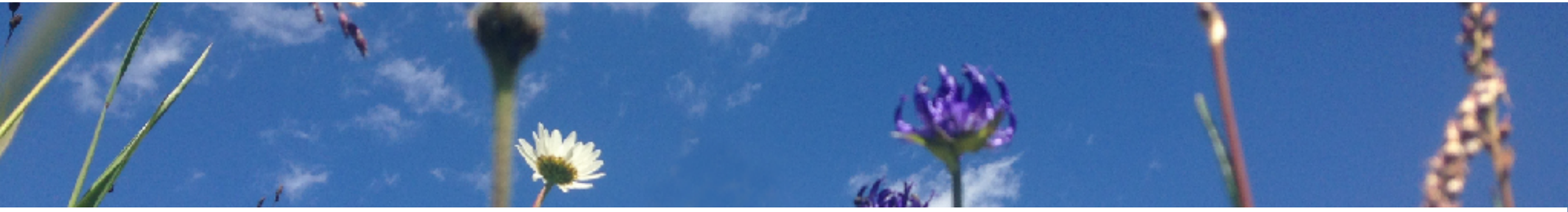
COMMUNITY ASSEMBLY & THE FUNCTIONING OF ECOSYSTEMS

Emma Ladouceur

Modelling species distributions and biodiversity patterns



iDiv

January 26, 2022

GOOD MORNING!

TODAY

- Ecosystem Function
- Forms groups & Debate
- Learn about ecosystem function experiments
- Work with Ecosystem Function Data in R
- Receive Project topics and Options

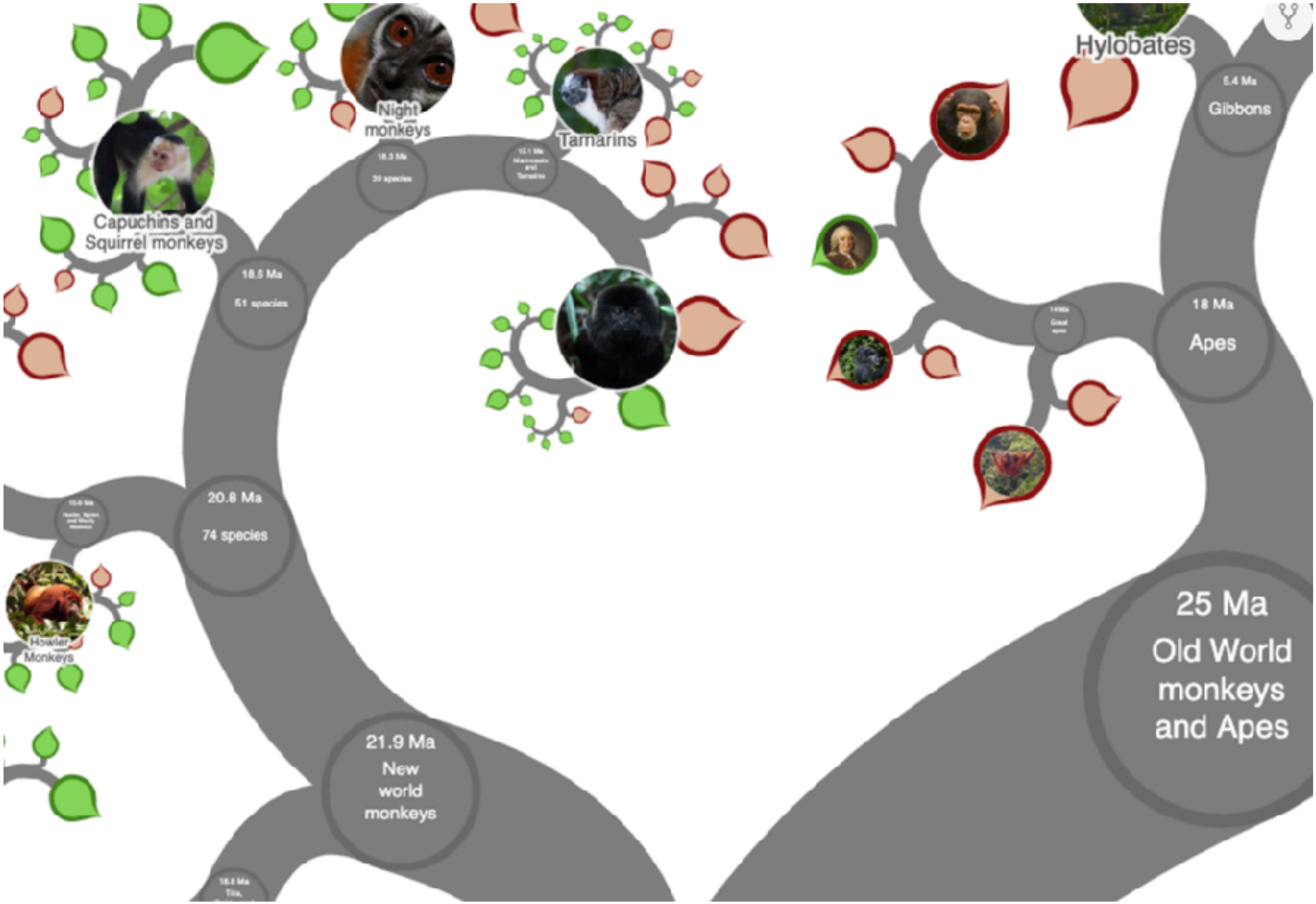
“

In nature nothing exists alone.

-Rachel Carson, Silent Spring

LET'S START AT THE BEGINNING: SPECIES

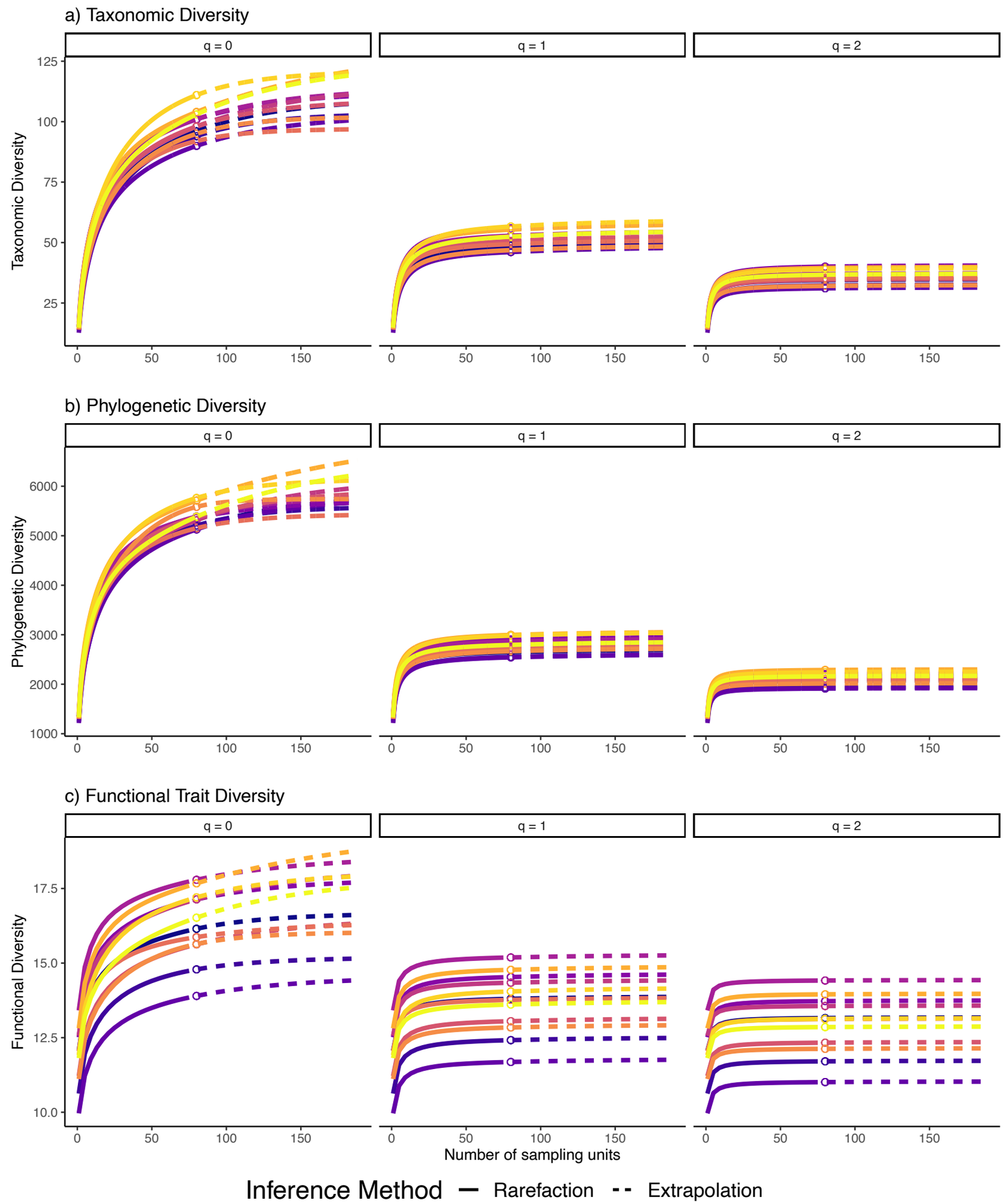
WHERE DO WE BELONG?



Encyclopedia of Life

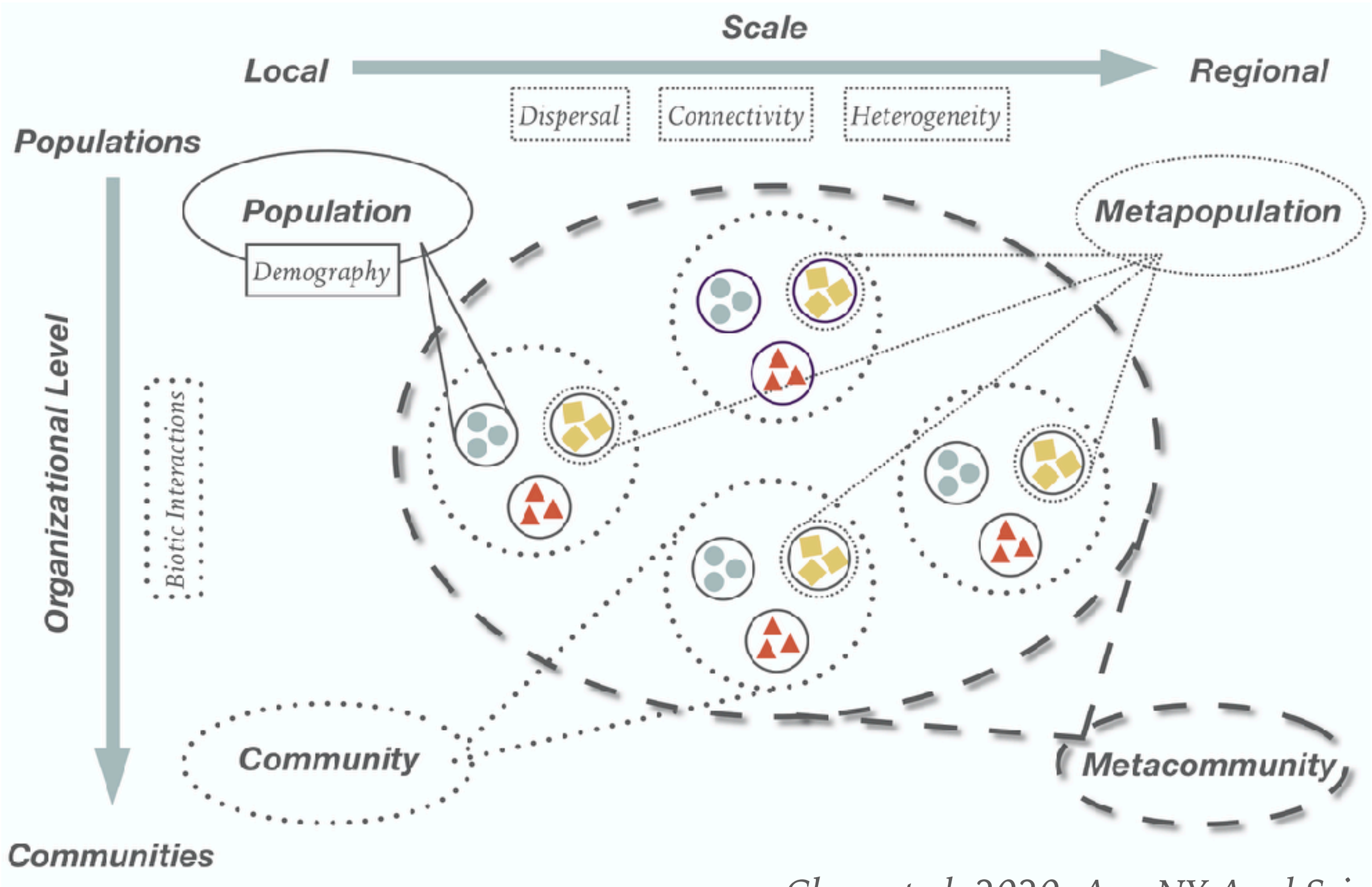
SO NOW WE KNOW…

MANY WAYS TO THINK ABOUT & MEASURE SPECIES DIVERSITY



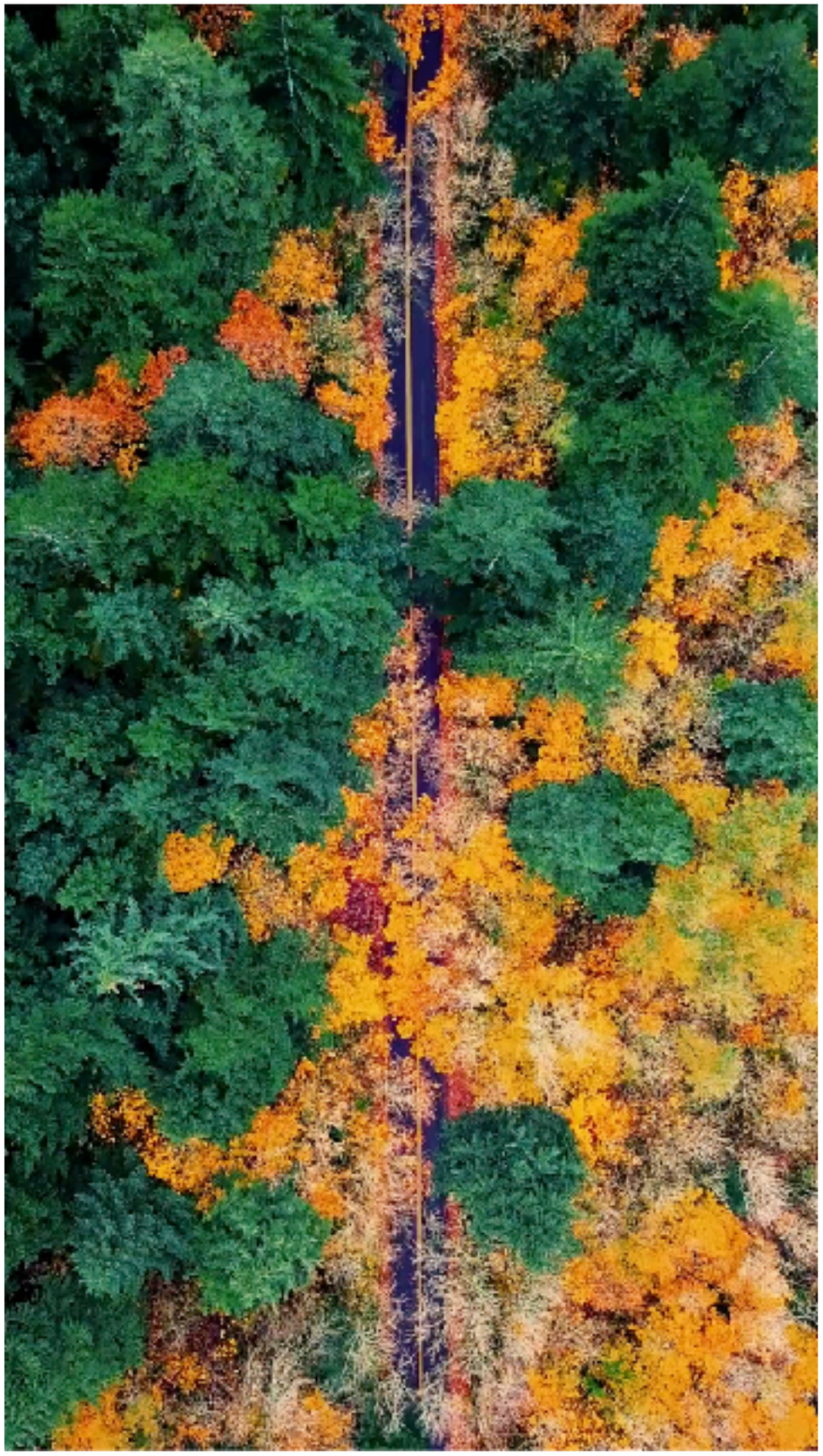
Ladouceur et al. In Prep

AND THESE FACETS AND SCALES ARE INTERACTING



Chase et al. 2020, Ann NY Acad Sci

MAKING UP FUNCTIONING COMMUNITIES -> ECOSYSTEMS



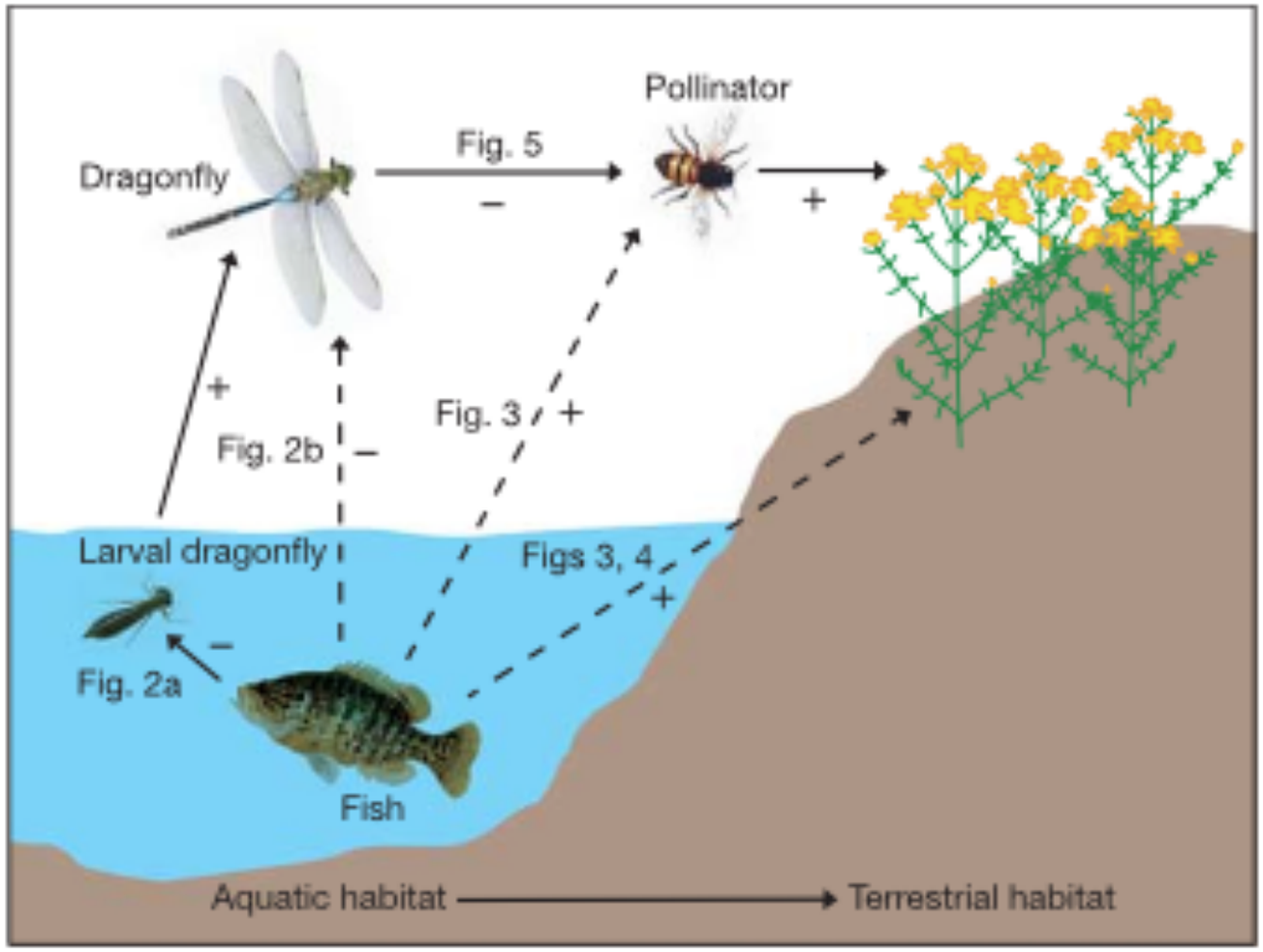


Figure 1 | Interaction web showing the pathway by which fish facilitate plant reproduction. Solid arrows indicate direct interactions; dashed arrows denote indirect interactions. The sign refers to the expected direction of the direct or indirect effect (see the text). Figure numbers indicate which figure presents data supporting each of the predicted effects. (Figure created by S. White and C. Stierwalt.)

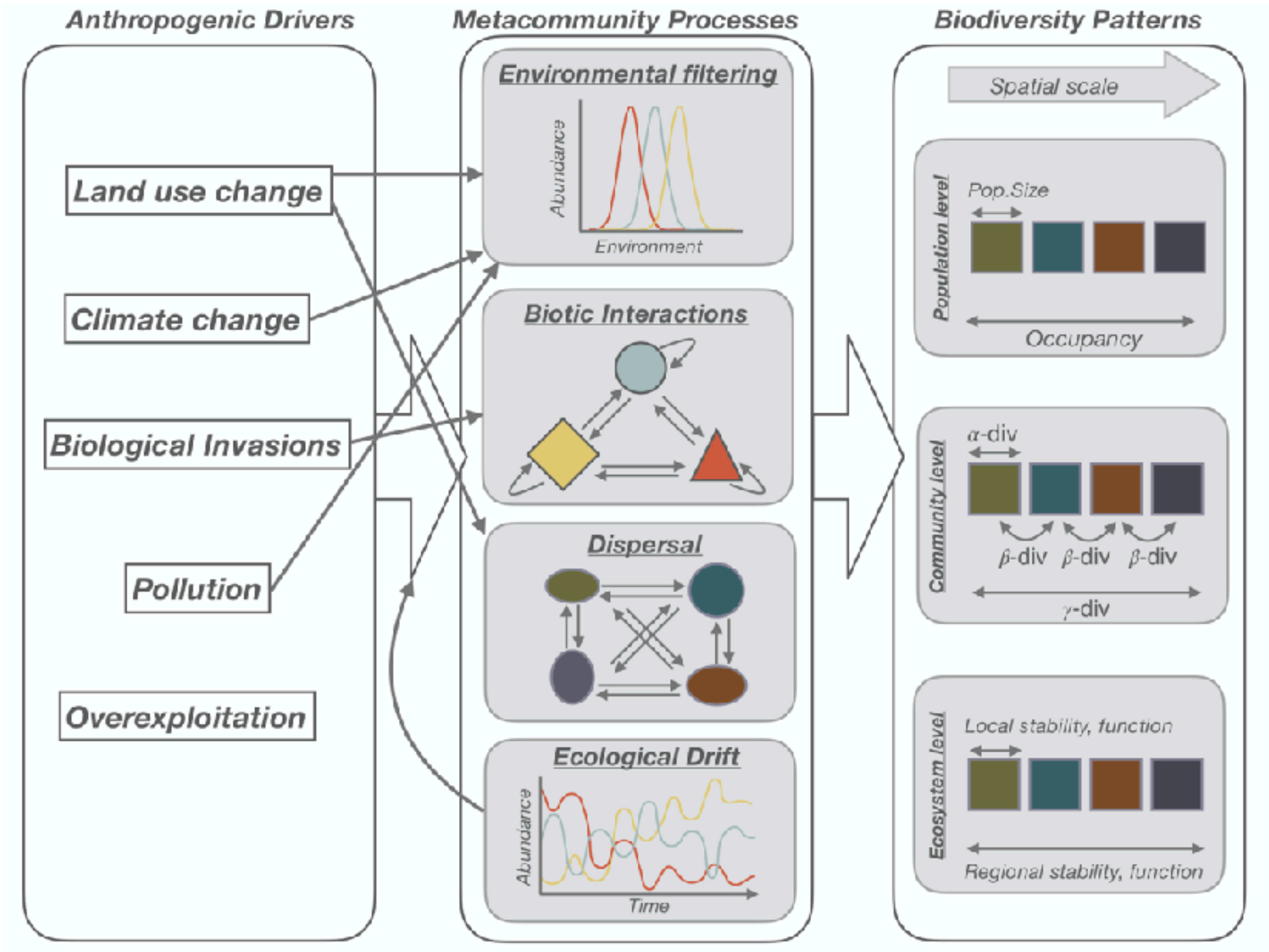
Knight et al. 2005, Nature

ECOSYSTEM FUNCTIONING IS....

- The combined effects of all natural processes that sustain an ecosystem
- The collective life activities of organisms from multiple trophic levels and the collective effects they have on their environment

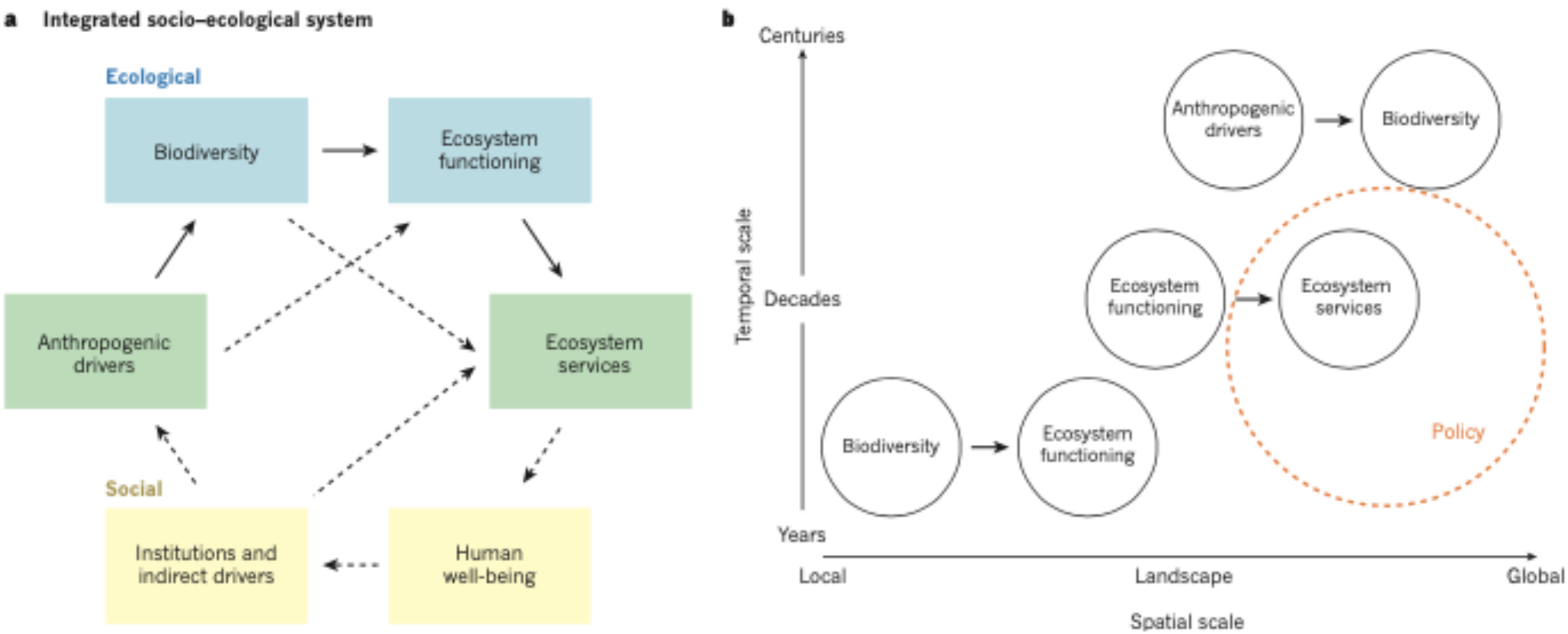
Reiss et al, 2009, TREE; Naeem et al. 1999 Issues in Ecology

METACOMMUNITIES & ANTHROPOGENIC CHANGE



Chase et al. 2020, Ann NY Acad Sci

HUMANS & SCALE



Isbell et al. 2017 Nature

HOW CAN WE TELL THE DIFFERENCE?

HOW CAN WE TELL THE DIFFERENCE?

HOW CAN WE TELL THE DIFFERENCE?

HOW CAN WE TELL THE DIFFERENCE?

HOW CAN WE TELL THE DIFFERENCE?

HOW CAN WE TELL THE DIFFERENCE?

SO HOW DO WE MEASURE AN ECOSYSTEM?

- How do we know?
- If it's healthy or degraded?
- If its functioning properly?
- Or struggling?

USE THIS JAM BOARD

- Ecosystem Functioning Jam Board
- We will watch each video for ~30 seconds each
- Jot down your ideas
- What do these systems have in in terms of their function?
- What is different?
- What is measurable?
- Pose questions

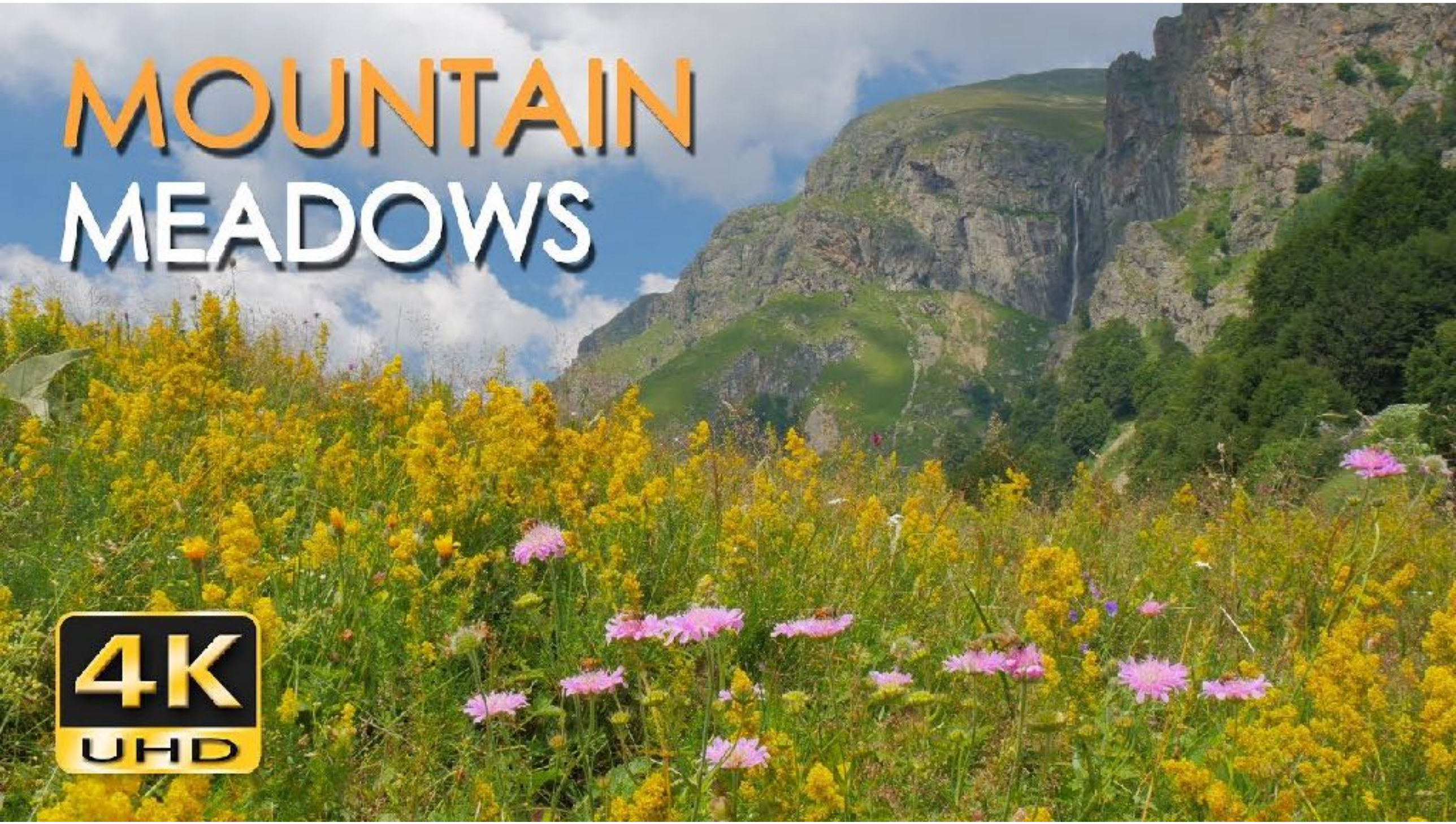
CONSIDERING ECOSYSTEMS

Sounds of the Peruvian Amazon Rainforest - 25 minutes

CONSIDERING ECOSYSTEMS

CONSIDERING ECOSYSTEMS

CONSIDERING ECOSYSTEMS



CONSIDERING ECOSYSTEMS

CONSIDERING ECOSYSTEMS

CONSIDERING ECOSYSTEMS

CONSIDERING ECOSYSTEMS

CONSIDERING ECOSYSTEMS

CONSIDERING ECOSYSTEMS

LET'S REVIEW OUR IDEAS

- Jam board discussion

ECOSYSTEM FUNCTIONING

Biomass

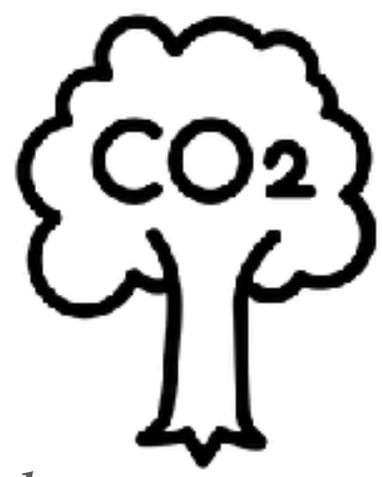
Nutrient absorption

Abundance

Productivity

Trophic diversity

Energy flux

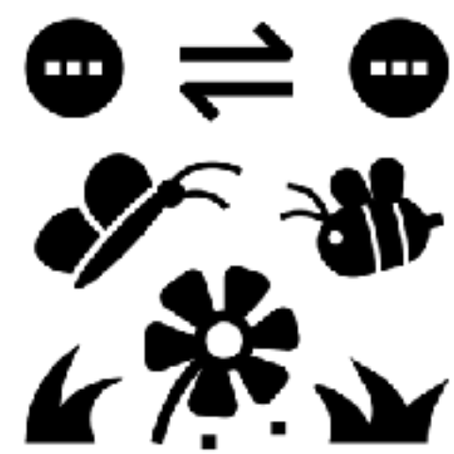


Carbon sequestration

Services

Complexity

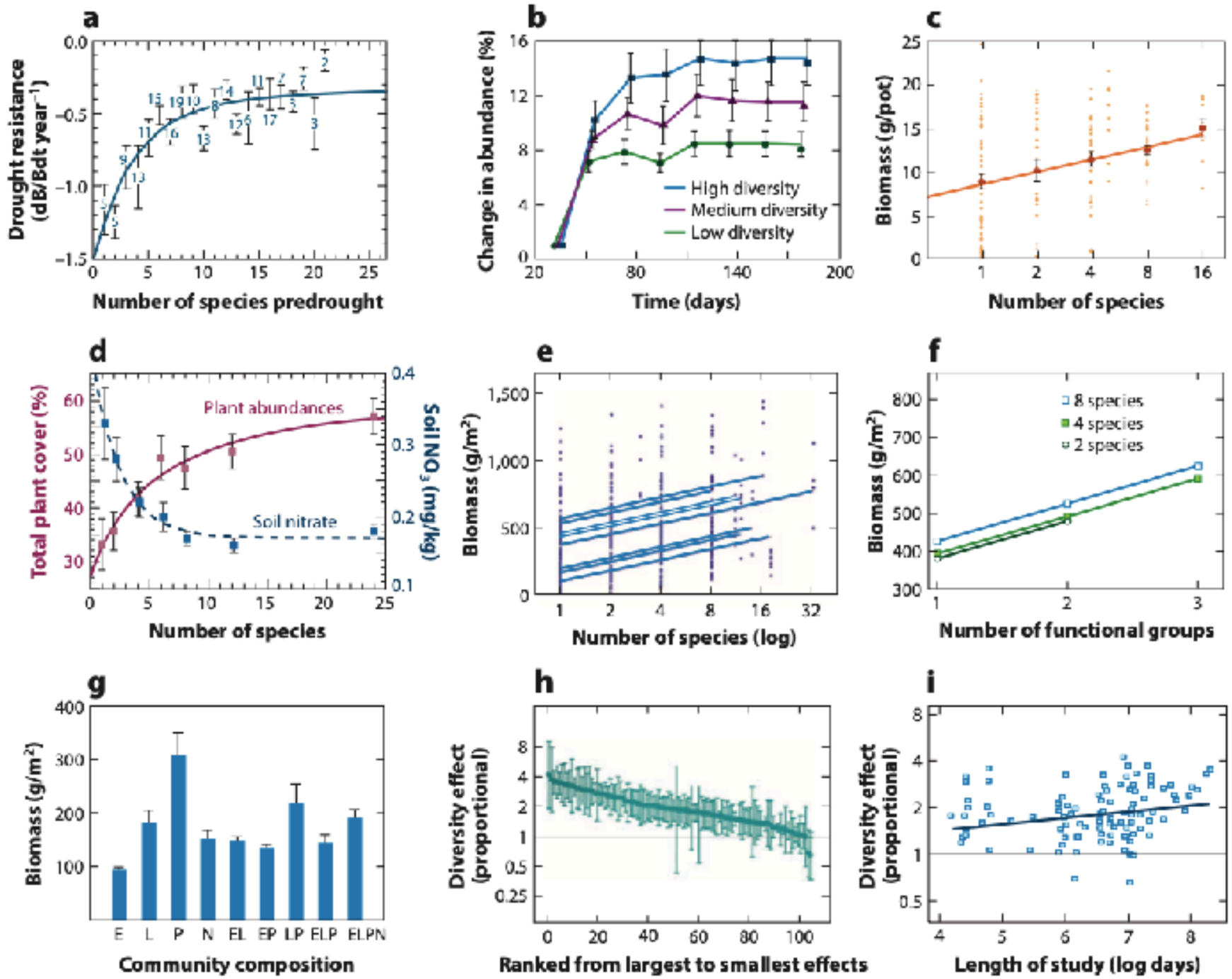
Sound



Networks & Webs

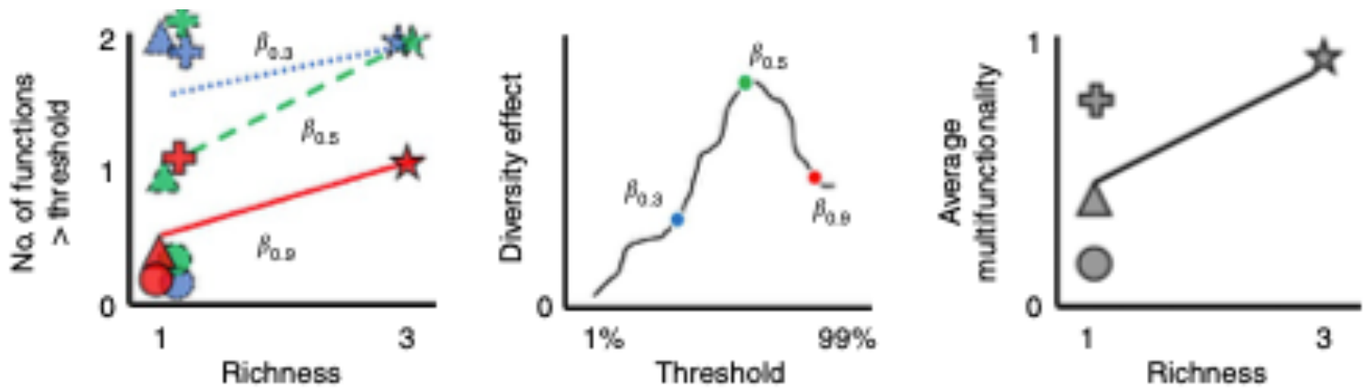
Images from the Noun Project

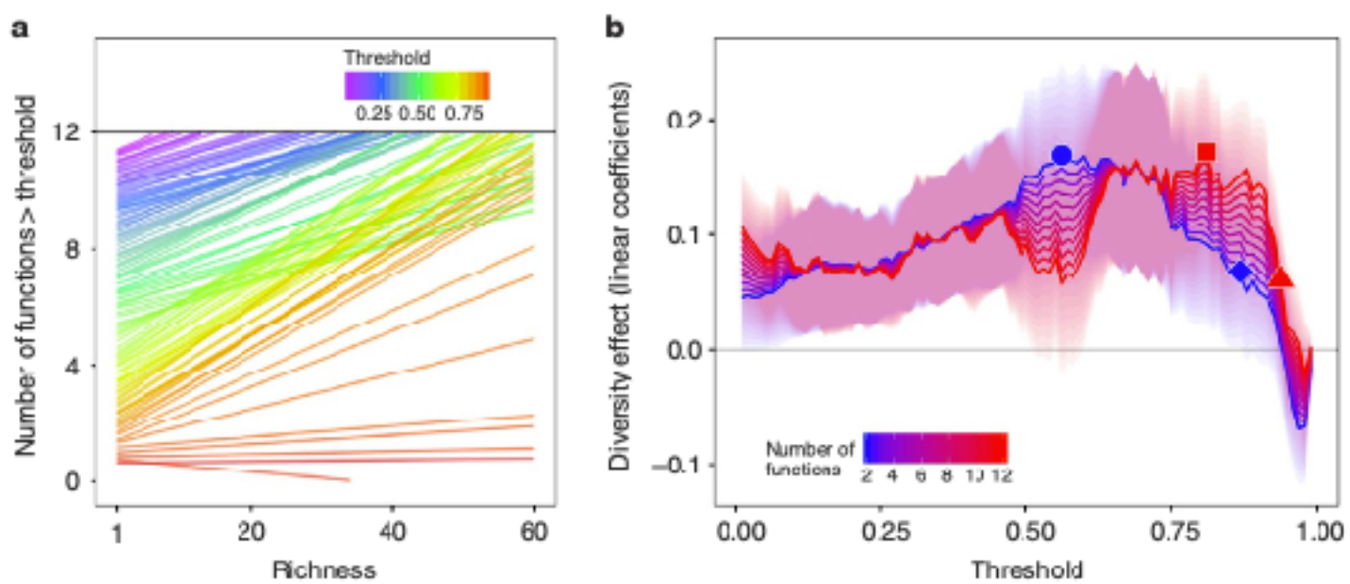
STRONG EVIDENCE FOR A POSITIVE RELATIONSHIP

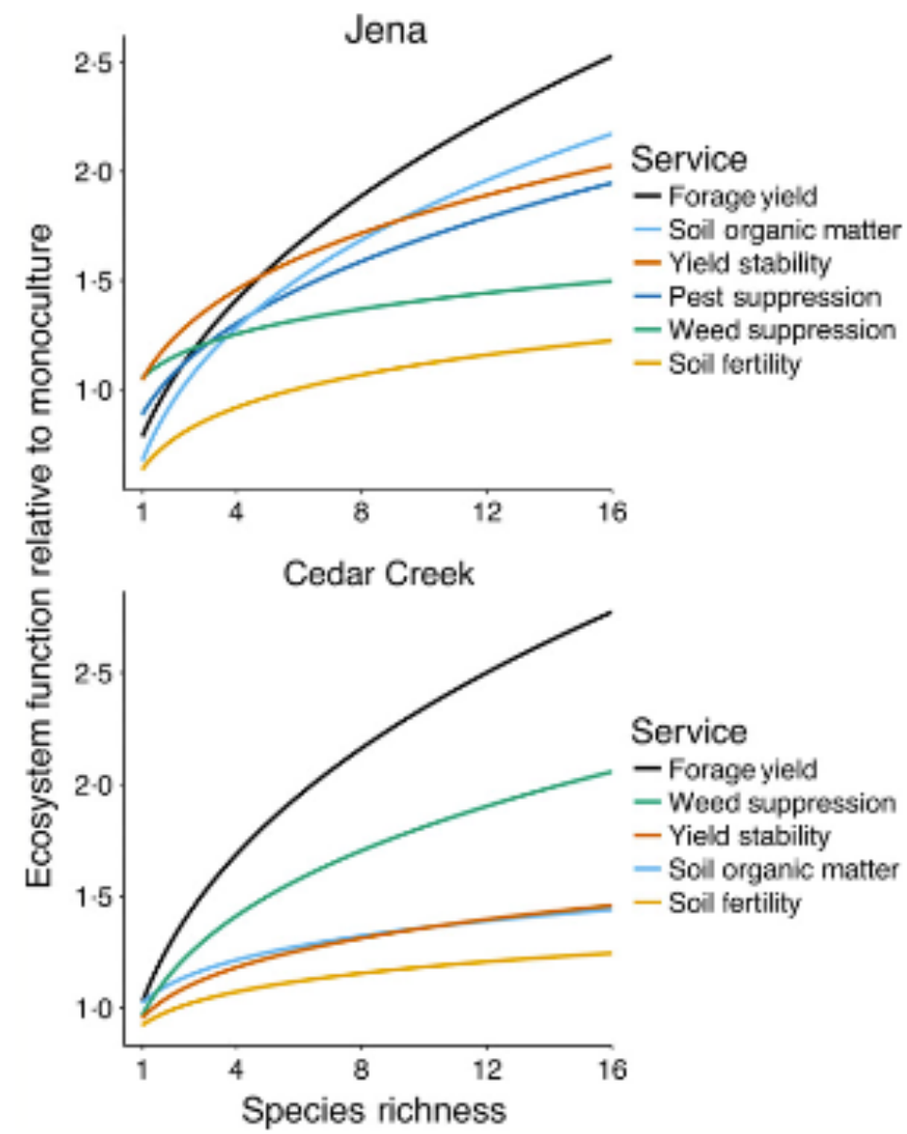


Tilman 2014, Annu. Rev. Ecol. Evol.

"MULTIFUNCTIONALITY"

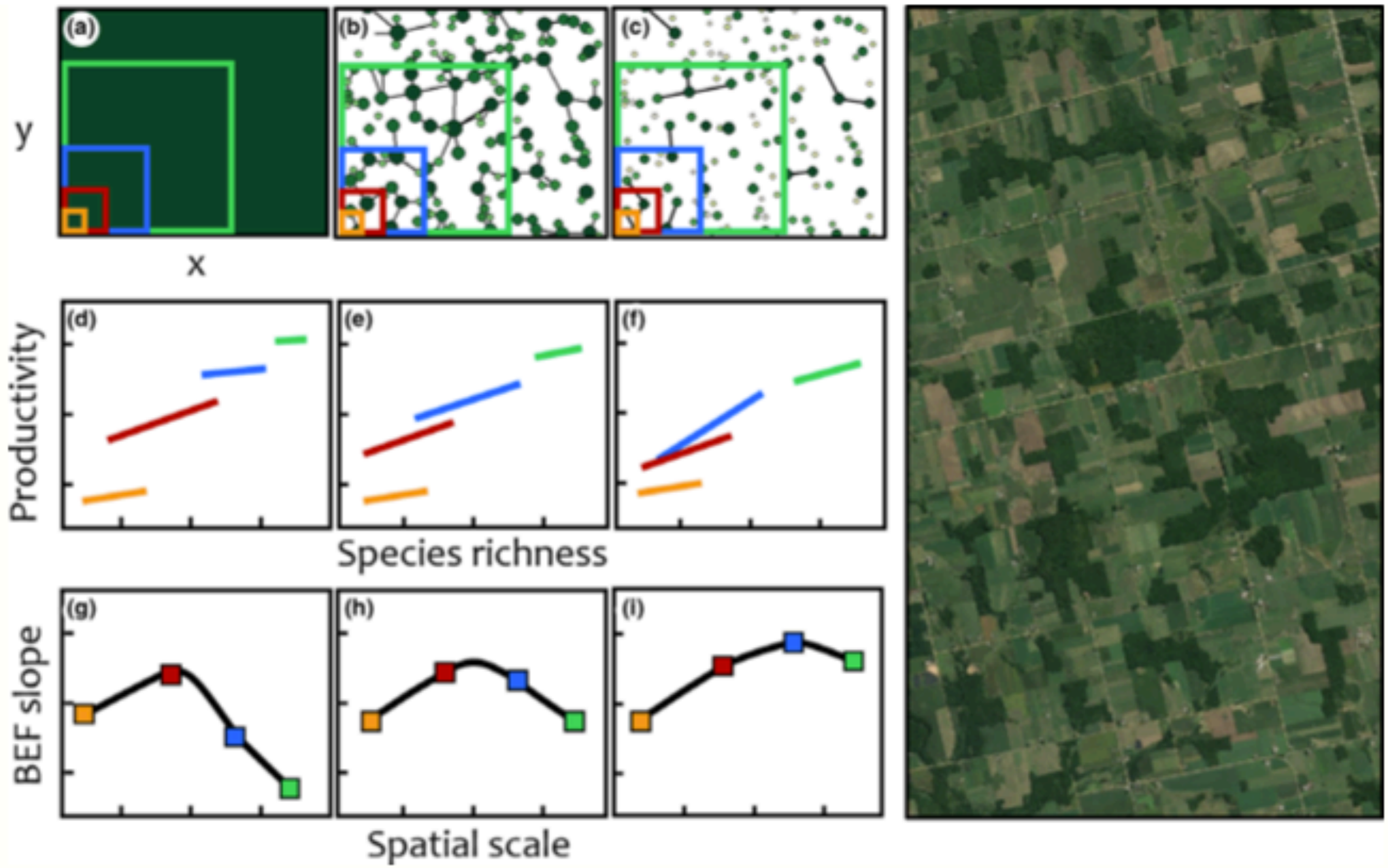






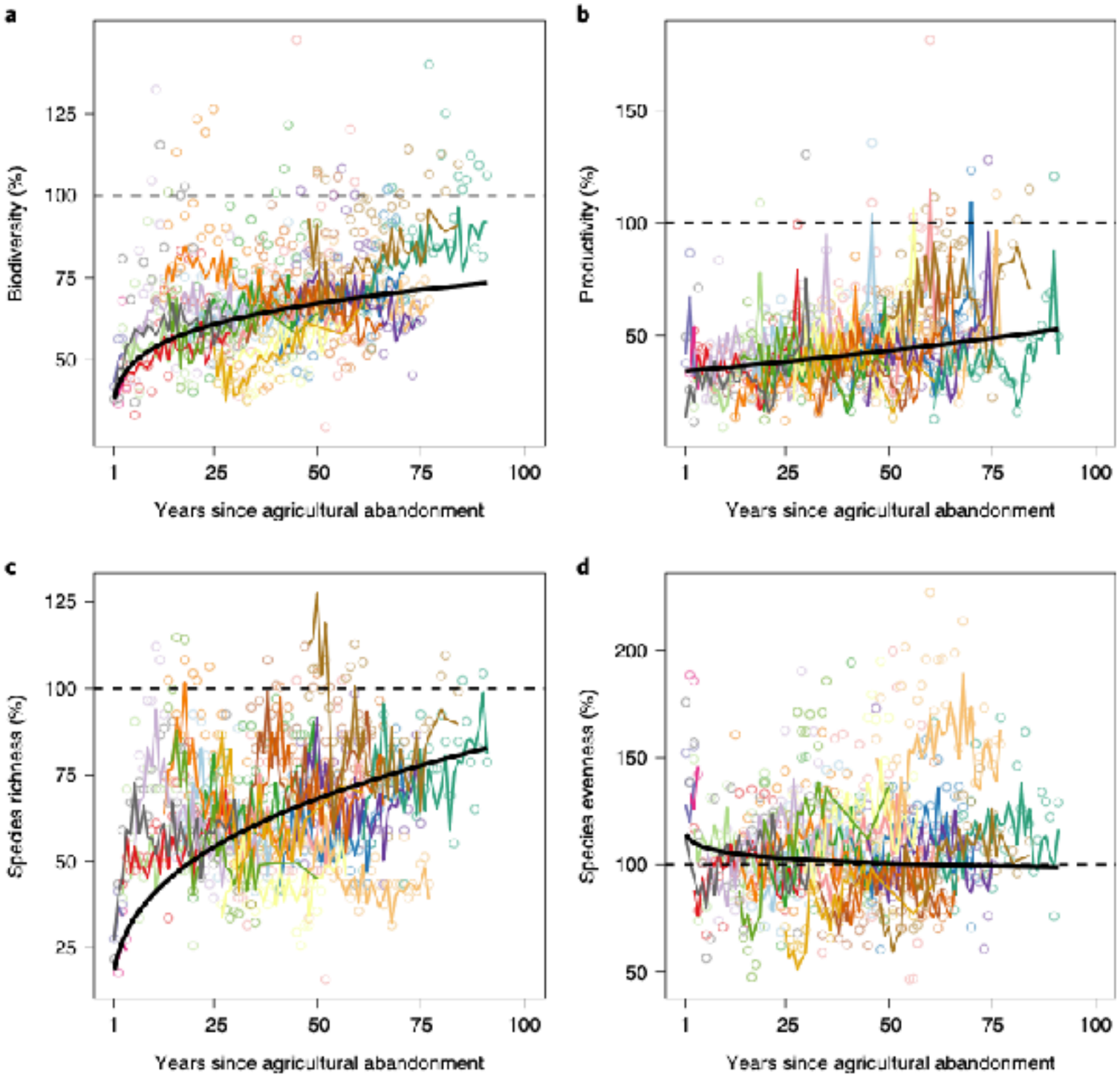
Lefcheck at al. 2015 Nature Communications; Isbell et al. 2017 Ecology

DISTURBANCE, HUMANS & SCALE



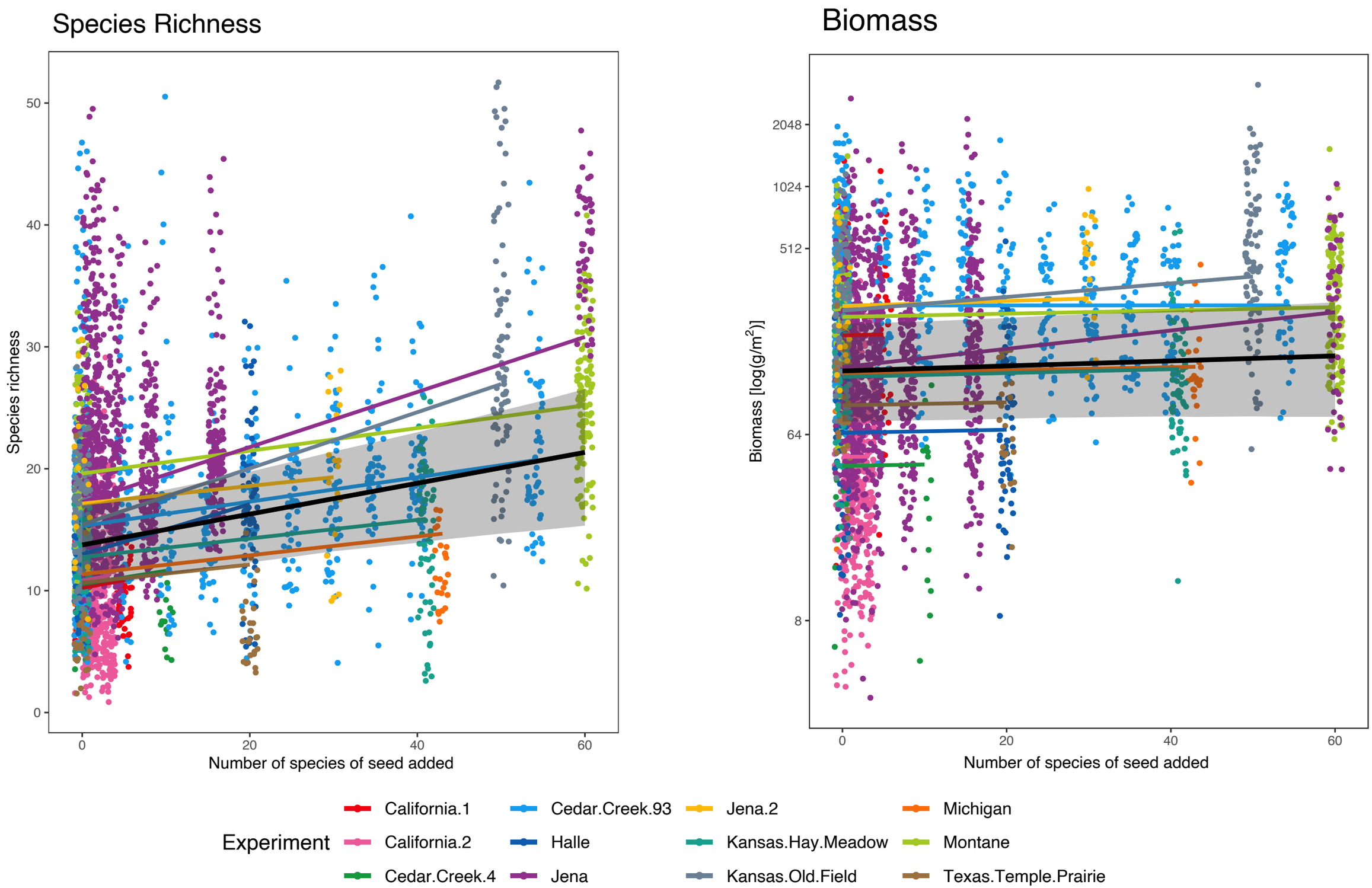
Gonzalez et al. 2021 Ecology Letters

BIODIVERSITY AND FUNCTIONING CAN RECOVER AFTER DISTURBANCE TOGETHER

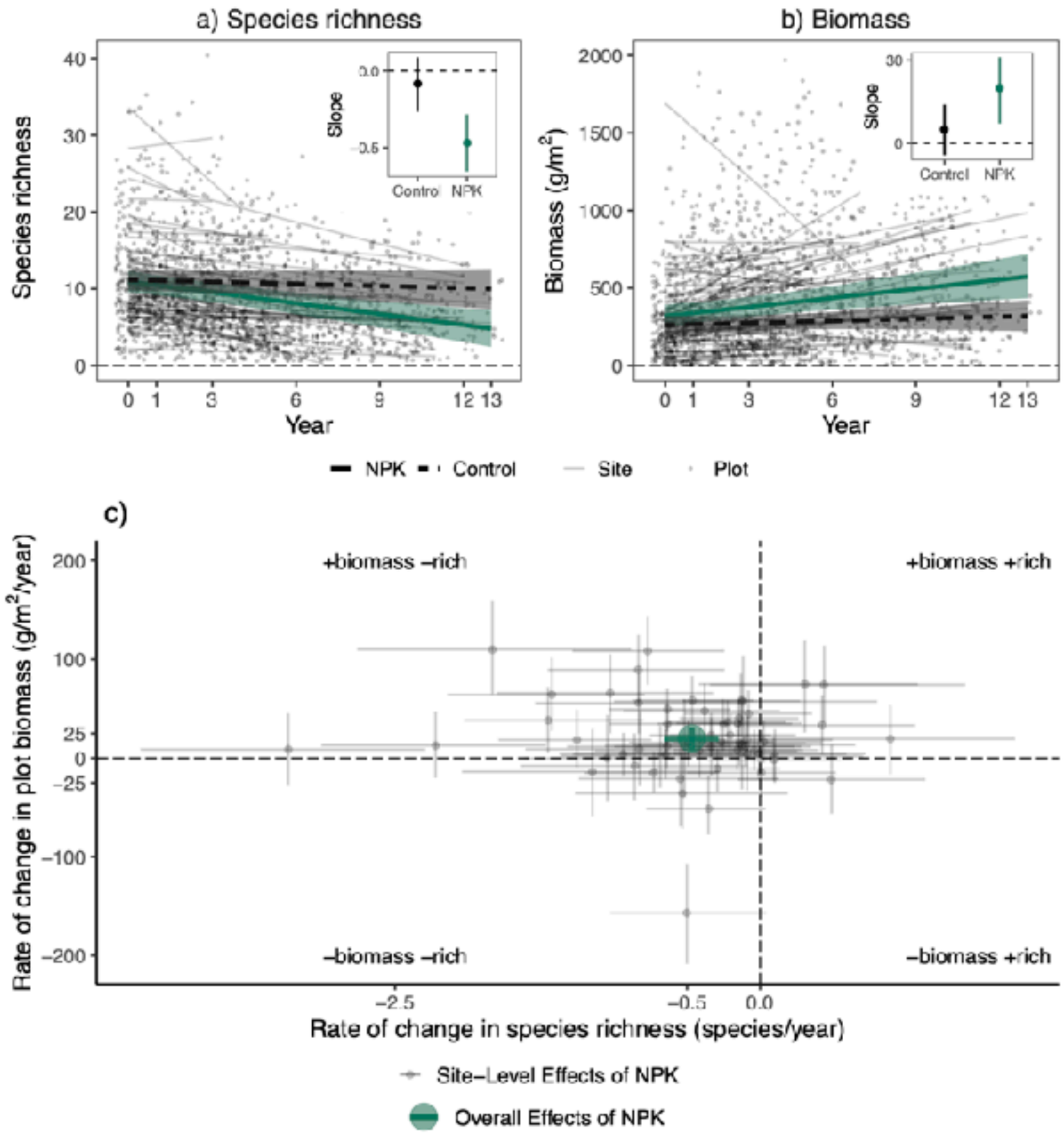


Isbell et al. 2019 NEE

OR RESPONSES CAN BE DECOUPLED



Ladouceur et al. 2020, Ecology Letters



Ladouceur et al. 2022, Authorea Pre-Prints

A VARIETY OF EXPECTATIONS AS TO WHY

Barry et al. 2019, TREE

A VARIETY OF WAYS TO PARTITION AGGREGATE MEASURES

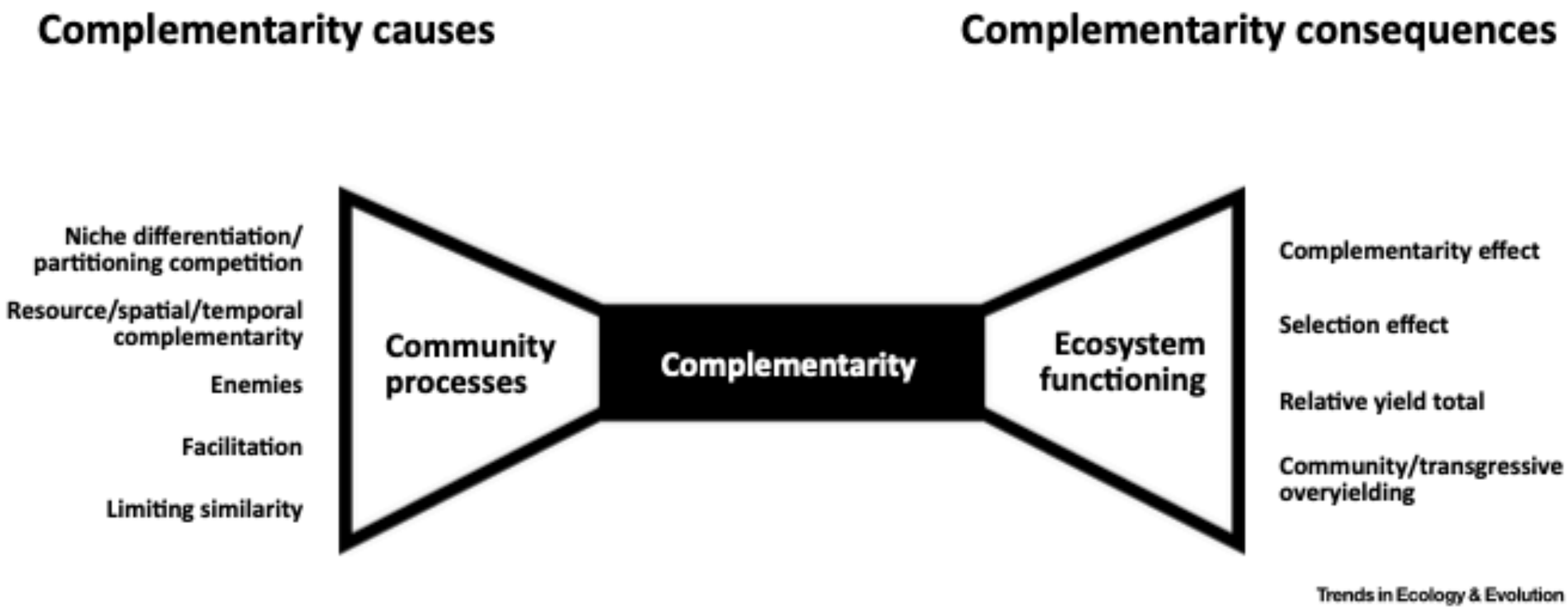


Figure 1. Looking Inside the Black Box of Complementarity. We found that in the biodiversity–ecosystem functioning literature, uses for the term complementarity generally fall into two categories: complementarity causes (see left), and complementarity consequences (see right) of the coupling between diversity and ecosystem functioning. On the left, we list potential causes that, historically, are credited with driving complementarity. On the right, we list consequences that have historically been derived from species being complementary in some fashion. Some studies use complementarity as both a cause and a consequence. When complementarity is used by itself, which is common, it is often unclear whether the intended definition falls under a specific usage (on either the causes or consequences side) or rather as the center portrays. We believe that the multitude of uses of complementarity on both sides of this model and in the center, without explicitly stating which perspective is taken, often leads to misinterpretation and confusion in communicating.

Barry et al. 2019, TREE

COMMUNITY ASSEMBLY AND THE FUNCTIONING OF ECOSYSTEMS

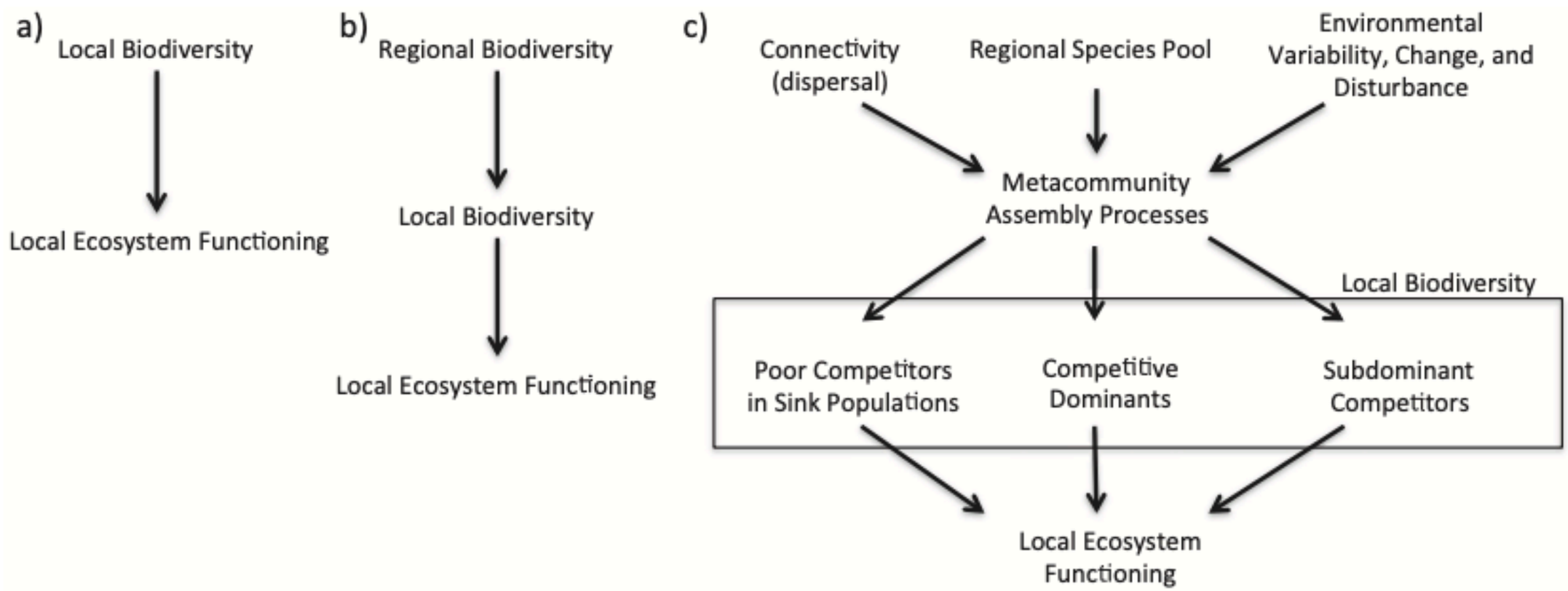


FIG. 1. Three increasingly complex conceptual views of how biodiversity affects ecosystem functioning: (a) a direct causal relation between local biodiversity and ecosystem functioning, but the effects of the regional species pool are ignored. (b) Regional biodiversity as an ultimate driver of local biodiversity but with the assumption that this relationship is simple (e.g., monotonic). (c) The metacommunity view in which multiple drivers (connectivity and environmental variability and change, as well as regional biodiversity) affect different components of local diversity (poor competitors that exist as sink populations, subdominant species, and competitively dominant species) that then differentially affect ecosystem functioning.

Leibold, Chase & Ernest 2017, Ecology

COMMUNITY ASSEMBLY AND ECOSYSTEM FUNCTIONING

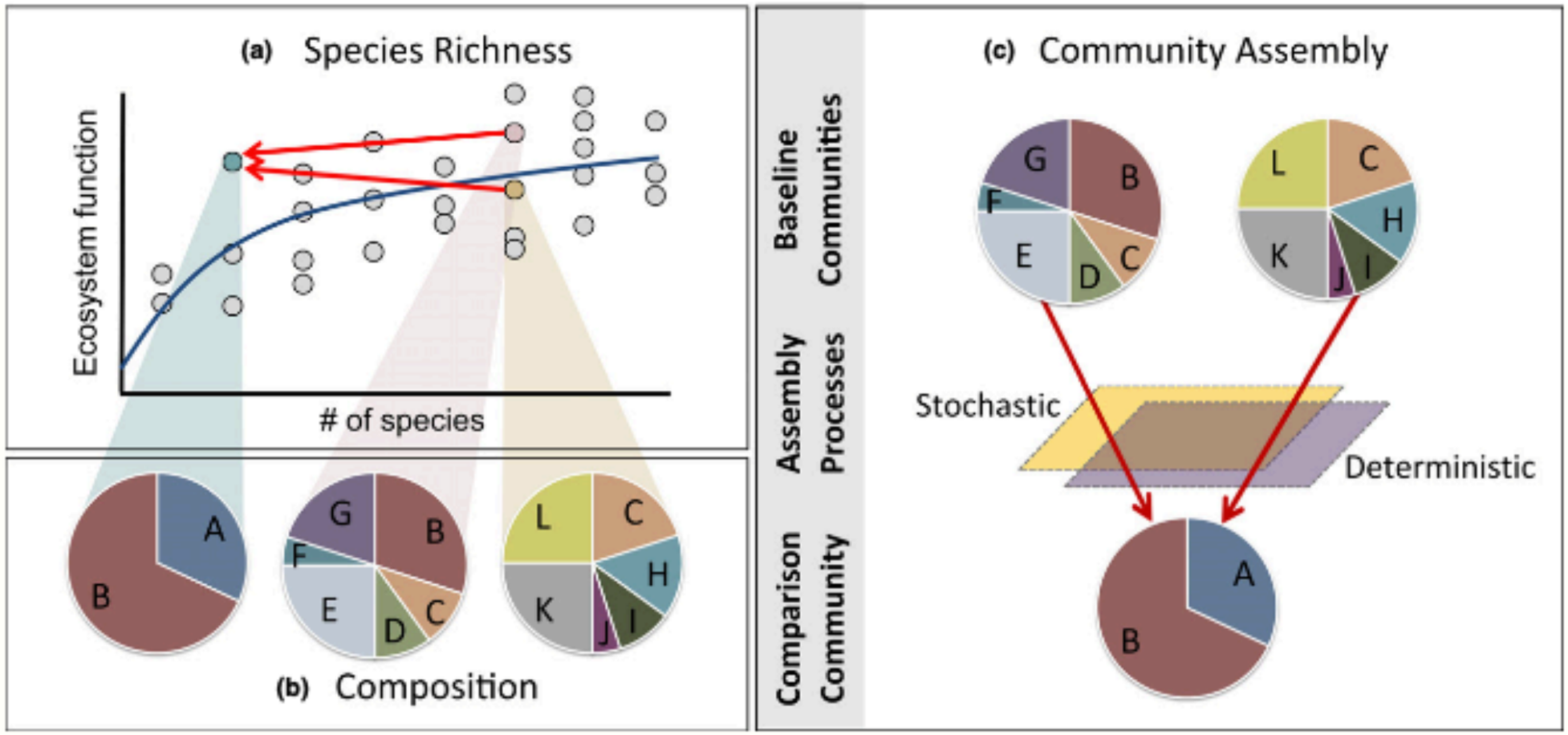
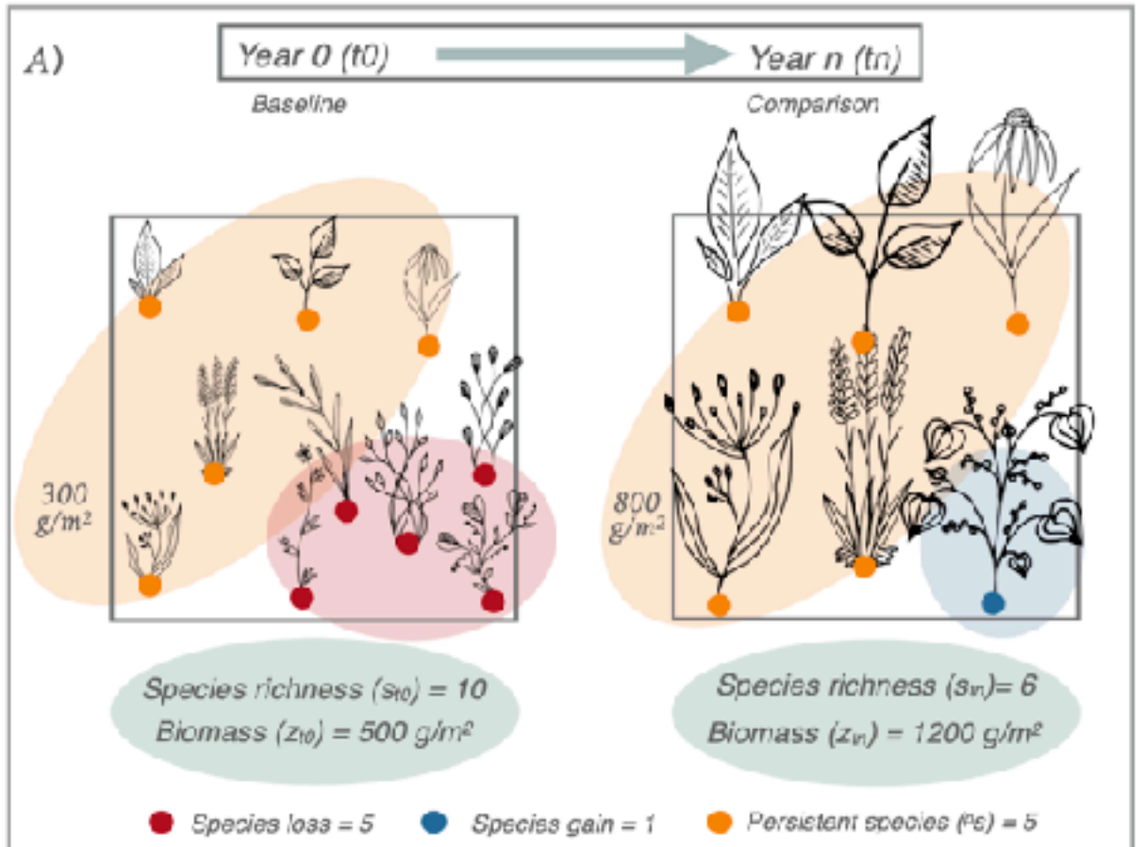


Figure 1 Community assembly and the functioning of ecosystems (CAFE) concept figure. The relationship between ecosystem function and species richness is composed of three key interrelated components: (a) The general increasing trend of ecosystem function with increasing number of species. Each circle is a community. The red arrows indicate transitions of a community from one state to another, which might result from community assembly, driven by an external perturbation or internal dynamics (panel c), leading to changes in community composition and species richness. (b) The species composition of each community and each species' contribution to total ecosystem function for that community. Each species is denoted by a letter and colour, and each species' contribution to ecosystem function is represented by the size of the pie slice. (c) The community assembly processes that lead to changes in community composition, structure and species richness along the red arrows in panel a (between temporally or spatially separated communities; i.e. baseline vs. comparison communities). For example, deterministic assembly processes could shape community composition through physiological constraints and biotic interactions, and/or stochastic assembly processes could shape community composition through environmental stochasticity, random dispersal patterns and random mortality due to perturbation.

Bannar-Martin et al. 2017, Ecology Letters

BY TRACKING SPECIES IDENTITIES WE CAN QUANTIFY GAINS AND LOSSES



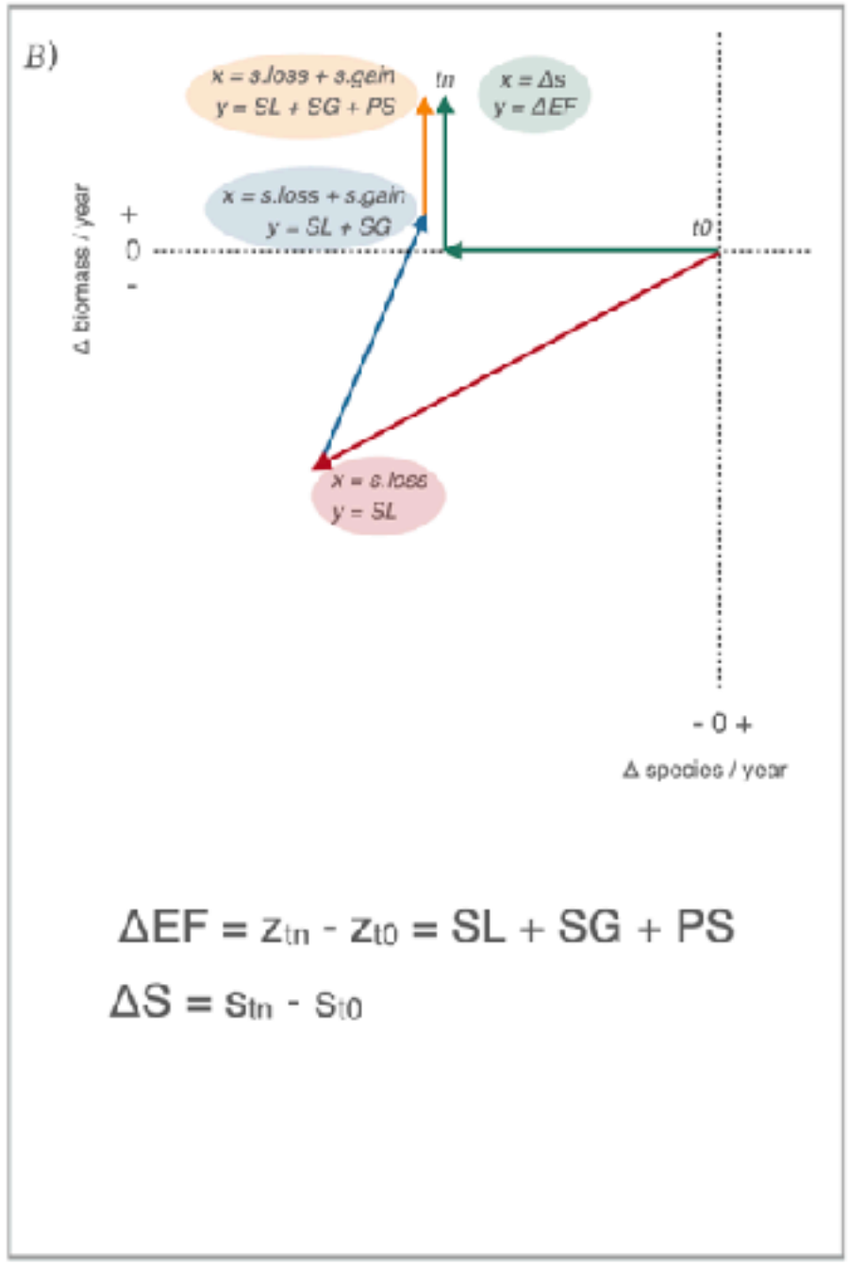
species loss (s.loss) = $^{p}s - s_{t0} = -5$

species gain (s.gain) = $s_{tn} - {}^{p}s = 1$

biomass change due to species loss (SL) = $^{p}z_{t0} - z_{t0} = -200$

biomass change due species gain (SG) = $z_{tn} - {}^{p}z_{tn} = 400$

persistent species change in biomass (PS) = $^{p}z_{tn} - {}^{p}z_{t0} = 500$



$\Delta EF = z_{tn} - z_{t0} = SL + SG + PS$

$\Delta S = s_{tn} - s_{t0}$

z = ecosystem function

^{p}z = ecosystem function of persistent species

z_{tn} = ecosystem function at time = n

z_{t0} = ecosystem function at t = 0

s = # of species

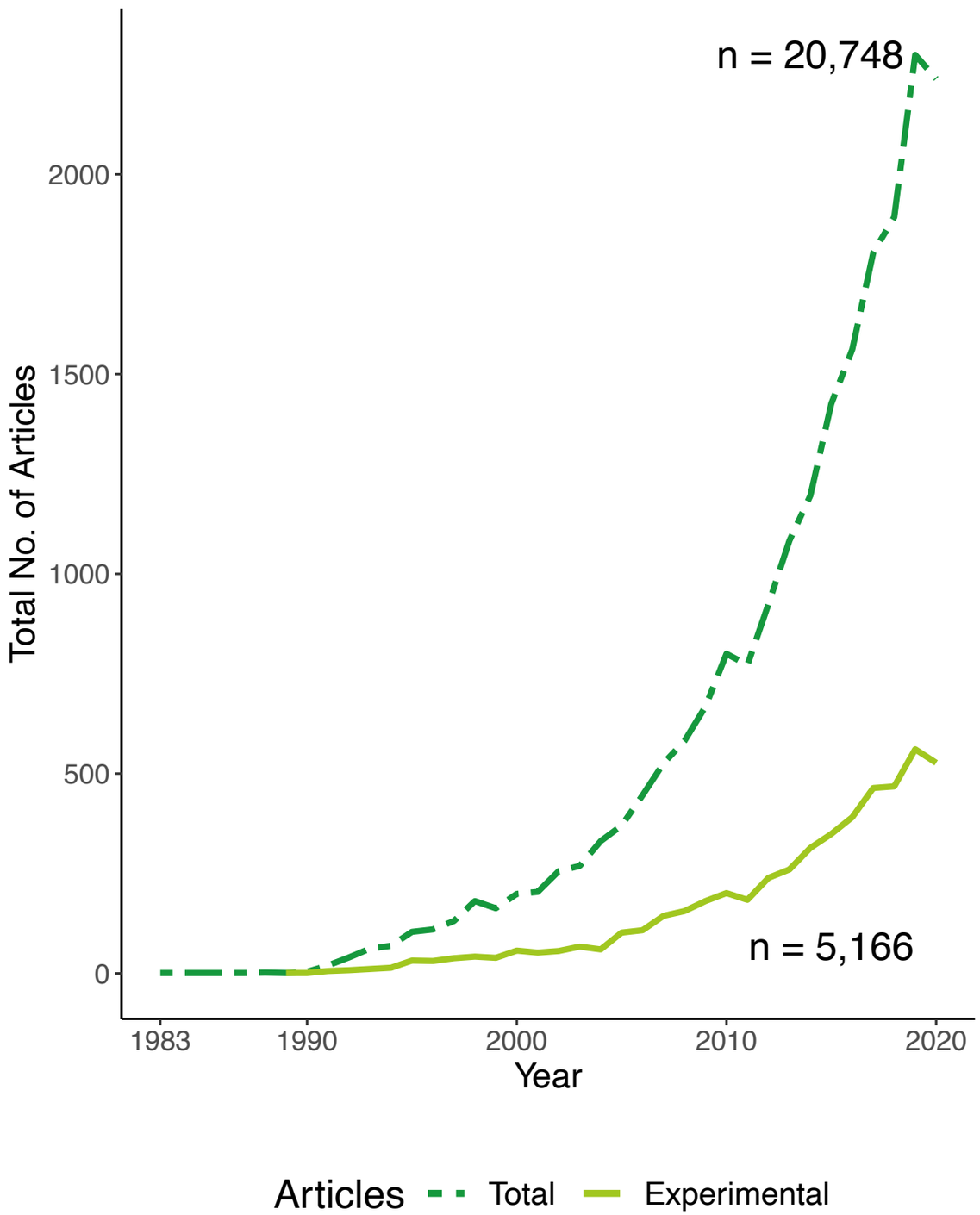
^{p}s = # persistent species

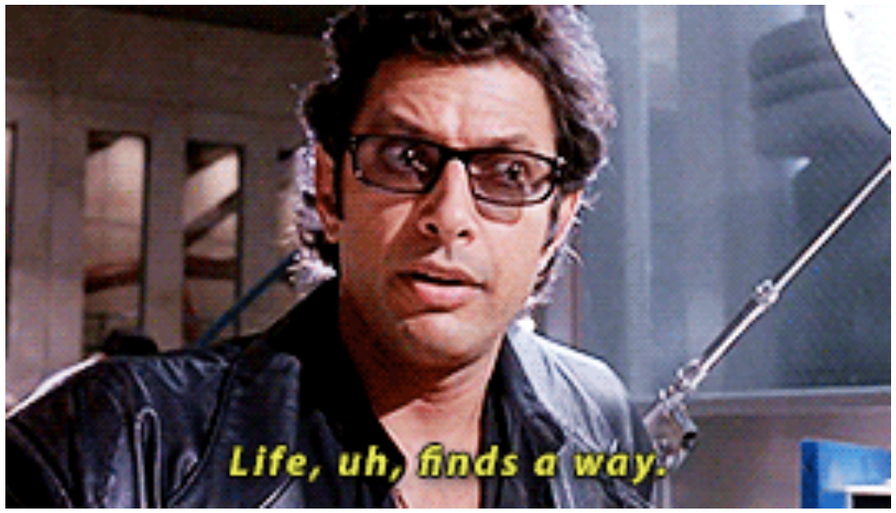
s_{tn} = # of species at time = n

s_{t0} = # of species at t = 0

Ladouceur et al. 2022, Authorea Pre-Prints

ENTER: ECOLOGICAL RESTORATION





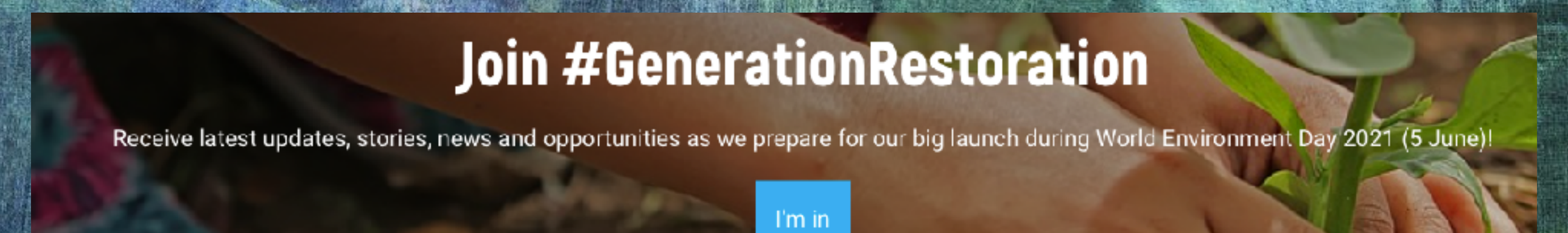
"This summer is too hot"
me: Have you ever planted trees?
"No"
me:

THE DECADE

UN environment programme

Food and Agriculture Organization of the United Nations

Convention on Biological Diversity



AMBITIOUS GOALS

UN Decade on Ecosystem Restoration: 2021-2030
United Nations

Goal	Estimated Cost	Projected Results
350 million hectares (ha) of land	800 billion USD	13-26 gigaton of green house gas removal 9 trillion USD in ecosystem services Improved well-being of 3.2 billion people

Bonn Challenge: 2011-2020 (extended to 2030)
Government of Germany & the IUCN

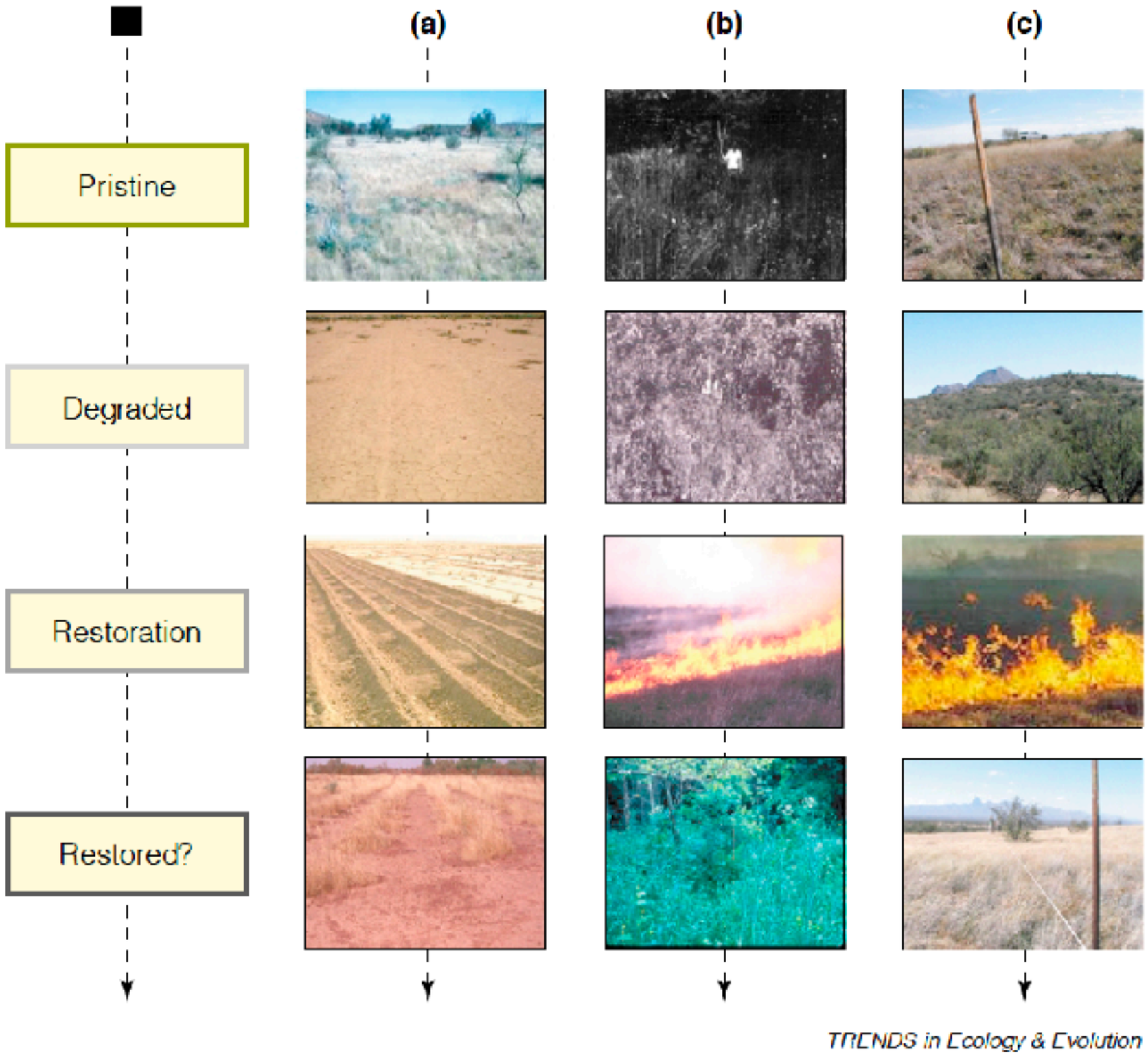
Goal	Estimated Cost	Projected Result
150 million ha of forested land by 2020 350 million ha of forested land by 2030	?	62 commitments, 22 countries 172.35 million ha pledged

Regional Initiatives

African Forest Landscape Initiative (AFR100)	100 million ha
ECCA30 : Europe, the Caucasus, & Central Asia	30 million ha
Initiative 20X20: South America	20 million ha
AGADIR Commitment: Mediterranean	Undefined

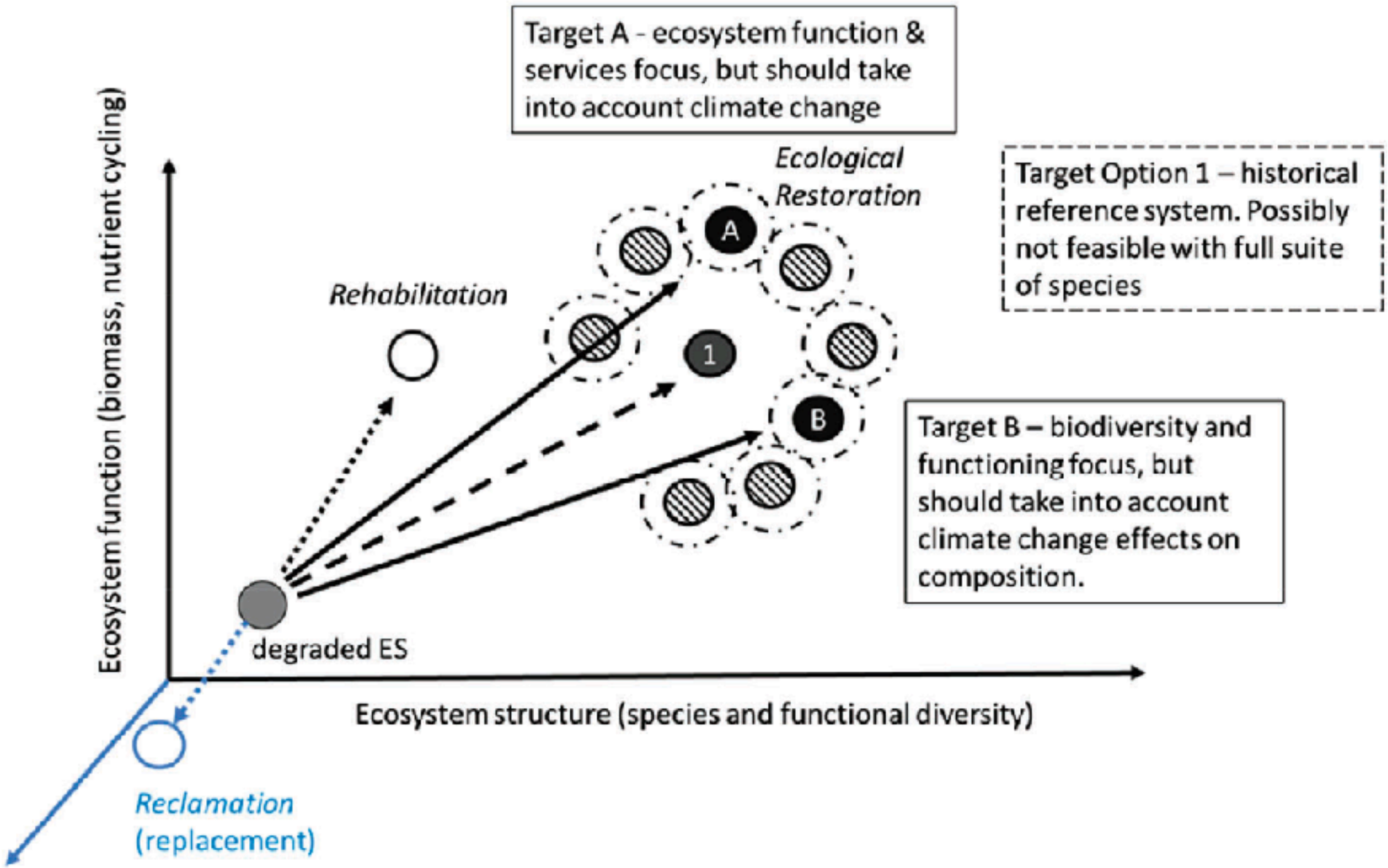
Ladouceur & Shackelford 2020, Restoration Ecology

ECOLOGICAL RESTORATION



Suding et al. 2004, TREE

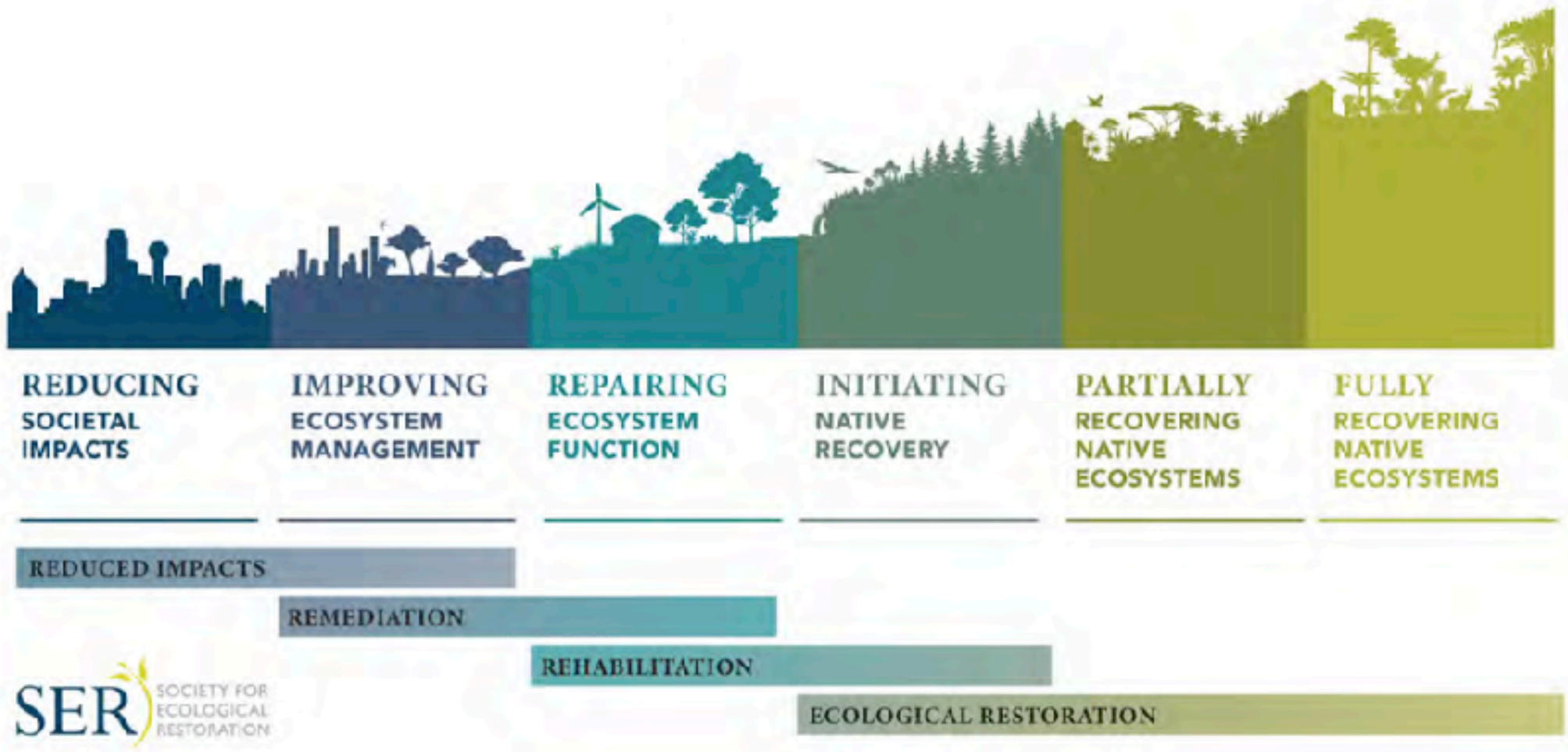
ECOLOGICAL RESTORATION



Temperton et al. 2019

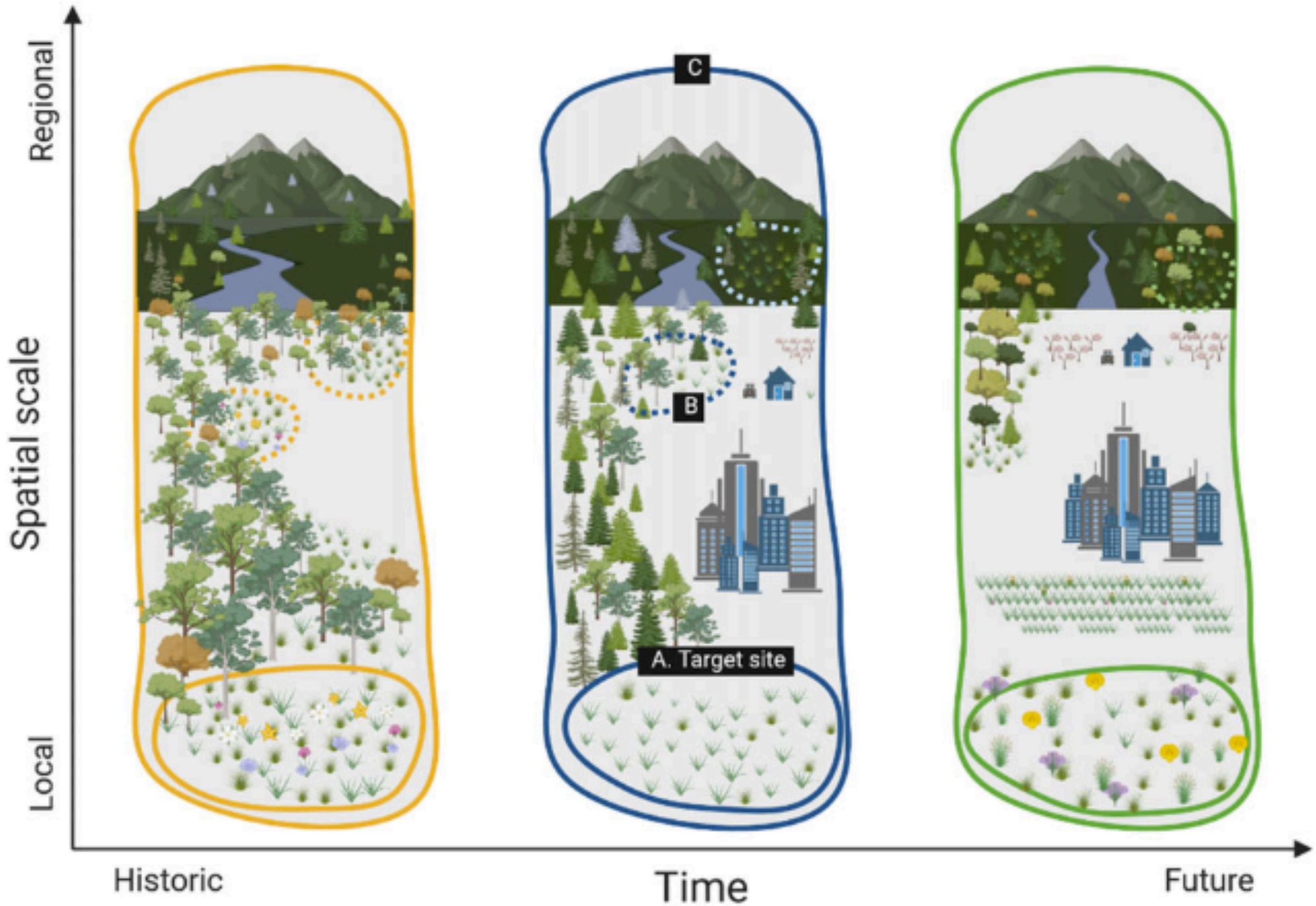
Types of Action Along the Restorative Continuum

Naturalization	*Land sharing*	*Land sparing*
Carbon sequestration initiatives	*Passive restoration*	*Active restoration*
Native species focused green space	*Ending disturbances*	*Regional connectivity*
Urban heat island effect prevention	*Invasive species management*	*Re-introducing natural processes*
Ecological urban & regional design		



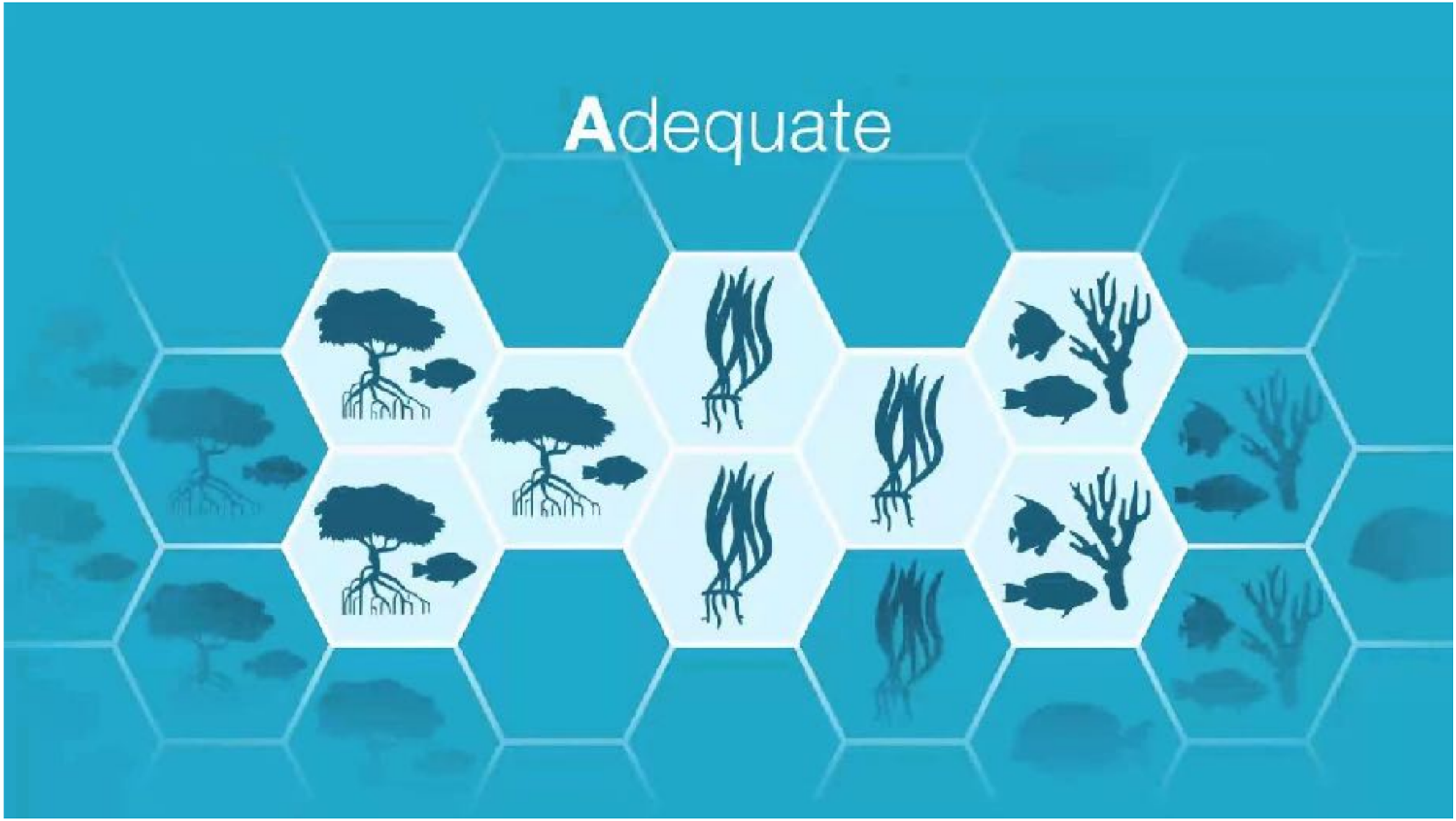
SER, International Standards, Gann et al. 2019

MAKING DECISIONS & UNDERSTANDING RESTORATION OUTCOMES



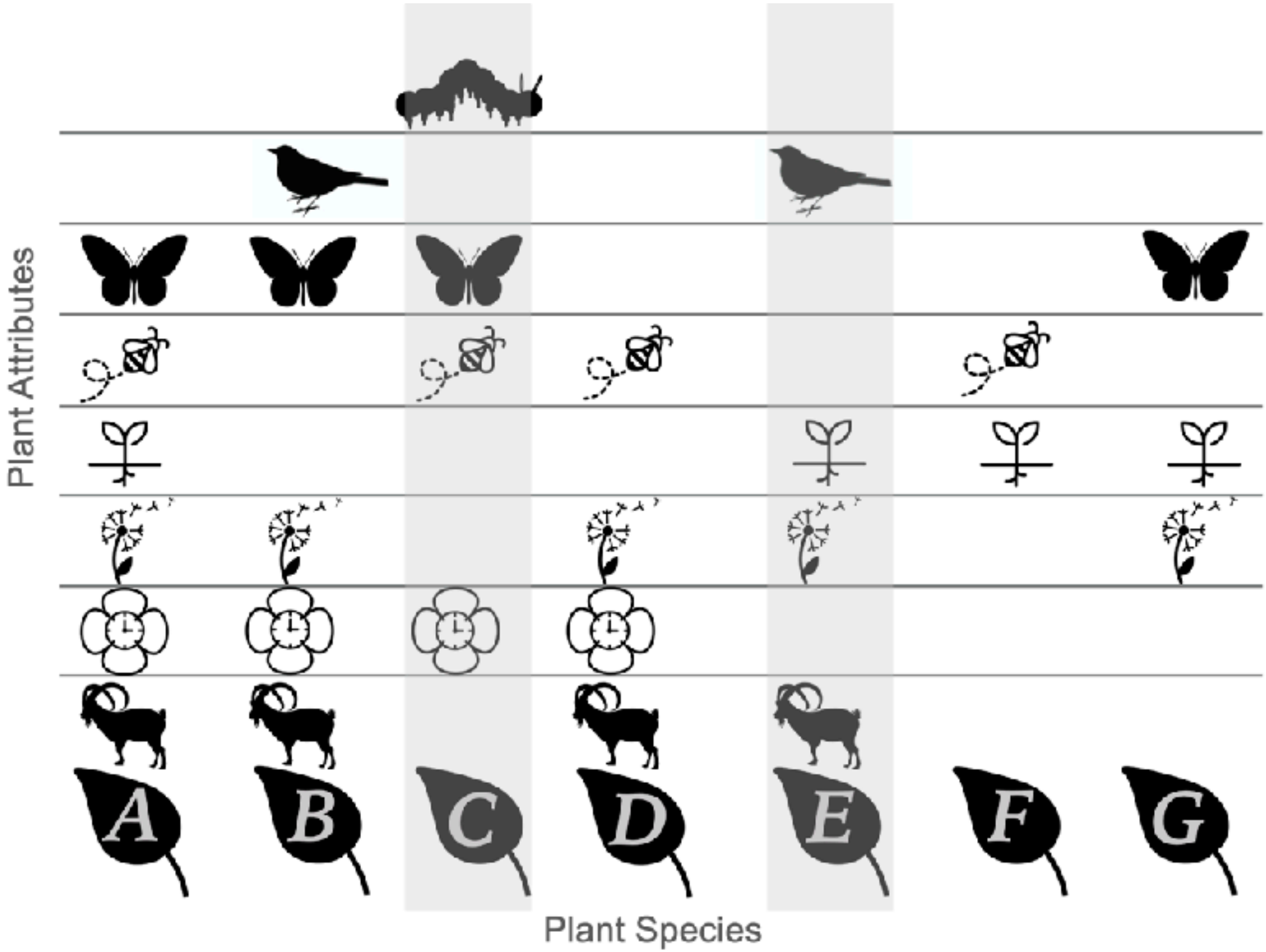
Shackelford et al. 2021, Restoration Ecology

[SPATIAL] DECISIONS…DECISIONS…. DECISIONS



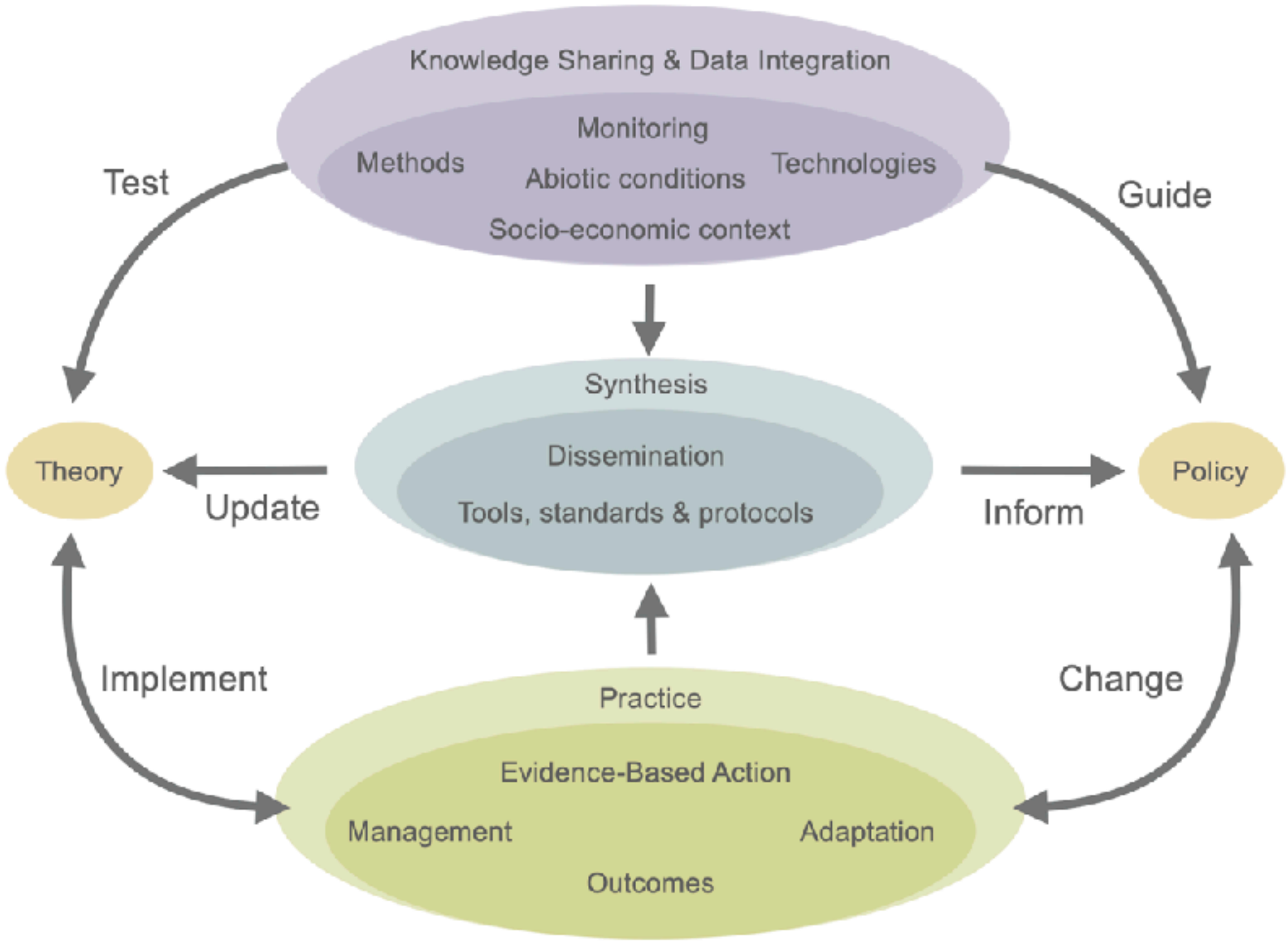
McGowan & Possingham et al.

[NON-SPATIAL] DECISIONS…DECISIONS…. DECISIONS



Ladouceur et al. 2021, Journal of Applied Ecology

KNOWLEDGE SHARING & DATA INTEGRATION



Ladouceur et al. 2021, Ecological Solutions & Evidence

UP NEXT

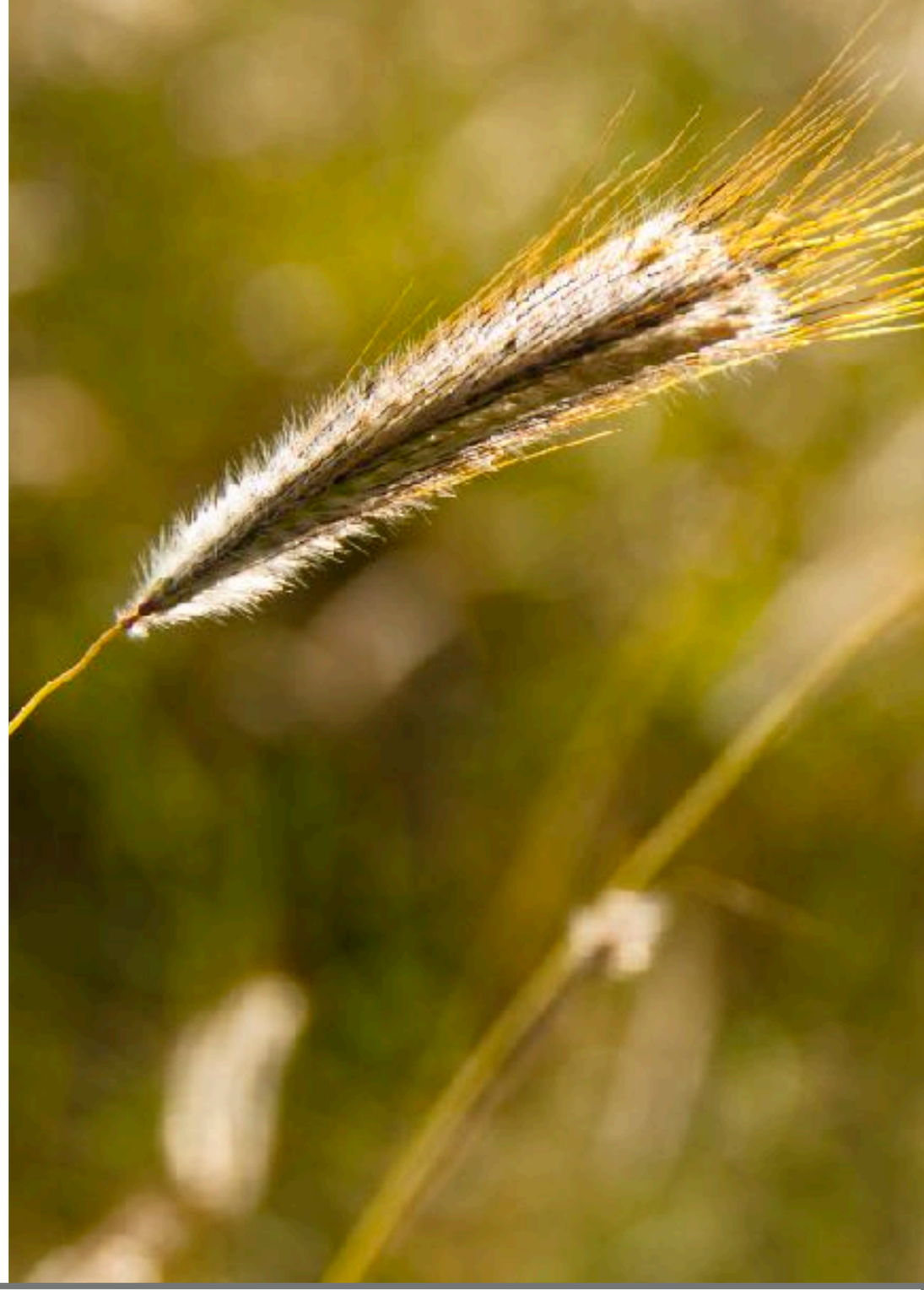
- Forms groups & Debate
- Learn about ecosystem function experiments
- Do an analysis activity in R
- Receive Project topics and Options

THANK YOU

emmala@gmail.com

@re_sprout

globalrestoreproject.com



iDiv

Unterstützt von / Supported by

Alexander von Humboldt Stiftung/Foundation

UFZ HELMHOLTZ Zentrum für Umweltforschung

University of Victoria