# Lecture 2
# Introduction to community ecology
# &
# Typical data collected in community ecology

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# Lecture 2

## Part 1. Introduction to community ecology: How does HMSC relate to theory in community ecology?

1.1. What is community ecology?
1.2. What is an ecological community?
1.3. What are the prevailing theories in community ecology?

## Part 2. Typical data collected in community ecology: What kind of data does HMSC take as input?

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# 1.1. What is community ecology?

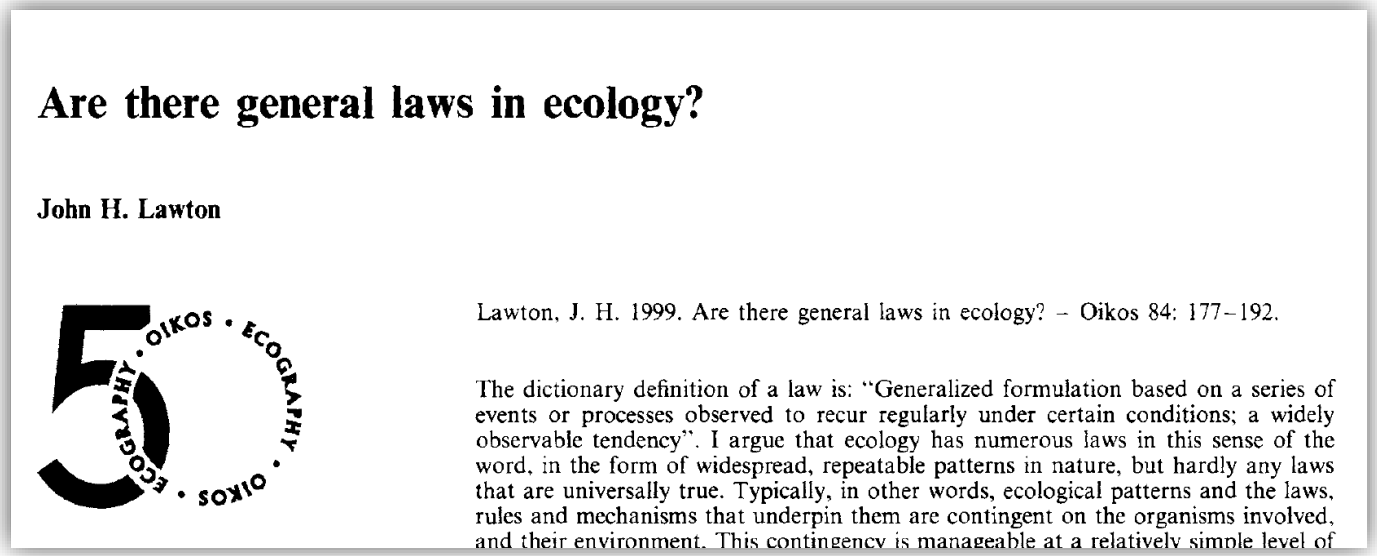
http://www.enviropedia.org.uk

A multidisciplinary field that aims to describe and understand the spatio-temporal structure and dynamics of ecological communities.

It has relatively recently rooted in ecology as a field, as its entity as field has been strongly questioned.

# 1.1. What is community ecology?

Lawton 1999: ”community ecology is a mess with so much contingency that useful generalizations are hard to find”



**Are there general laws in ecology?**

**John H. Lawton**

Lawton, J. H. 1999. Are there general laws in ecology? – Oikos 84: 177–192.

The dictionary definition of a law is: "Generalized formulation based on a series of events or processes observed to recur regularly under certain conditions; a widely observable tendency". I argue that ecology has numerous laws in this sense of the word, in the form of widespread, repeatable patterns in nature, but hardly any laws that are universally true. Typically, in other words, ecological patterns and the laws, rules and mechanisms that underpin them are contingent on the organisms involved, and their environment. This contingency is manageable at a relatively simple level of

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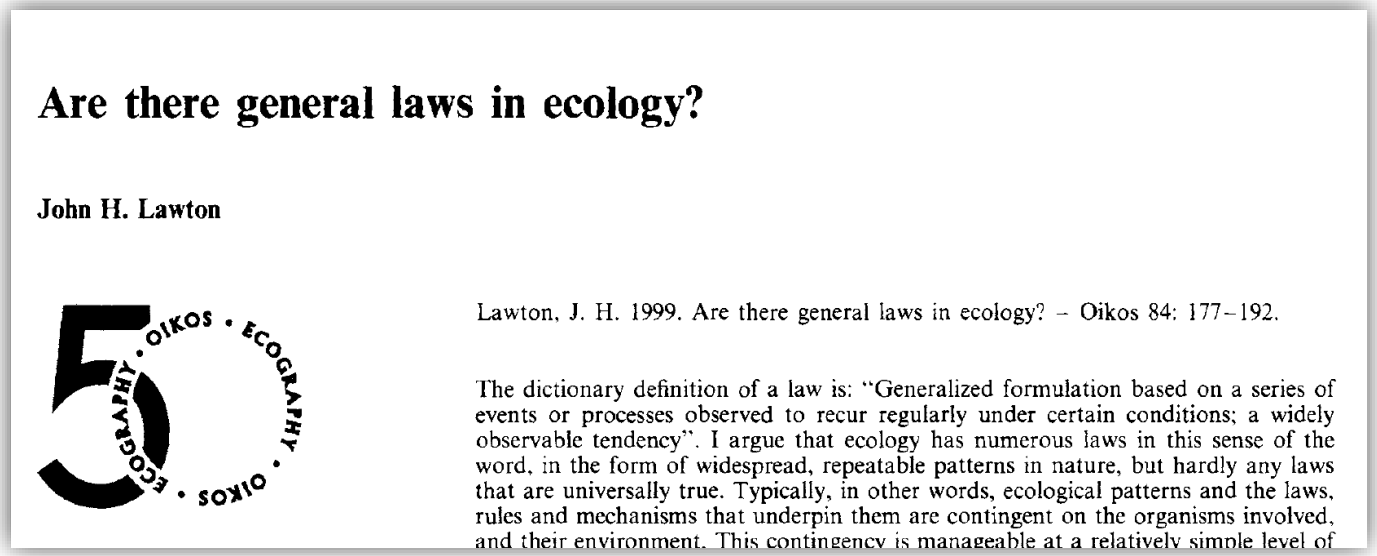

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The last two decades have experienced a proliferation of unifying theory and general conceptual frameworks in community ecology

# 1.2. What is an ecological community?

http://www.enviropedia.org.uk

Although the term ecological community has acquired disparate meanings through history…

The assemblage of at least two potentially interacting species at a given time and location

# 1.2. What is an ecological community?

In typical HMSC analyses we usually work on data on specific taxonomical groups (**taxocenes**), and often it is unclear how the species are ecologically related (**species assemblage data**)

*Plant community*

https://www.dreamstime.com/

*Fungal community*

https://www.dreamstime.com/

*Bird community*

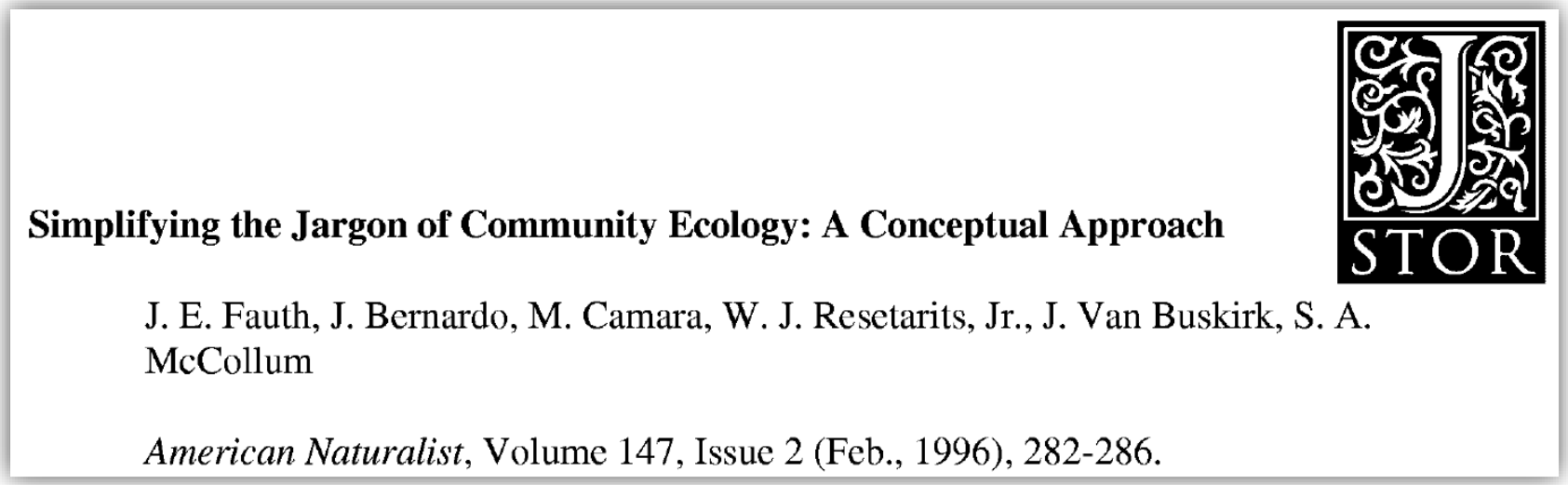
https://depositphotos.com/

# 1.2. What is an ecological community?

**Can we use the term ”ecological community”?**

In HMSC we follow the consensual definition by Fauth et al (2016):

A collection of species occurring in the same place and at the same time, the species not being necessarily restricted by phylogeny or resource use, and allowing the spatial boundaries to be either natural (e.g. islands) or arbitrary (e.g. study plots).



# 1.3. What are the prevailing theories in community ecology?

## 1.3.1. The assembly rules framework

## 1.3.2. Metacommunity Theory

## 1.3.3. Vellends theory of ecological communities

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1.3.1. The assembly rules framework

HMSC

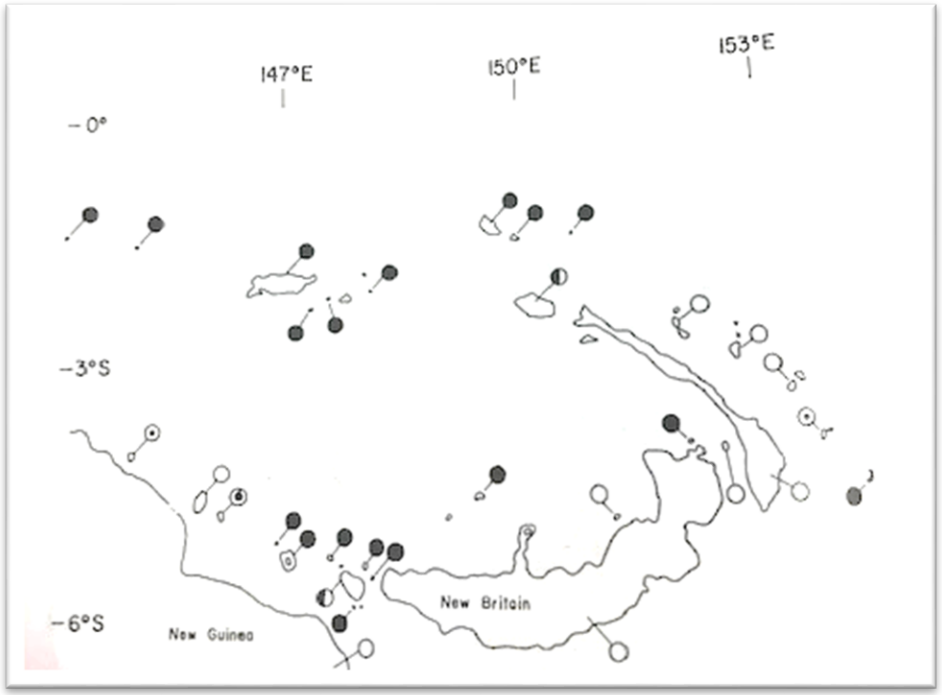
1.3.2. Metacommunity Theory

1.3.3. Vellends theory of ecological communities

# 1.3.1. The assembly rules framework

**What is an assembly rule?**

Diamond (1975) introduced the term ‘assembly rule’ to refer to the restricted species combinations to which competitive interactions can lead.




Distribution of two fruit dove species in New Guinean islands. Split circles are co-occurrences and dots are co-absences

*Fruit doves*


https://www.naturepl.com/

# 1.3.1. The assembly rules framework

**What is an assembly rule?**

After Diamond's work, the meaning of assembly rule was broadened, from competition to any ecological process favouring or disfavouring the occurrence of a species (Keddy 1992).

# 1.3.1. The assembly rules framework

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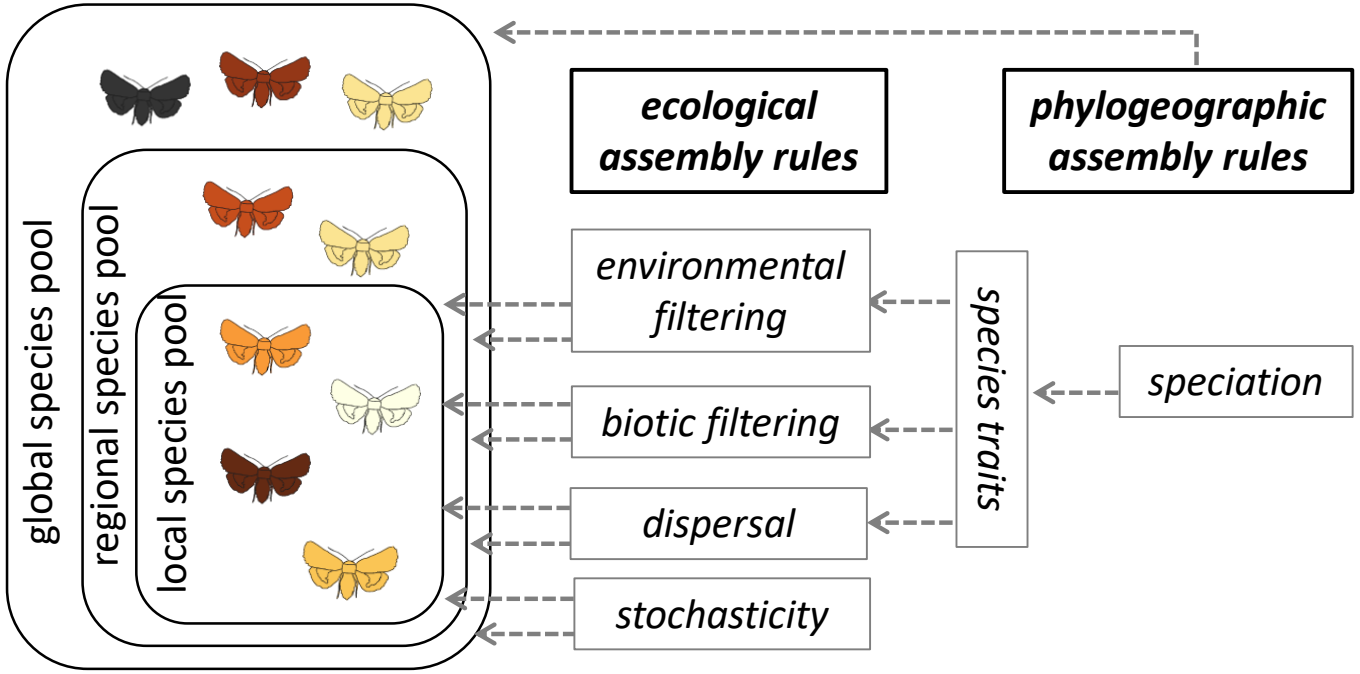
More generally than in Diamonds definition, co-occurrence of species is a product of **stochasticity**, **historical patterns** of speciation and migration, **dispersal**, **abiotic environmental factors**, and **biotic interactions**, with none of these processes being mutually exclusive.

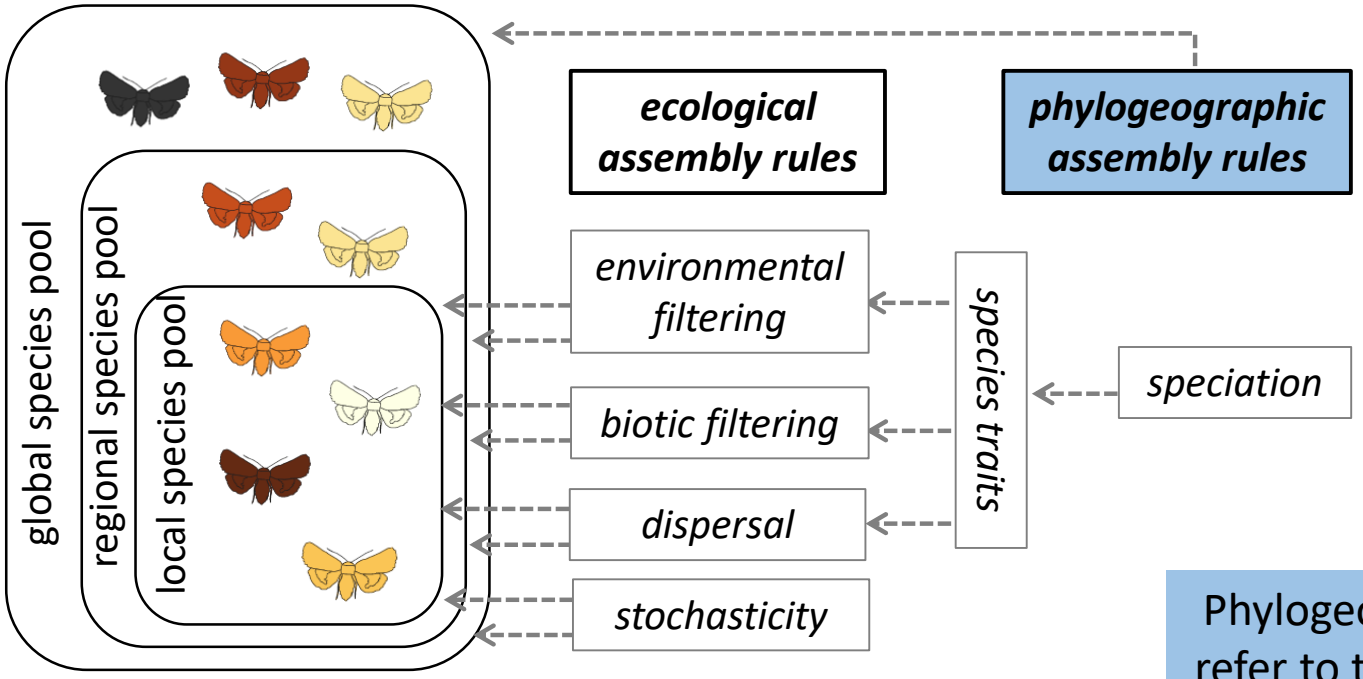
# 1.3.1. The assembly rules framework

Rather than **assembly rules**, nowadays we talk about **assembly processes**



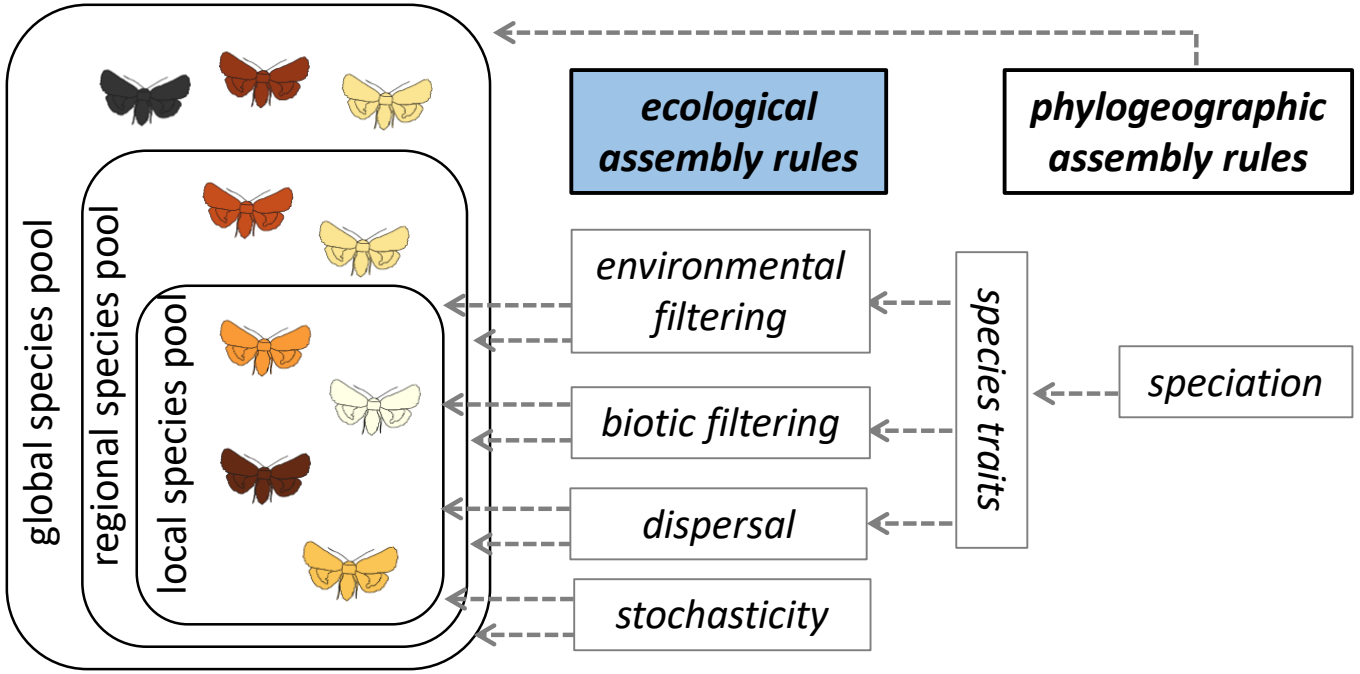

The assembly processes can be conceptually viewed as '**filters**' acting at the scales ranging from the regional species pool to increasingly finer scales until the local community composition is determined (Zobel 1997)

# 1.3.1. The assembly rules framework



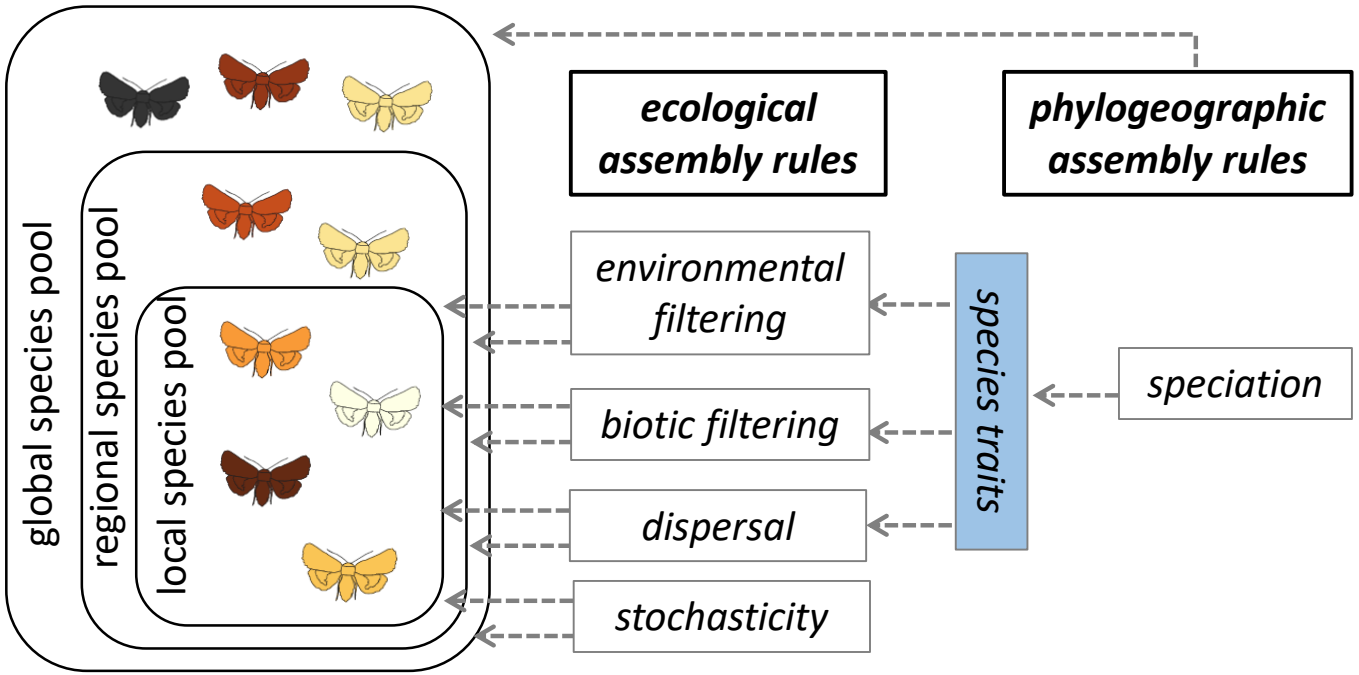

Phylogeographic assembly rules refer to the historical patterns of **speciation** and large-scale **migration**

# 1.3.1. The assembly rules framework



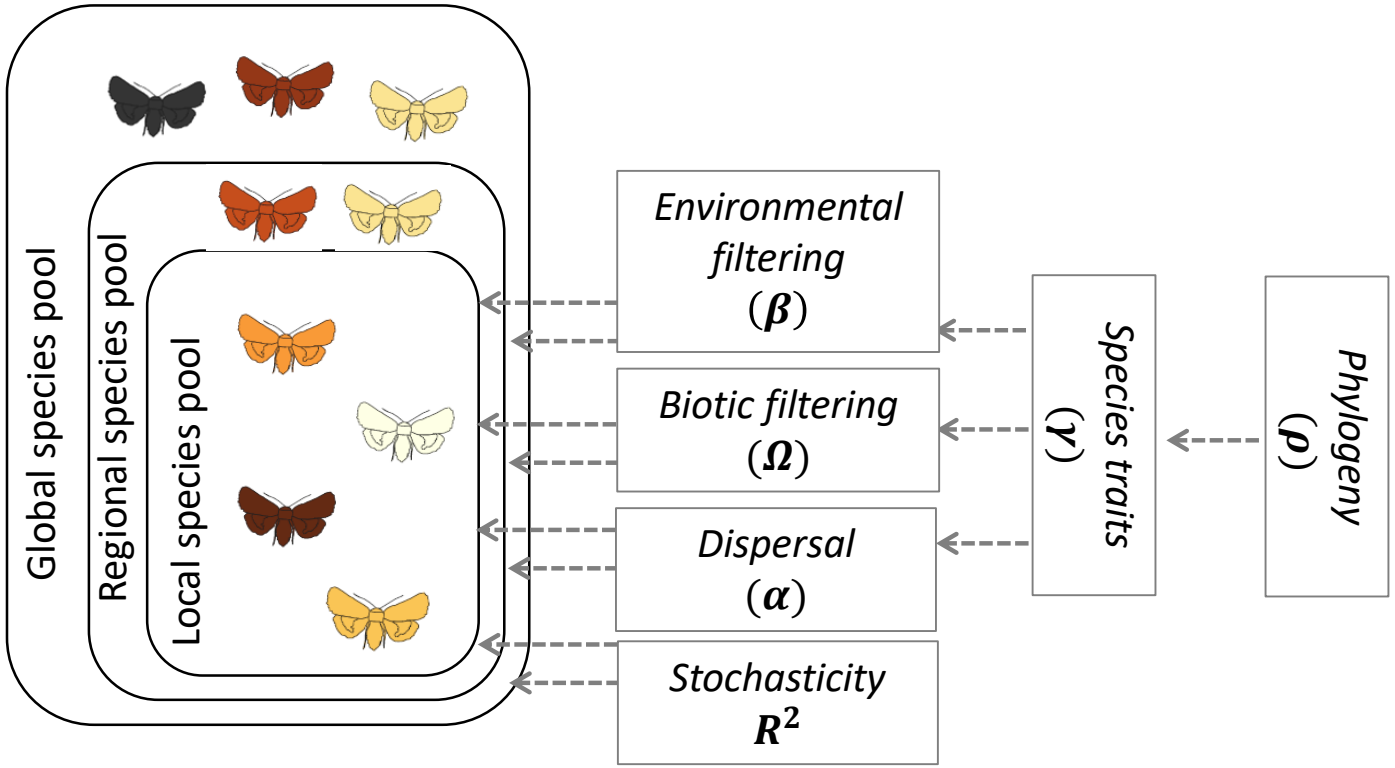

Ecological assembly rules refer to smaller-scale dispersal (**dispersal assembly rules**), the effects of the abiotic environment (**environmental filtering**), biotic interactions (**biotic filtering**) and **stochastic processes**

# 1.3.1. The assembly rules framework




Response traits influence ecological assembly processes (competitive ability, dispersal capability, resource specialization…)

# 1.3.1. How HMSC relates to the assembly rules framework



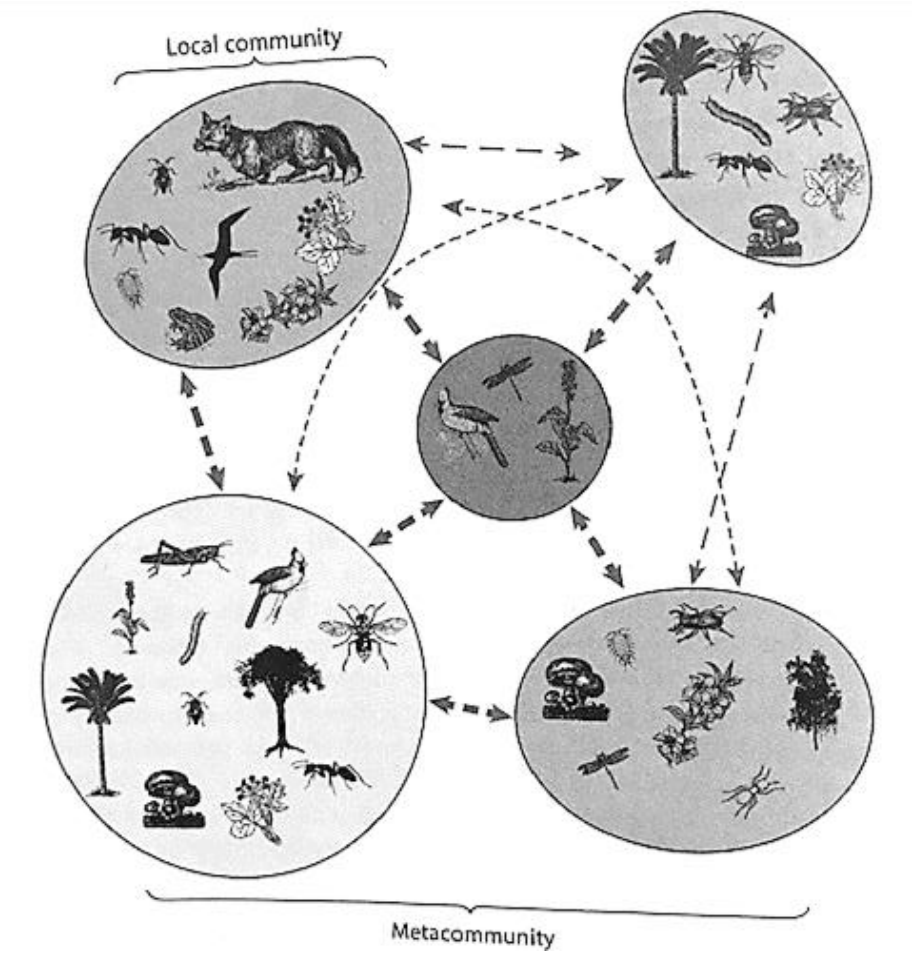

Otso Ovaskainen,[1,2]*
Gleb Tikhonov,[1] Anna Norberg,[1]
F. Guillaume Blanchet,[3,4]
Leo Duan,[5] David Dunson,[5]
Tomas Roslin[6] and
Nerea Abrego[2,7]

ECOLOGY LETTERS
*Ecology Letters*, (2017) **20**: 561–576 doi: 10.1111/ele.

How to make more out of community data? A conceptual framework and its implementation as models and software

# 1.3.2. Metacommunity Theory

Metacommunity Theory explains how networks of local communities result from the interplay of **stochastic** (e.g. demographic stochasticity) and **deterministic** (e.g. niche differentiation, competition & dispersal rate) processes **at different spatial scales**




*Leibold and Chase 2017*

*Ecology Letters*, (2004) 7: 601–613 doi: 10.1111/j.1461-0248.2004.00608.x

REVIEW

## The metacommunity concept: a framework for multi-scale community ecology

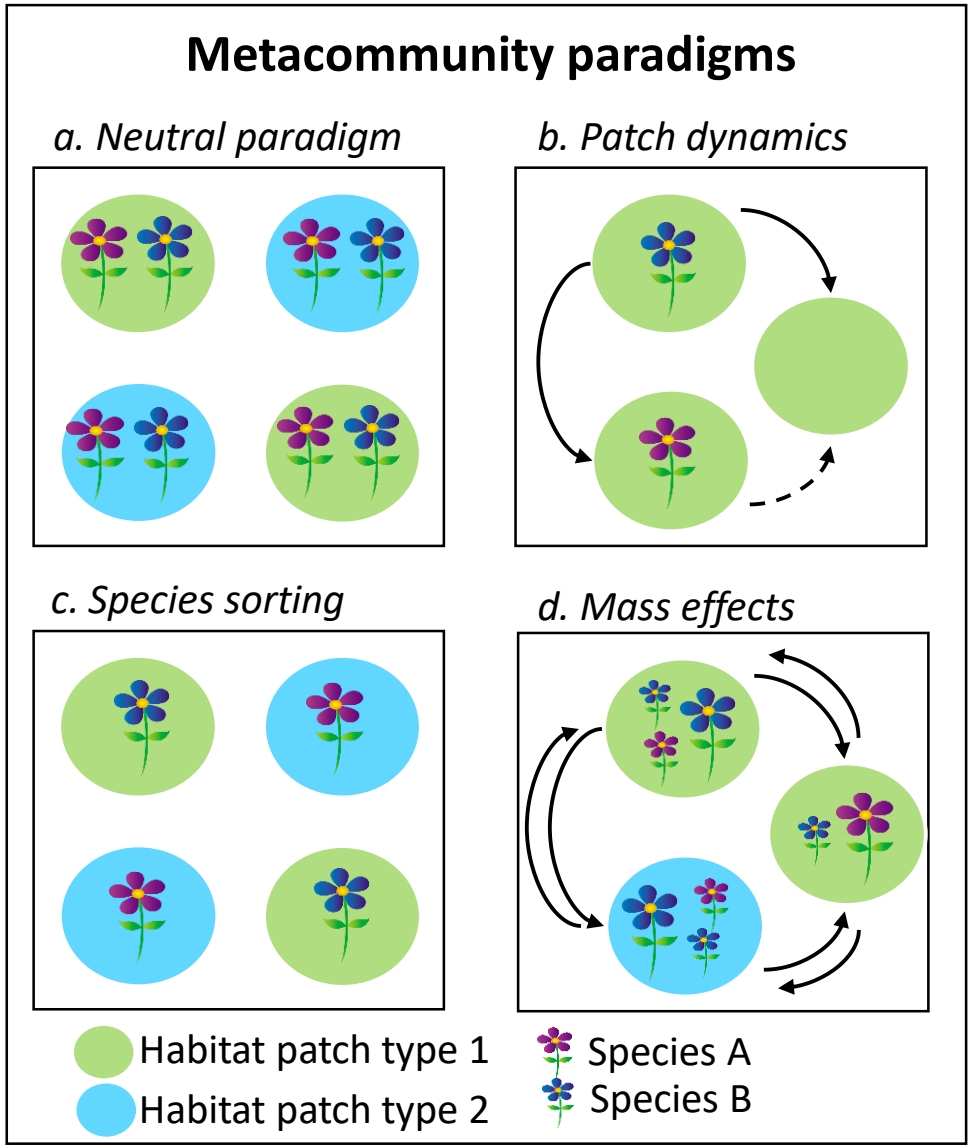
M. A. Leibold,[1]* M. Holyoak,[2] N. Mouquet,[3,4] P. Amarasekare,[5] J. M. Chase,[6] M. F. Hoopes,[7] R. D. Holt,[8] J. B. Shurin,[9] R. Law,[10] D. Tilman,[11] M. Loreau[12] and A. Gonzalez[13]

**Abstract**

The metacommunity concept is an important way to think about linkages between different spatial scales in ecology. Here we review current understanding about this concept. We first investigate issues related to its definition as a set of local communities that are linked by dispersal of multiple potentially interacting species. We then identify four paradigms for metacommunities: the patch-dynamic view, the species-sorting view, the mass effects view and the neutral view, that each emphasizes different processes of

# 1.3.2. Metacommunity Theory

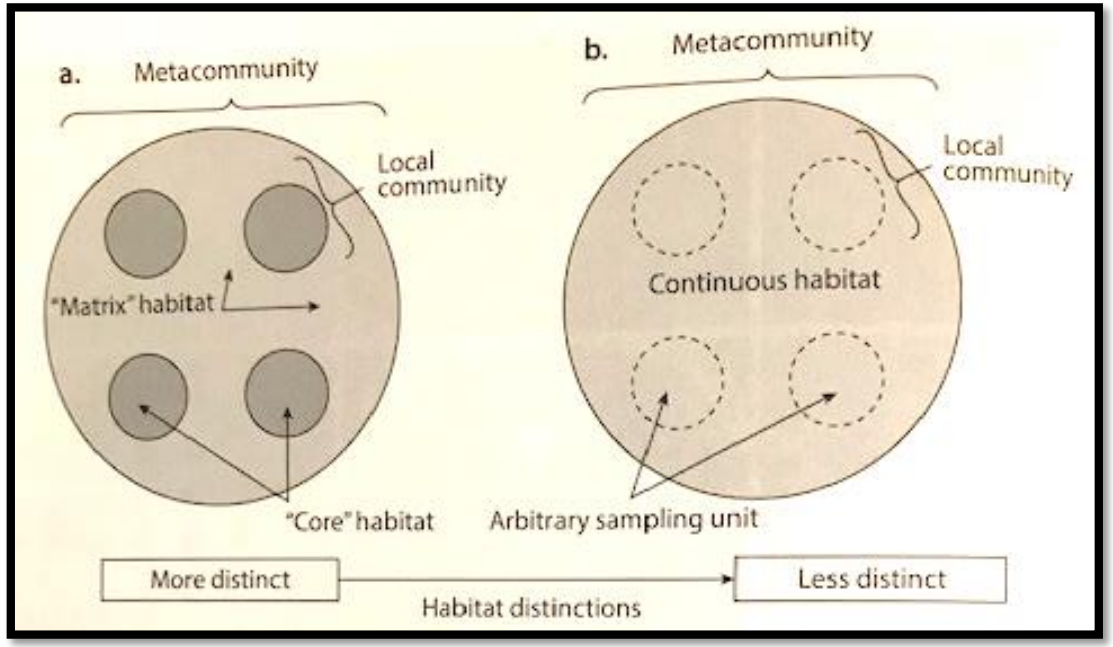
Metacommunity Theory synthesizes four **perspectives** (also called archetypes or paradigms), each arising from different – but not mutually exclusive – conceptual perspectives:



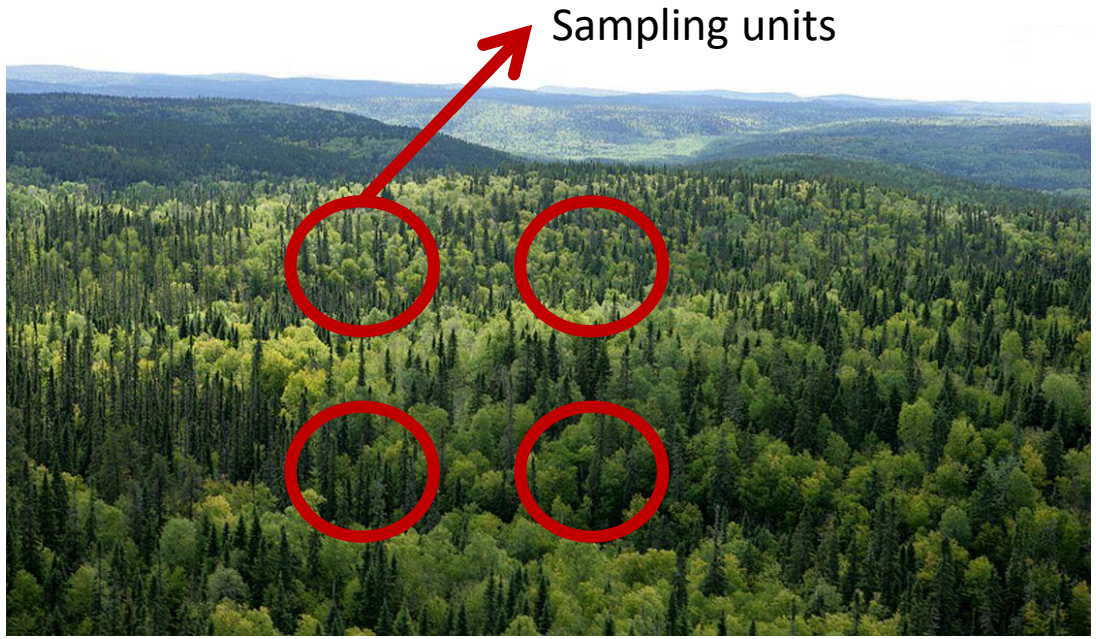
# 1.3.2. Metacommunity Theory

**Assessing the empirical communities from the metacommunity perspectives is challenging**

Habitats are often more continuous than conceptualized in Metacommunity Theory. Local communities lack of discrete boundaries




*Leibold and Chase 2017*

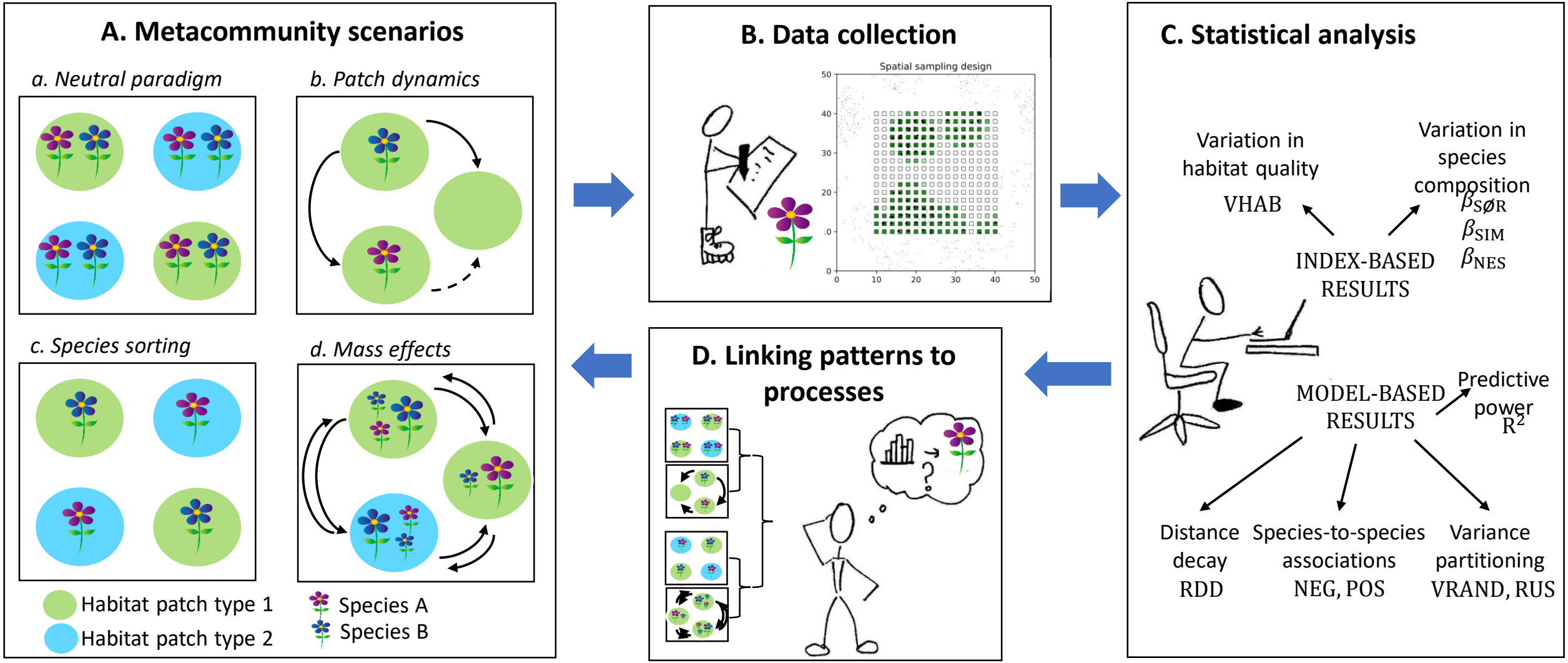


# 1.3.2. Metacommunity Theory

ECOGRAPHY

**What can observational data reveal about metacommunity processes?**

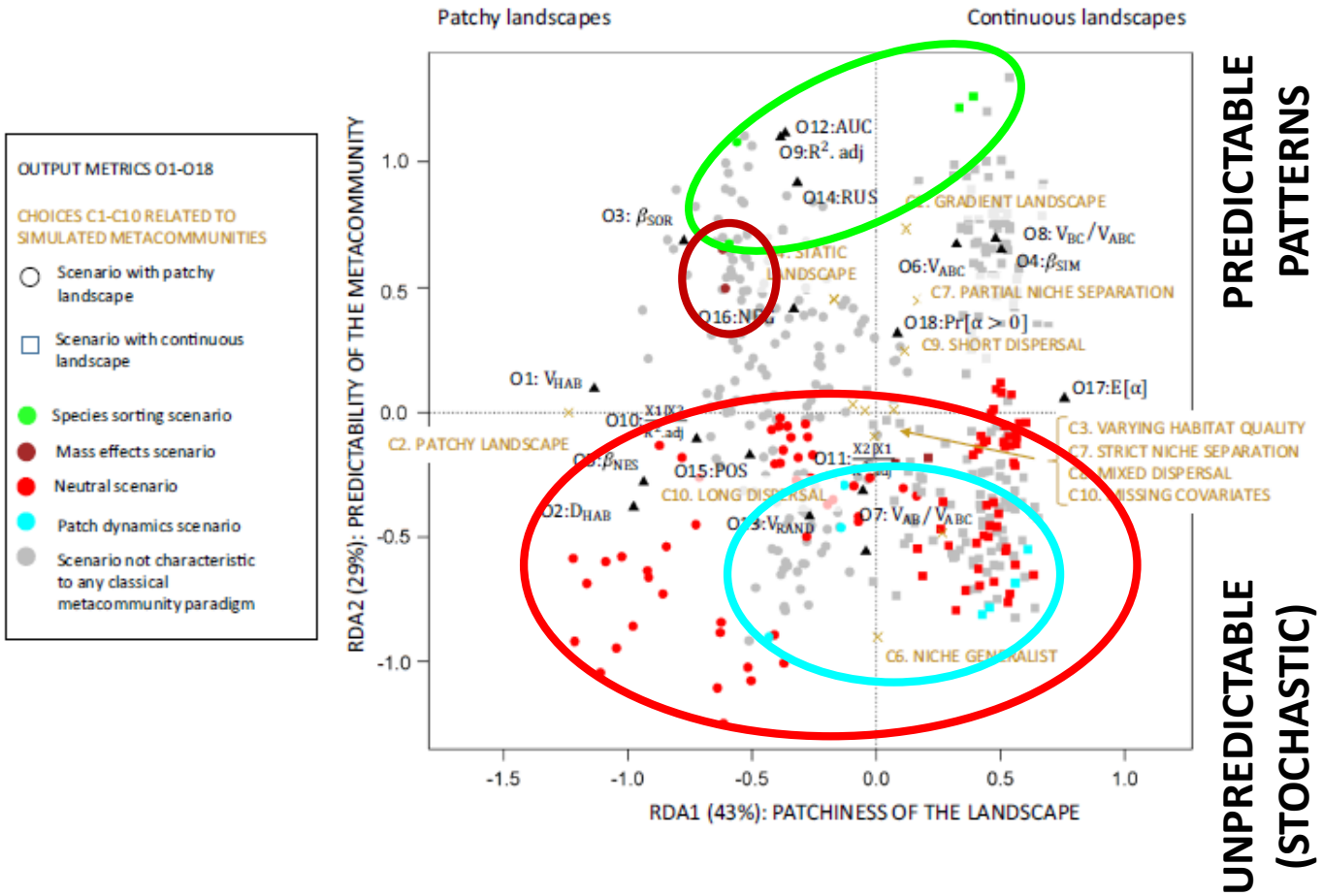
Otso Ovaskainen, Joel Rybicki and Nerea Abrego



# 1.3.2. Metacommunity Theory

## What kind of signature do the metacommunity paradigms leave?

- SPECIES SORTING
- MASS EFFECTS
- NEUTRAL
- PATCH DYNAMICS



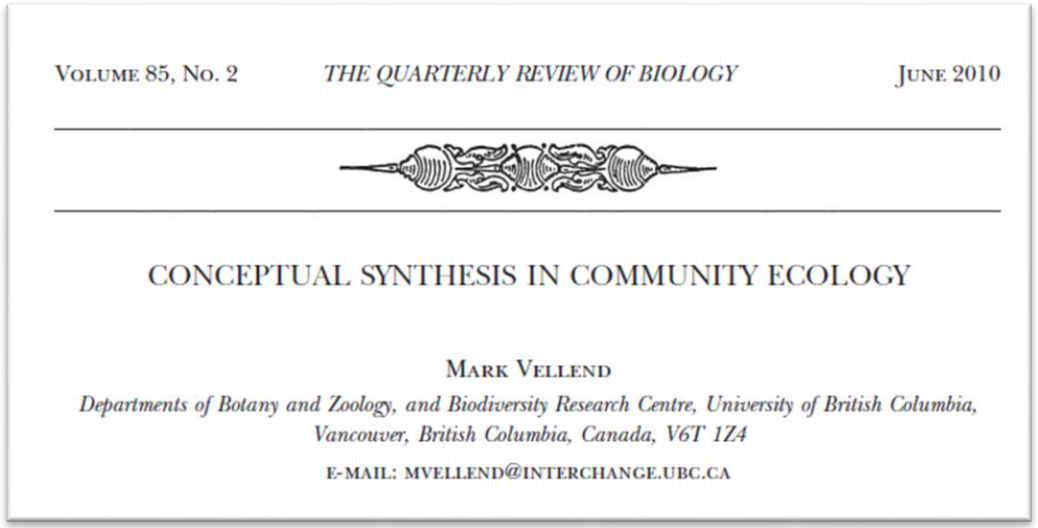

**HMSC:**

*Predictive power through cross validation ($R^2$)*

*The match between environmental conditions and species occurrences ($\beta$)*

# 1.3.3. Vellends theory of ecological communities

Vellend proposed that all processes can be synthesized into **four "high-level" processes**



VOLUME 85, No. 2 *THE QUARTERLY REVIEW OF BIOLOGY* JUNE 2010

CONCEPTUAL SYNTHESIS IN COMMUNITY ECOLOGY

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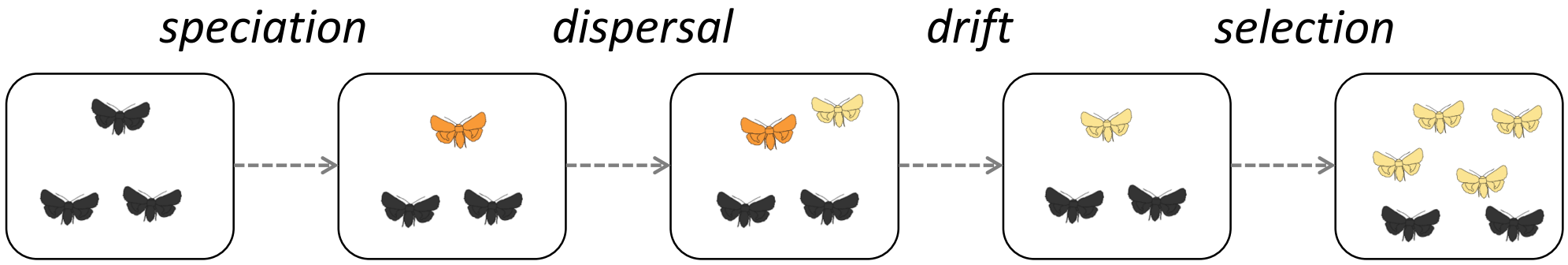

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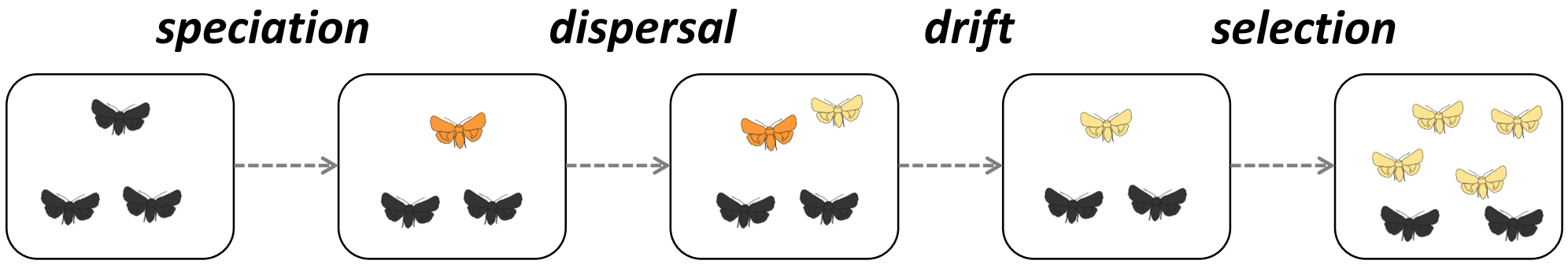


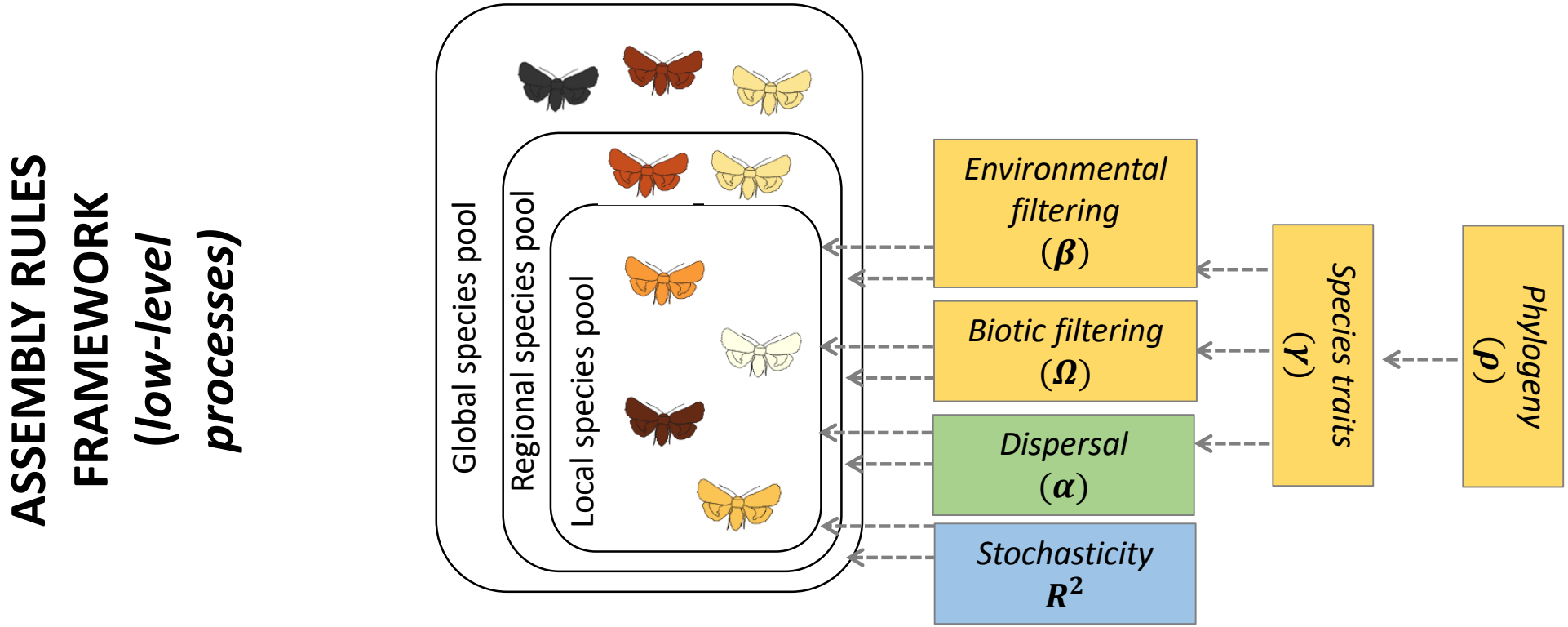

Creation of new species through evolutionary processes

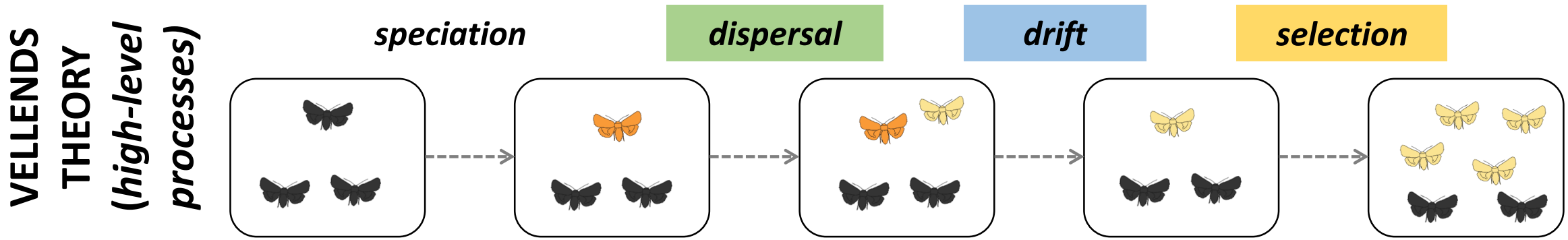
Movement of organisms in space

Stochastic changes in the occurrence and abundance of species

Processes creating deterministic fitness differences among individuals of different species

# 1.3.3. Vellends theory of ecological communities



# Lecture 2

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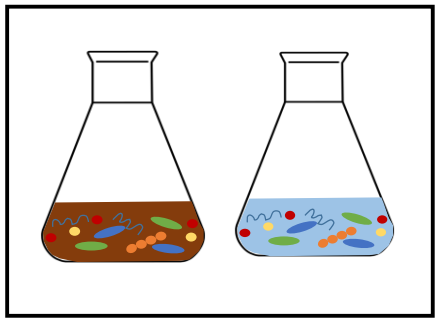
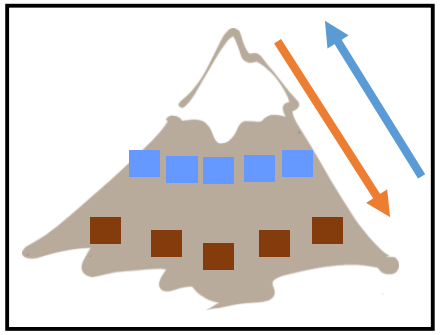
## Part 2. Typical data collected in community ecology: What kind of data does HMSC take as input?

# 2. Typical data collected in community ecology

- Lab experiments

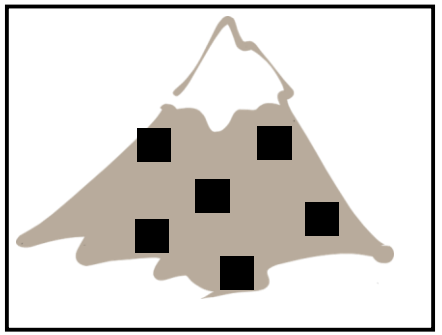


- Field experiments



**Manipulative observational studies**

- Field observations



**Non-Manipulative observational studies**

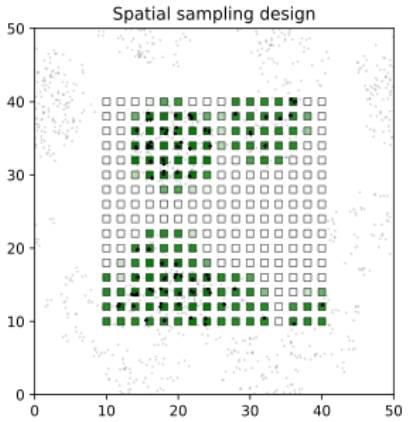
# 2. Typical data collected in community ecology

Non-manipulative observational are the most common type of data in community ecology.

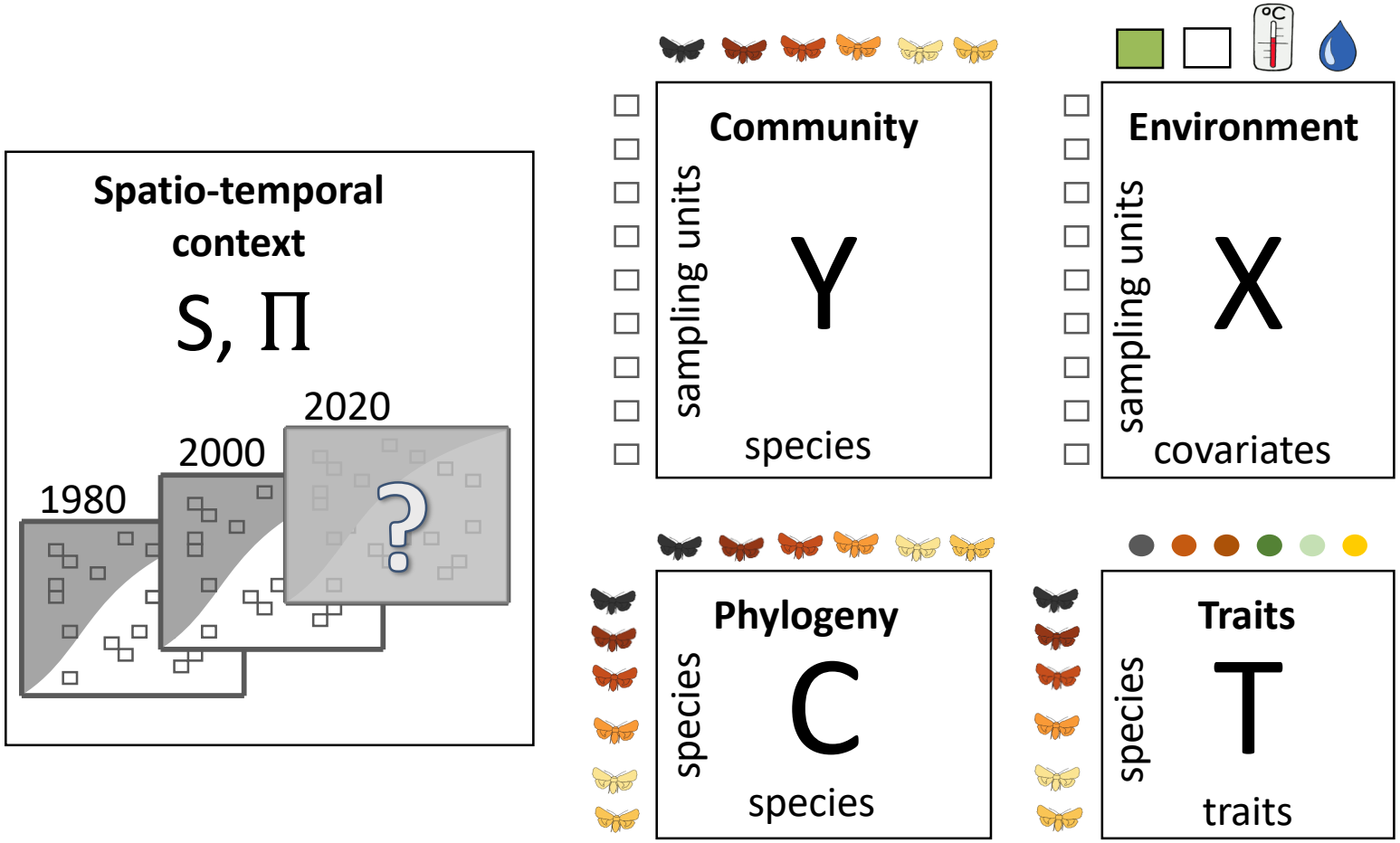
These data are shaped by the full complexity of assembly processes.

However, because the processes cannot be observed directly it is difficult to causally link the observed patterns to the underlying processes.

**Data collection**



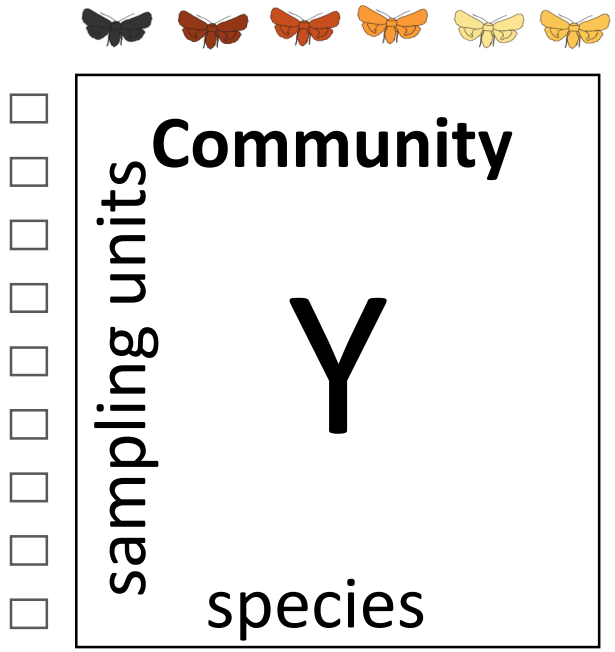
# 2. Typical data collected in community ecology



# 2. Typical data collected in community ecology – The community data

By community data we refer to data about species occurrence or abundance in a set of temporal and/or spatial replicates (**sampling units**).

Depending on the objectives of the study and subject organisms, community ecologists record community data in various ways



# 2. Typical data collected in community ecology – The community data

**Direct** species observations:

When species are recorded through direct observations

**Indirect** species observations

When species are recorded through indirect cues

# 2. Typical data collected in community ecology – The community data

**Direct** species observations:

For example vascular plants, insects, lichens… are usually recorded by direct observations

Sound recordings for birds and frogs or camera trapping for mammals are also a type of direct observation


https://en.wikipedia.org


http://www.countrysideinfo.co.uk/hpr_survey_00/methods.htm

# 2. Typical data collected in community ecology – The community data

**Indirect** species observations:

Mammals are often recorded using indirect cues such as tracks and droppings

DNA-based molecular identification of environmental samples is also an indirect way of recording species

***Mammal tracks***

http://www.naturetracking.com/mammal-tracks/

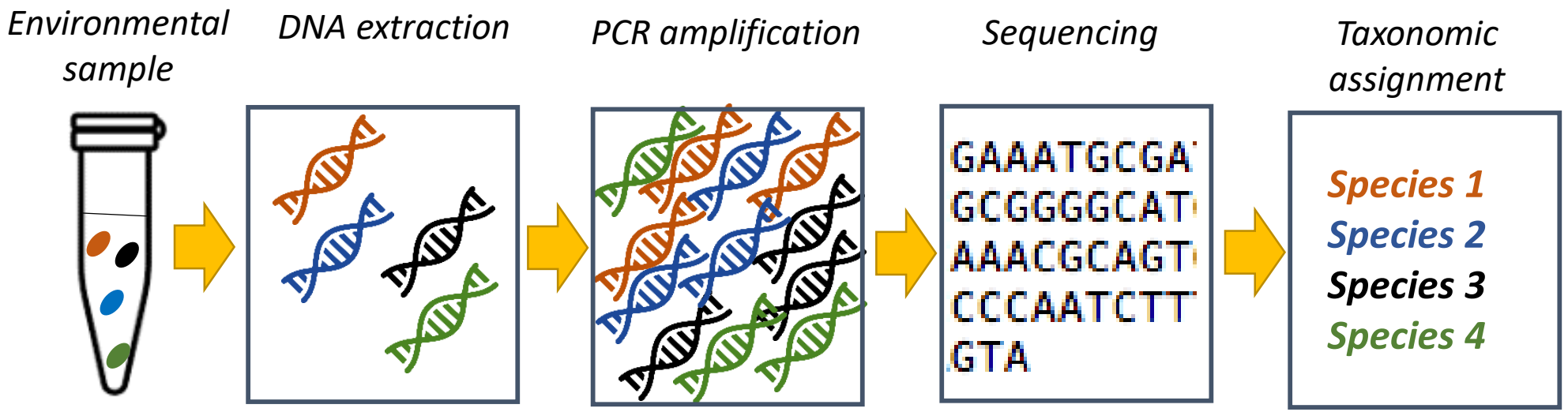
***Soil sampling for latter eDNA analyses targetting soil biota (fungi, bacteria, microarthropods)***

https://www.winfieldunited.com/

# 2. Typical data collected in community ecology – The community data

**Metabarcoding** approaches applied to environmental samples (eDNA approaches) are becoming increasingly used in community ecology.

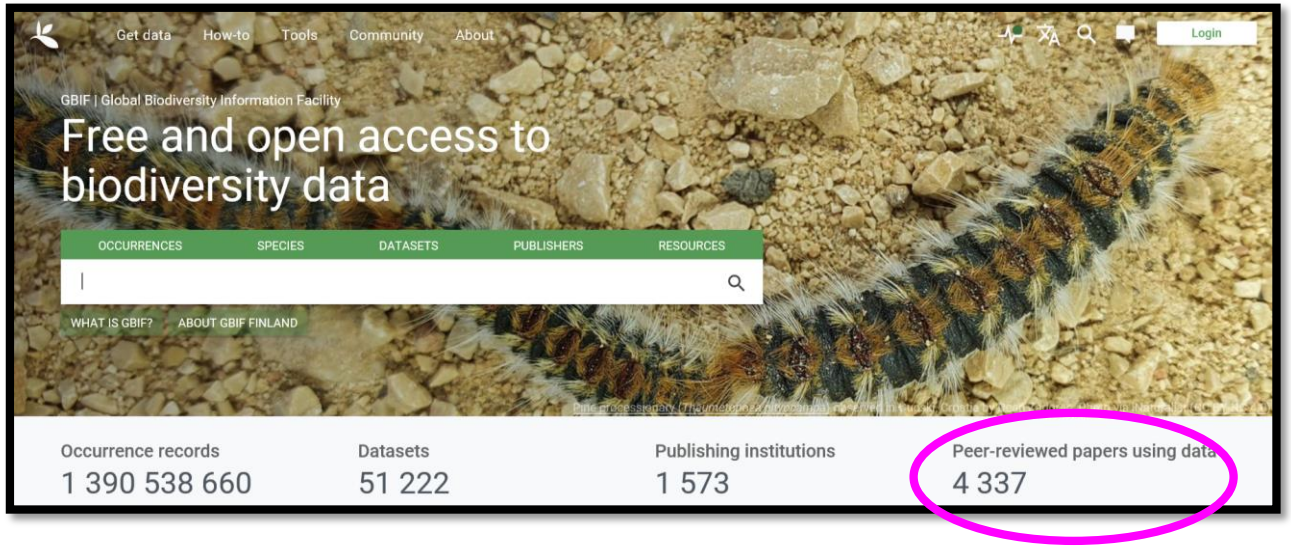
This is done by amplifying and sequencing **barcode gene regions** (ITS region for fungi, COI region for animals…).



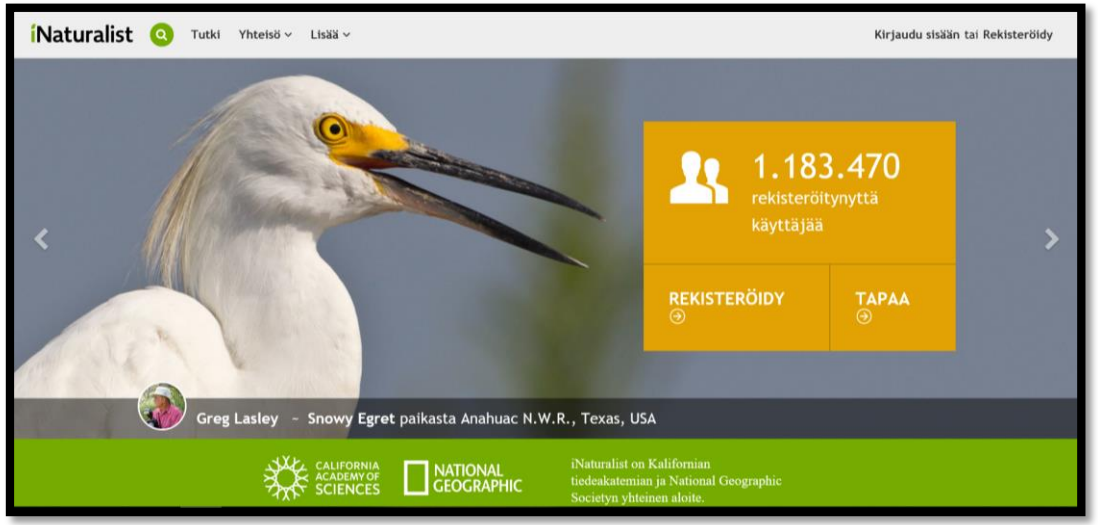
# 2. Typical data collected in community ecology – The community data

Data originating from databases compiling many sources are also becoming increasingly used

**Global Biodiversity Information Facility (GBIF)**




**iNaturalist**



# 2. Typical data collected in community ecology – The community data

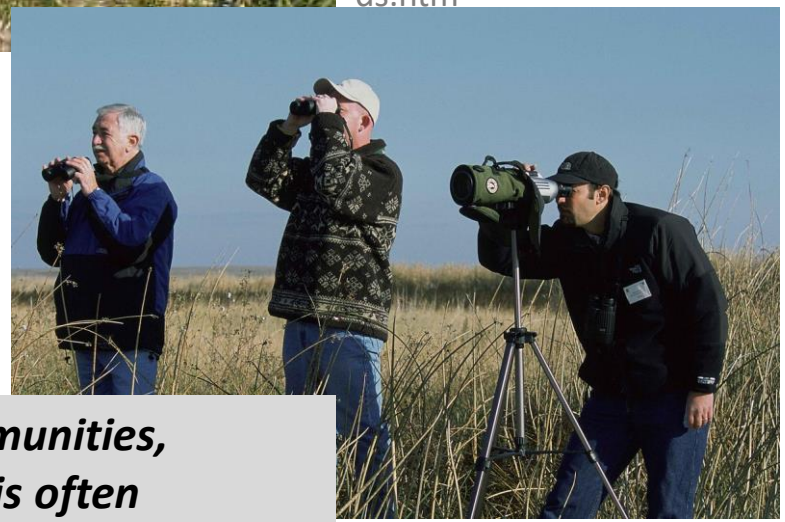
Species can be measured in many ways:

- Presence/absence
- Abundance (percentage cover, counts of individuals, biomass)

***In plant communities, abundance is often measured using percentage cover or biomass***

http://www.countrysideinfo.co.uk/hpr_survey_00/methods.htm

***In fungal communities, it is challenging to quantify the abundance of the species based on fruit bodies and thus presence-absence data is usually recorded***



***In bird communities, abundance is often measured by counting the number of individuals***

https://en.wikipedia.org/

# 2. Typical data collected in community ecology – The community data

***Imperfect detection***

**False negatives:** When due to too little sampling effort not all species and individuals are recorded in the sampling units → Typical in direct surveys

**False positives:** When errors such as misidentifications introduce data on species/individuals that are not present → Typical in DNA-based surveys

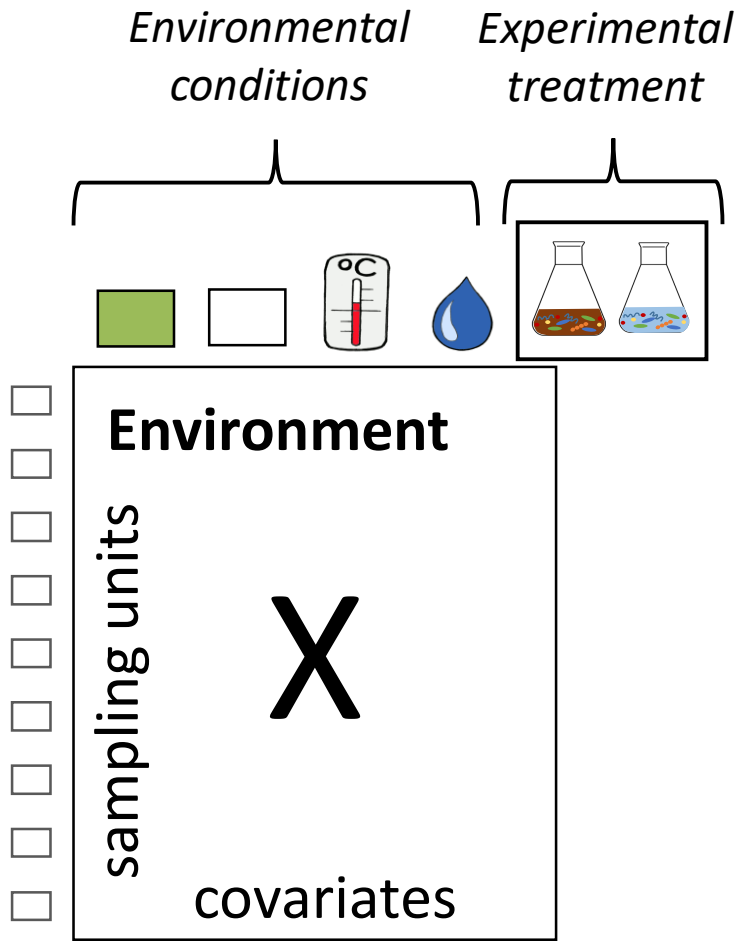
***Biased sampling effort***

→ Data originating from databases compiling many sources are spatially biased toward where people live or most accessible places and taxonomically biased toward charismatic species

# 2. Typical data collected in community ecology – The environmental data

By environmental data we refer to data about the environmental conditions in the set of temporal and/or spatial replicates (**sampling units**) where the community data has been recorded.

The environmental data that are recorded are those that the ecologists hypothesizes to be important for the species/community under study



# 2. Typical data collected in community ecology – The environmental data

Environmental data can be measured directly or indirectly.

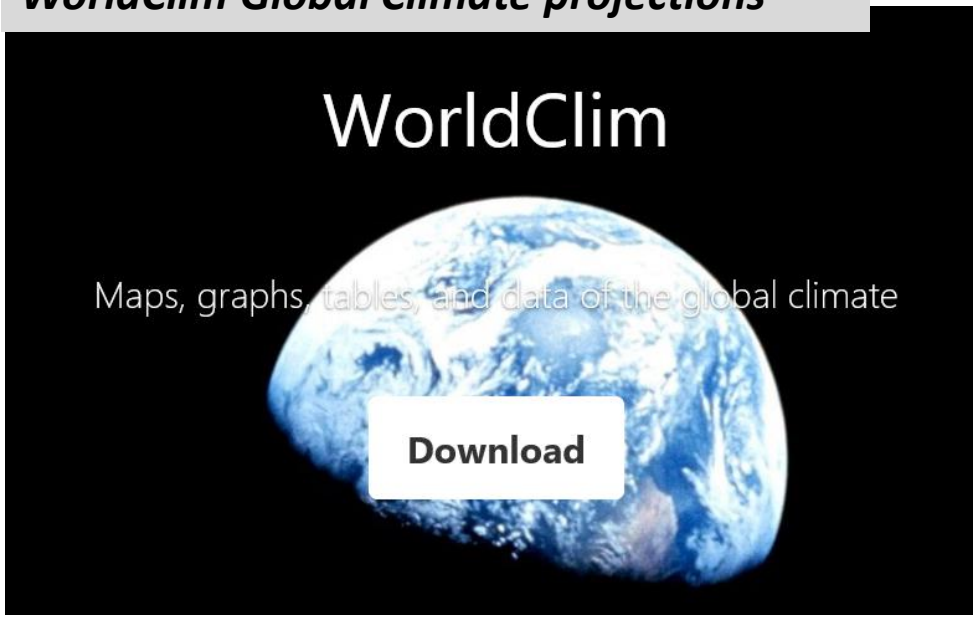
Small-scale environmental conditions (e.g. microclimate, soil nutrient content) are usually measured directly

Large-scale environmental conditions (e.g. macroclimate) are often measured from projected data

***Temperature data logger***

https://fi.vwr.com/

***WorldClim Global Climate projections***

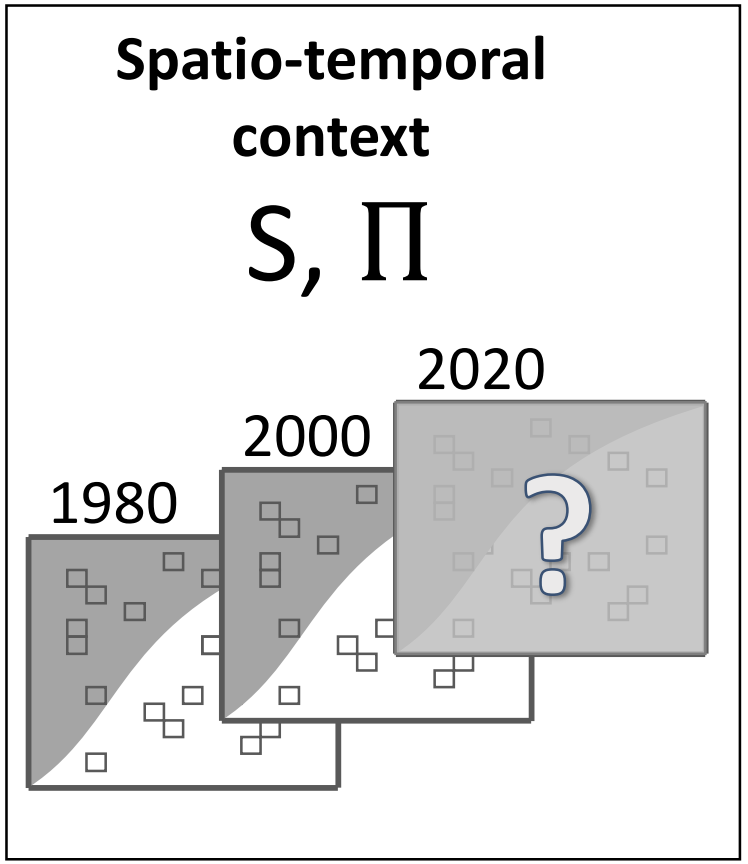


# 2. Typical data collected in community ecology – The spatio-temporal context

The spatial and temporal scales are recorded along with the community data:

**Temporal studies:**
Day/month/year of sampling

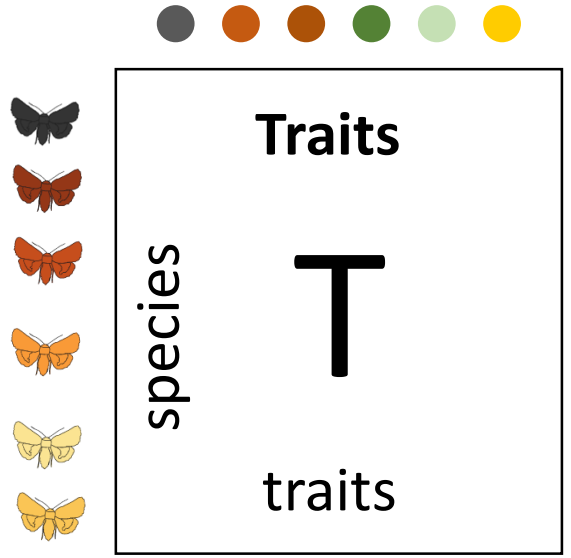
**Spatial studies:**
Plot/site identity
Latitude and longitude coordinates



# 2. Typical data collected in community ecology – The trait data

When the aim is to understand how species' traits influence assembly processes, one can include species-level traits

The traits that are measured are those that the ecologist hypothesizes to influence species responses (called **response traits)**



# 2. Typical data collected in community ecology – The trait data

Traits can be measured directly in the field, or indirectly from existing data sources such as databases or published literature.

***Open Traits Network***

https://opentraits.org/

***Bird body-size measurement***

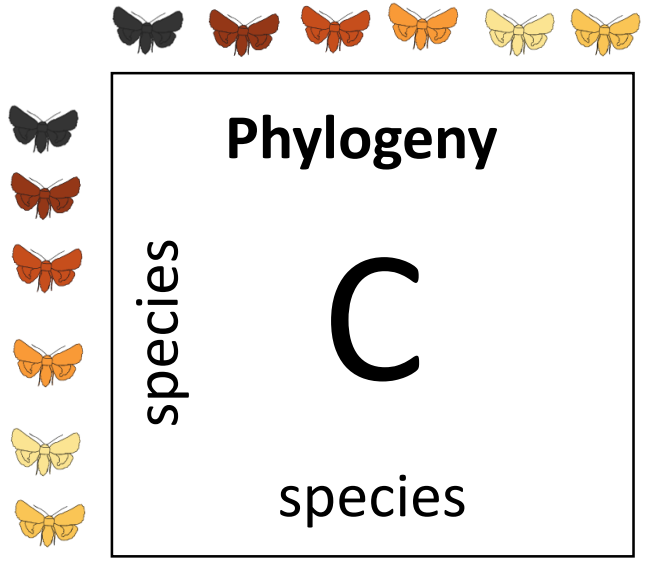
https://news.cgtn.com/

***Leaf area measurement***

https://www.tactivity.in/

# 2. Typical data collected in community ecology – The phylogeny data

When the aim of the study is to understand how phylogenetic relationships affect species' responses to the environment, one can include phylogenetic data

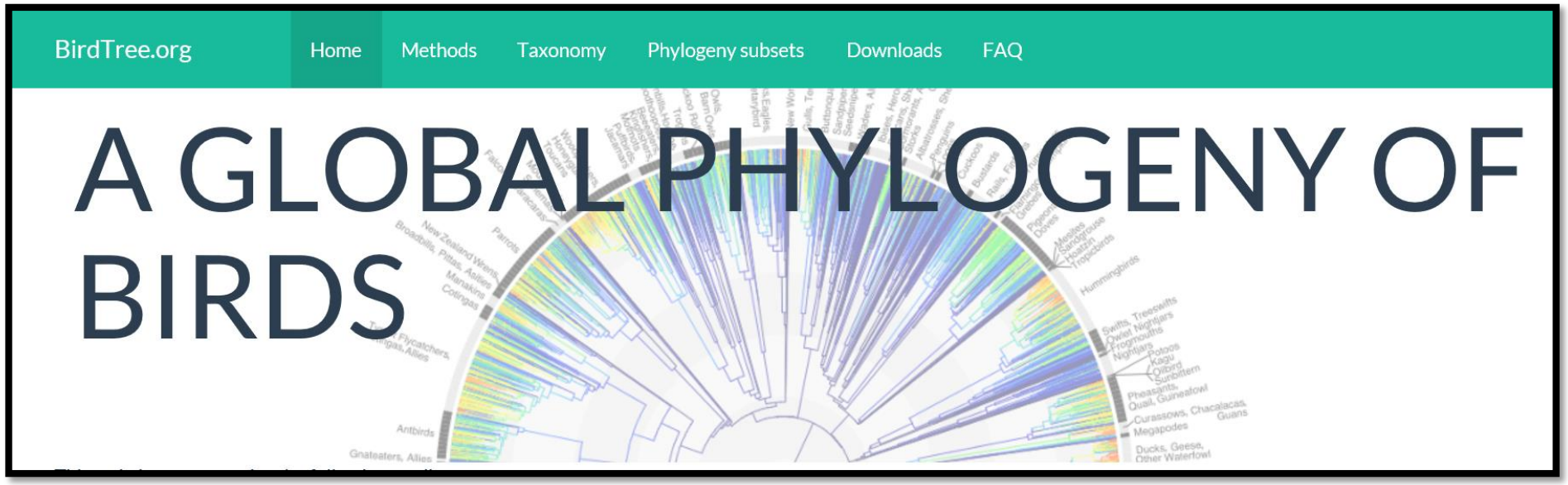


# 2. Typical data collected in community ecology – The phylogeny data

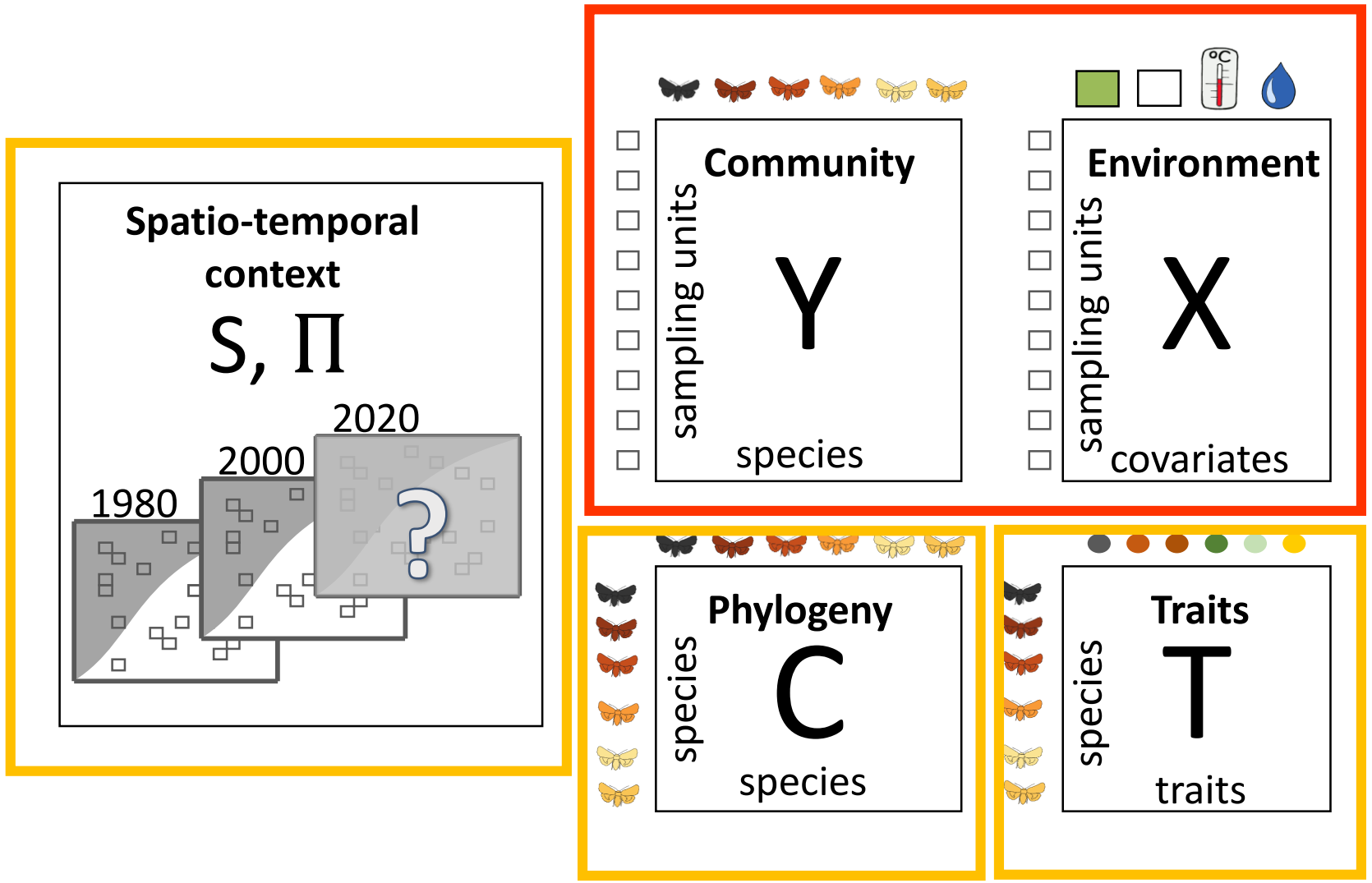
The phylogeny is not usually measured directly, but compiled from existing data.

When quantitative phylogenetic data is not available for the subject community, taxonomic trees may used as a proxy of phylogeny.

***BirdTree: Phylogeny of birds***



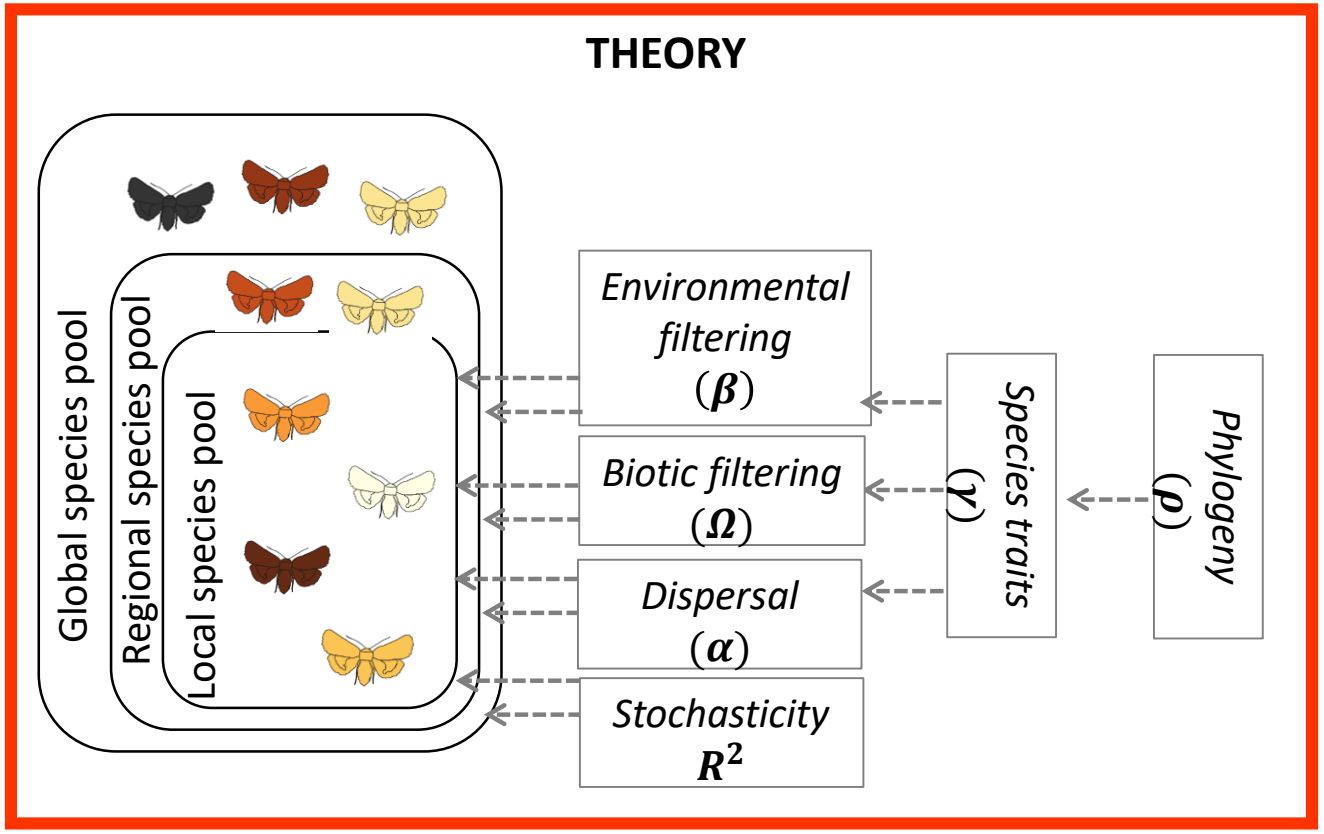
# 2. Typical data collected in community ecology

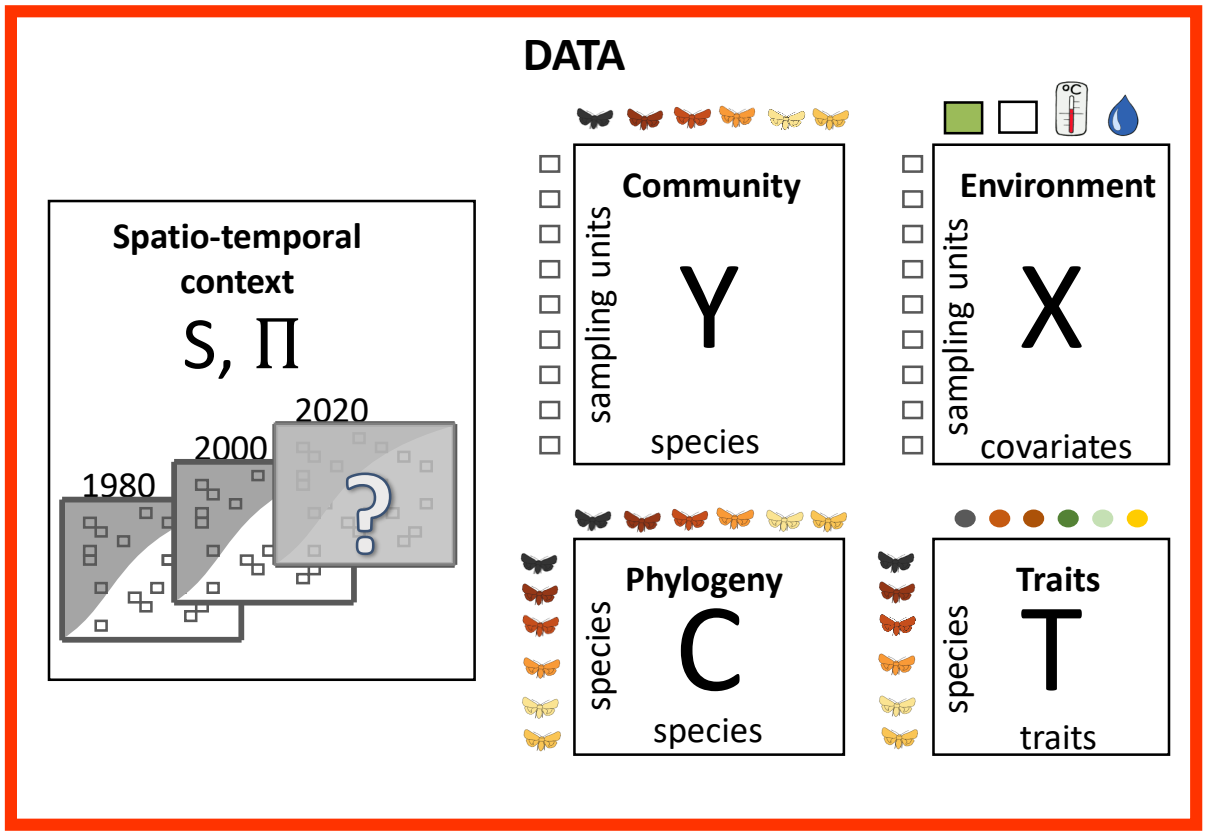


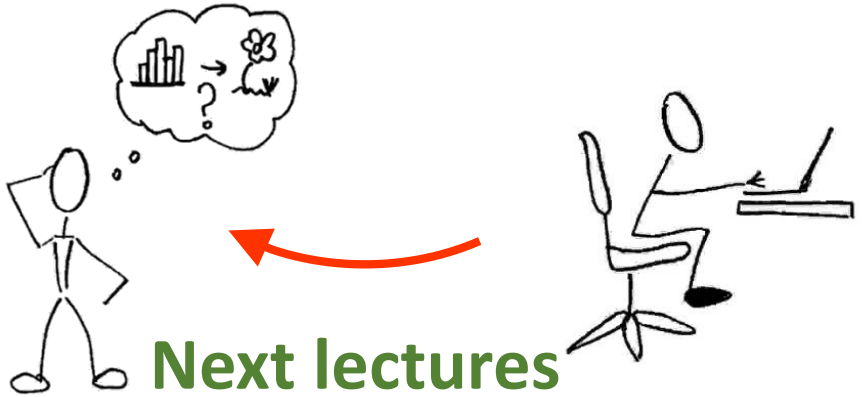

HMSC basic input data

HMSC optional input data

# Lecture 2



Next lectures