Landscape Diversification & Agricultural Intensification

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Ph.D.

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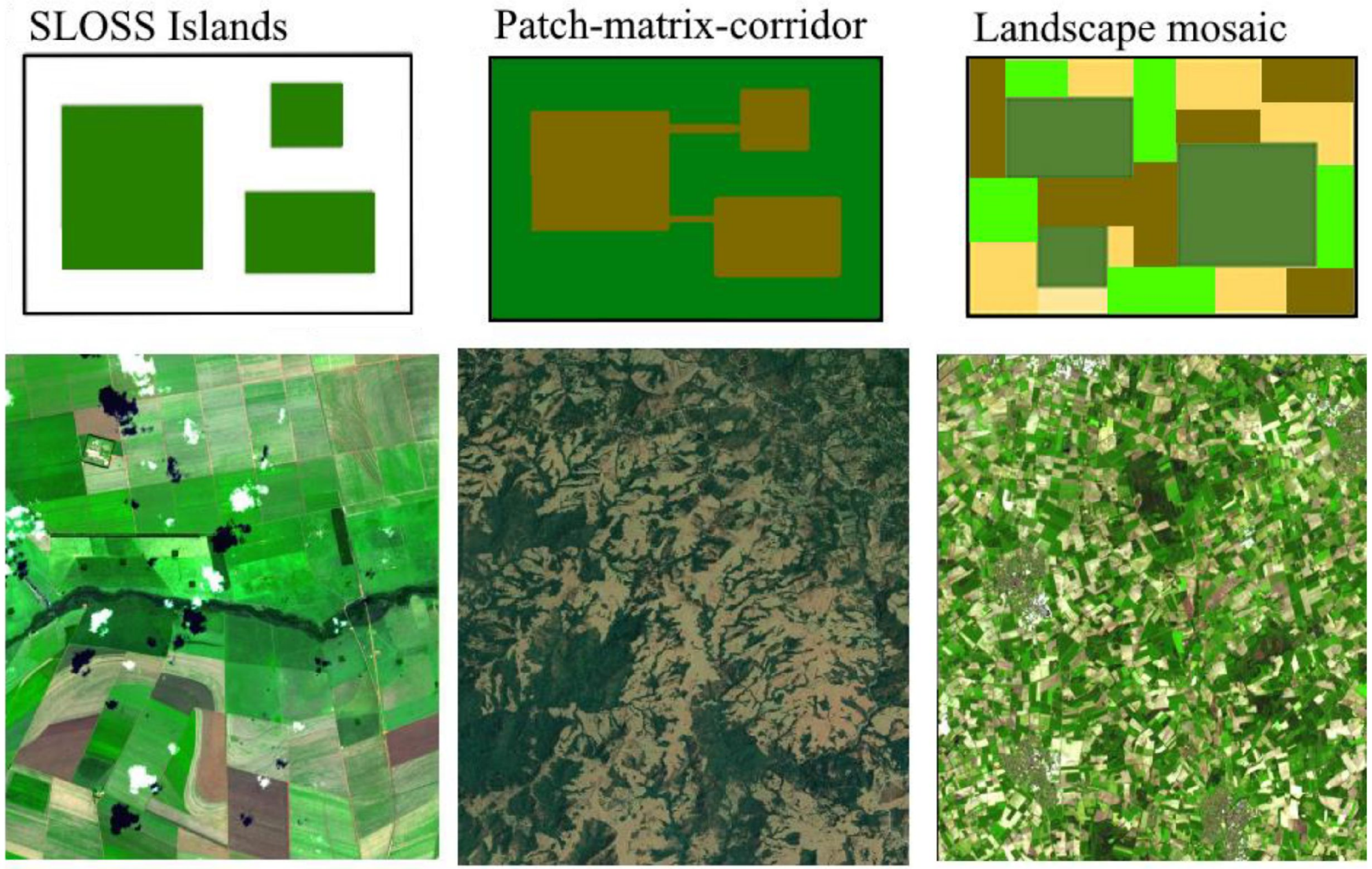
Terms

- Landscape Diversity = is the complexity and diversity of landscape elements in composition, structure and function.
- A landscape is "a mosaic of heterogeneous land forms, vegetation types, and land uses" (Urban et al., 1987). Therefore, assemblages of different ecosystems (the physical environments and the species that inhabit them, including humans) create landscapes on Earth.



Fu Bojie, Chen Liding. LANDSCAPE DIVERSITY TYPES AND THEIR ECOLOGICAL SIGNIFICANCE[J].Acta Geographica Sinica, 1996, 51(5): 454-462.

Terms

Agricultural Intensification = the process of increasing the inputs of agricultural resources (e.g. labor, land, time, fertilizer, pesticides, seed, feed, technologies or knowledge) to increase the level of yield per unit of farmland or pasture.

Although agricultural intensification can take many forms, it always involves the intensification of some types of agricultural input with a view to increase levels of yields.

It is often associated with the drastic change of a landscape and the loss of biodiversity – going from heterogeneity to homogeneity landscape.

https://www.tabledebates.org/glossary/agricultural-intensification

https://www.innovationnewsnetwork.com/rice-production-under-climate-change/6708/

https://www.newfoodmagazine.com/news/76219/small-farms-global/

Terms

- Agroecology = is an applied science that studies ecological processes applied to agricultural production systems.
- Agroecosystems are characterized by both planned and unplanned diversity. Planned diversity includes the spatial and temporal arrangement of domesticated plants and animals that farmers purposely include in the system, along with beneficial organisms that are deliberately added.
- Unplanned diversity includes weedy plants, herbivores, predators, microbes, and other organisms that persist in the system after it has been converted to agriculture or colonize it from the surrounding

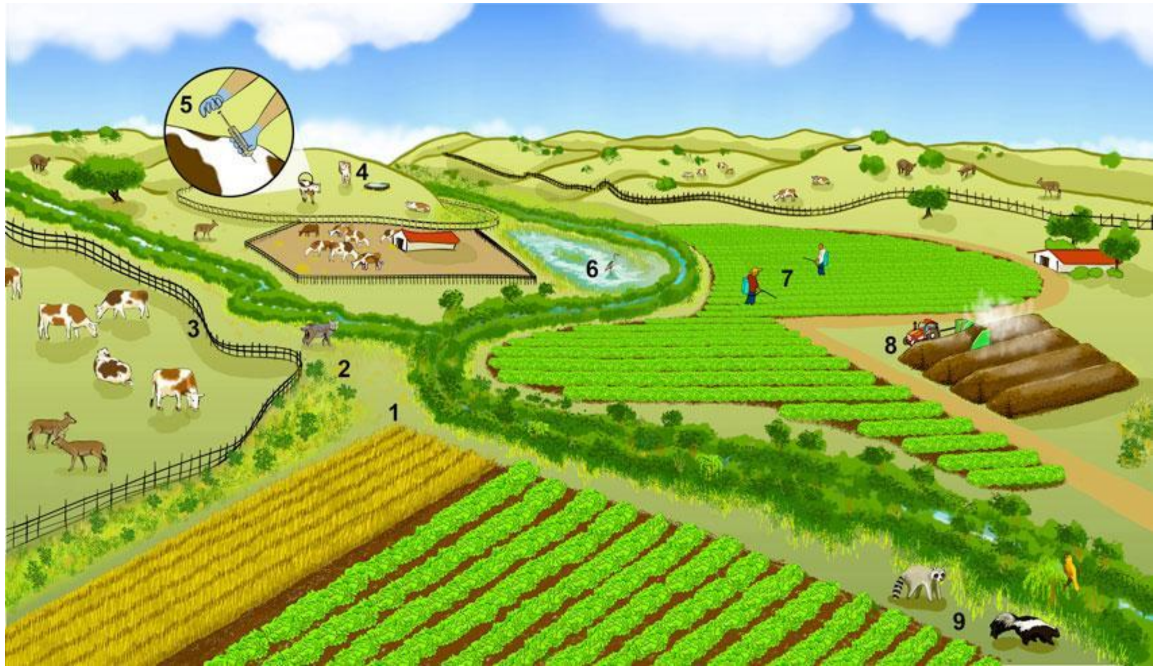
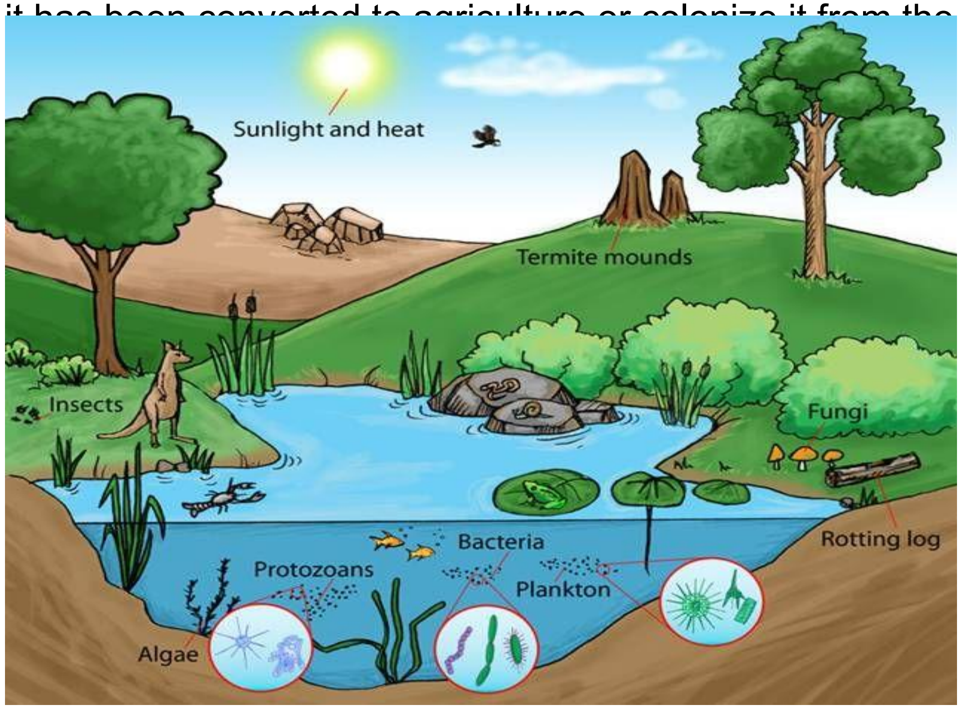


Illustration by Mattias Lanas and Joseph Burg. www.news.Berkeley.edu



Agroecology is sustainable farming that works with nature. Ecology is the study of relationships between plants, animals, people, and their environment - and the balance between these relationships. Agroecology is the application of ecological concepts and principals in farming.

(Ecology of Agriculture
Alison G. Power, in Encyclopedia of Biodiversity (Second Edition), 2013)

Terms

- Anthropocene = is a proposed geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change.

Officially, the current epoch is called the Holocene, which began 11,700 years ago after the last major ice age. The word Anthropocene is derived from the Greek words *anthropo,* for “man,” and *cene* for “new,”.

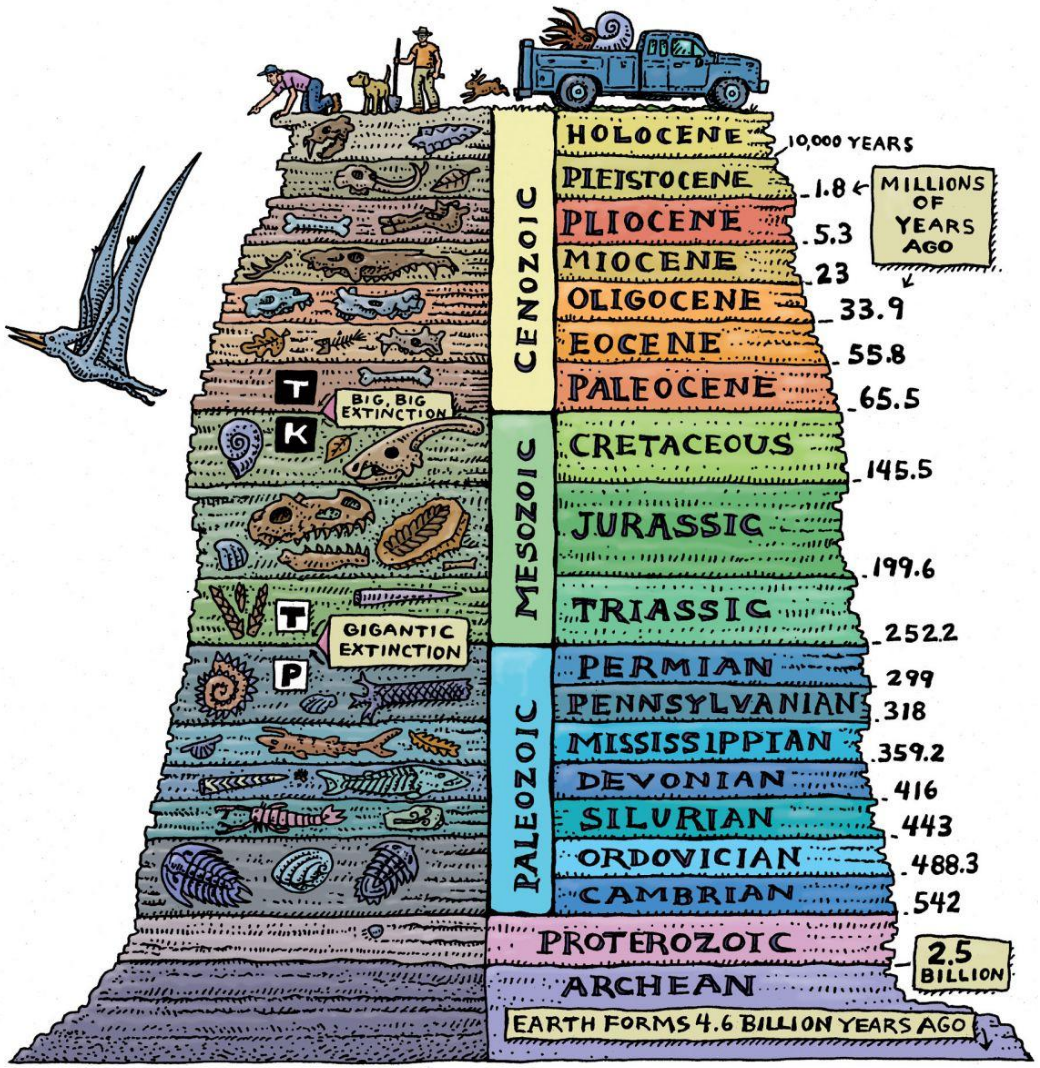


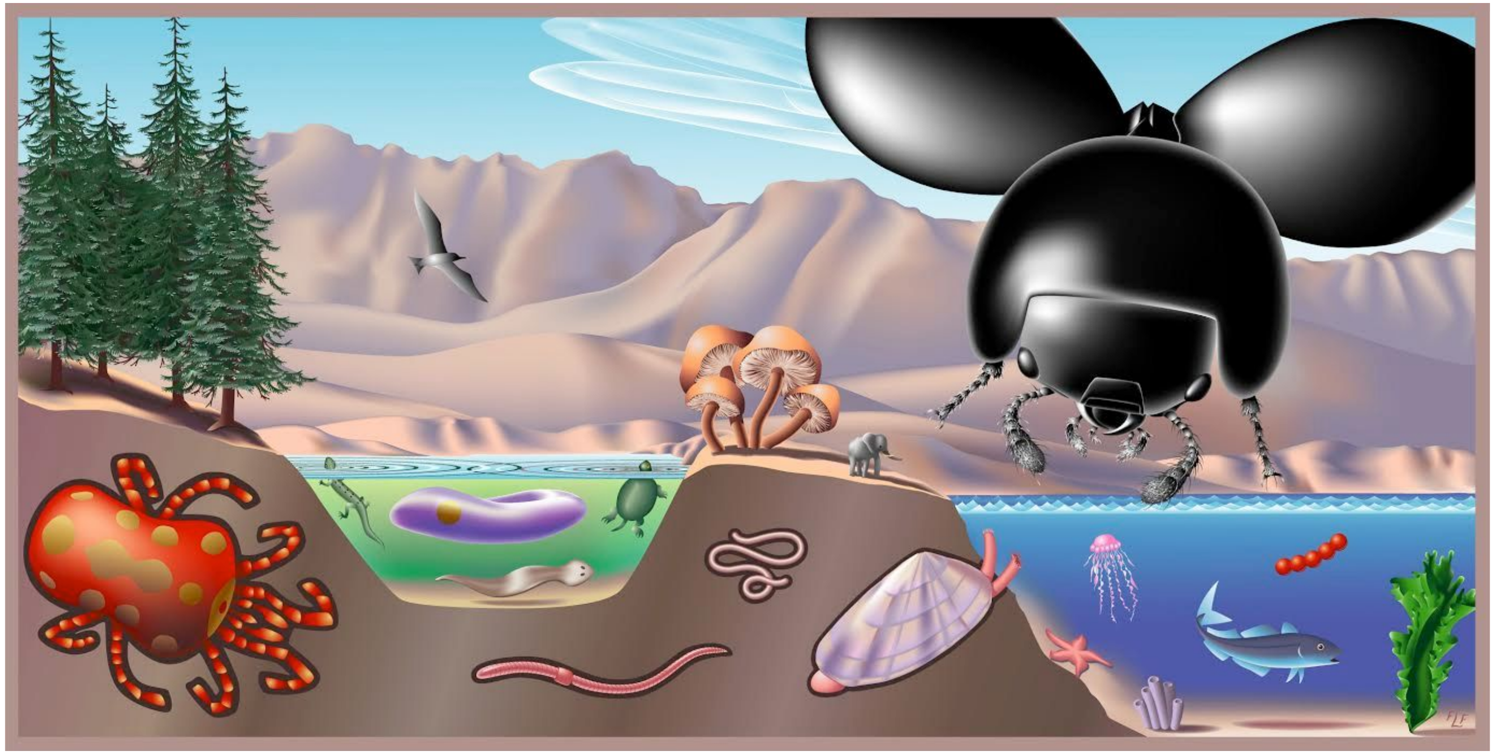
Photo by an environmental scientist (crime) investigator of hundreds of fly-tipped tires in a disused chalk quarry in North Kent, England. By Cugerbrant - Own work, CC BY-SA 4.0.

Terms

- Biodiversity = Biodiversity is the biological variety and variability of life on Earth. Biodiversity is a measure of variation at the genetic, species, and ecosystem level

- Benefits of biodiversity:
  - Ecosystem services
  - Ecosystem efficiency

Species scape



A species scape is an illustration of different species that symbolize life on earth (Wheeler 1990). Each of the organisms pictured represents different groups of living things and the size of each picture indicates the known number of species in that group.

Terms

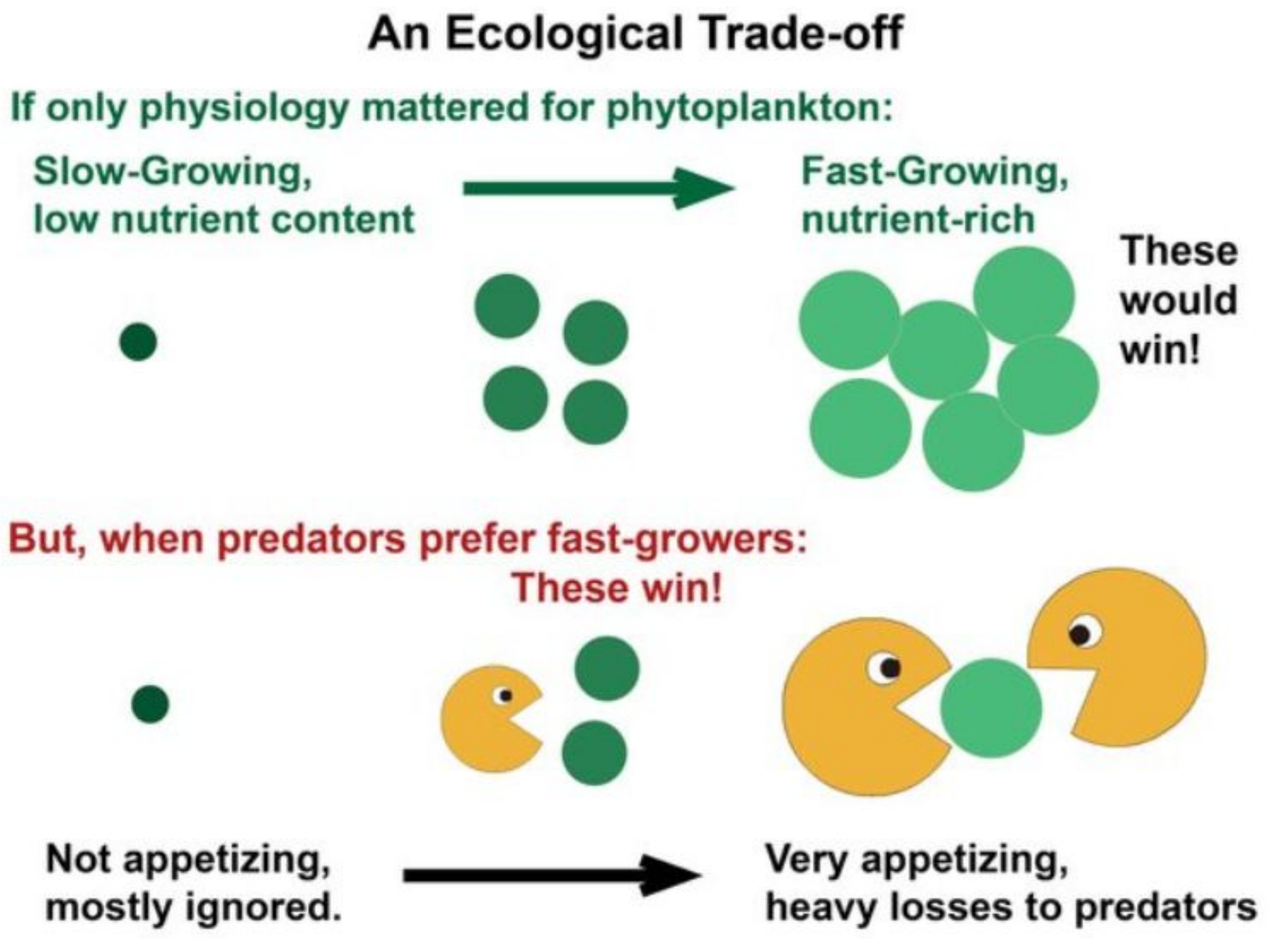
- Ecological Trade-off = In biology, a trade-off exists when one trait cannot increase without a decrease in another (or vice versa).

Ex: the size and number of eggs that a fish, bird or turtle can produce in a given clutch.

Or

Ecological trade-offs which depend on the interactions of predator and prey. Ex. displaying the evolution of competitive ability for nutrient uptake.

So we are left contemplating what is the “best” strategy? We have to weigh the benefits and draw backs of these trade-offs.



The Problem

Agricultural intensification has drastically changed the landscape and given rise to a loss of biodiversity, notably in insect faunas. This loss of biodiversity is part of a more general trend of insect reductions in the Anthropocene.

Questions

How do we balance the need to produce enough agriculture (and food) while maintaining biodiversity?

- Does more diverse always = better?

What are the conversations being had in the scientific community regarding this topic?

What is the solution?

- Is there one right way?

What are some other ideas, possibilities, and/or concepts we should consider regarding this topic?

Significance

Decades of research have fostered the now-prevalent assumption that non-crop habitat facilitates better pest suppression by providing shelter and food resources to the predators of crop pests.

The idea that non-crop habitat enhances pest control and represents a win-win opportunity to conserve biodiversity and bolster crop yield has emerged as an agroecological paradigm.

(Altieri and Letourneau 1982, Oerke et al. 1994, Matson et al. 1997, Wilby and Thomas 2002, Bianchi et al. 2006)

Hypotheses

Three broad hypotheses are often used to explain why:

1. Agriculture intensification is thought to reduce natural enemies populations, which are often negatively influenced by pesticide use (DeBach 1974) or by reductions in plant diversity at the local or landscape levels (Root 1973, Andow 1991, Bianchi et al. 2006).
2. Agriculture intensification is thought to increase pest densities because some pests, particularly specialists, are expected to find and remain in large monocultures of their host plants more readily than in more diverse plant communities (Root 1973).
3. Agriculture intensification is thought to relax anti-herbivore defenses, which are often reduced through breeding for yield (less plant diversity) (Harris 1980) or negatively influenced by chemical fertilization (Throop and Lerdau 2004).

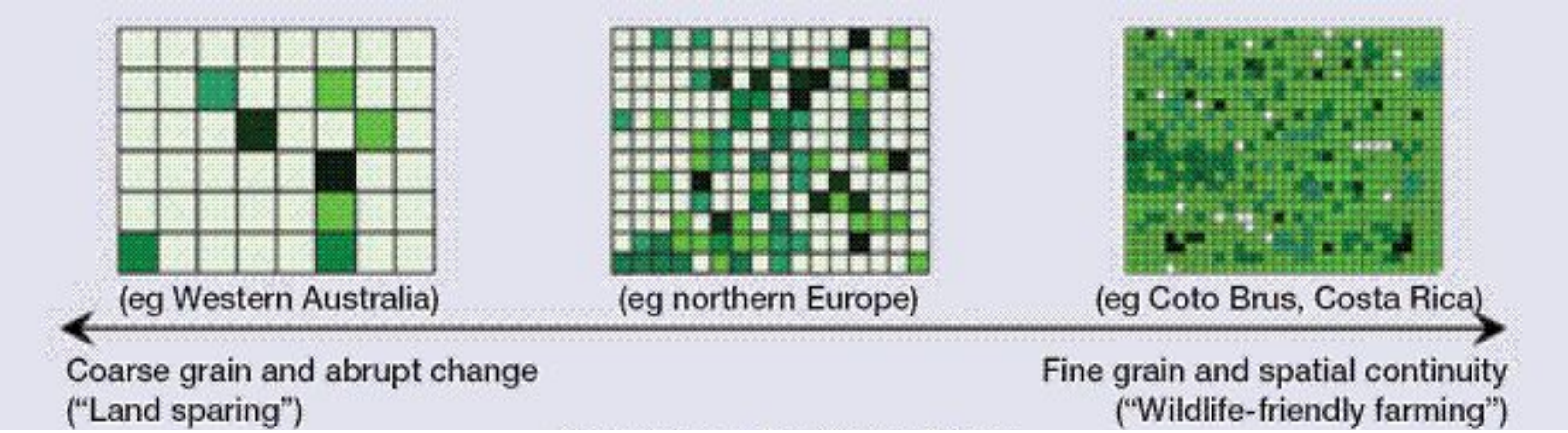
Case Study 1:

One hypothesis of agricultural ecology is that fine-grain spatial heterogeneity in cropping systems (i.e. many small agricultural fields) should provide better pest control than coarse-grain heterogeneity in cropping systems (i.e. large agricultural fields).

Lots of small fields = better pest control

Than

Fewer big fields = worse pest control



Fischer, J., Brosi, B., Daily, G. C., Ehrlich, P. R., Goldman, R., Goldstein, J., Lindenmayer, D. B., Manning, A. D., Mooney, A. H., Pejchar, L., Ranganathan, J., Tallis, H. (2008). Should agricultural policies encourage land sparing or wildlife-friendly farming? Frontiers in Ecology and the Environment.

Case Study 1:

Native herbivore becomes a key pest after dismantlement of a traditional farming system

- Andean Potato Weevil (*Premnotrypes* spp.) specialist potato feeders native to the Andes.
- Potatoes have been domesticated in the Andes for 5,000 years.
- These weevils have one life cycle per year and it begins shortly after potato planting.
- These weevils cannot fly, but they have been known to walk 300 meters in 10 days to find their host (Chavez Ajata 1997); the delicious potato.
- The larvae burrow into the tubers causing severe damage
- No promising natural enemies or resistant cultivars have been identified.

Fig. 1. The Andean potato weevil and key features of San Antonio de Mujlli farming systems. (a) Potato tuber heavily infested with weevil larvae. (b) Temporary storage of potatoes within a harvested field. (c) Potato sector within a sectoral fallow system. (d) Potato tuber (cultivar Waych'a) with bruising characteristic of weevil infestation

S. Parsa (2010). Native Herbivore Becomes Key Pest After Dismantlement of a Traditional Farming System. *American Entomologist 56(4)*

Case Study 1

- Andean potato weevils reached pest status only within the past century.
  - But why?
- Reported that Andean potato weevil damage was negligible in sites where traditional farming systems were still maintained (Alcazar and Cisneros 1997, 1999).
  - But why?
- Traditional agriculture in the highlands of Peru and Bolivia often involved an **agropastoral rotation system** known as **sectoral fallow** (Orlove and Godoy 1986). Under this system, a farming community arranged their available land as a circuit of multiple sectors (Fig. 2a).
- A typical community could have close to 1,000 ha of land divided into ten sectors of roughly 100 ha each (Orlove and Godoy 1986).
- During any given year, one of these sectors housed all potato production in the community, with hundreds of individual fields sown in close proximity to one another, producing essentially a large potato monoculture (Figs. 1c, 2a).

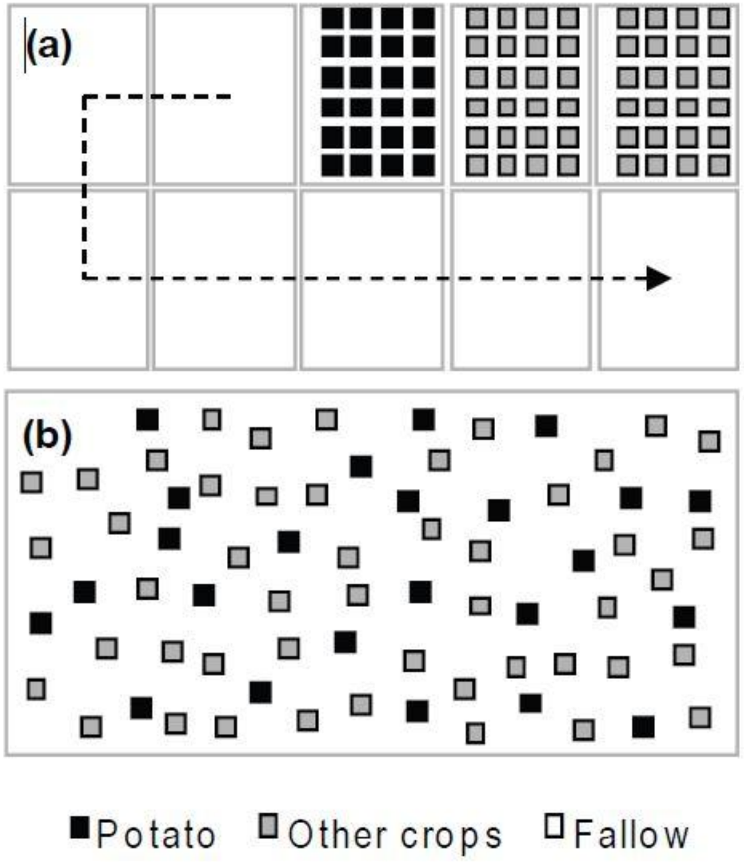


Fig. 2. Schematic diagram of potato fields under two Andean land-use systems. (a) Sectoral fallow system with ten sectors (arrow points at the direction of sector transfer). (b) Private farm or mosaic system.

American Entomologist • Volume 56, Number 4

S. Parsa (2010). Native Herbivore Becomes Key Pest After Dismantlement of a Traditional Farming System. *American Entomologist 56(4)*

Case Study 1

Paradoxical Features of Sectoral Fallow Systems:

1. The concentration of potato fields into large monoculture analogs (i.e., potato sectors) seems antithetical to sustainable pest management, particularly under traditional agriculture, because the adoption of large-scale monocultures is thought to worsen insect pest problems (Altieri and Letourneau 1982, Altieri 2002).

2. The yearly transfer of potato fields into adjacent sectors, instead of more distant ones, also seems counterproductive. Indeed, it seems the worst possible strategy, because it minimizes the distance weevils have to walk from their overwintering sites to colonize new potato fields.

S. Parsa (2010). Native Herbivore Becomes Key Pest After Dismantlement of a Traditional Farming System. *American Entomologist 56(4)*

Case Study 1:

Conclusions:

Provides a valuable case study because it challenges two fundamental generalities regarding the response of herbivore pests to agricultural intensification.

1. Contrary to what is typically expected, changes in ag cultivation went from large monocultures to mosaic of smaller patches and increase biodiversity. Yet weevils became more abundant even though we would expect a depression in pest populations.

2. Ag intensification is expected to disrupt herbivore suppression broadly, i.e. decrease number of beneficials and predators thus increasing populations of all pests in an agroecosystem. However, that was not the case in this study.

The mismatch between these observations and theory highlights our relatively poor understanding of the mechanisms underlying the worsening of pest problems that often accompanies agricultural intensification.

S. Parsa (2010). Native Herbivore Becomes Key Pest After Dismantlement of a Traditional Farming System. *American Entomologist 56(4)*

Case study 1: Lessons learned?

- What lessons can we learn from this story?
  In regards to....
  - Traditional/native cropping systems and their knowledge?
  - Landscape diversification?
  - Monoculture cropping systems?
  - Ecological trade-offs?

Case Study 2:

PNAS

Check for updates

SEE COMMENTARY

Crop pests and predators exhibit inconsistent responses to surrounding landscape composition

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- Meta- analysis = combines the results of multiple scientific studies addressing the same question.
- Big data
- Utilized pest control database encompassing 132 studies & 6,759 sites worldwide.
- Modeled:
  - Natural enemy
  - Pest abundance
  - Predation rates
  - Crop damage

As a function of landscape composition.

Summary

- Study consisted of largest pest-control database of it’s kind.
- Non-crop habitat surrounding farm fields does affect multiple dimensions of pest control.
- However, actual responses of pests and predators are highly variable across geographic landscapes and cropping systems.

Thus, when pest control does not benefit from non-crop vegetation, farms will need to be carefully comanaged for competing conservation and production (yield) goals.

Conclusions/ Discussion

- Does context matter?
- Harm in oversimplifying concepts?
- What are the consequences of applying a single concept to all situations?
- What distinctions can we draw between a natural ecosystem where biodiversity is paramount and an agroecosystem where you have to balance biodiversity with production?
- Are there situations where homogeneity in a landscape is helpful?
- And if there is benefit of increase biodiversity to pest control, must we ask to what **degree** is this benefit in order to fully understand the trade-off and be able to make informed management decisions at the farm level?

Discussion

- Do we have to be weary of viewing biodiversity in a single context?
  - And why
- Does our approach vary with the systems we work in?

Perhaps we have to **avoid being too dogmatic and keep an open mind.**

This quickly moves into the subject of science philosophy.

Philosophy of science is a branch of philosophy concerned with the foundations, methods, and implications of science.

Philosophical Questions to Ponder

- How do we keep an open mind and not get too attached to what we know?
- How do you cultivate a culture in science that keeps an open mind?
- Saying “keep an open mind” is easier said than done.
  - What is the process or practice of questioning our assumptions or preconceived ideas?
  - Is it even important to do so?
- How we conceptualize (connect) these concepts is something we should review, examine, and discuss as it affects our approach to science. True or False?

Questions?