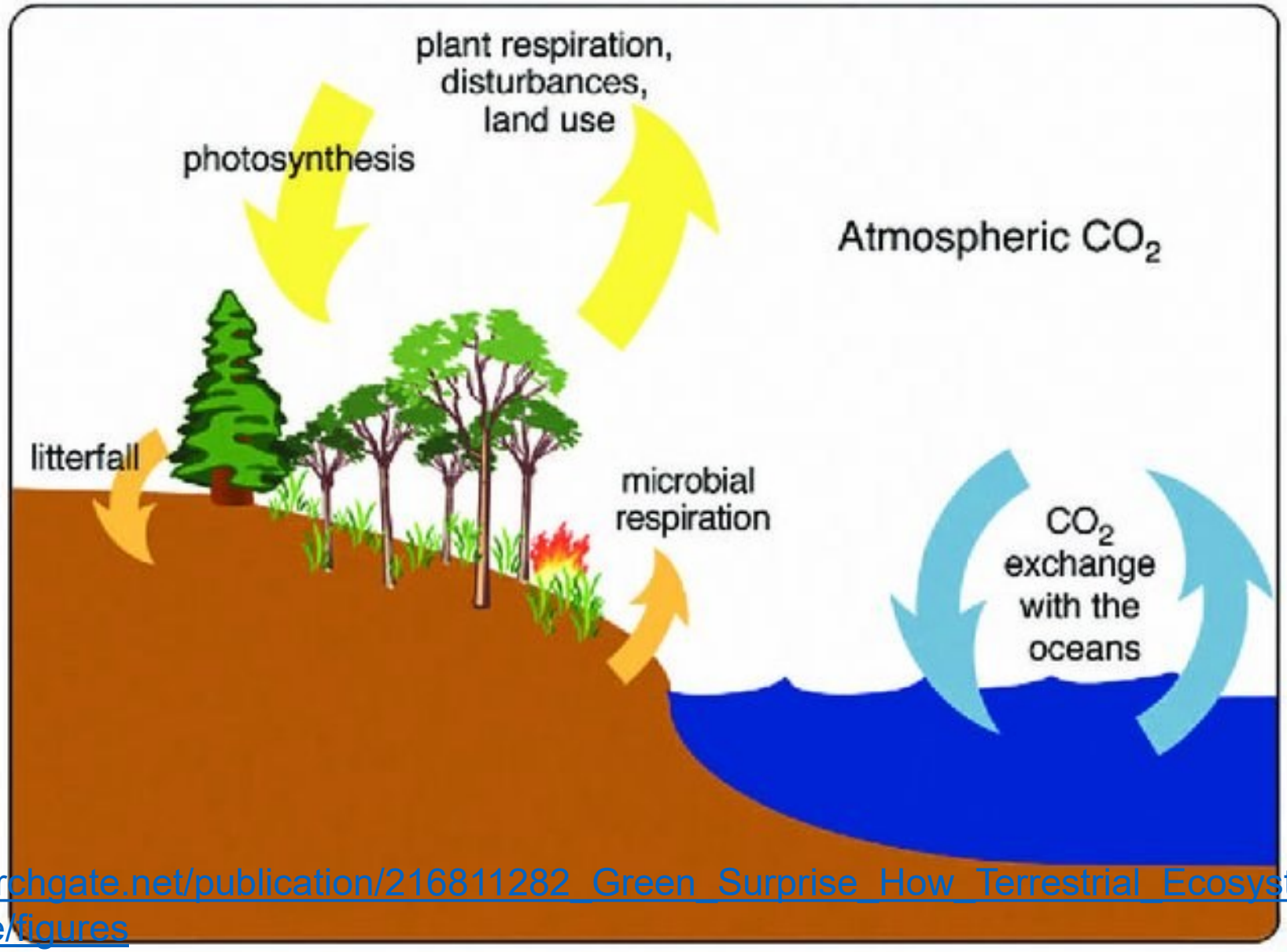
1) Associazione di **specie animali e vegetali** che vivono in un dato luogo in equilibrio biologico dinamico

2) Unità di ambiente fisico in cui vive una singola popolazione o una biocenosi

A simple ecosystem

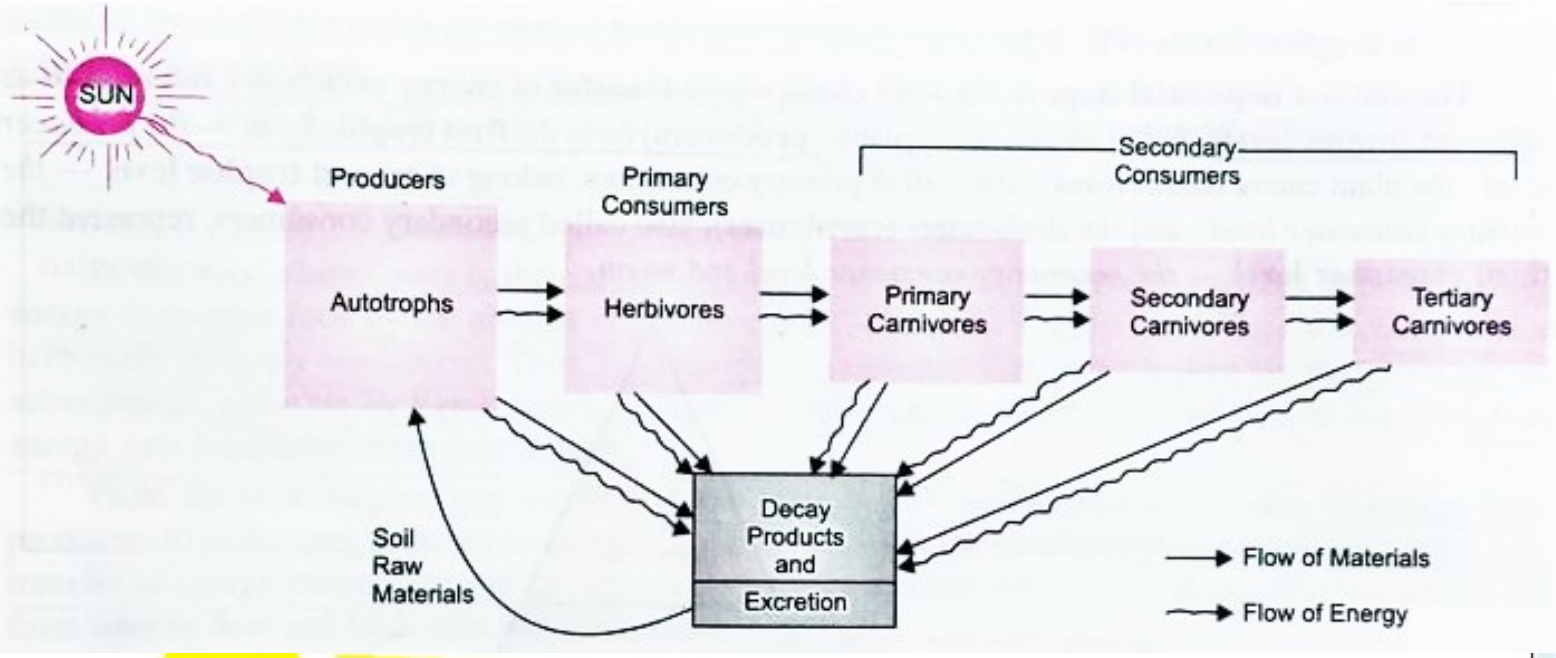


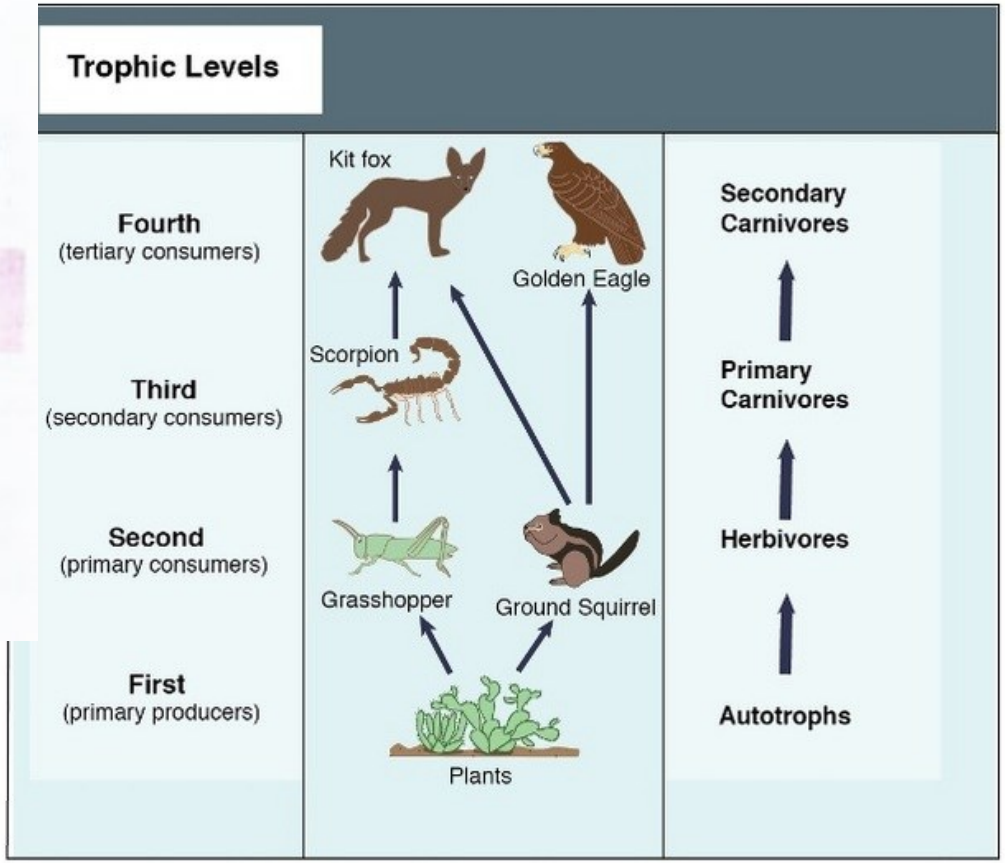
https://www.sciencelearn.org.nz/images/1113-simple-ecosystem-diagram The University of Waikato Te Whare Wānanga o Waikato | www.sciencelearn.

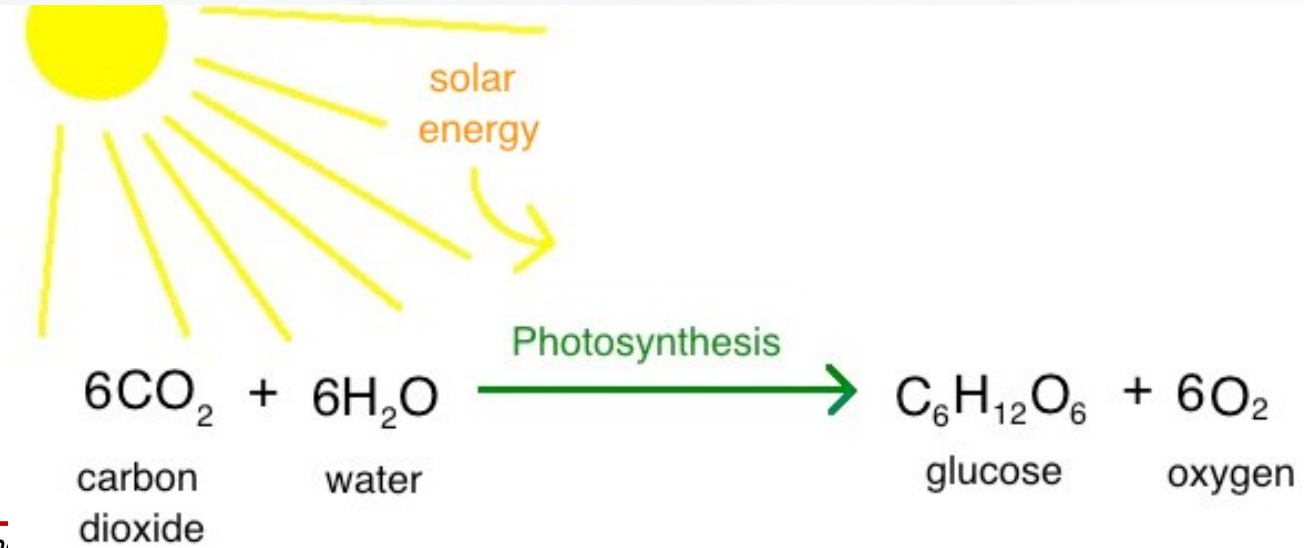


https://www.researchgate.net/publication/216811282_Green_Surprise_How_Terrestrial_Ecosystems_Could_Affect_Earth%27s_Climate/figures

A simple ecosystem







https://www.nature.com/scitable/knowledge/library/food-web-concept-and-applications-84077181/

https://tinyurl.com/27a5ftu9

Tipologie di ecosistemi

1. **Ecosistemi terrestri**

2. **Ecosistemi acquatici**: acque lotiche (rivi, ruscelli, torrenti, fiumi)

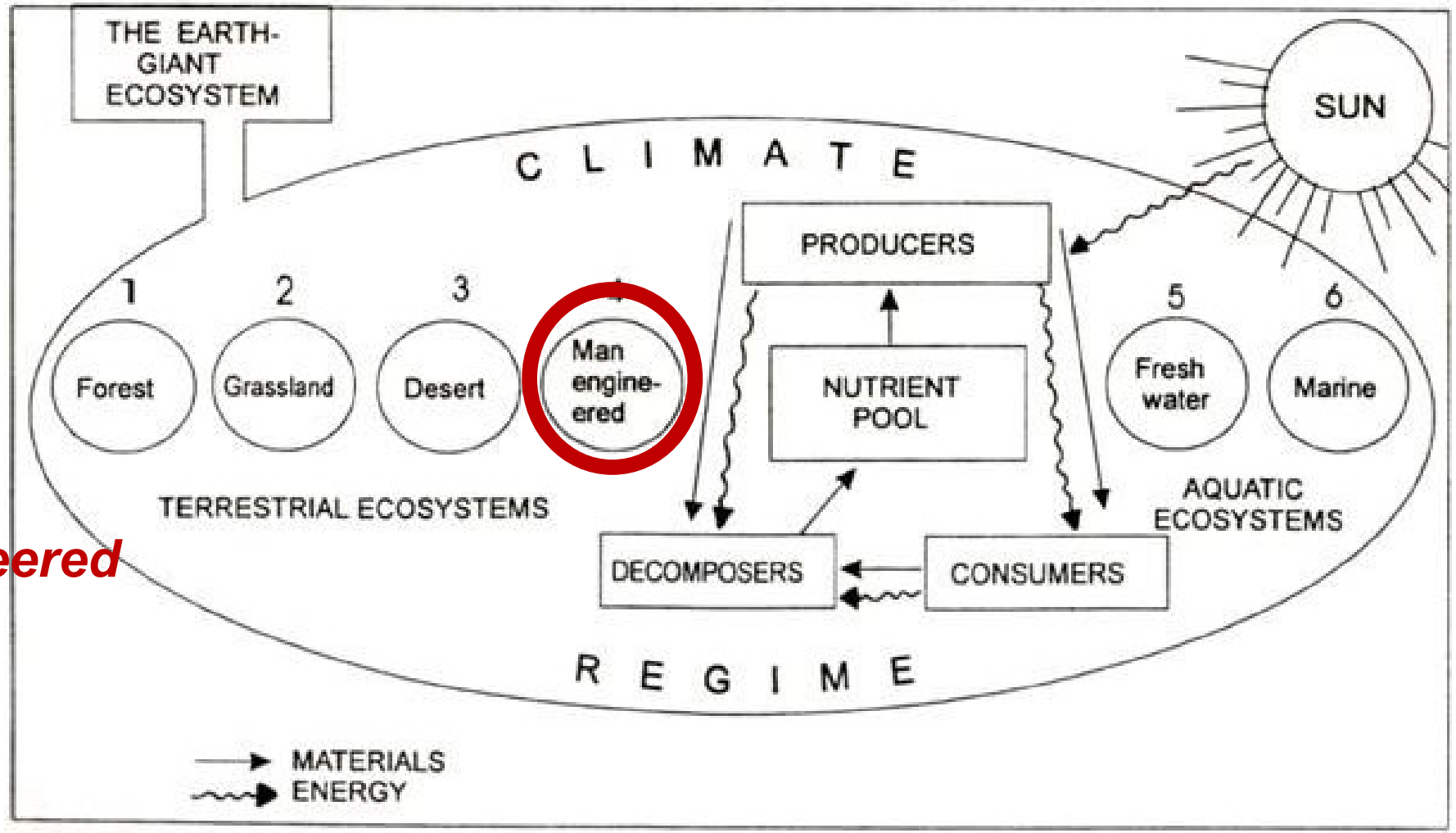
   acque lentiche (assenza di correnti; laghi, stagni, paludi e acquitrini)

3. **Ecosistemi marini**

4. Ecotoni

Tipologie di ecosistemi

1. Ecosistemi forestali
2. Ecosistemi erbacei
3. Ecosistemi desertici
4. Ecosistemi acque dolci
5. Ecosistemi marini
6. Ecosistemi ***man engineered***



6. Ecosistemi *man engineered*

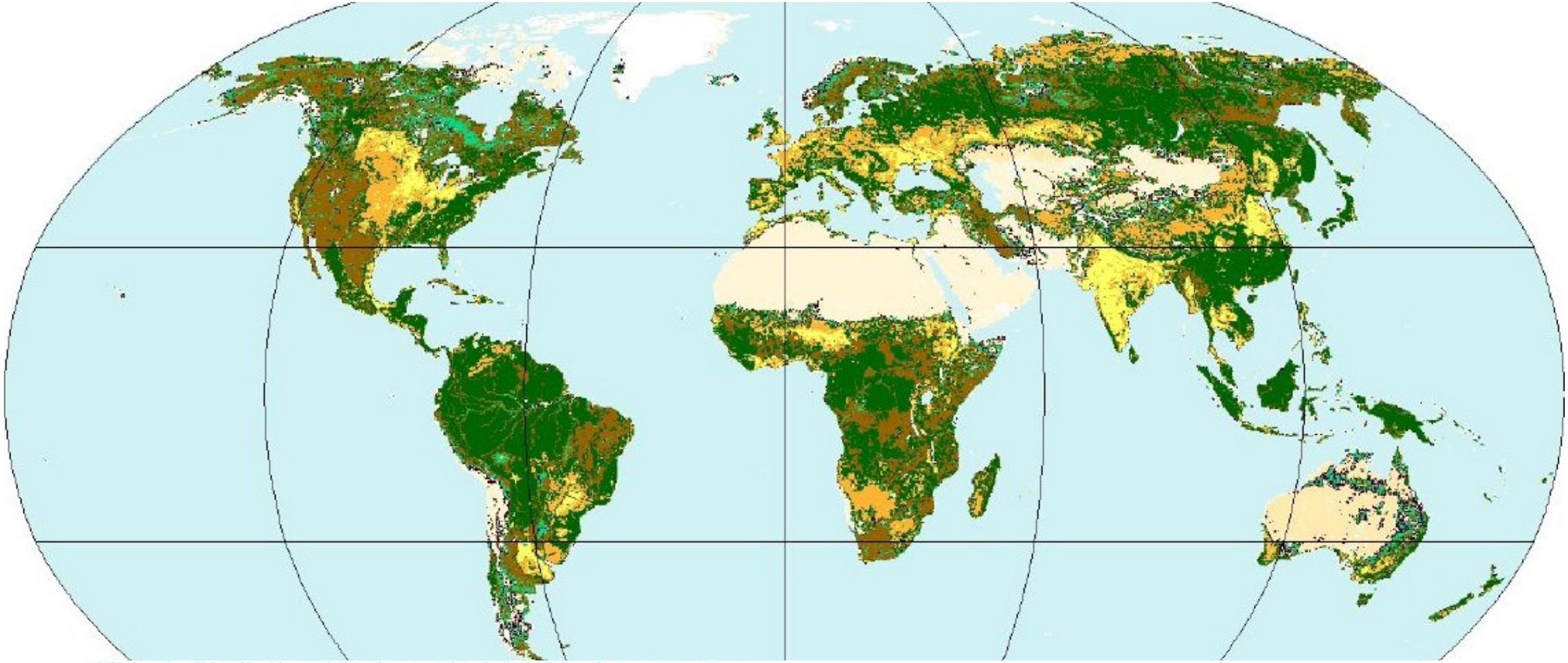
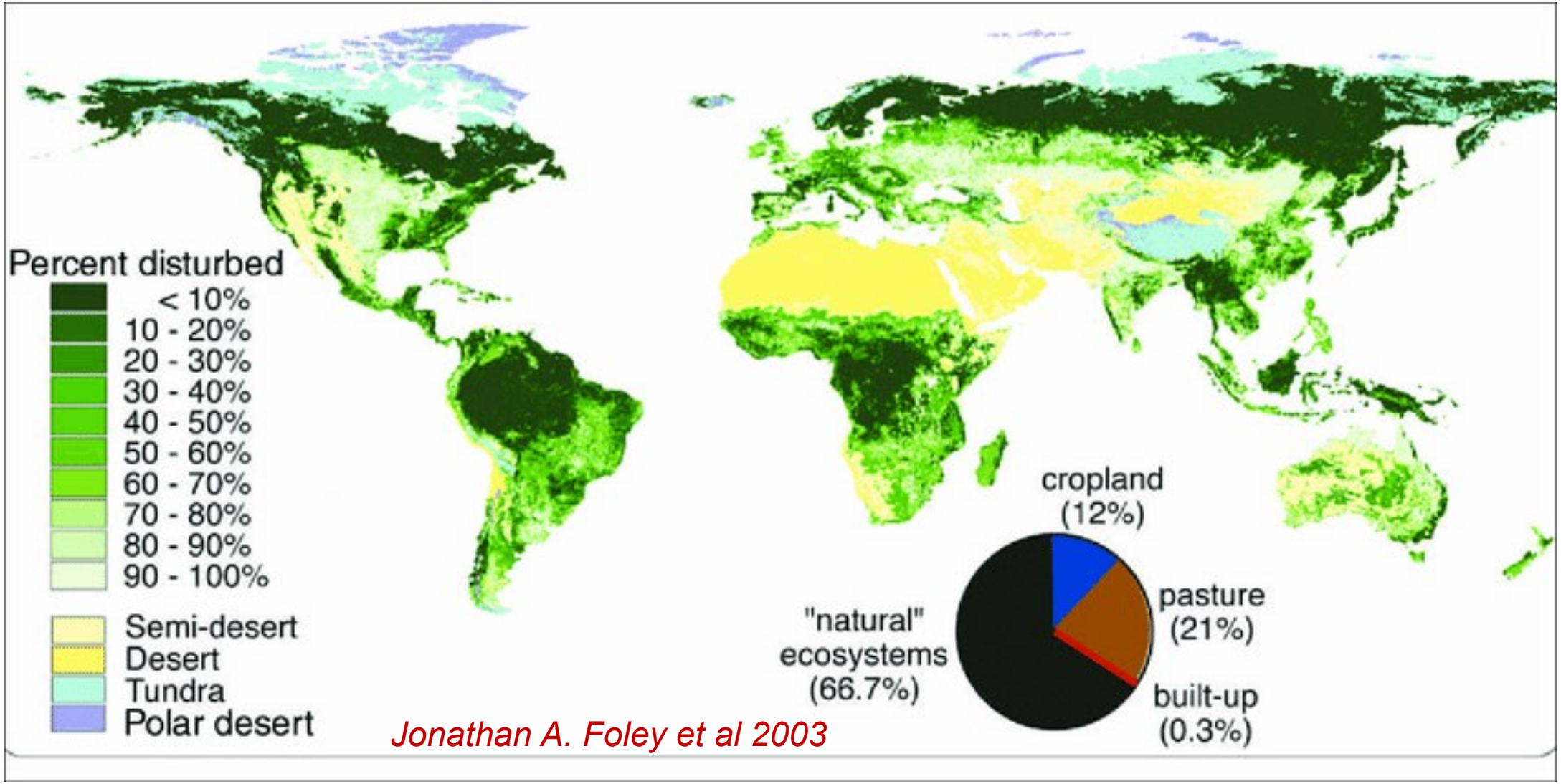


Figure 3 – Distribution of dominant GLC-SHARE Land Cover Database.

01	Artificial Surfaces	04	Tree Covered Area	07	Mangroves	10	Snow and Glaciers + Antarctica
02	Cropland	05	Shrubs Covered Area	08	Sparse Vegetation	11	Water bobies
03	Grassland	06	Herbaceous Vegetation	09	Baresoil		Antartica

(FAO, 2010)

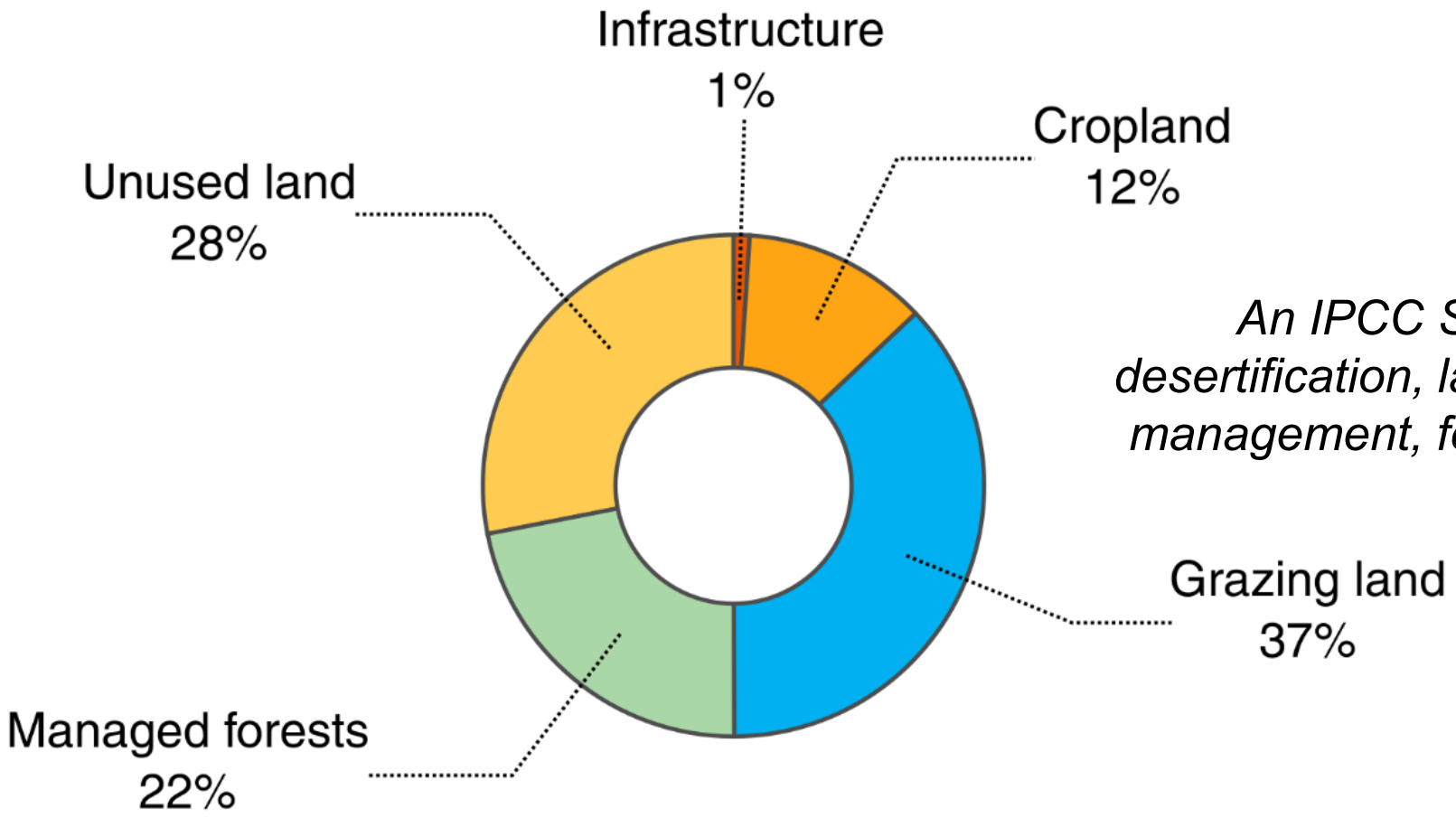
6. Ecosistemi *man engineered*



Jonathan A. Foley et al 2003

https://www.researchgate.net/publication/216811282_Green_Surprise_How_Terrestrial_Ecosystems_Could_Affect_Earth%27s_Climate

GLOBAL LAND USE IN 2015 (IPCC 2019)



IPCC Special Report
Climate Change and Land

An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems

IPCC (2019) Special Report on Climate Change and Land

Città o ecosistema/i urbano/i?

Ecosistema naturale (o seminaturale)

E' in grado di auto-alimentarsi con un bilancio finale in equilibrio.

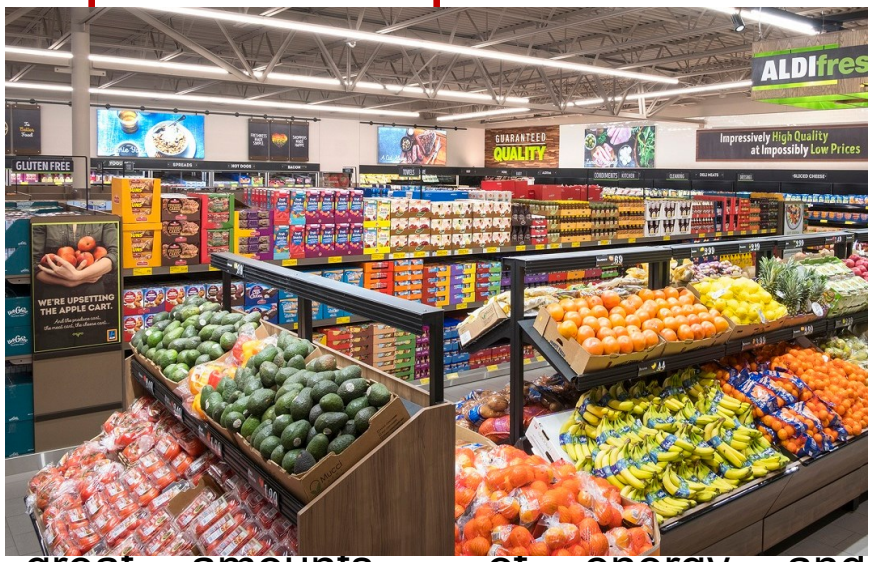
Sistema autotrofo

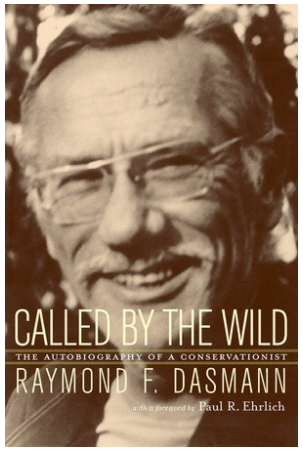
Ecosistema urbano

Dipende drasticamente da risorse esterne al sistema, con un bilancio in/out sempre squilibrato (domanda di cibo, energia elettrica, acqua…).

Sistema eterotrofo

Ecosystem People vs Biosphere People





other ecosystem groups

great amounts of energy and

Ecosystem People, Biosphere People, Ecological Refugees

Social Change
Volume 53, Issue 1, March 2023, Pages 7-28

https://doi.org/10.1177/00490857231152416

Social Change Annual Lecture

Ecosystem People, Biosphere People, Ecological Refugees

Madhav Gadgil

Abstract

One may assign people to three broad categories from an ecological perspective. Ecosystem people meet the bulk of their resource requirements from a limited area near their habitation through gathering or low-input agriculture and animal husbandry. Biosphere people enjoy access to resources garnered from the entire biosphere and made available through markets, while ecological refugees are people that have lost access to their traditional base of natural resources yet have very limited access to resources through markets. In India today the ever-growing pressure of biosphere people is converting an increasingly large proportion of ecosystem people into ecological refugees.

Keywords

Ecosystem people, biosphere people, ecological refugees, report of the Western Ghats Ecology Expert Panel, Forest Rights Act

Madhav Gadgil, Fikret Berkes and Carl Folke

Indigenous Knowledge for Biodiversity Conservation

Indigenous peoples with a historical continuity of resource-use practices often possess a broad knowledge base of the behavior of complex ecological systems in their own localities. This knowledge has accumulated through a long series of observations transmitted from generation to generation. Such "diachronic" observations can be of great value and complement the "synchronic" observations on which western science is based. Where indigenous peoples have depended, for long periods of time, on local environments for the

this world view nor scientific knowledge have been particularly successful when confronted with complex ecological systems. These complex systems vary greatly on spatial and temporal scales rendering the generalizations that positivistic science has come up with of little value in furnishing practical prescriptions for sustainable resource use (3, 4). Science-based societies have tended to overuse and simplify such complex ecological systems, resulting in a whole series of problems of resource exhaustion and environmental degradation.

It is in this context that the knowledge of indigenous societies

JOURNAL ARTICLE

Indigenous Knowledge for Biodiversity Conservation

Madhav Gadgil, Fikret Berkes and Carl Folke

Ambio

Vol. 22, No. 2/3, Biodiversity: Ecology, Economics, Policy (May, 1993), pp. 151-156 (6 pages)

Published By: Springer

La biodiversità

La biodiversità

La diversità biologica comprende la ***varietà*** *e la* ***variabilità*** *tra organismi viventi e i complessi ecologici in cui vivono.*
La diversità può essere definita come il ***numero di elementi diversi e*** *la loro* ***frequenza relativa****.*
Nella biodiversità tali elementi sono organizzati in più livelli, dall'ecosistema in toto alle strutture chimiche che costituiscono le basi dell'ereditarietà.
Il termine comprende la diversità di ecosistemi, specie, geni e la loro abbondanza relativa.

Office Technology Assessment USA 1987

La ricchezza della vita sulla Terra, i milioni di piante, animali e microrganismi, i geni che essi contengono, i complessi ecosistemi che essi costituiscono nella Biosfera

WWF 1989

La biodiversità

La biodiversità

- **α-biodiversità**: ricchezza specifica locale (densità in rapporto all'area occupata)
- **β-diversità**: quanto cambia la composizione specifica lungo un gradiente ambientale o geografico
- **γ-diversità**: richiama α-biodiversità ma su ampie porzioni di superficie (scala regionale, continentale)

Misurare la biodiversità

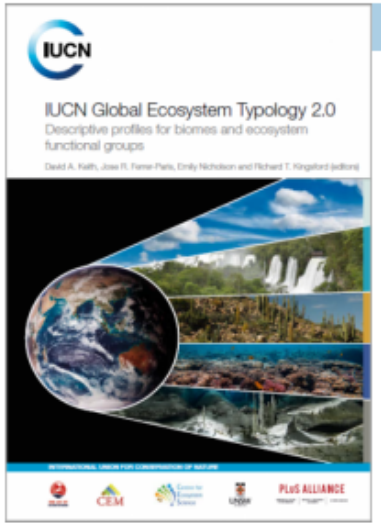
- Indice di Margalef
- Indice di Shannon-Wiener
- Indice di Pielou
- Indice di Simpson
- Indici di diversità tassonomica
- Indici di diversità funzionale

$$H' = -\sum_{j=1}^{s} p_j \log_e p_j$$

$$D = 1 - \left(\frac{\Sigma\, n(n-1)}{N(N-1)} \right)$$

IUCN Global Ecosystem Typology 2.0

Complete Title: IUCN Global Ecosystem Typology 2.0 : descriptive profiles for biomes and ecosystem functional groups



IUCN Publication

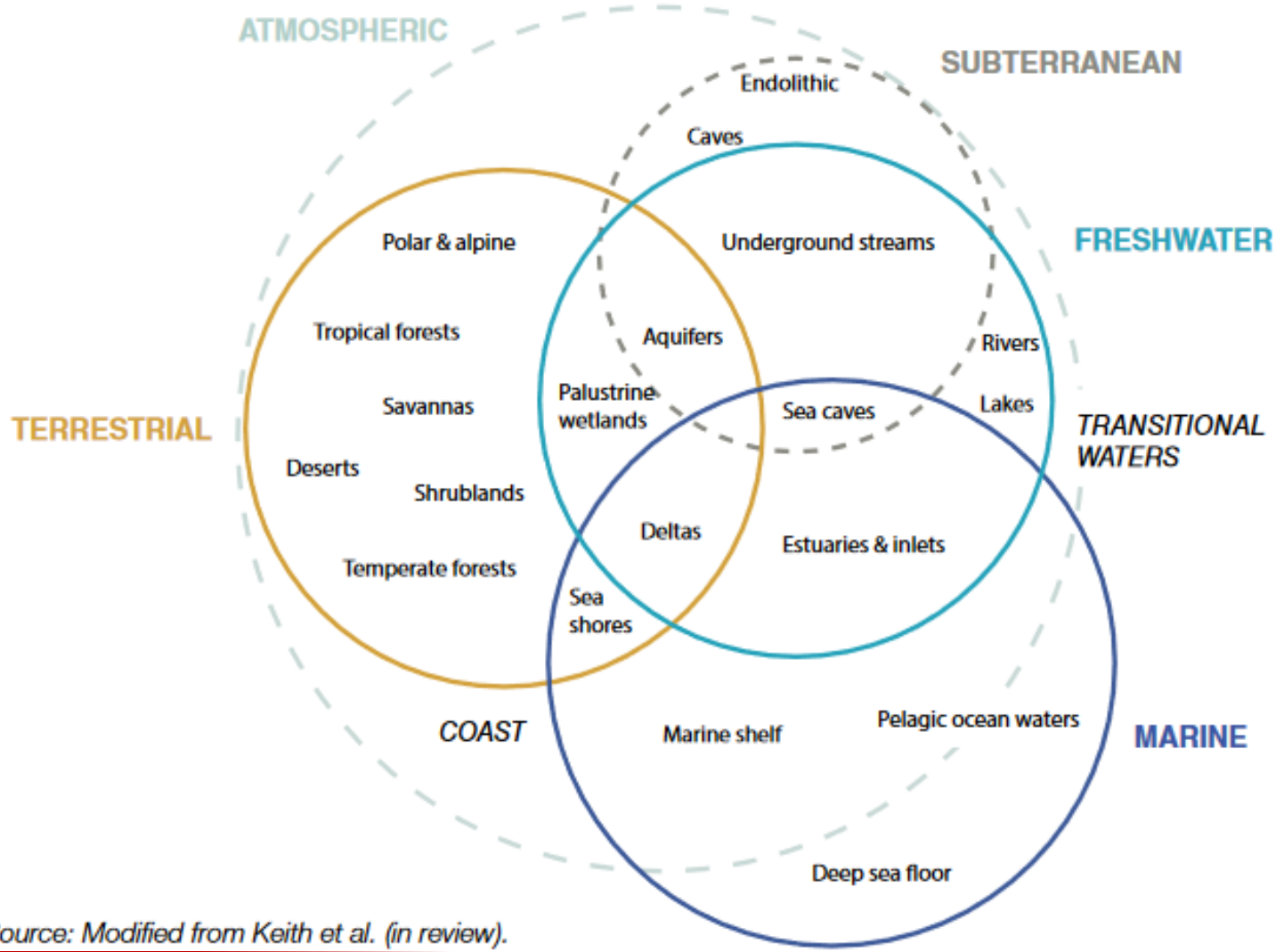
Author(s): Keith, David A. | Ferrer-Paris, Jose R. | Nicholson, Emily | Kingsford, Richard |

Organization(s): IUCN | IUCN Commission on Ecosystem Management (CEM) | IUCN Global Ecosystem Management Programme |

Abstract:
Ecosystems are critically important components of Earth's biological diversity and as the natural capital that sustains human life and well-being. Yet all of the world's ecosystems show hallmarks of human influence, and many are under acute risks of collapse, with consequences for habitats of species, genetic diversity, ecosystem services, sustainable development and human well-being. The IUCN Global Ecosystem Typology is a hierarchical classification system that, in its upper levels, defines ecosystems by their convergent ecological functions and, in its lower levels, distinguishes ecosystems with contrasting assemblages of species engaged in those functions. This report describes the three upper levels of the hierarchy, which provide a framework for understanding and comparing the key ecological traits of functionally different ecosystems and their drivers. An understanding of these traits and drivers is essential to support ecosystem management.

https://portals.iucn.org/library/node/49250

Figure 3 Continuous variation and transitions states among realms. Broken lines represent overlaps of Subterranean (grey) and Atmospheric realms (light blue) in a fourth dimension. Transitional realms and biomes shown in italics.



Source: Modified from Keith et al. (in review).

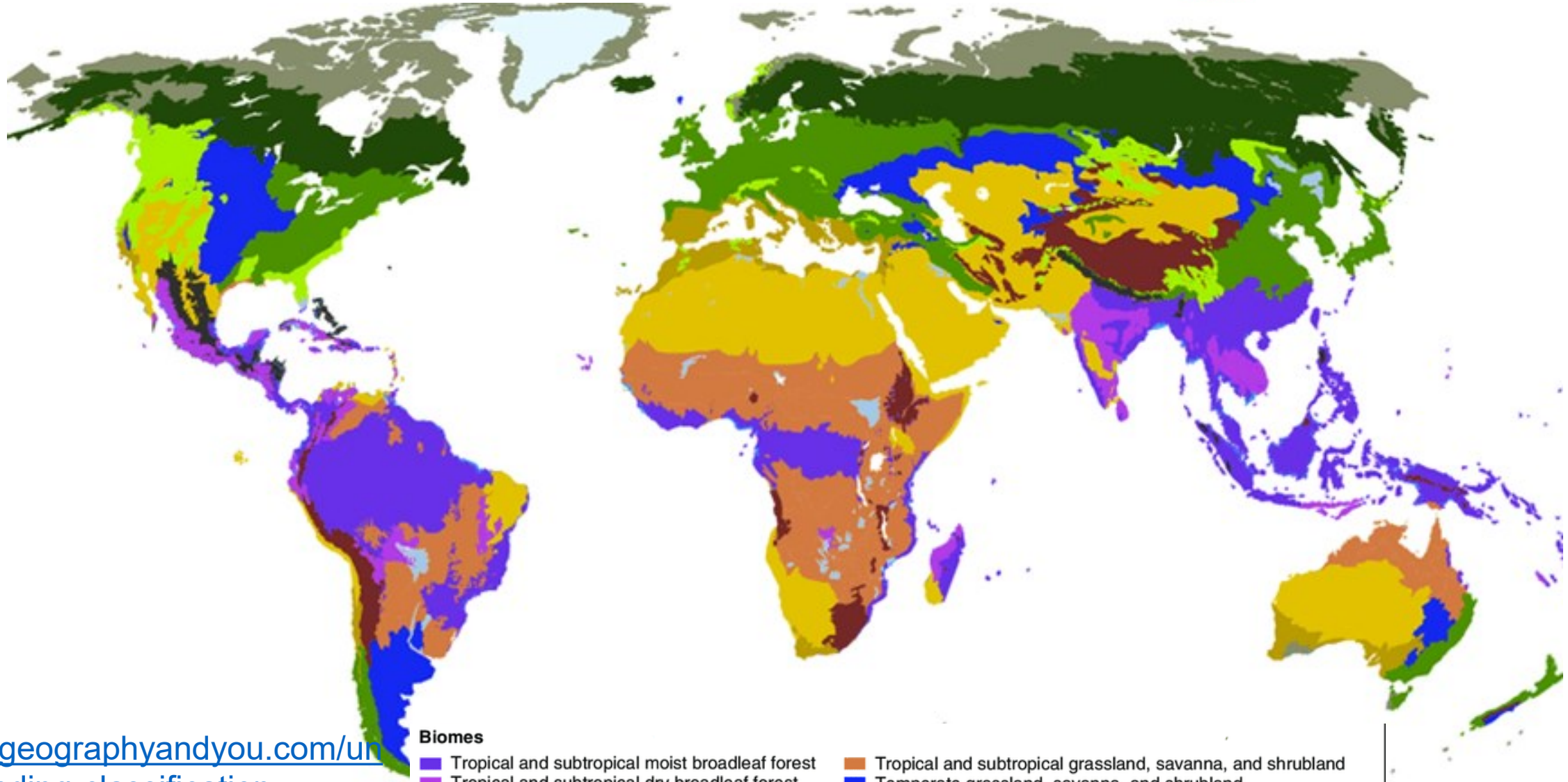
BIOMI

A biome describes the world's major communities of living things. Biomes are classified according to the predominant plants that are found there. The animals that live in the biome are uniquely adapted to live in that *particular environment*. **This is because temperature, the type of soil, and the amount of light and water all affect the types of plants and animals that live within a biome.**

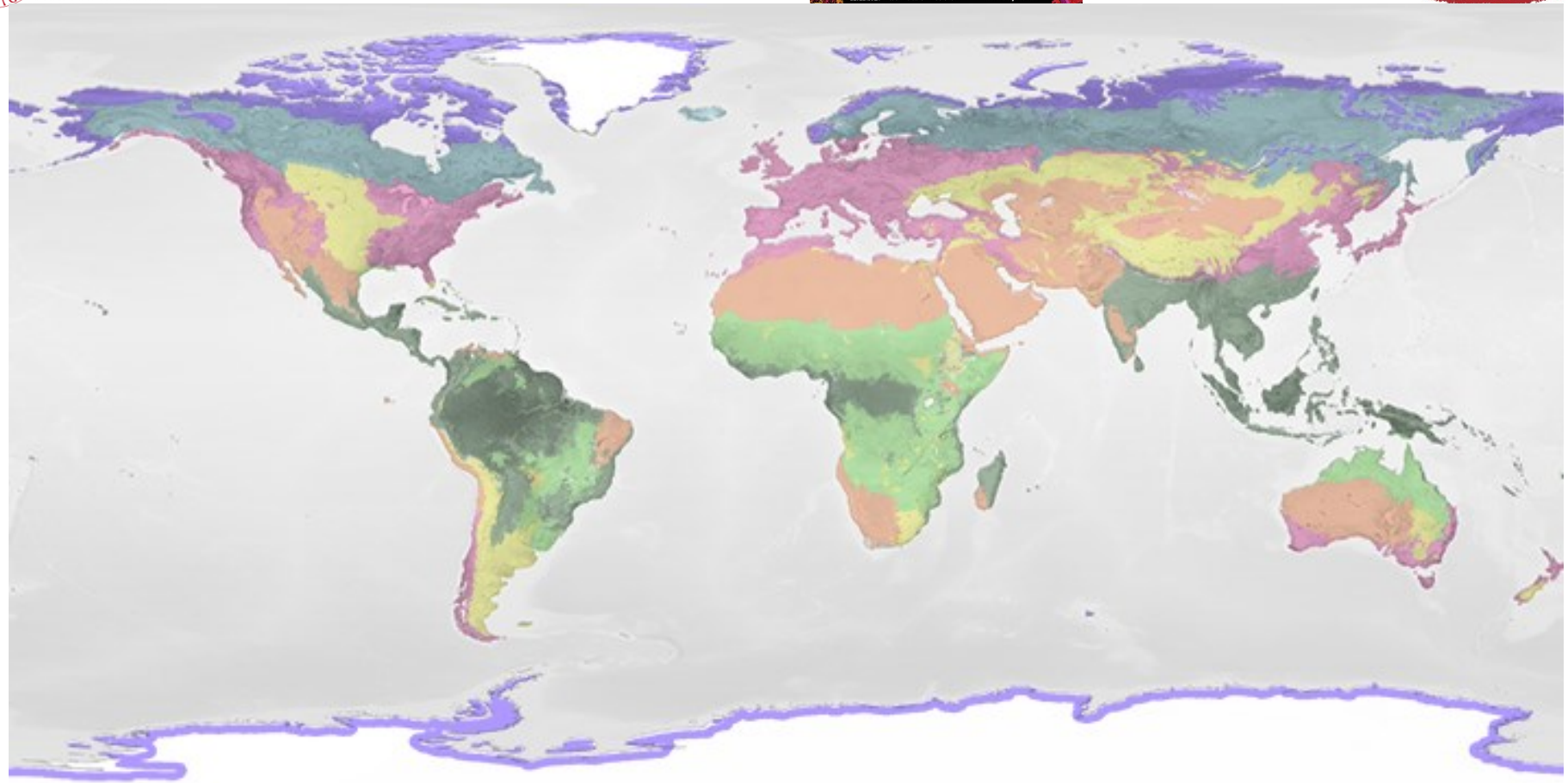
The biome concept evolved from its original application to continental-scale vegetation units **associated with major climate types**, to units reflecting functional and evolutionary processes, albeit still with an emphasis on terrestrial vegetation (Mucina, 2019).

A biome refers to a region of the world characterized by its resident life, environment, and climate.
Temperature, precipitation, and amount of sunlight all affect what type of life resides in a particular biome and help define each biome.
There are a number of biomes around the world, including **savanna**, **rainforest**, **desert**, taiga, and marine biomes.

https://www.ecologia.polimi.it/wp-content/uploads/2016/03/chap5_ricklefs_biomes.pdf



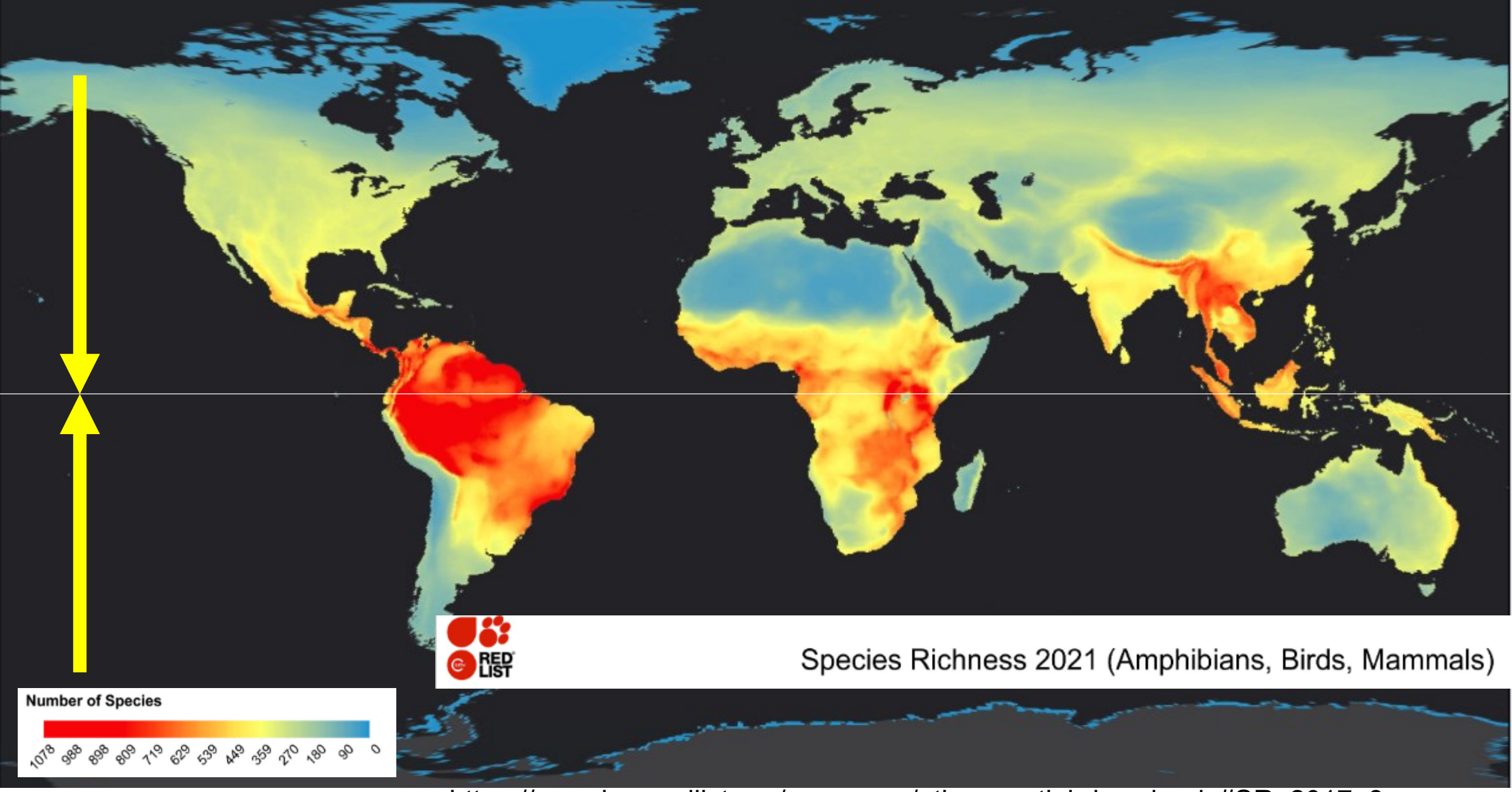
https://geographyandyou.com/understanding-classification-biomes-world/



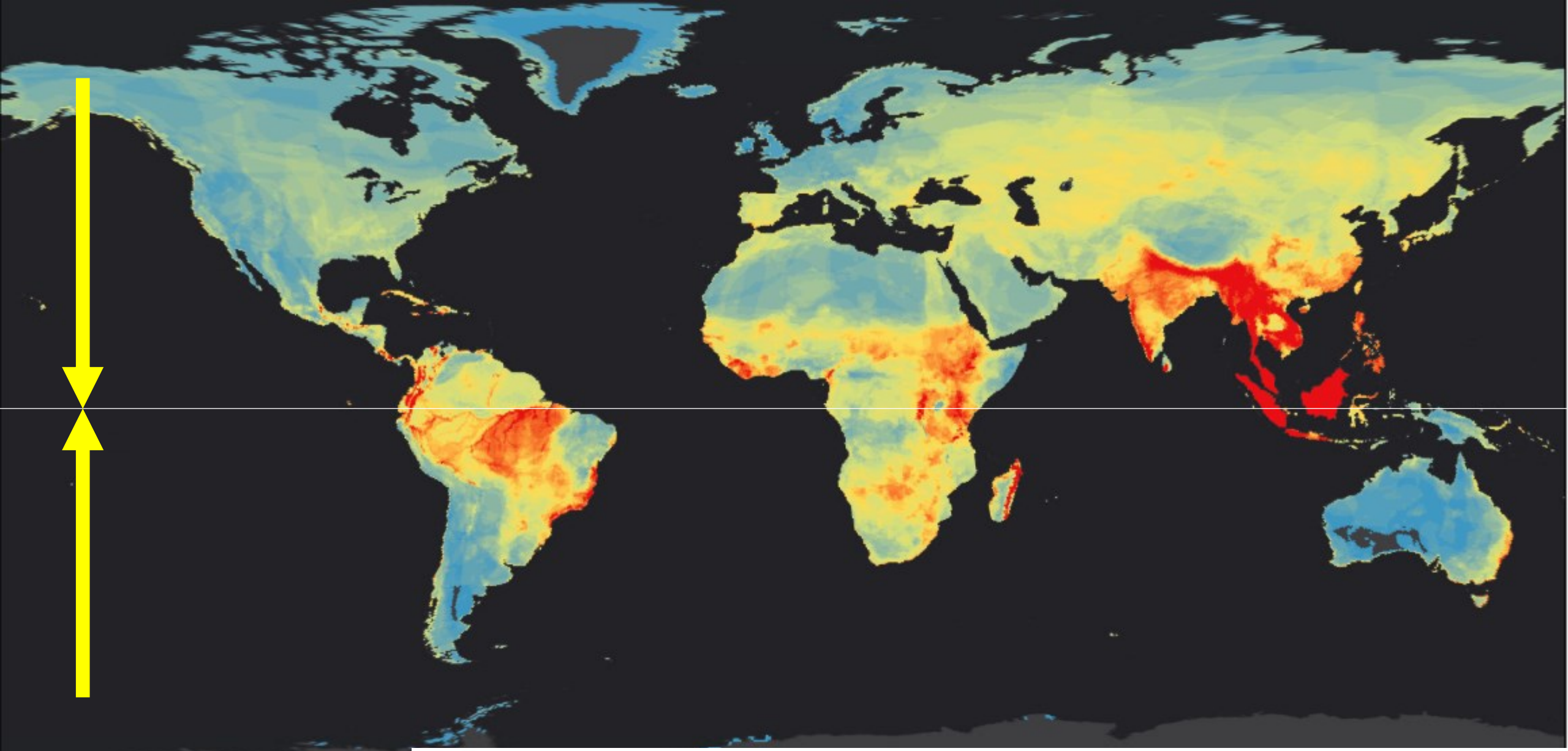
Click on a biome button below for more information on that biome (download image).

Rainforest | Grassland | Coniferous Forest | Temperate Deciduous Forest | Desert | Tundra | Shrubland

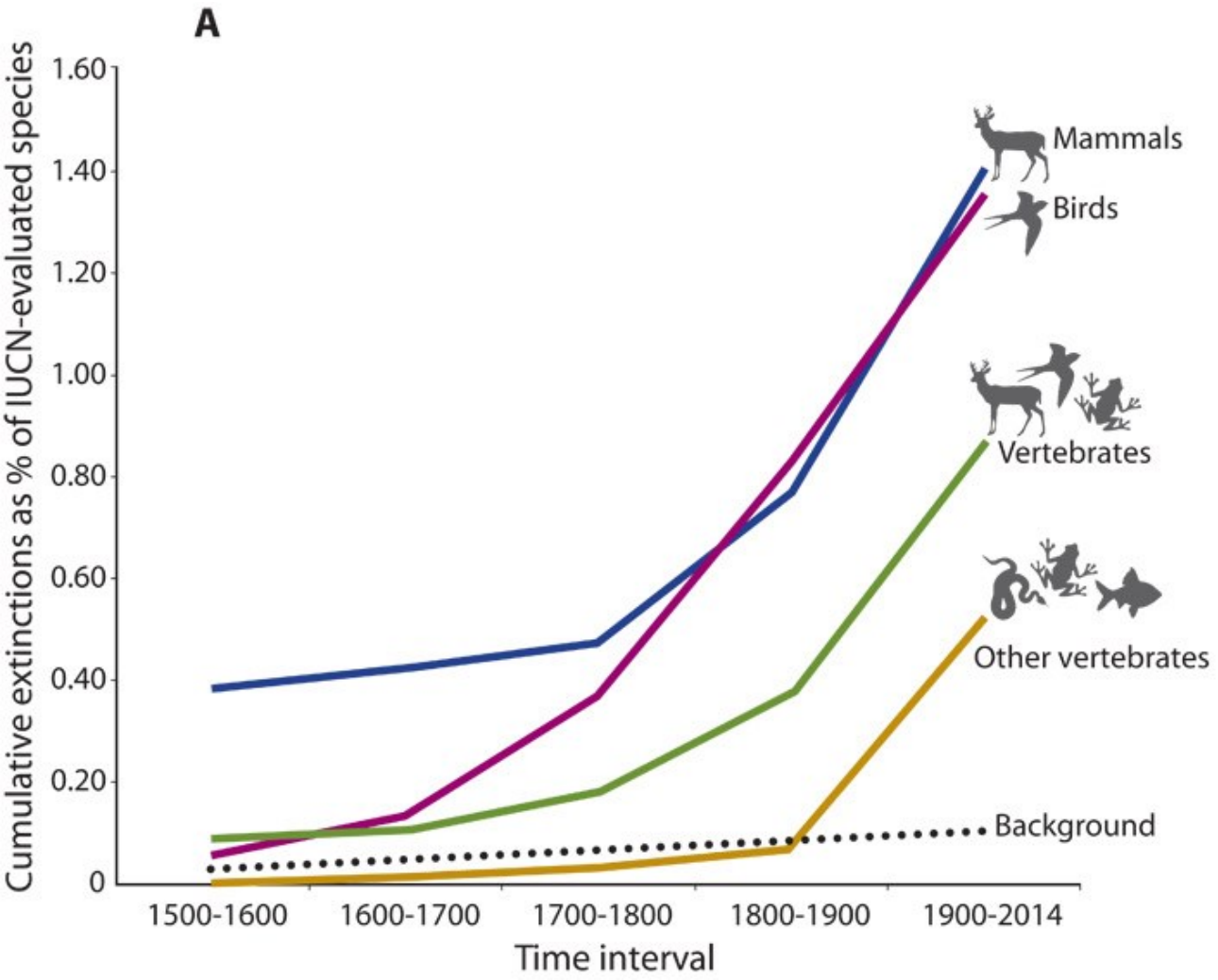
https://earthobservatory.nasa.gov/biome



https://www.iucnredlist.org/resources/other-spatial-downloads#SR_2017_3



Threatened Species Richness 2021 (Amphibians, Birds, Mammals)



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HOME > SCIENCE ADVANCES > VOL. 1, NO. 5 > ACCELERATED MODERN HUMAN–INDUCED SPECIES LOSSES: ENTERING THE SIXTH MASS EXTINCTION
RESEARCH ARTICLE | ENVIRONMENTAL SCIENCES

Accelerated modern human–induced species losses: Entering the sixth mass extinction

GERARDO CEBALLOS, PAUL R. EHRLICH, ANTHONY D. BARNOSKY, ANDRÉS GARCÍA, ROBERT M. PRINGLE, AND TODD M. PALMER Authors Info & Affiliations

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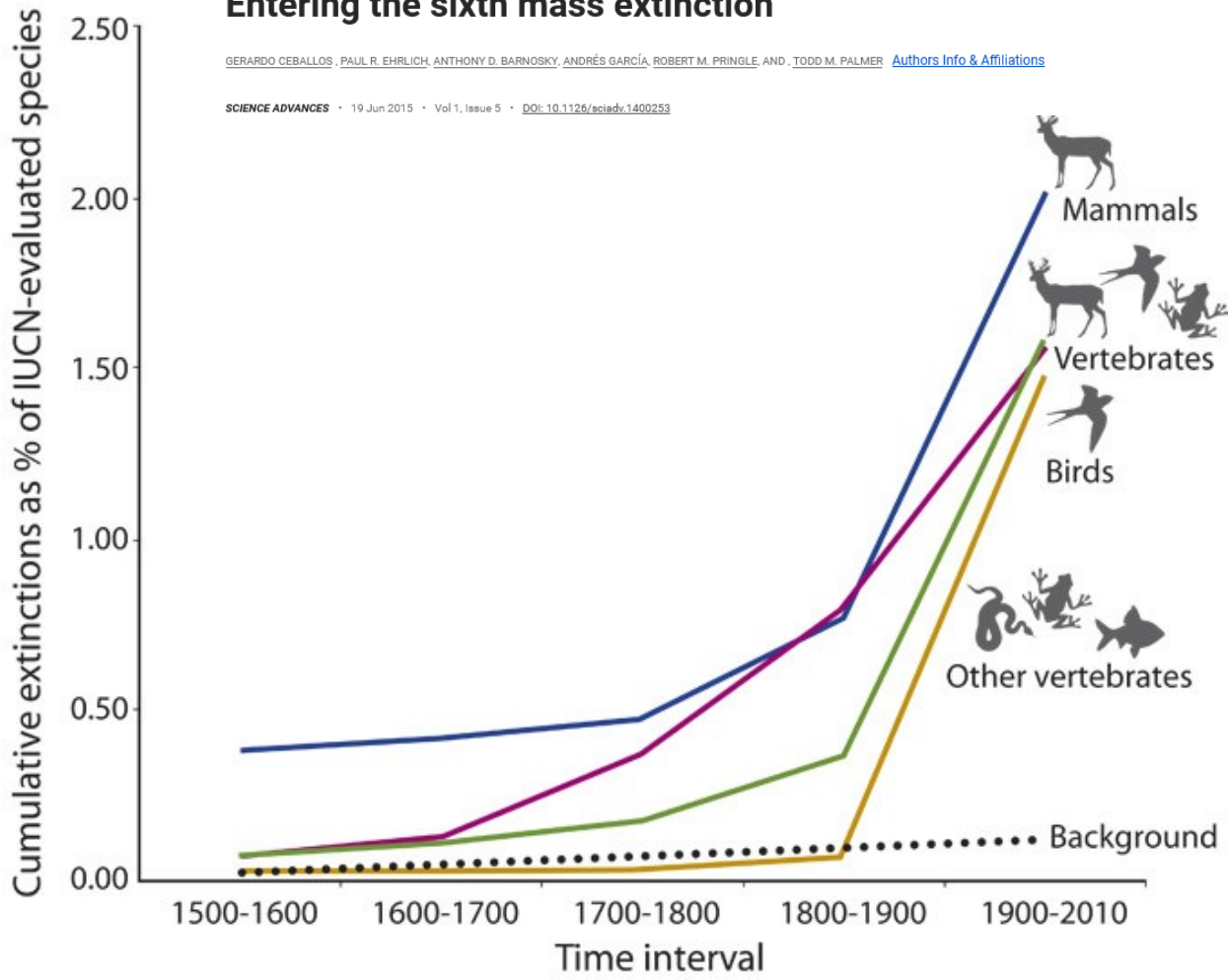


https://www.science.org/doi/10.1126/sciadv.1400253

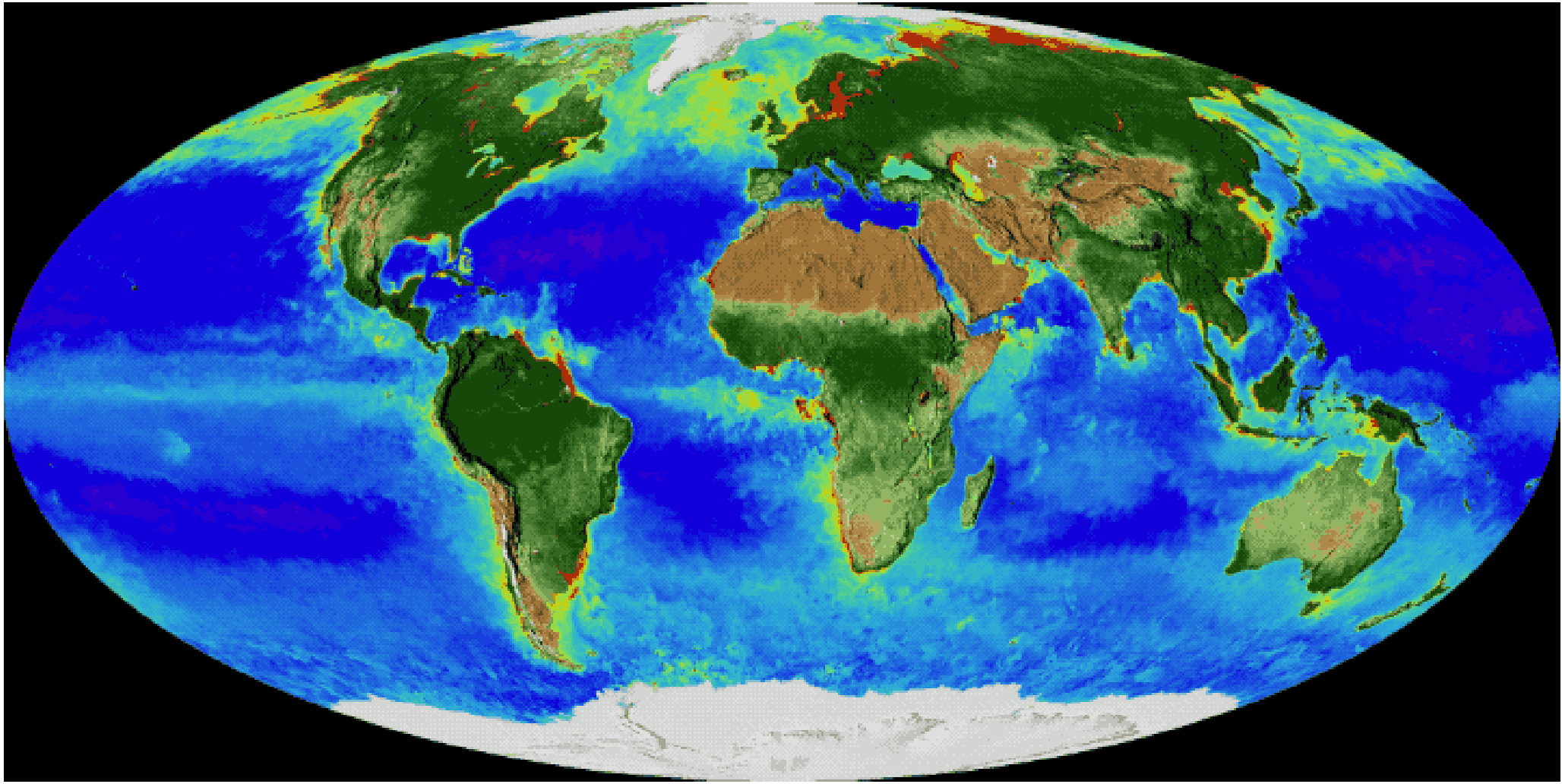
La **Bios**fera

- *The domain of life on Earth*
- Ecosistema globale (tutte le componenti biotiche ed abiotiche)
- Flusso di energia (fotosintesi e respirazione)
- Cicli biogeochimici (idrologico, C, N_2, O_2,…)

Yearly Cycle Earth's Biosphere

The Earth's Breathe

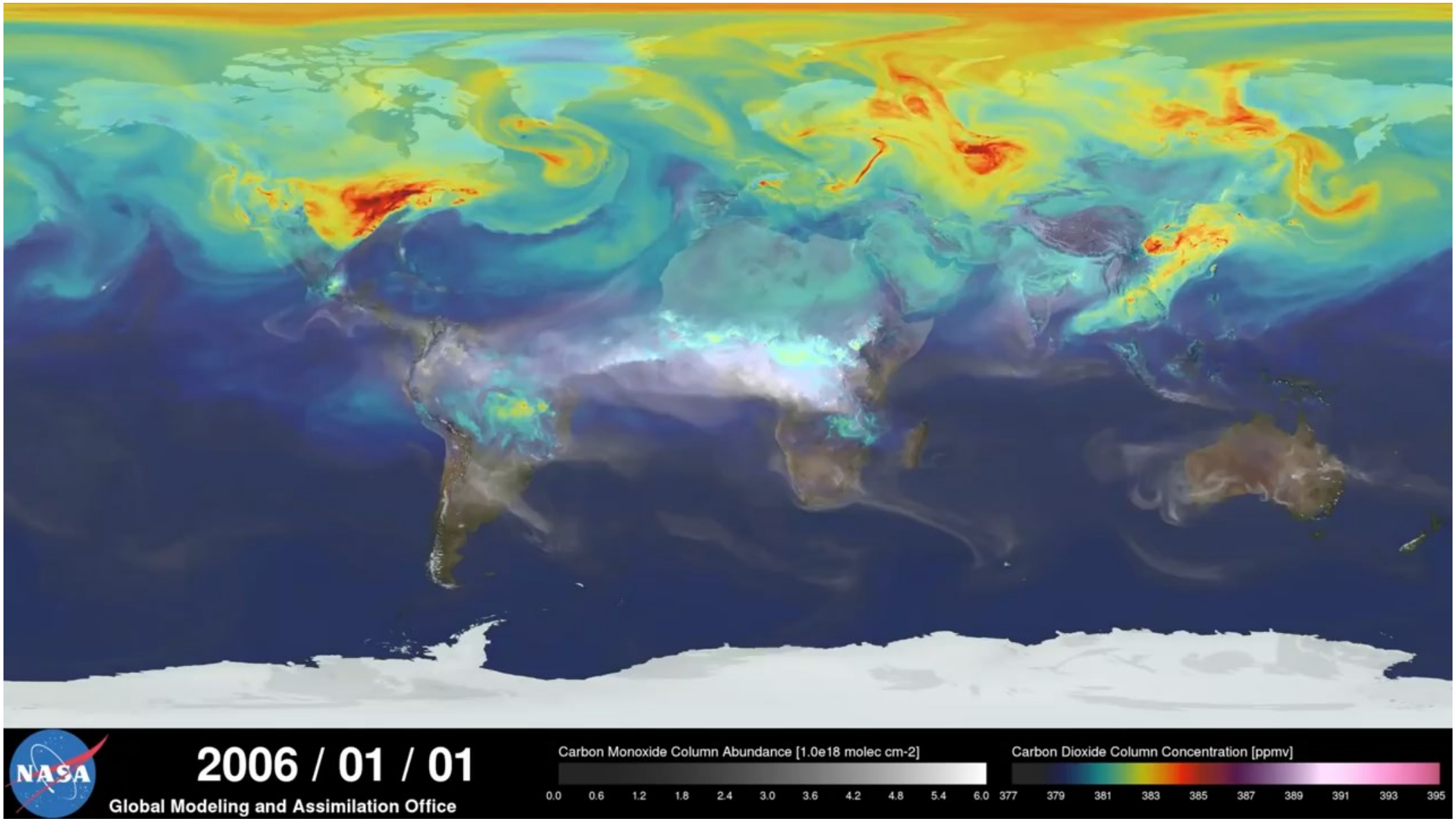
https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=30709



Credit: *NASA's Goddard Space Flight Center*.

“Nature Run”

NASA



https://www.nasa.gov/press/goddard/2014/november/nasa-computer-model-provides-a-new-portrait-of-carbon-dioxide/

Clima e biomi/ecosistemi

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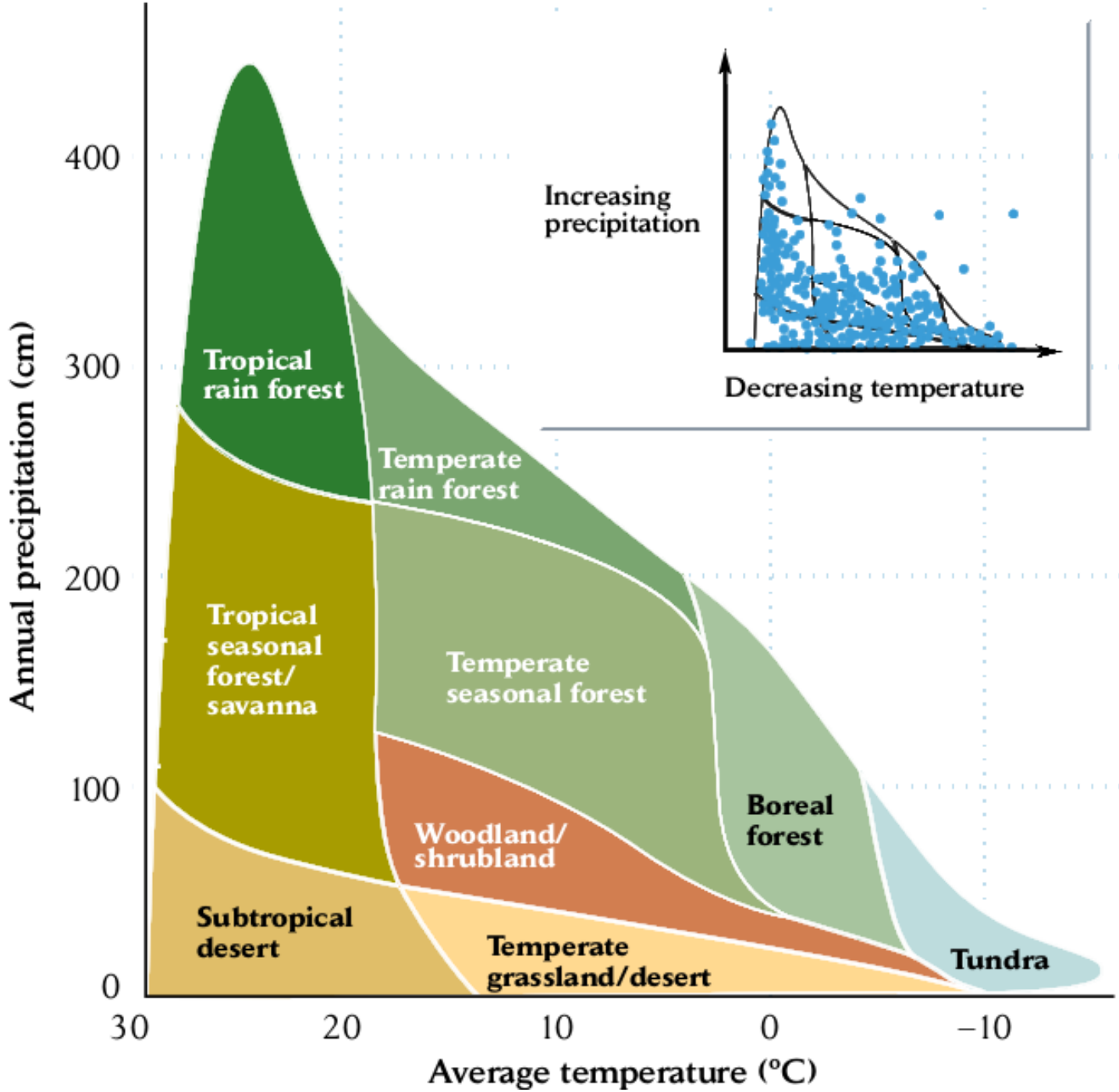
Whittaker's System Classification Different Biomes

Biome name		Climate zone	Vegetation
Tropical rain forest	I	Equatorial: Always moist and lacking temperature seasonality	Evergreen tropical rain forest
Tropical seasonal forest/ savanna	II	Tropical: Summer rainy season and "winter" dry season	Seasonal forest, scrub, or savanna
Subtropical desert	III	Subtropical (hot deserts): Highly seasonal, arid climate	Desert vegetation with considerable exposed surface
Woodland/shrubland	IV	Mediterranean: Winter rainy season and summer drought	Sclerophyllous (drought-adapted), frost-sensitive shrublands and woodlands
Temperate rain forest	V	Warm temperate: Occasional frost, often with summer rainfall maximum	Temperate evergreen forest, somewhat frost-sensitive
Temperate seasonal forest	VI	Nemoral: Moderate climate with winter freezing	Frost-resistant, decidous, temperate forest
Temperate grassland/ desert	VII	Continental (cold deserts): Arid, with warm or hot summers and cold winters	Grasslands and temperate deserts
Boreal forest	VIII	Boreal: Cold temperate with cool summers and long winters	Evergreen, frost-hardy needle-leaved forest (taiga)
Tundra	IX	Polar: Very short, cool summers and long, very cold winters	Low, evergreen vegetation, without trees, growing over permanently frozen soils

Figure 5.4 Heinrich Walter classified the climate zones of the world according to the annual cycle of temperature and precipitation. The biome names given to these zones under Whittaker's classification scheme are shown in the left-hand column.

Figure 5.5 Whittaker's biomes are delineated according to average temperature and precipitation. Whittaker plotted the boundaries of observed vegetation types with respect to average temperature and precipitation. In climates intermediate between those of forest and desert biomes, climatic seasonality, fire, and soils determine whether woodland, grassland, or shrubland develops. *Inset:* average annual temperature and precipitation for a sample of localities more or less evenly distributed over the land area of the earth. Most of the points fall within a triangular region that includes almost the full range of climates. Only the climates of high mountains do not fall within the triangle. From r . h . Whittaker, *Communities and Ecosystems,* 2nd ed., Macmillan, New York (1975).



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