ENV-462
Urban ecology

Designing urban
ecological infrastructures

Plan

1. A crash course in wildlife ecology
   - The area & isolation paradigm
   - Metapopulation dynamics
   - Seral stages
   - The two sides of disturbances
   - Spatial heterogeneity
2. A diagnostic toolkit
   - The guild approach
   - The ecological infrastructure framework
3. Keys to restoring an ecological infrastructure
   - Consolidating core areas
   - Restoring conectivity
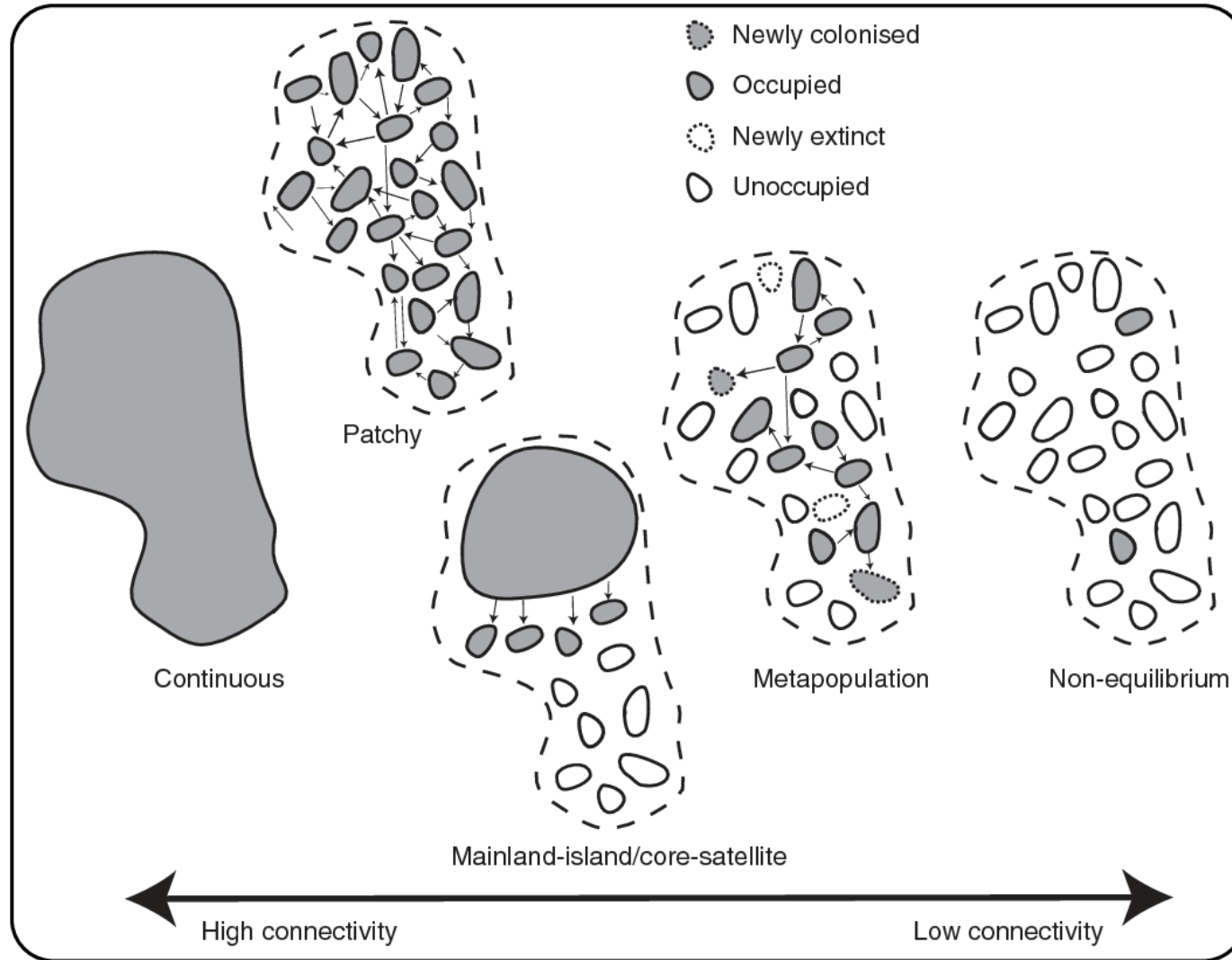   - A centrifugal approach
   - Do's and don't's
4. Take-home message
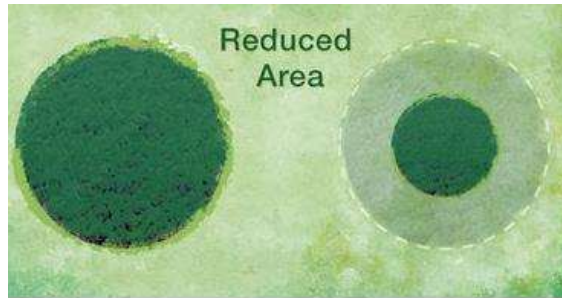
The area & isolation paradigm
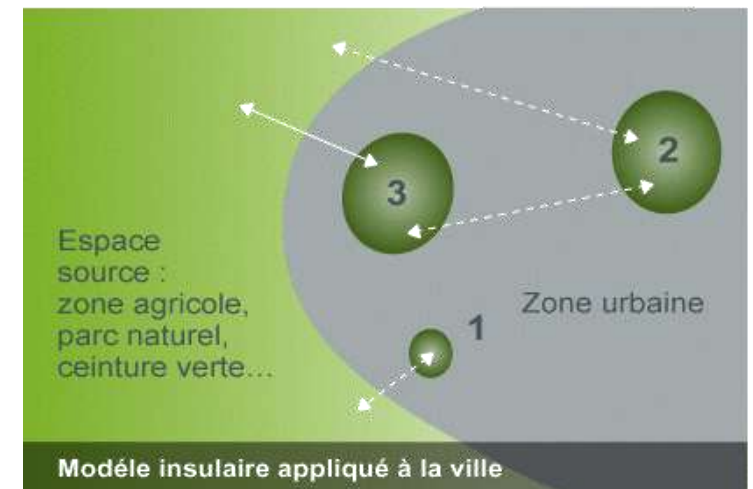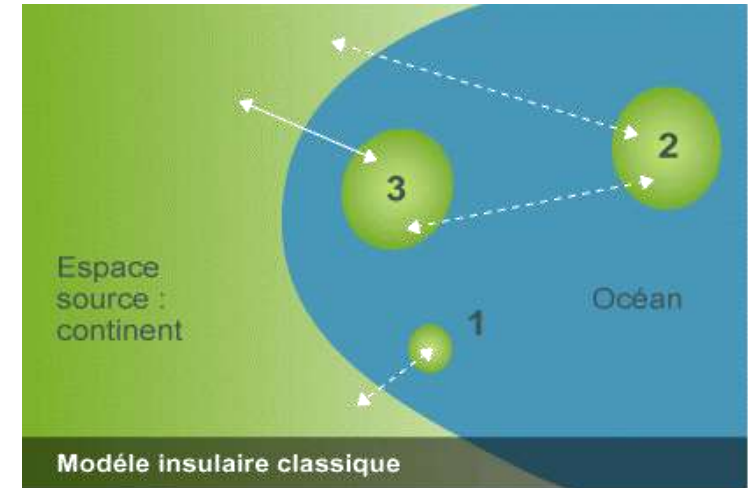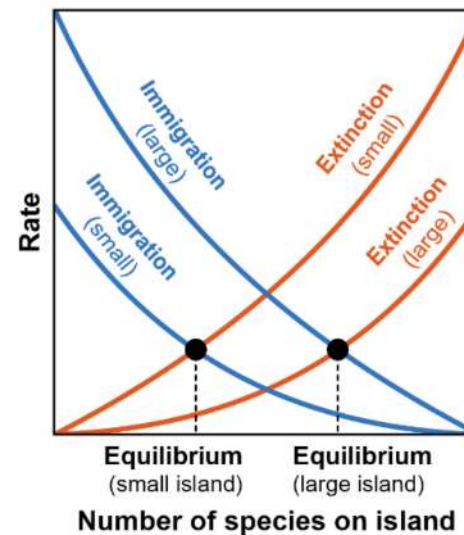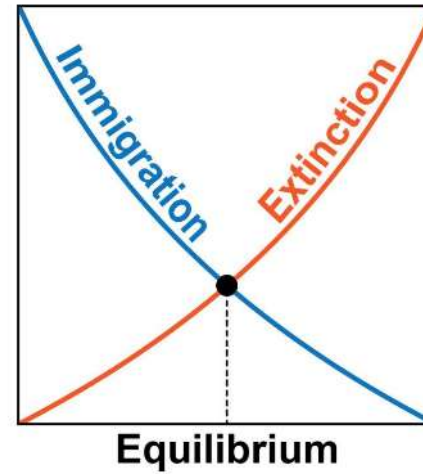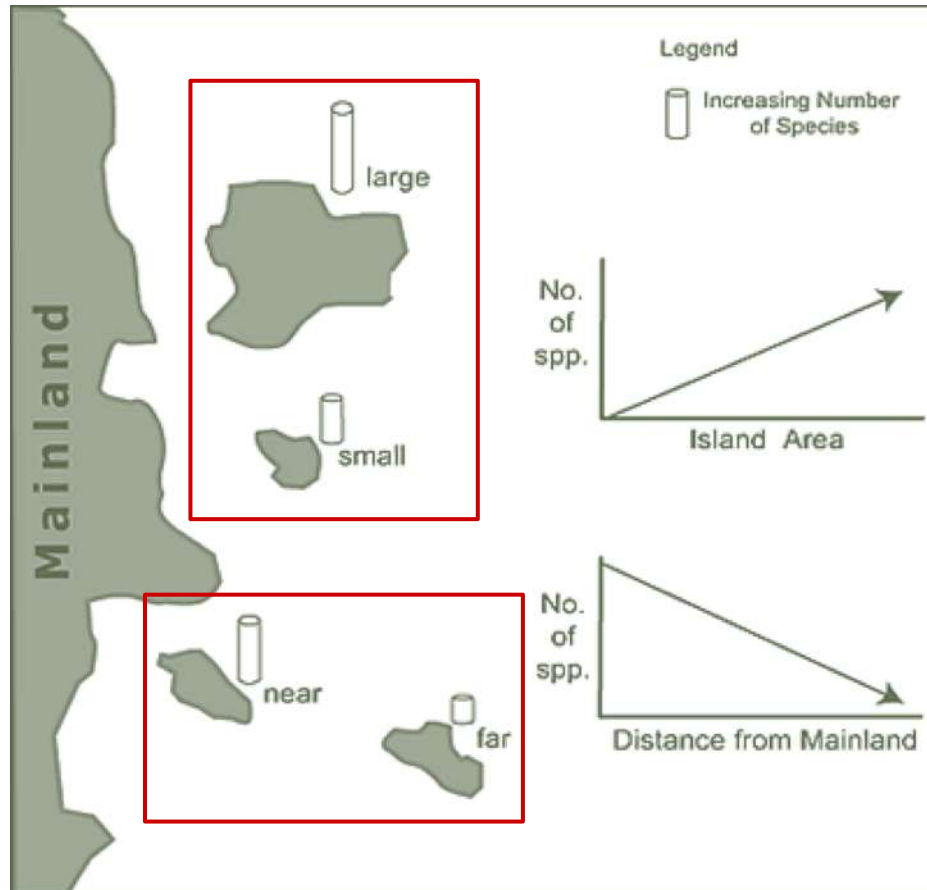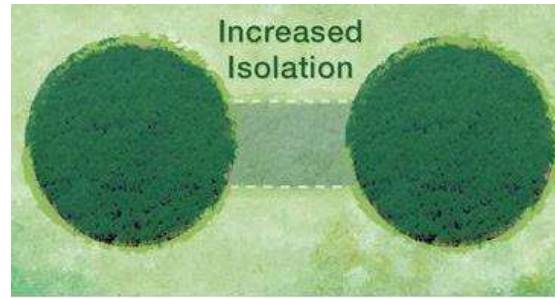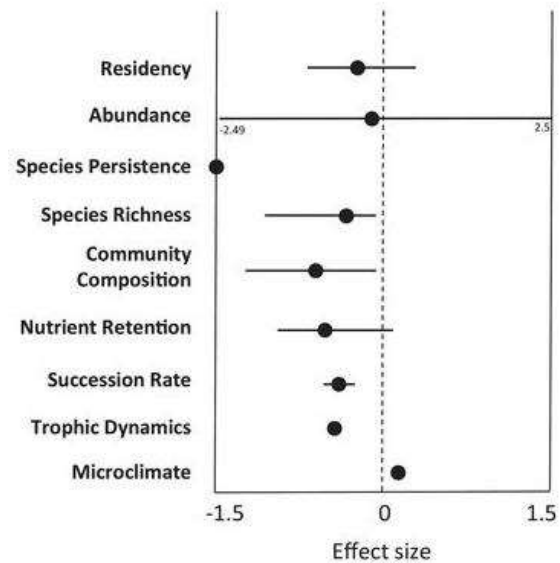
The area & isolation paradigm
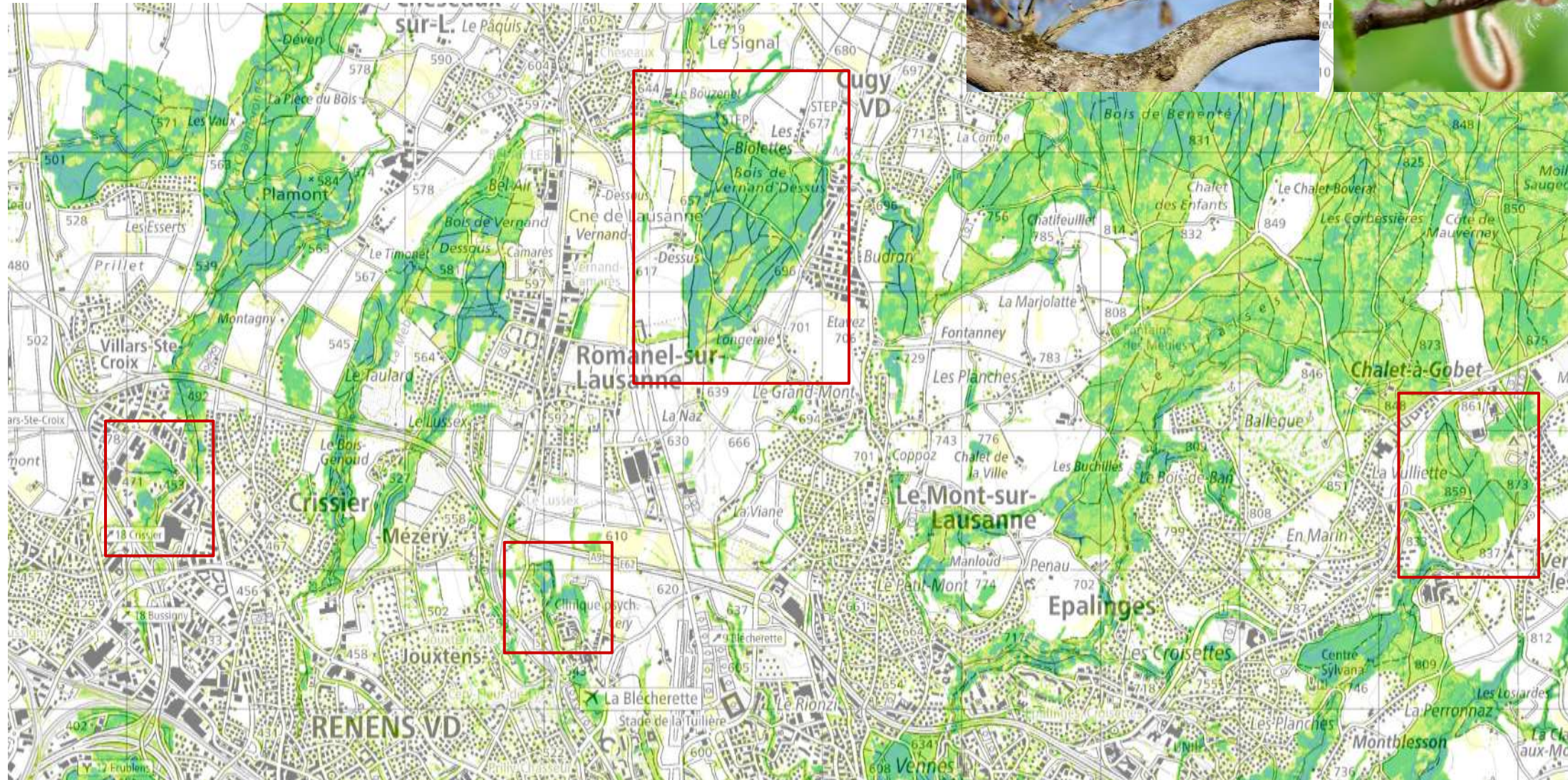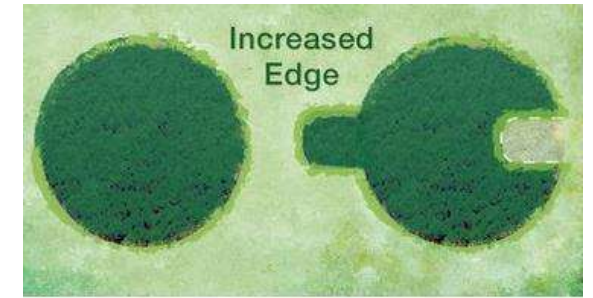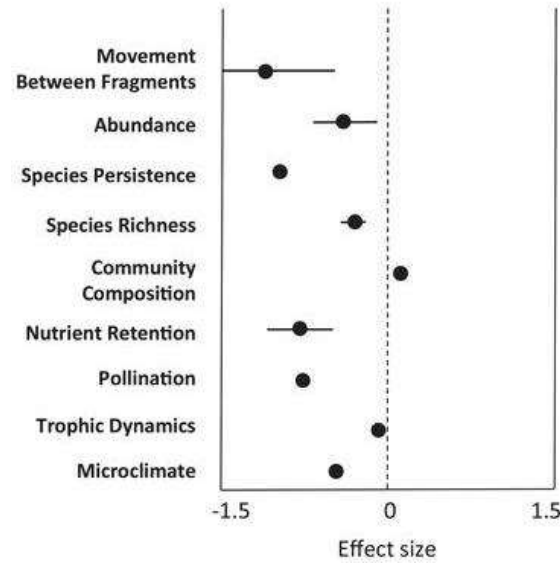
Reducing connectivity kills metapopulations

Habitat fragmentation and edge effects
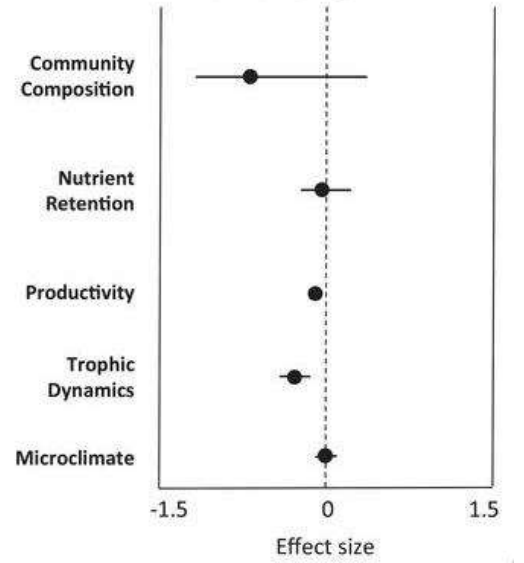
Habitat loss and extinction debt
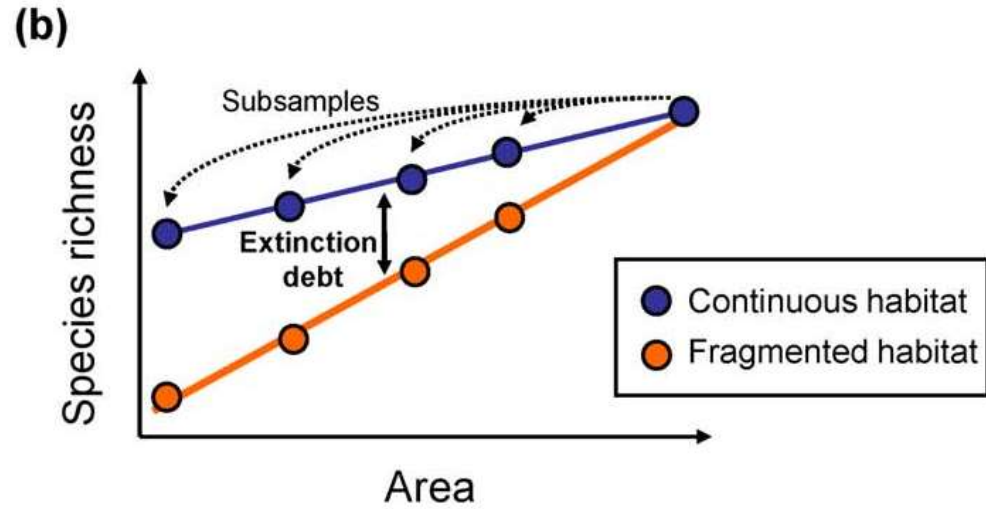
TRENDS in Ecology & Evolution

Kuussaari et al. 2009. Trends in Ecology and Evolution
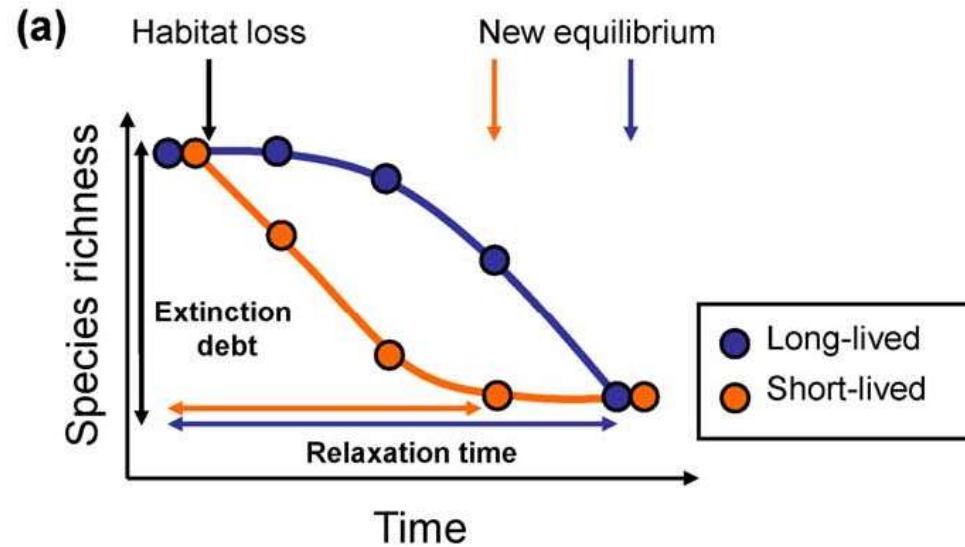
Succession, seral stages and climax

- **Primary** succession begins with bare rock (no soil)
- **Secondary** succession starts after **disturbances** (soil present)
- **Climax** is rarely reached (unstable environments) and climate change shifts climatic climax

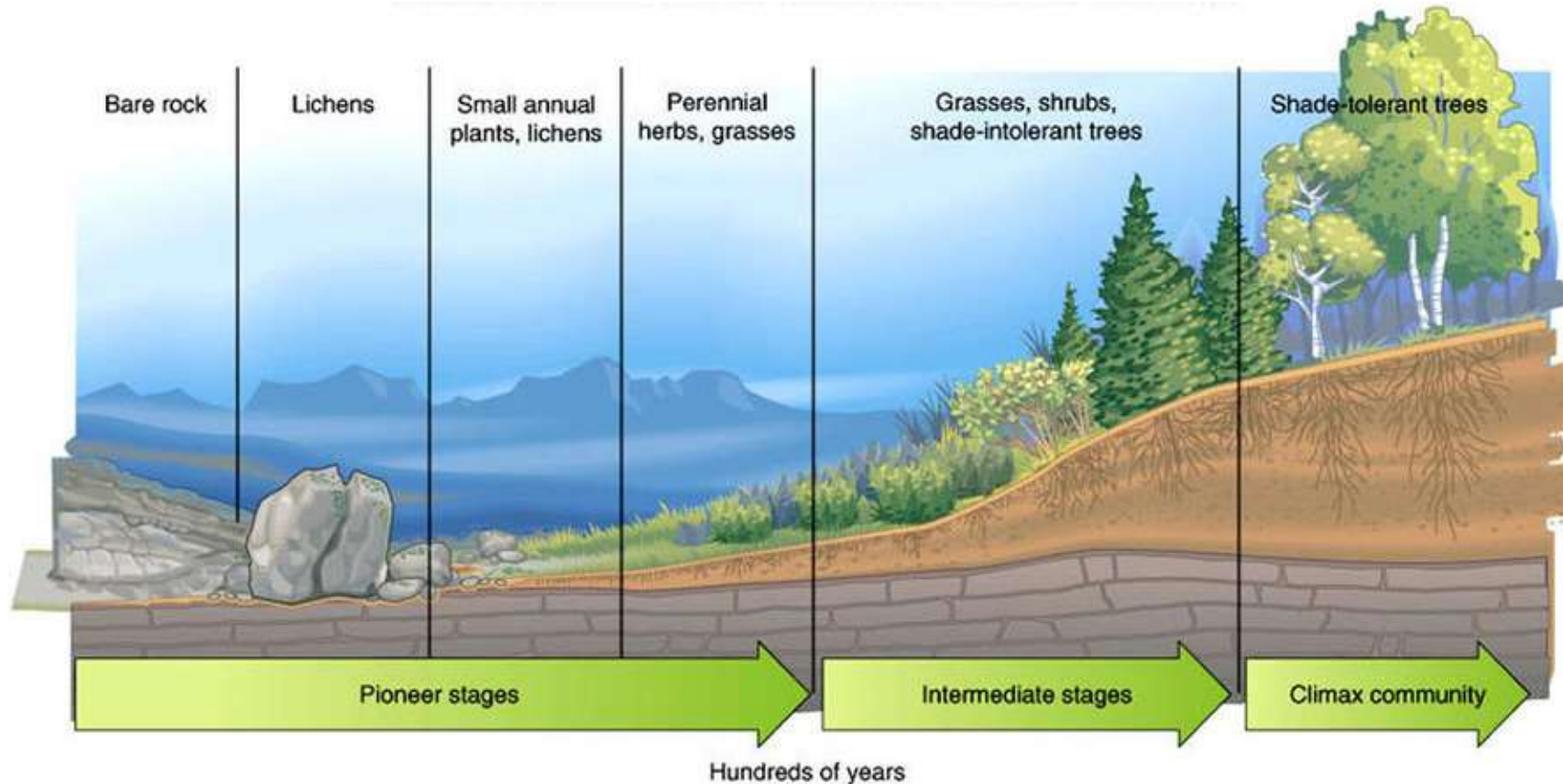# Intermediate disturbance hypothesis

- Species richness (and diversity) at the local scale peaks at:
  - intermediate values of disturbance frequency,
  - intermediate times after a disturbance, and
  - at intermediate spatial extents of disturbance

Connell 1978. Science
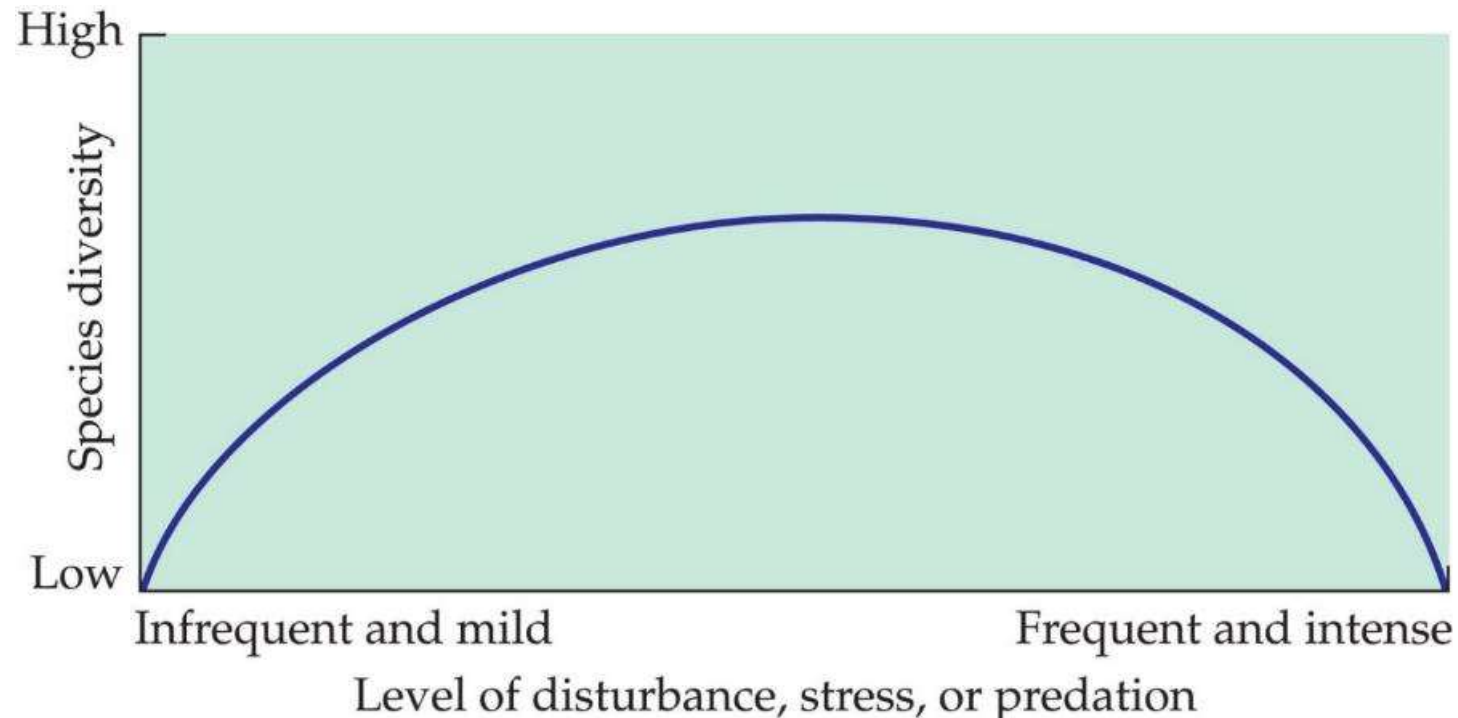
Community resilience and invasions

Different species

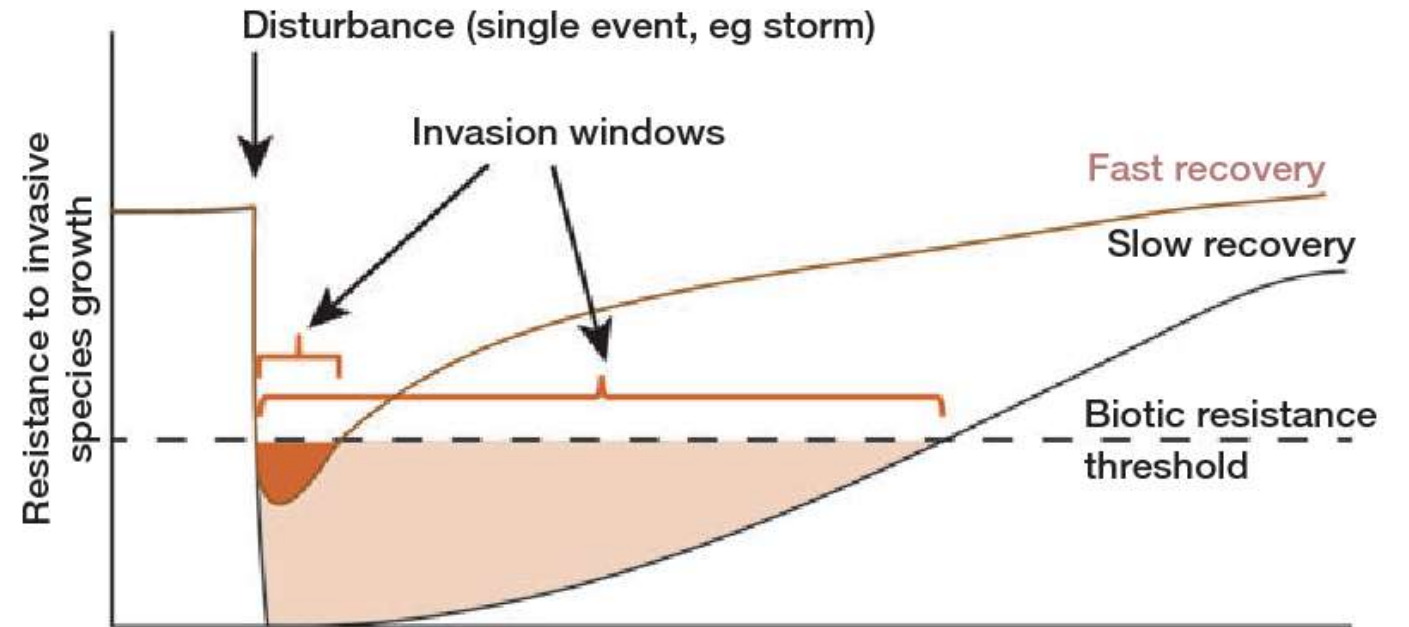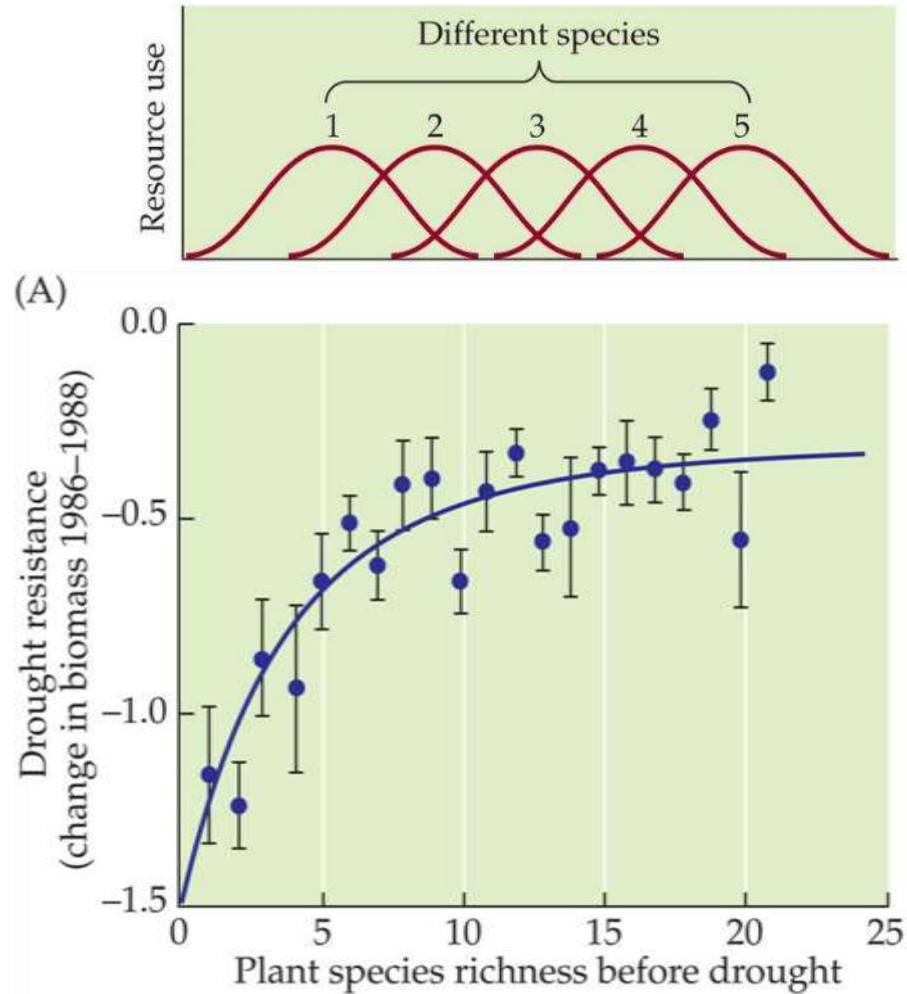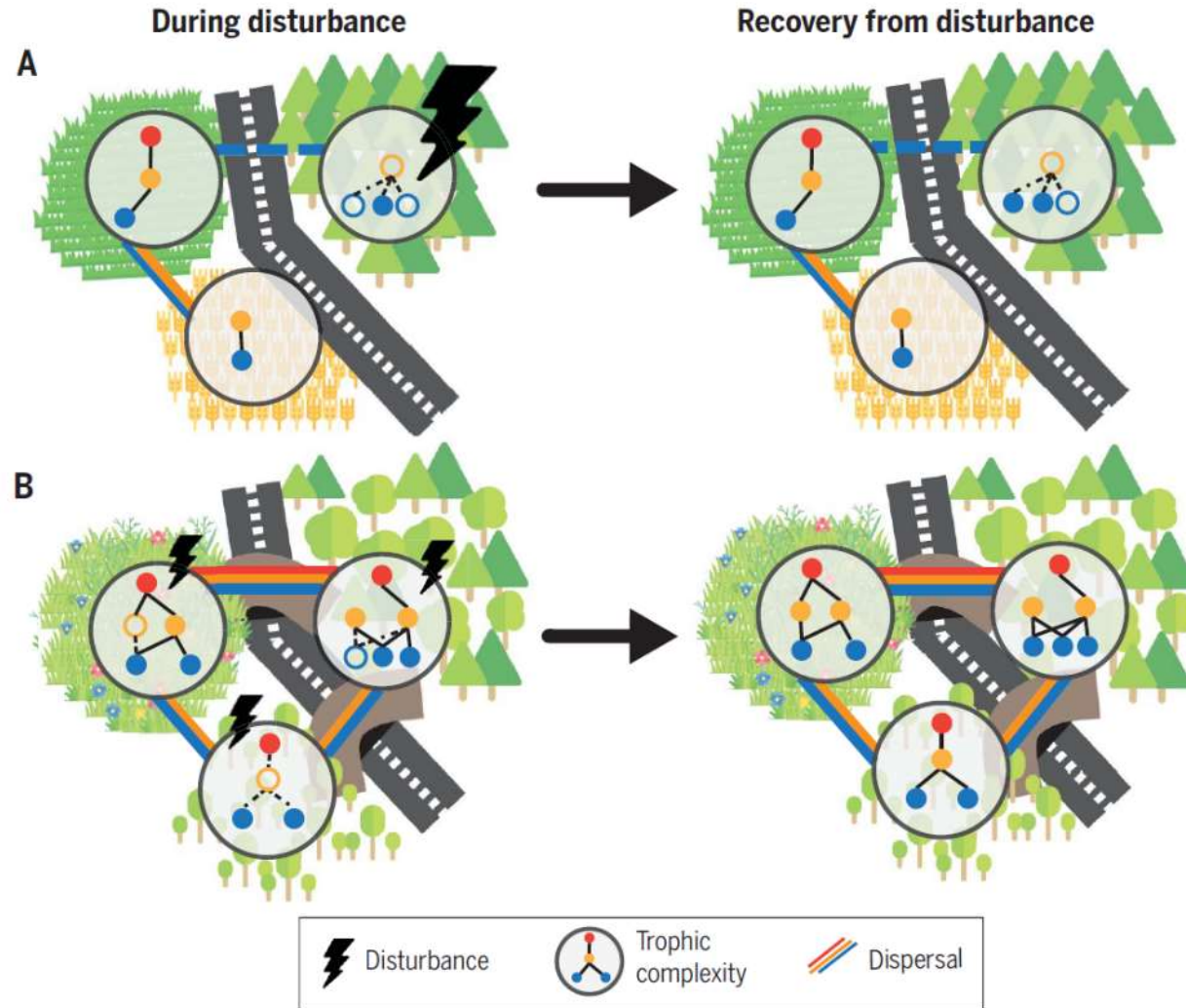Resource use

1 2 3 4 5

(A)

Drought resistance (change in biomass 1986–1988)

Plant species richness before drought

Disturbance (single event, eg storm)

Invasion windows

Resistance to invasive species growth

Fast recovery

Slow recovery

Biotic resistance threshold

Midgley 2012. Science
Hubbell 2005. Functional Ecology

Diez et al. 2012. Frontiers in Ecology and the Environemnet

Connectivity + diversity = resilience

During disturbance | **Recovery from disturbance**

A

B

Legend: ⚡ Disturbance | Trophic complexity | Dispersal

Cascading effects & ecological interactions
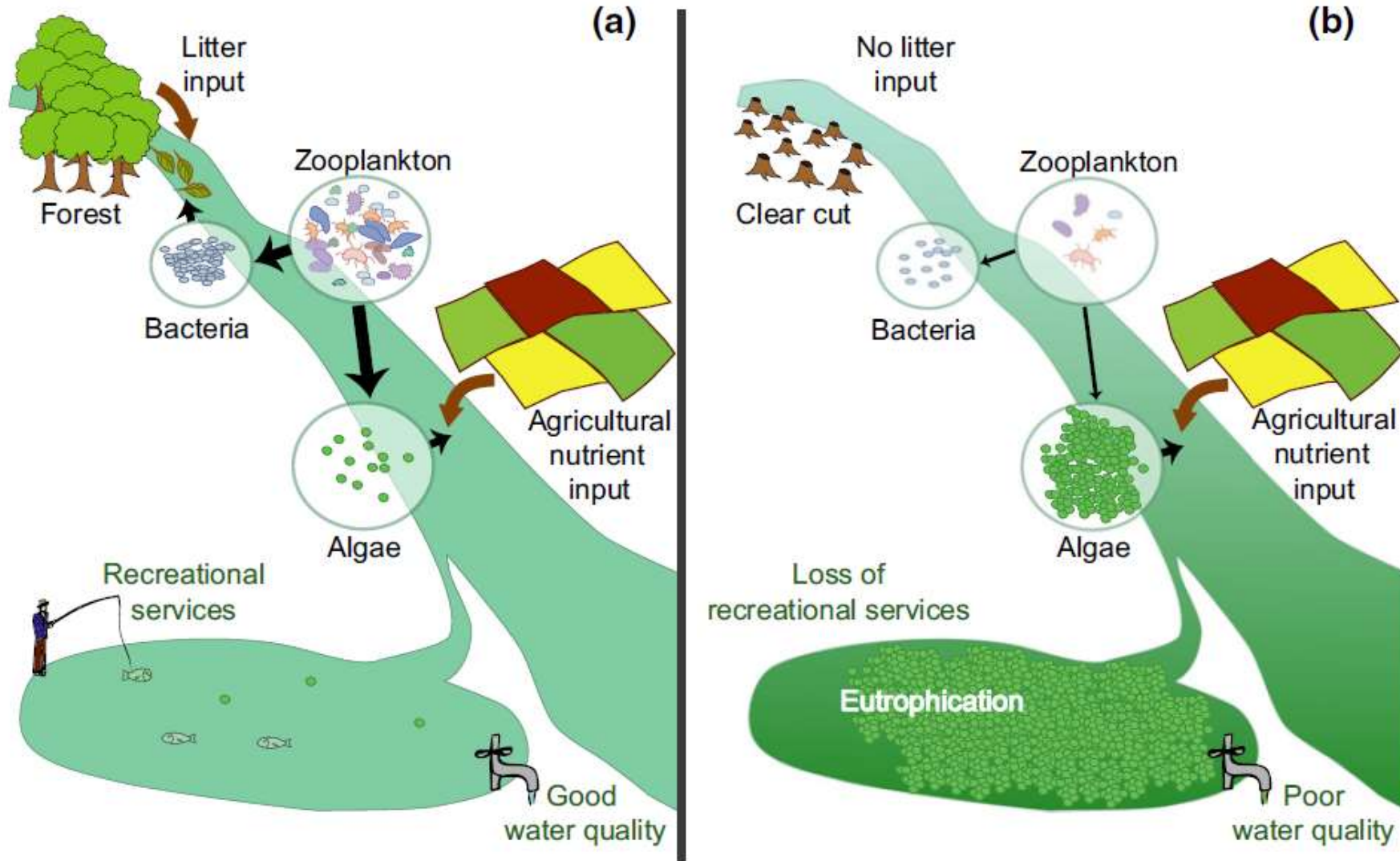
Urban sprawl as a radiating wave of disturbance

Urbanization can be modeled by looking at the probability that a given patch might undergo a transition over time, based on its location along a gradient from rural to urban.

Generally the probability of change in the rural environment is relatively low; **change is most likely along the urban fringe**; and the city center is more stable than the fringe but more likely to experience change than the rural environment.

In a typical city, **a wave of high disturbance radiates through time outward** from the initial city edge.
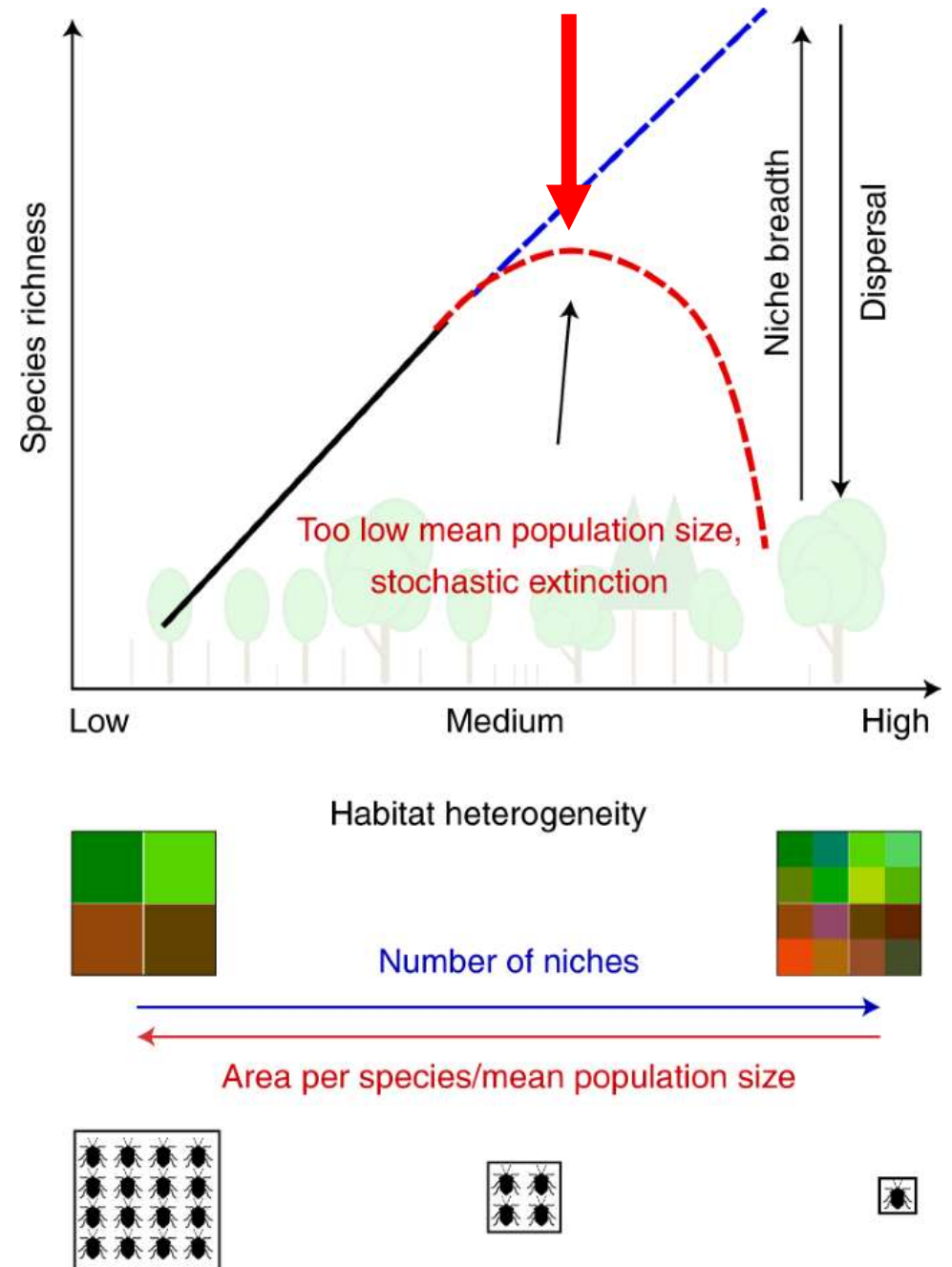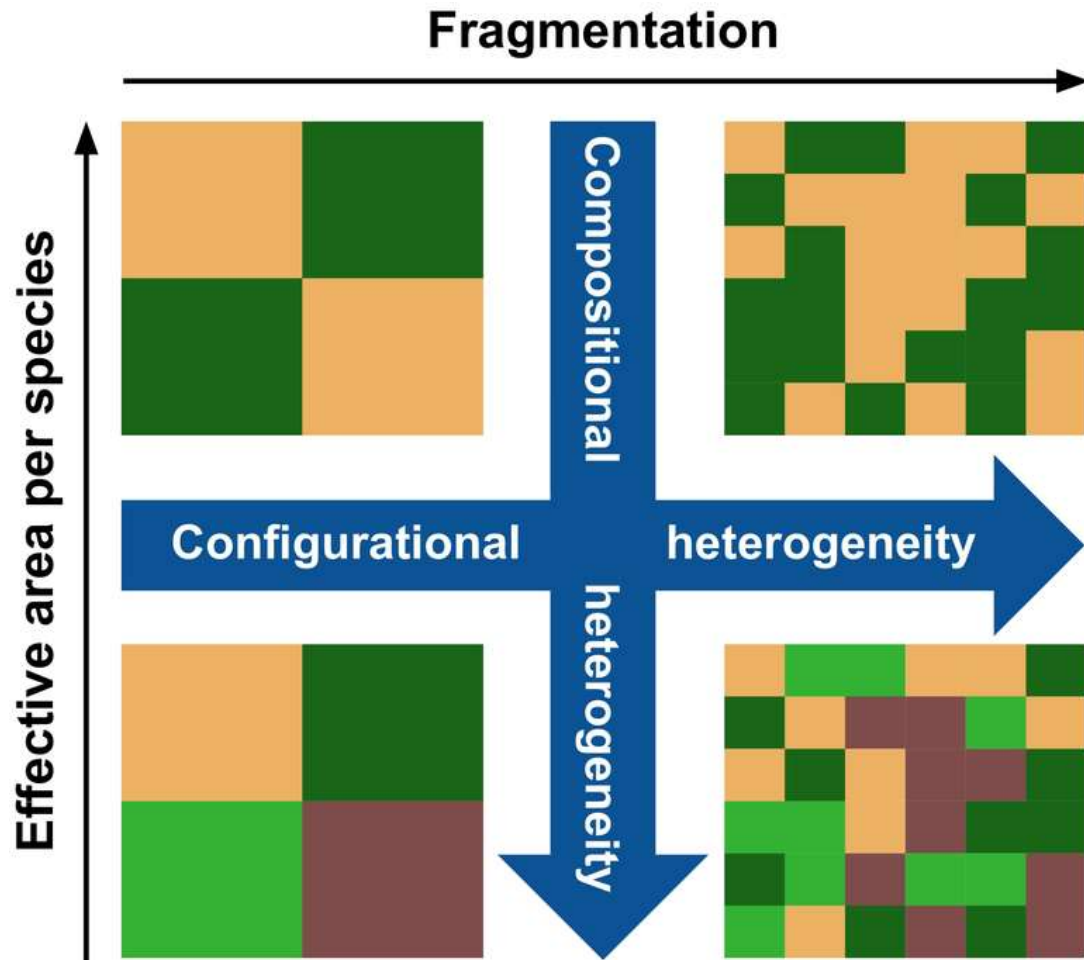

Collins et al. 2000. Am. Scient.
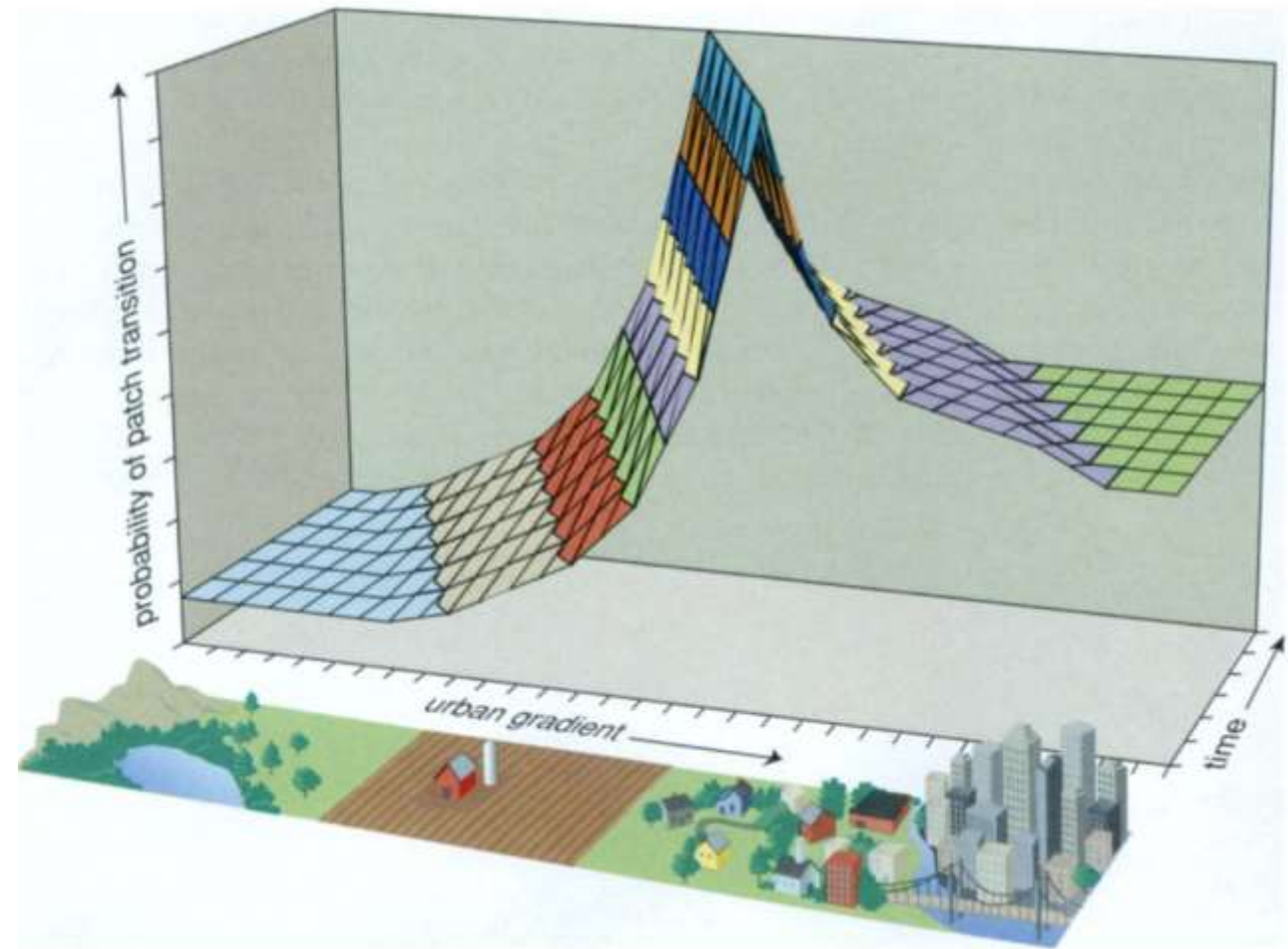
Liestal
1984-2004

Spatial heterogeneity: single large or several small?

Spatial heterogeneity
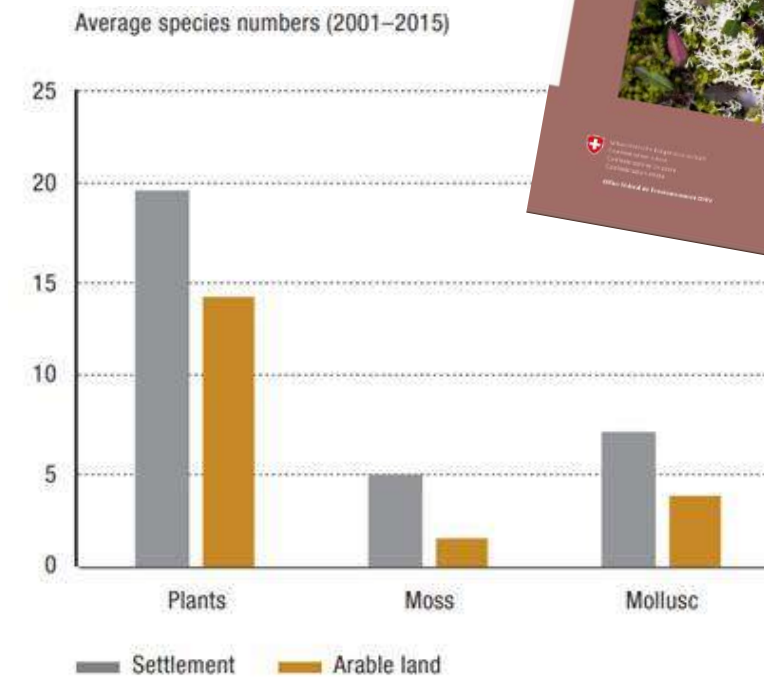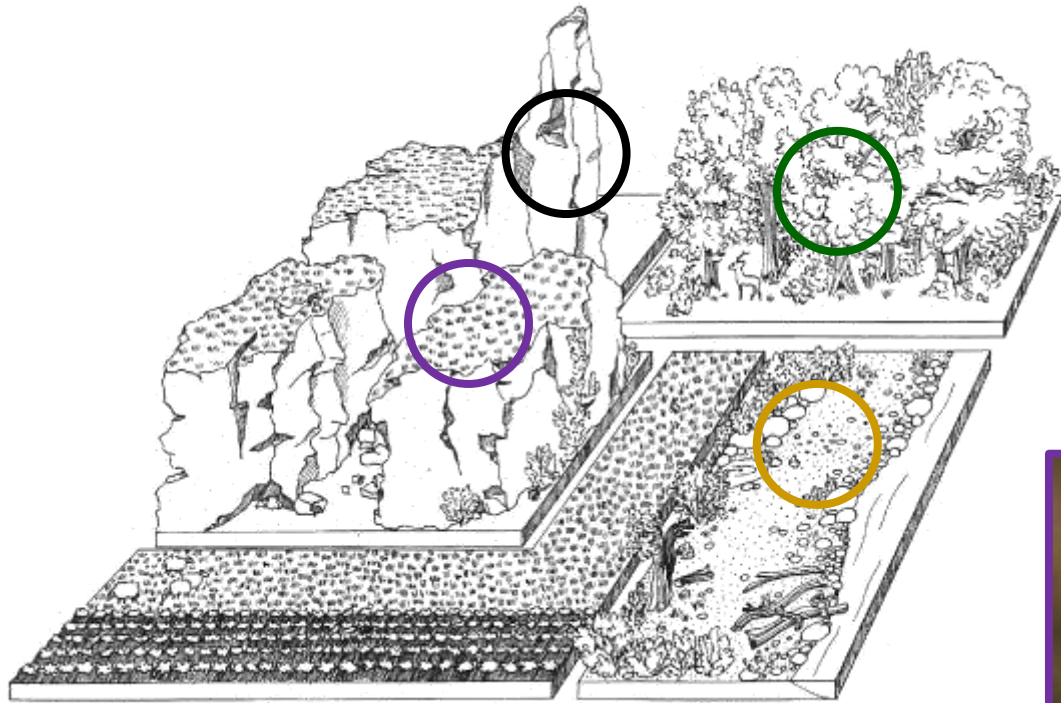

Average species numbers (2001–2015)

Fig. 51 *The average number of species of vascular plants, mosses and molluscs is significantly higher in settlements than in arable land. Source: BDM*

Diagnostic toolkit

- Acknowledge that urban habitats are **secondary** habitats

Primary habitats

Alternative habitats

Diagnostic toolkit: the guild approach

There are multiple ecological networks ... in interaction!

The "green" guild:
tree, forest & hedgerow species

Core area

Corridor
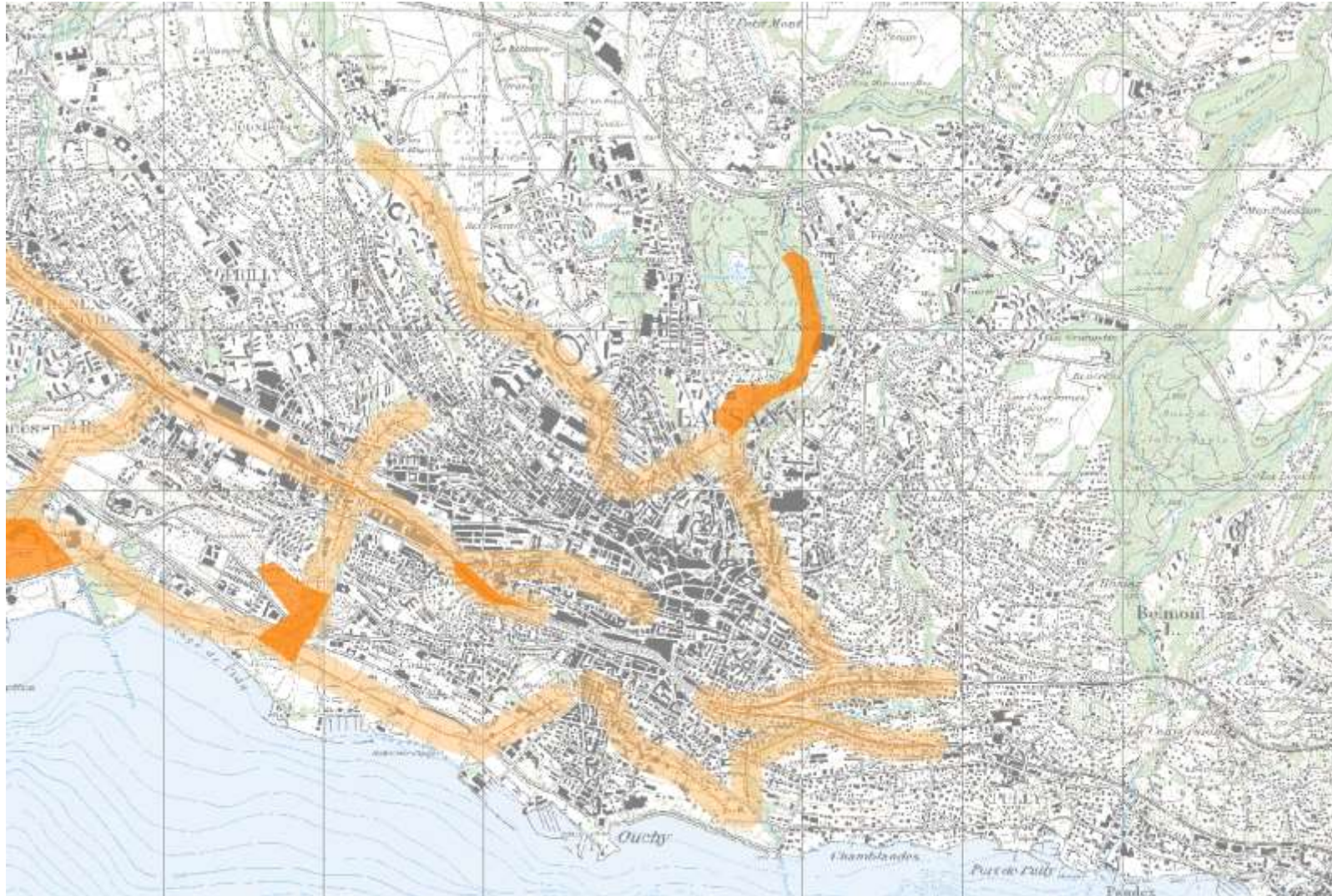
The "blue" guild:
lake, ponds & streams species

Core area

Corridor

The "orange" guild:
mesophilic grasslands & ruderal/pioneer species

Core area

Corridor

Core areas + corridors = ecological infrastructure
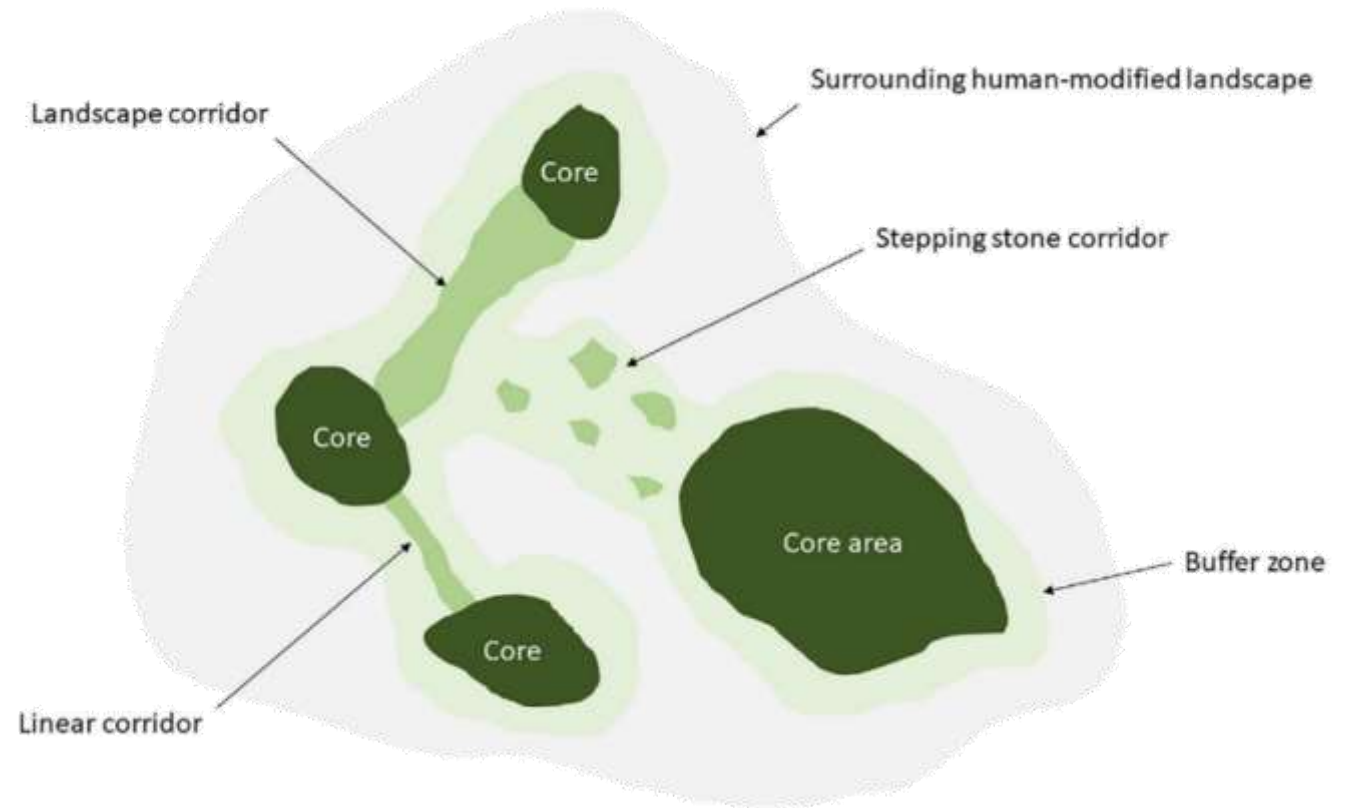
Forêt naturelle, îlots de vieux bois, forêts clairsemées

Haies, bosquets, vergers, allées

Bas- et hauts-marais, étangs, mares, lacs

Cours d'eau, zones alluviales, sources

Habitats secs (p.ex. prairies et pâturages)

Prairies maigres, jachères fleuries, surfaces rudérales

Landscape corridor

Surrounding human-modified landscape

Core

Stepping stone corridor

Core

Core area

Buffer zone

Core

Linear corridor

How to promote an ecological infrastructure (EI)?

- The ecological diagnosis is mostly based on:
  - Size of core areas (quantity, sources v. sinks of propagules),
  - Naturalness of the species community (quality),
  - Degree of disturbance (quality),
  - Connectivity.

- The consolidation of the EI follows this order:

  1. Strengthen and secure core areas (buffer or extension zones)
  2. Improve connectivity in a <u>centrifugal</u> manner (steppingstones and corridors)
  3. Develop new reservoirs of biodiversity

Planning examples at different scales (REN, 1990's)
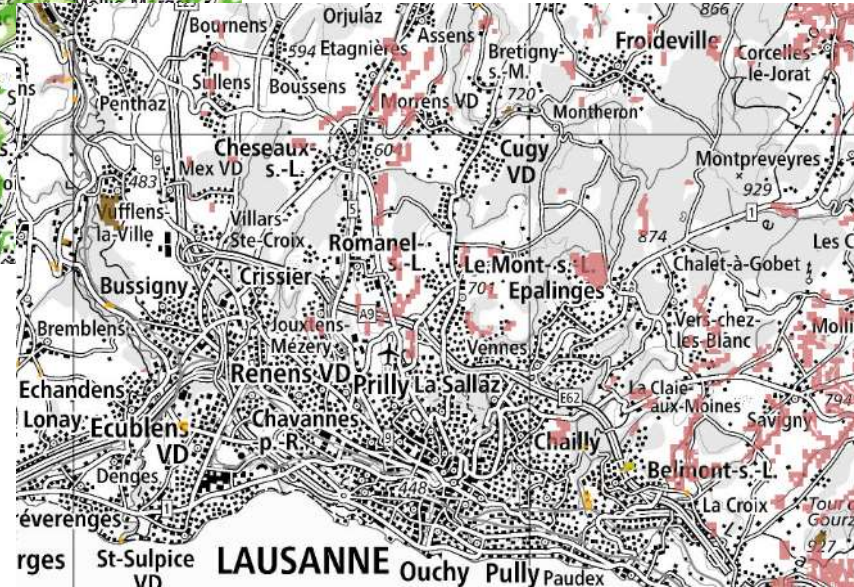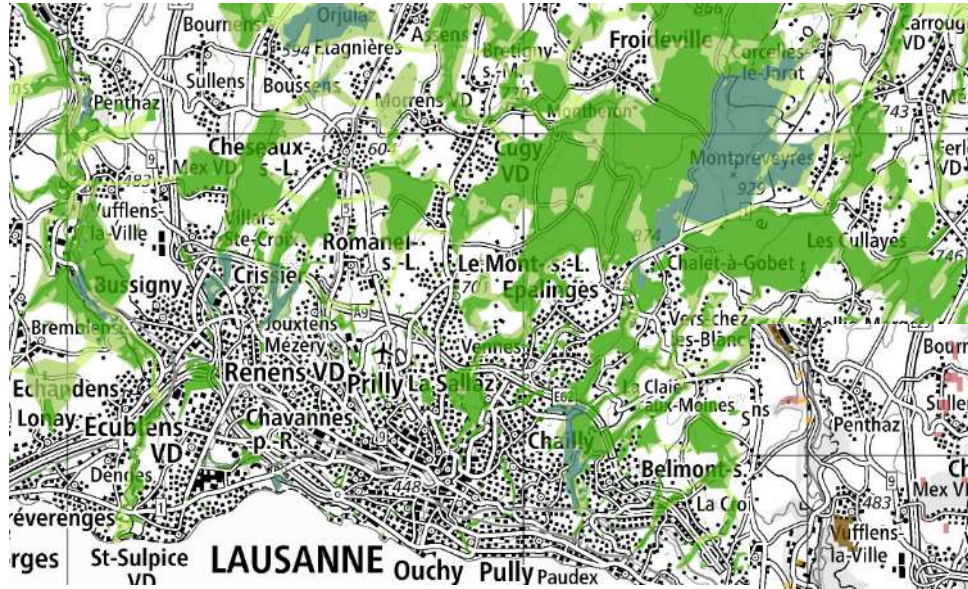
Planning examples at different scales (REC, 2000's)
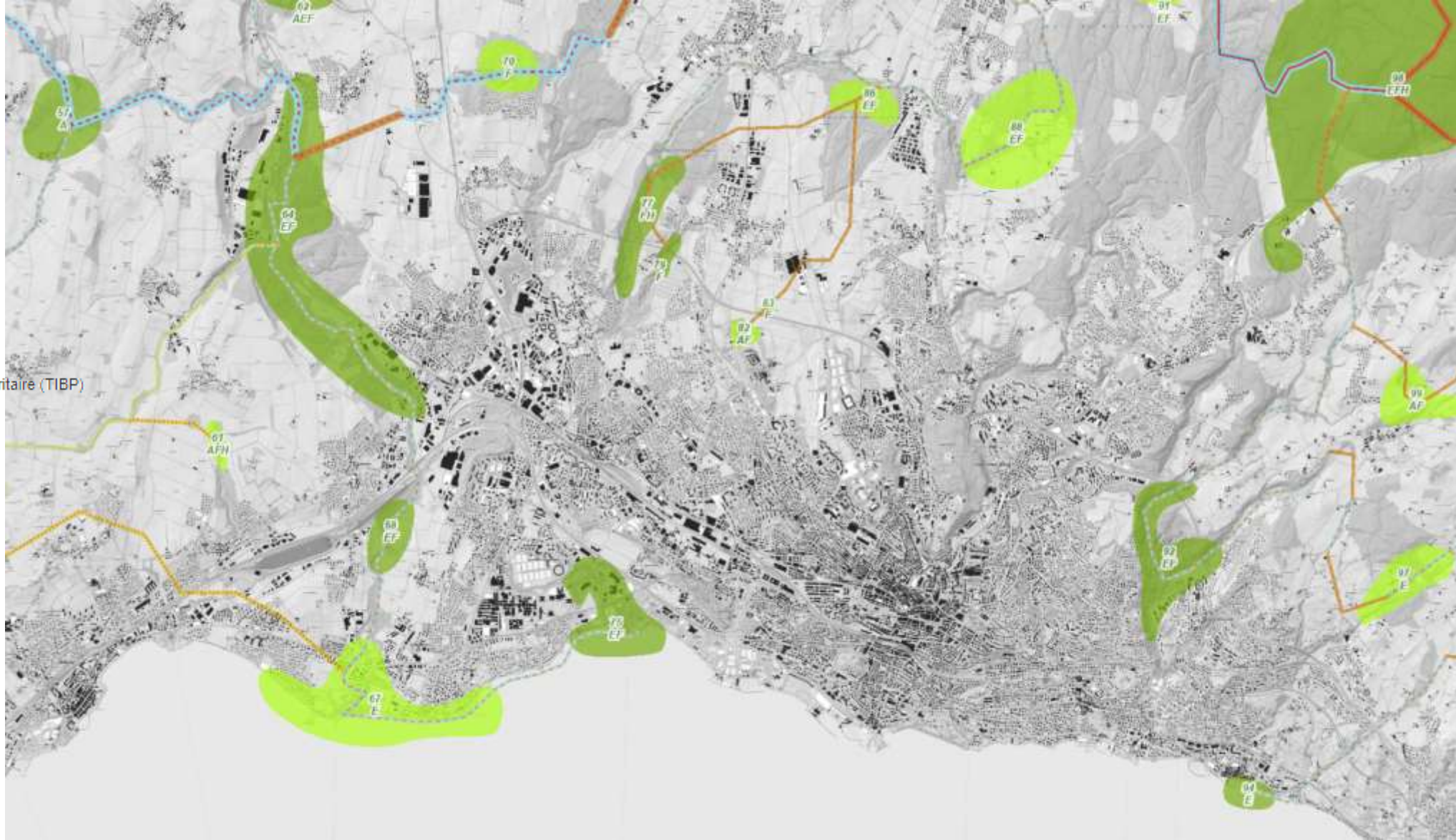
Planning examples at different scales (PALM, 2000's)

Espaces naturels à maintenir ou à renforcer:

- armature biodiversité
- espace cultivé
- liaison biologique
- maillage écologique
- espace naturel à restaurer
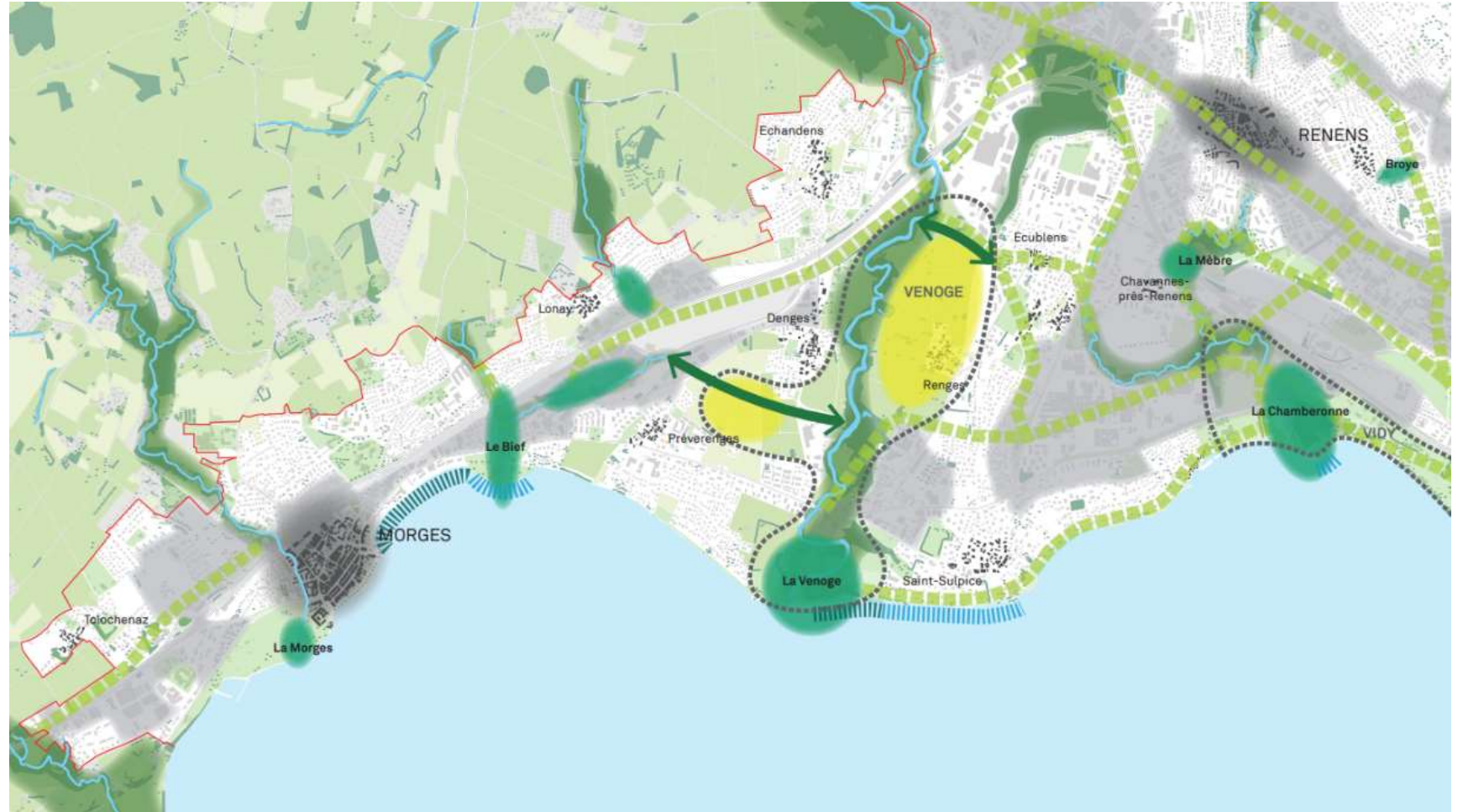
Planning examples at different scales (Nyon)

Stratégie globale du maillage paysager pour la Ville de Nyon

Les coulées vertes forment le réseau paysager principal, elles font partie ou sont en synergie avec les grandes structures paysagères que sont les échappés lacustres mis en évidence par le plan directeur cantonal et le plan directeur régional du district de Nyon

Ces coulées vertes constituées majoritairement de bandes forestières liées à des cours d'eau mettent en liaison l'arrière-pays le grand paysage du Jura et le Lac Léman. Elles traversent le paysage Nyon

Le maillage et l'association des différents réseaux et tend à se densifier pour en favoriser la qualité de vie et la qualité biologique du paysage nyonnais qui participe à un plus grand ensemble que sont le grand paysage du Jura et du lac Léman.

Les aménagements et espaces du domaine communale public entretenus par le Service des espaces verts et forêts sont en synergie et complémentarité au réseau principale (coulées vertes) et aux barreaux paysagers (par les strates végétales, les structures, les matériaux, les niches écologiques, la gestion de l'eau, les entretiens différenciés …)

Planning examples at different scales (SDHE)

Green EI

- Preserve old or senescent trees

- Increase the amount of dead wood on the ground

- Reduce artificial lights at night on the forest edges

- Replace single species hedgerows
  of exotic species with natural diversified hedges

- Promote canopy continuity, especially along streams

Blue EI

- Avoid waterproofing and promote infiltration
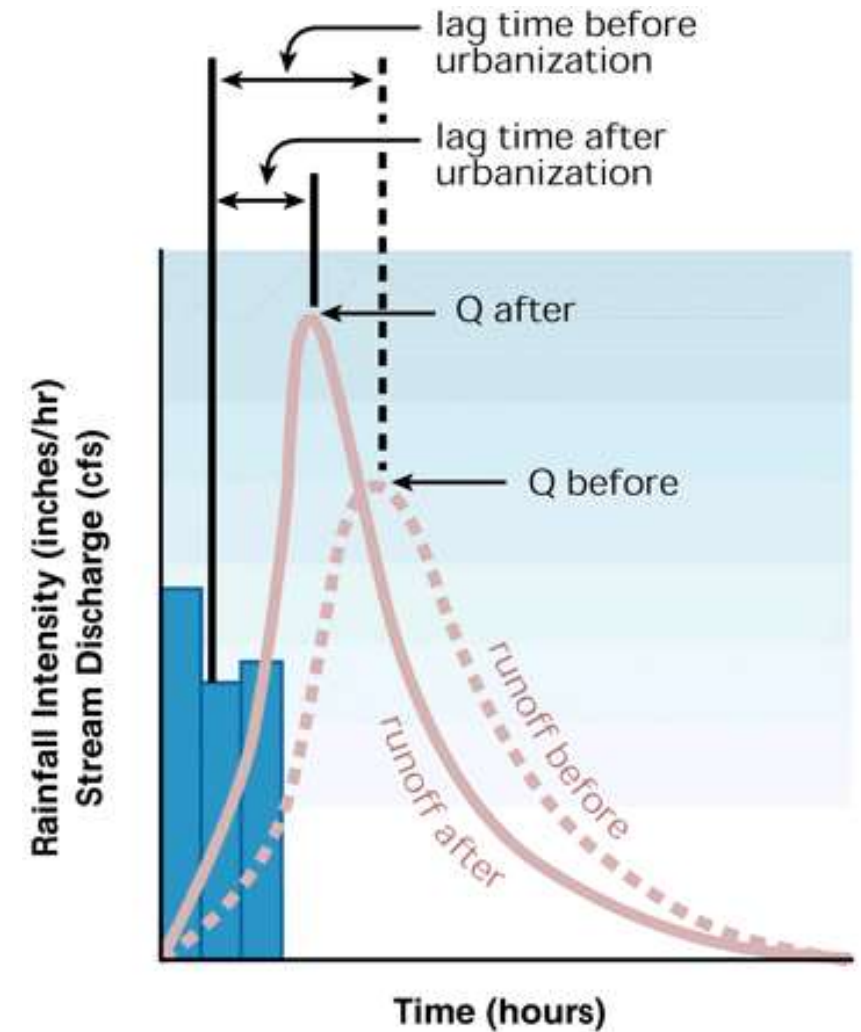
Blue EI

- Creation of new natural ponds (first) & streams (second) – see Red Lists

- Think about the hydroperiod and the requirements of species

- Be ready to adress the mosquito issue

Orange EI

- Promote natural vegetation
  (without biocides or fertilizer)

- Maintain uncut refuge areas

- Restore orchard and hedgerows
  (interface between the forest and grassland network)

- Add small structures such as drystone wall,
  pile of wood, pile of stone, etc.

- Develop extensive green roofs

Orange El

Brown EI (living soils)

- No soils, no biodiversity

- Become an earthworm and map the urban soil continuity

Priorization at the national scale

Fig. 1 : Part des catégories de menace de la liste rouge pour tous les milieux (TOTAL), et par écosystème

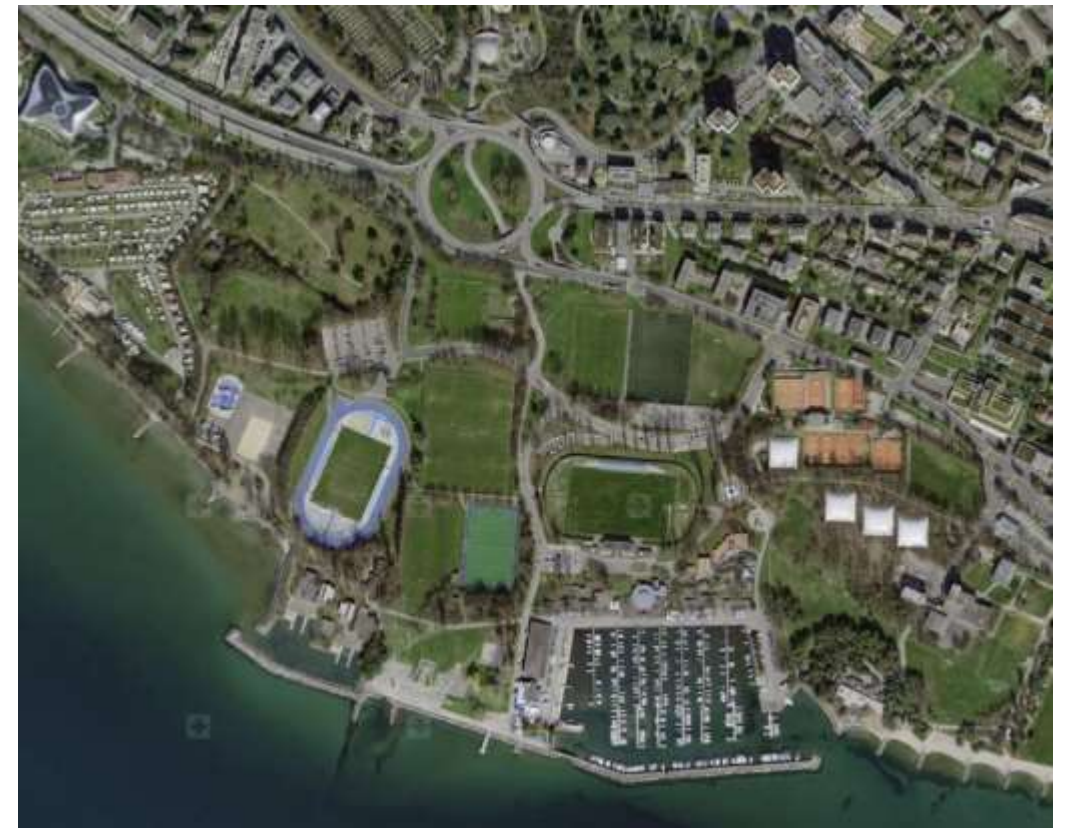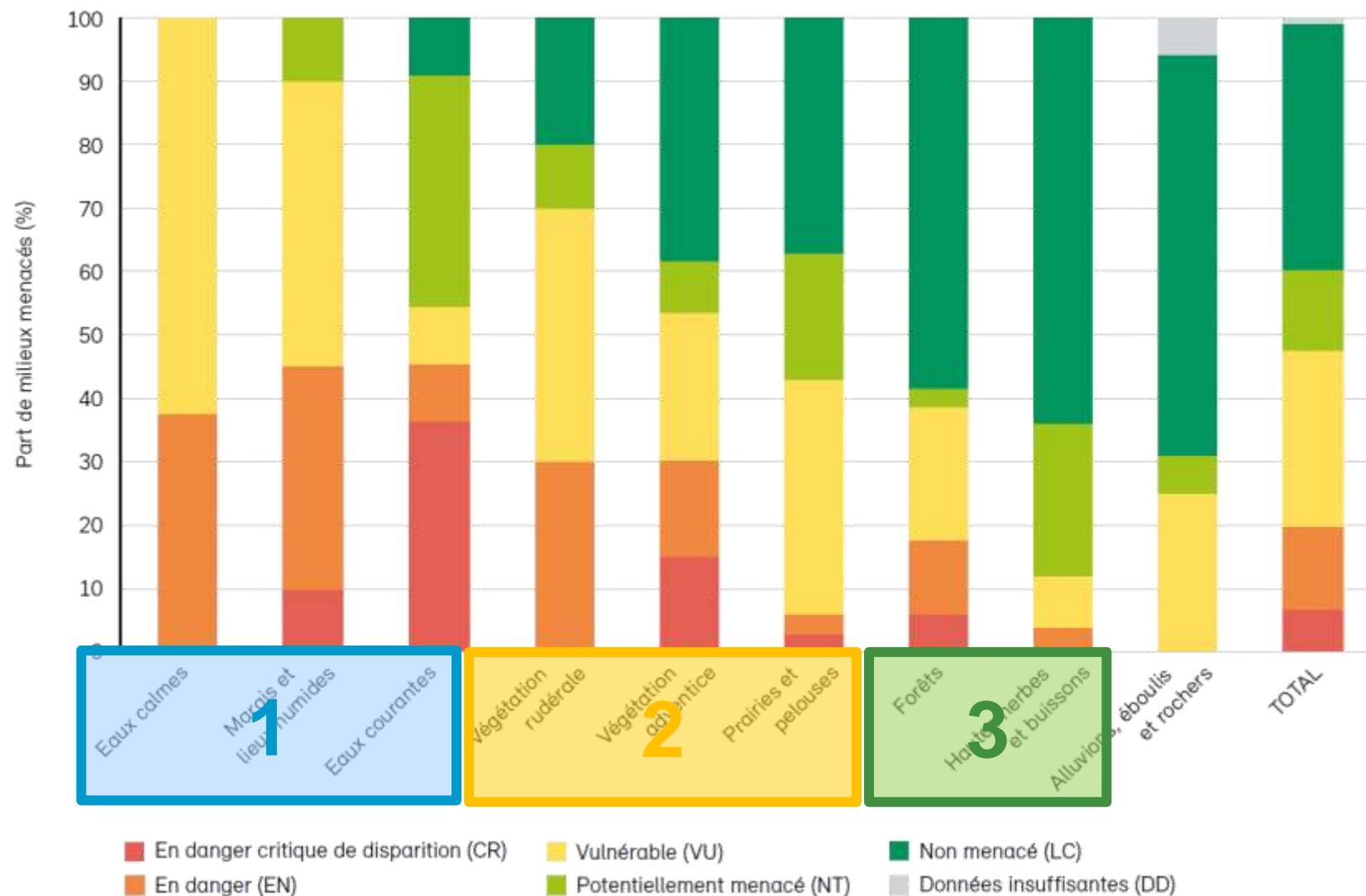*Les milieux classés dans les catégories CR, EN et VU sont considérés comme menacés.*

Common mistakes when planning an EI

- "Too little, too late": restoring ecological connectivity requires ambitious investments and long-term planning.

- General measures, not specific enough. The diagnostic stage is crucial, it defines the measures necessary to restore the EI. It requires a biological eye.

- Measures too focused on one or a few target and charismatic species, not on the restoration of ecological processes.

- Greenwashing. No real understanding of what is at stake (e.g. anecdotical tree planting, honeybee hives, very temporary ponds that act as ecological traps...)

Adressing sever disturbances: ALAN

25% | community 32%
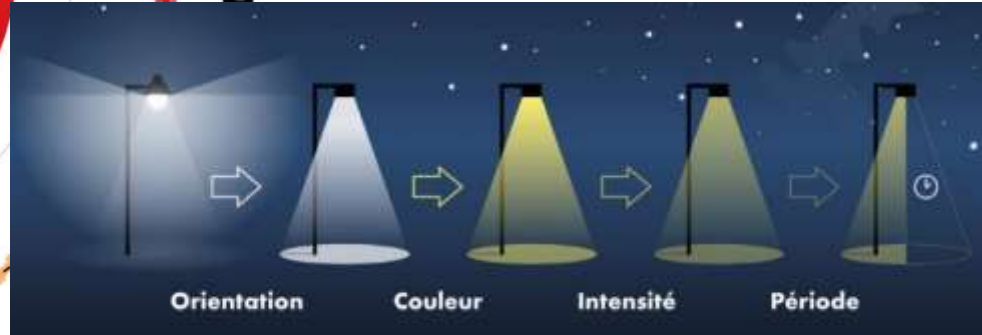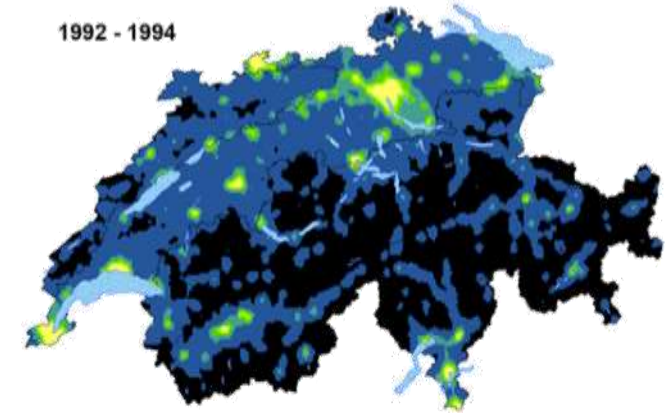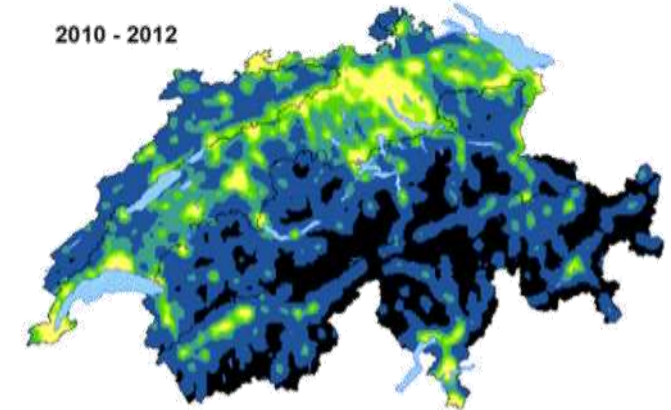
Evolution de l'obscurité nocturne entre 1994 et 2012

1992 - 1994

Pollution lumineuse, Suisse, 1994

2010 - 2012

Pollution lumineuse, Suisse, 2012

Orientation   Couleur   Intensité   Période

Adressing traps (for terrestrial species)

BiodiverCity: people want more!

Take home message

- Identify and preserve the **structuring elements of the ecological infrastructure** (core areas, biodiversity reservoirs, steppingstones and corridors)

- Improve **connectivity** by identifying obstacles, traps and disturbances, focusing on small terrestrial animals (e.g., hedgehog, snails, salamanders, beetles…)

- Plan ecological networks as you would any **transportation system**, with hubs and different lines.