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Ecosystem Resilience

What is it? How do we measure it? How do we improve it?

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gudp
Fonden for økologisk landbrug

Ecosystem resilience:

- An ecosystem's capacity to **absorb** both natural and management-imposed **disturbance** without losing **function**.

- Allows a system to continue functioning after a change.
- Ensures that it can behave in the same way over time.

Ecosystem resilience:

Deliver ecosystem services:

- Pollinating our crops
- Forming and maintaining soil
- Providing clean water

Adapt to climate change:

- Regulating climate
- Absorbing extreme weather
- Reducing erosion

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Indicators

Resilience can be classified into three categories:

- Resistance
- Recovery
- Adaptivity

Measured by:

Amount of external disturbance the system can handle

Time needed for the system to return to its previous equilibrium

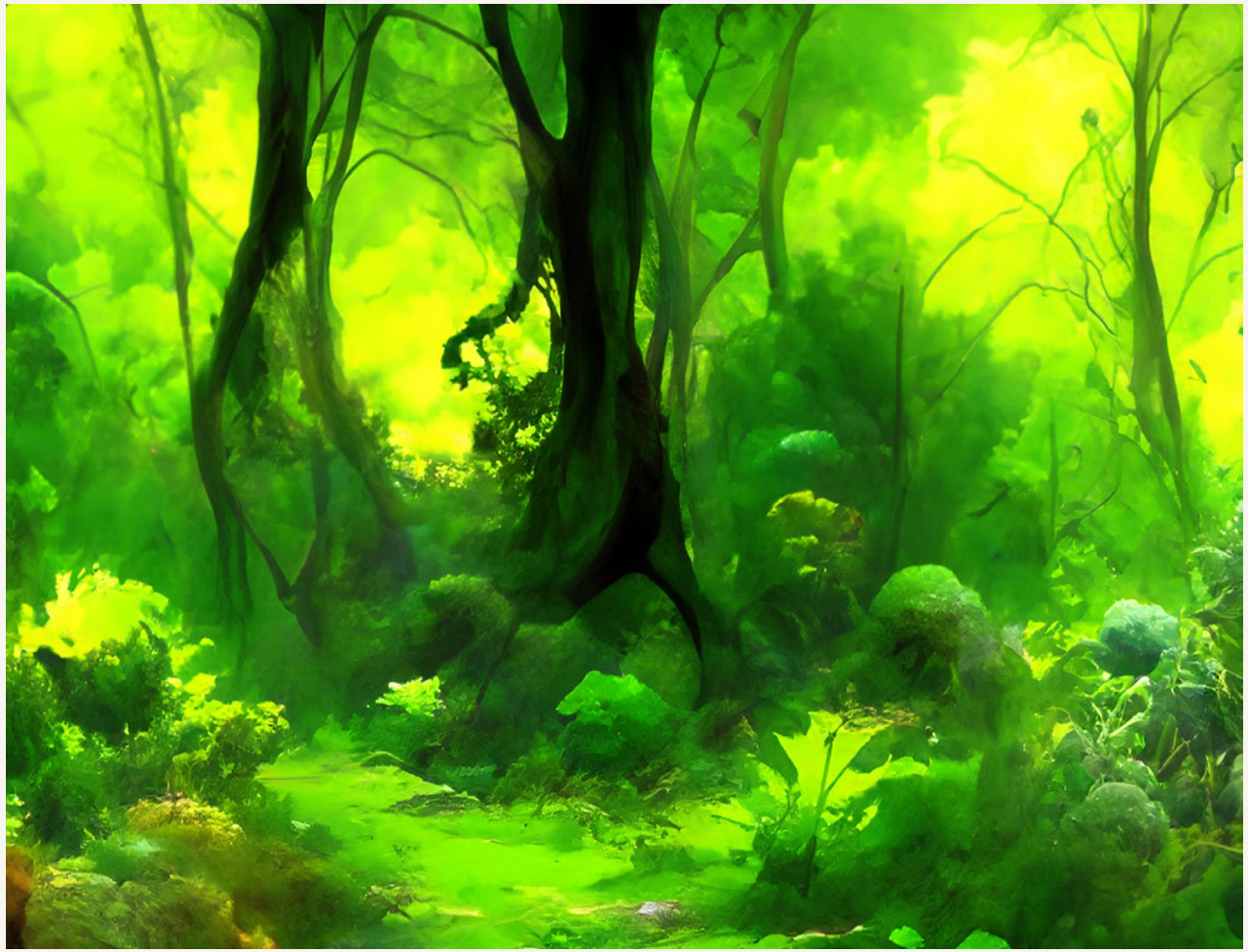
How to measure it?

- Diversity on multiple levels

- Habitat diversity (including connectivity)
- Species diversity
- Genetic diversity

- Ecological and functional redundancy

We cannot have a resilient ecosystem without high biodiversity. And vice versa.



How to improve it?

High diversity at all levels

Some individuals or habitats surviving and thriving

Genetic diversity = traits that are resistant to disturbances

= some will survive, as will the functions and services they provide

= chance that traits will evolve as conditions change

Evolution.

Survival of the fittest.

A common sight...

- Low habitat diversity
- Low species diversity
- Low genetic diversity
- Low functional diversity

Amount of external disturbance the system can handle?

Time needed for the system to return to its previous equilibrium?

Low resilience.

A common sight...

An ecosystem with low resilience is at risk of changing into a different state.

Single or series of natural or planned disturbance events such as fire, heavy rain, ploughing.

Soil degradation, compaction, desertification…

60 harvests left?

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Challenges:

- Humans are the biggest bringers of change. We are the apex predators above all.
- We can point and change any level of the food chain at a whim.

- Evolution or adaptation happens over millenia.
- Human interference, change can be forced within years.

This is how some species outcompete native species and become invasive.

With loss of species diversity, the system is no longer resilient to change.

Challenges:

China heard about European honeybees

Extremely low genetic diversity

Globally pollinators are estimated to have a yearly value in labor of about **2,400,000,000,000 dkk (TRILLION)**. That is the Danish gross domestic product in 2023.

All relate to function. The more functions a system has, the more likely it is to survive.

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“Loss of functions (species) in an ecosystem is the equivalent of randomly removing rivets from a plane.

It will continue flying for a while, but suddenly there will be catastrophic failure.”

-Ehrlich and Ehrlich, 1981

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Australian [redacted] Project

- Cattle brought to Australia in 1788
- 12 patties/day/cow
- Took months or years to decompose
- 200,000 ha / year grassland lost
- Flies everywhere
- Disease and medicine
- Parasites in most cows
- WHY??

- 1970

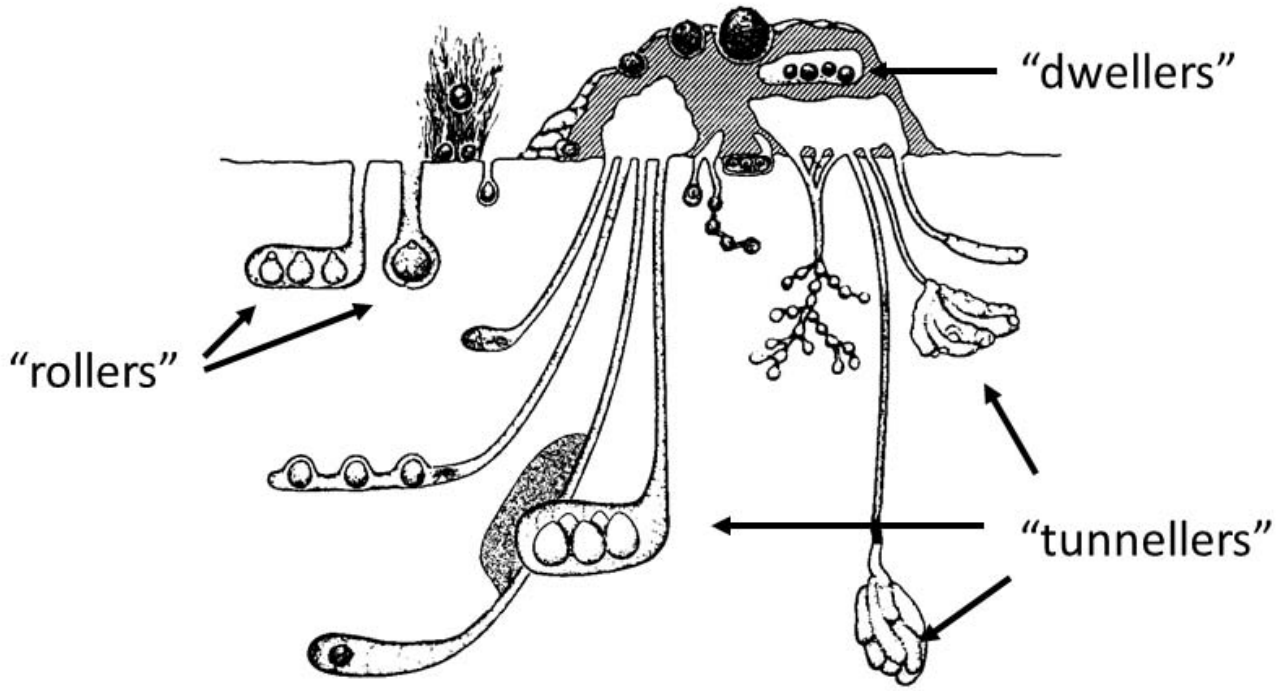

CreativeNature_nl via. istockphoto

Australian Dung Beetle Project

- 43 species of dung beetle introduced
- Today the population is 28 million cattle

- More grassland is freed than is used
- Patties dispersed within days

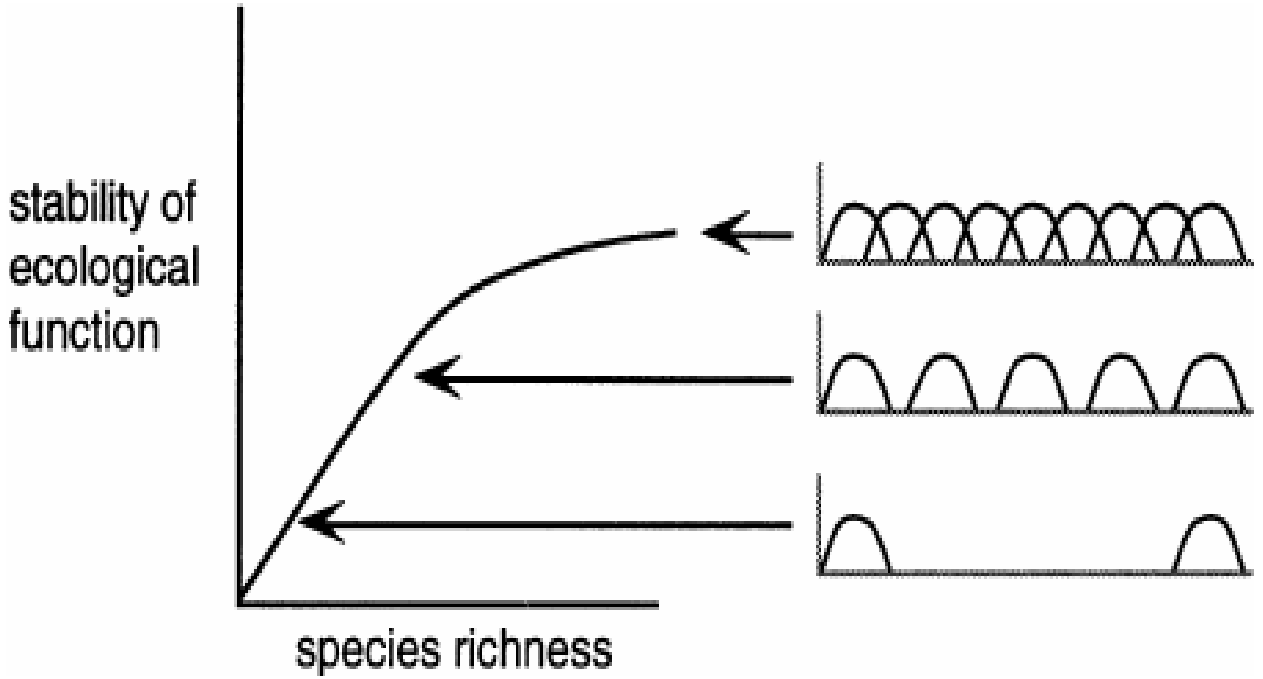
- 96% reduction in flies
- 85% reduction in parasites
- Almost no disease



Floate, 2023

Functional redundancy

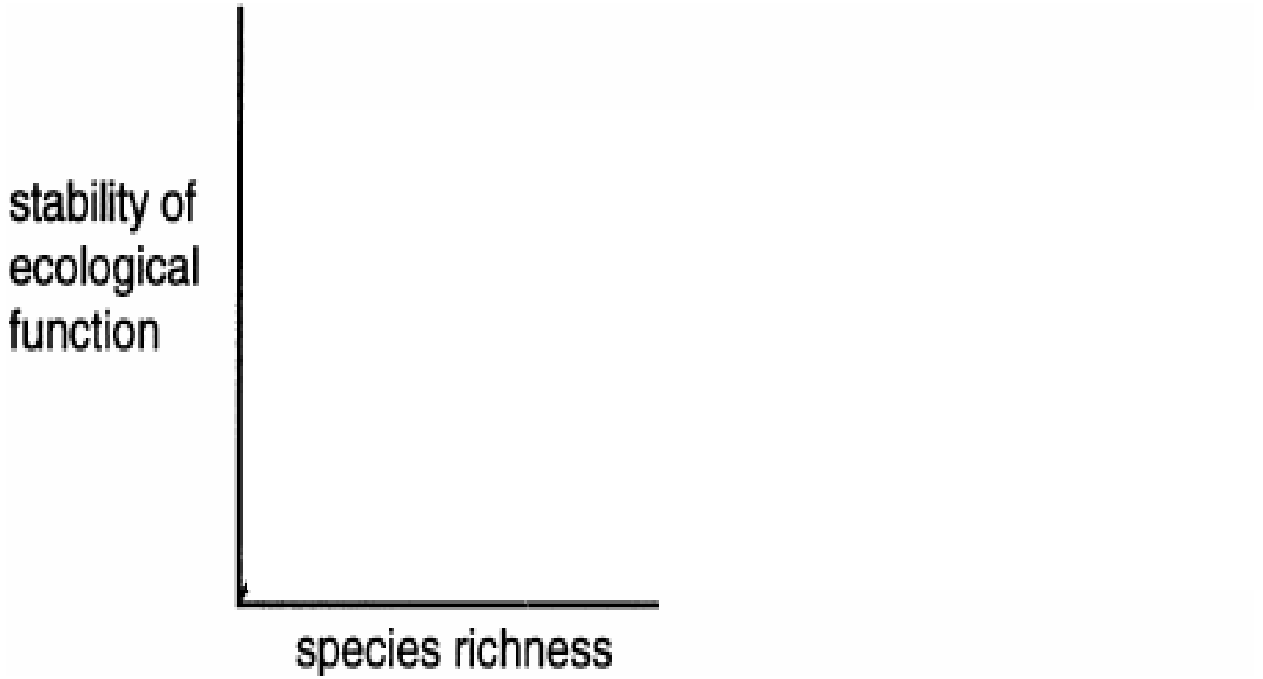
- Functional redundancy leads to resilience
- Redundancy: Insects, birds and mammals can all function as pollinators.
- Insurance effect of biodiversity makes it possible for function to be maintained even if some species are lost.
- Biodiversity increases the diversity of potential responses to disturbances and change.
- Ecosystem stability despite disturbances.



Floate, 2023

Peterson et al., 1998

Functional redundancy



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Functional redundancy

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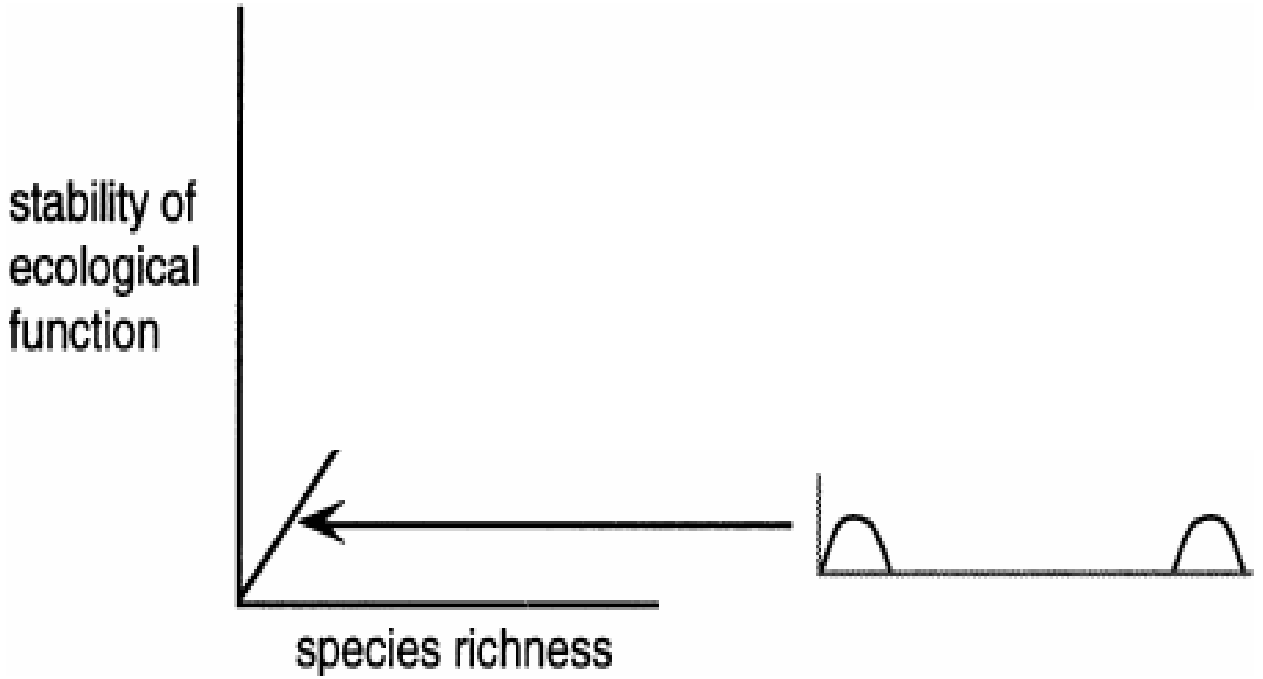

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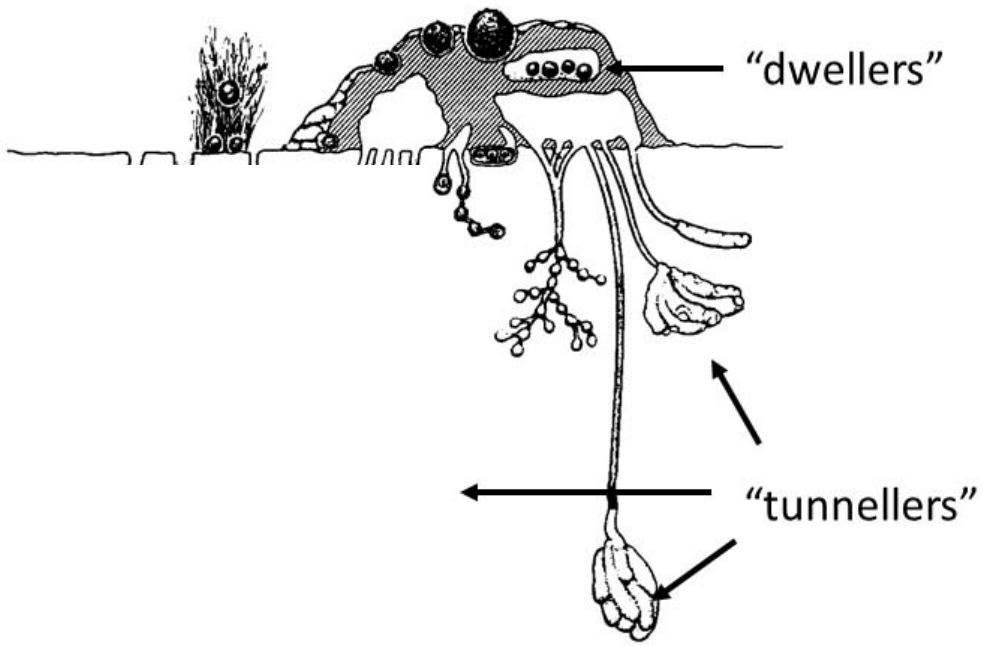

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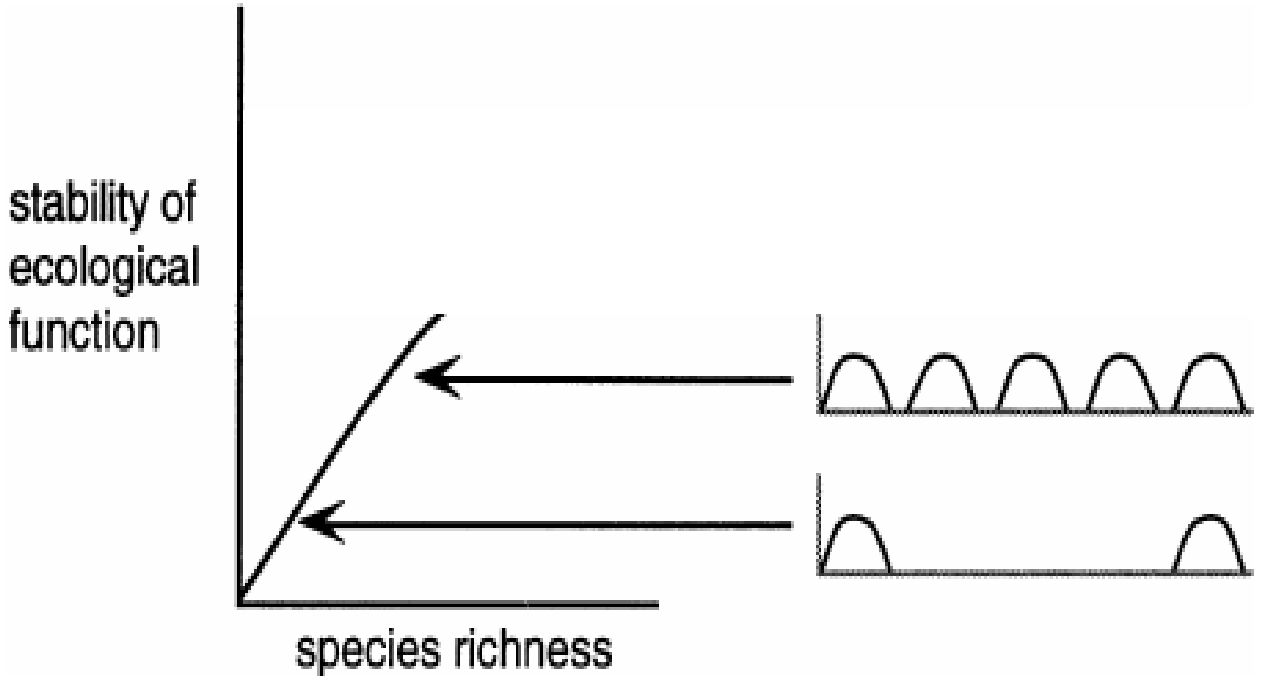

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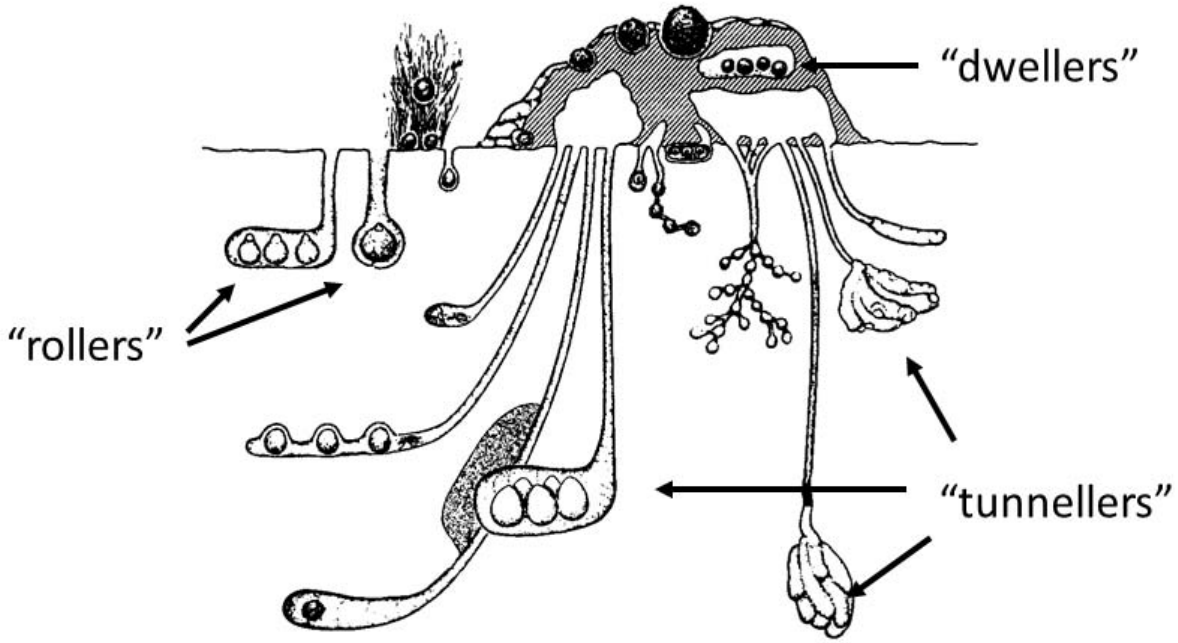

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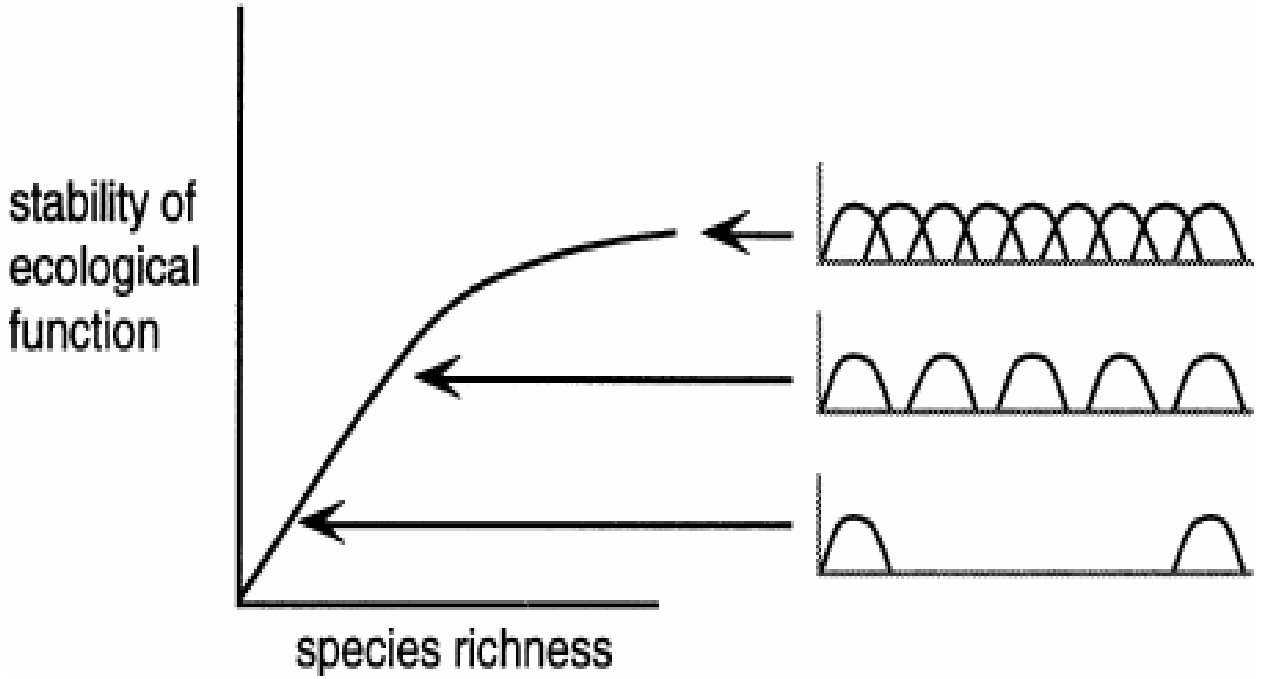

Peterson et al., 1998

Complexity = Resilience

Ecosystems that are more complex are more resilient than ecosystems that are less complex.

- Monoculture is simple
- Polyculture is semicomplex
- Nature is supercomplex

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Complexity = Resilience

Imagine a Jenga tower. If every layer has 3 bricks, many bricks can be removed without toppling.

- If one layer only has 1 brick, there is a high risk of the entire tower collapsing.
- If the bottom layer only has 1 brick, it is certain that the tower will topple.

Trophic cascades

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Complexity = Resilience

Chinese bees (bottom of food chain)
Invasive bees = loss of native pollinators = no functional redundancy = low genetic diversity = no more bees = no more pollination = no more fruit

Dung beetle (bottom of food chain)
No dung beetles = lots of dung = lots of parasites and disease = grazers leave the area, so land is lost

No change is irrelevant, no matter how small it may seem

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Ecosystem resilience in agriculture

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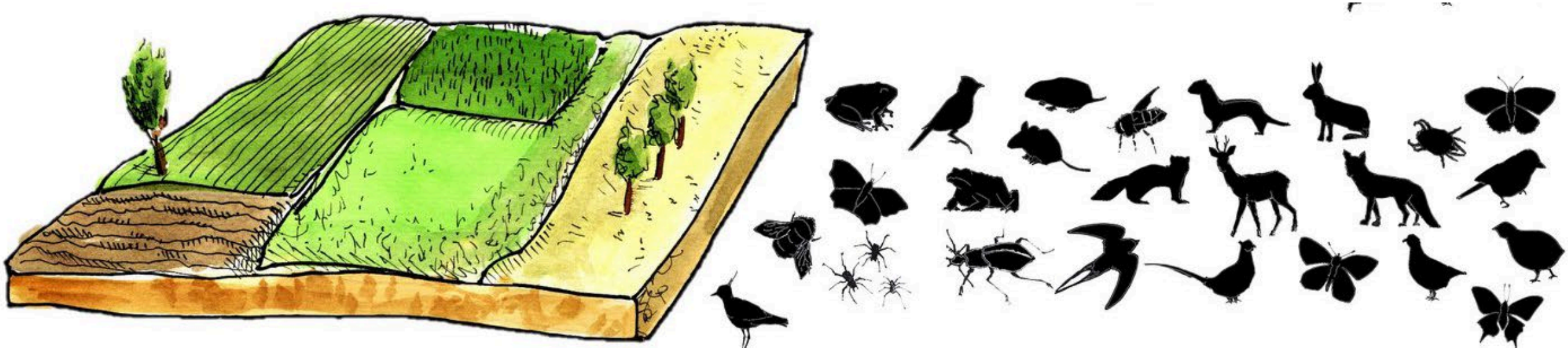

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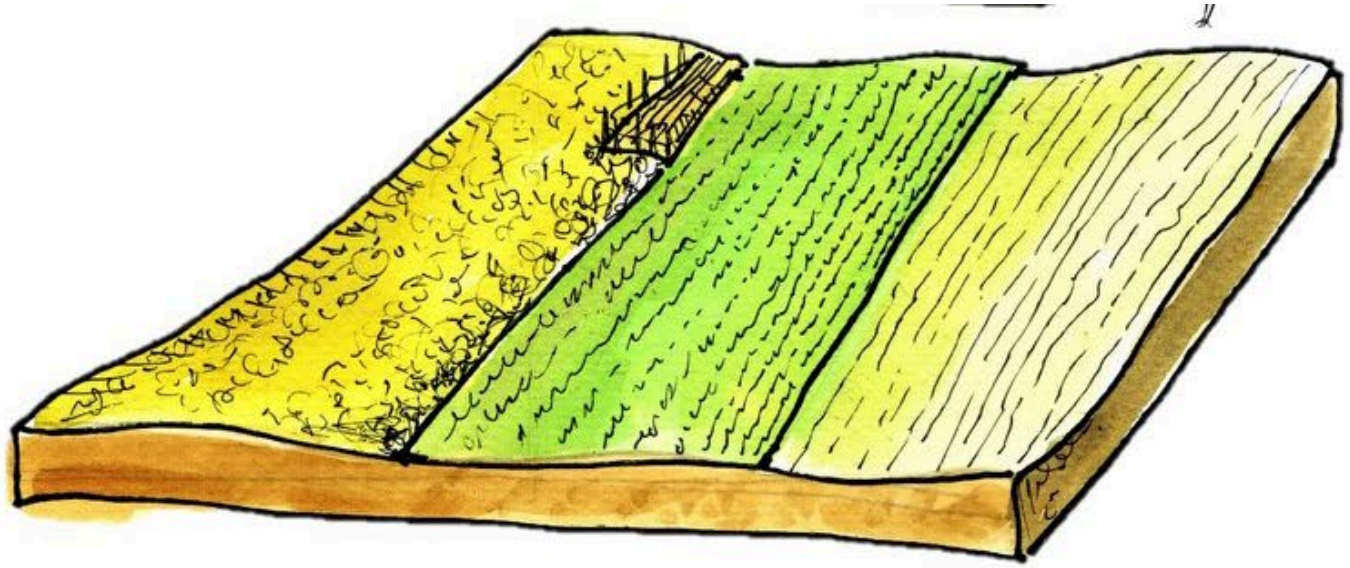

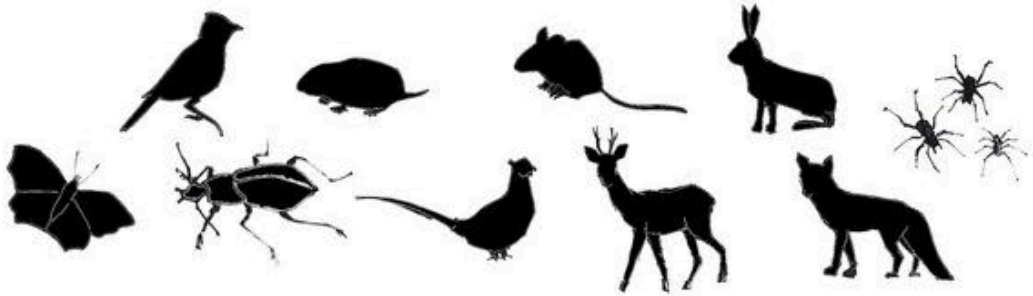

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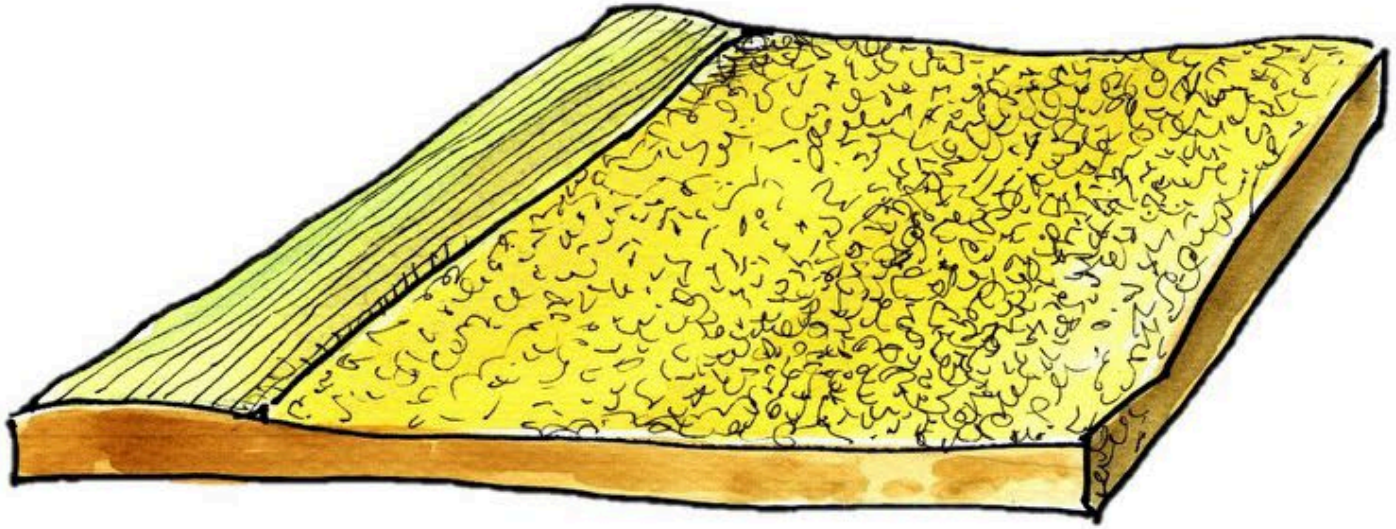

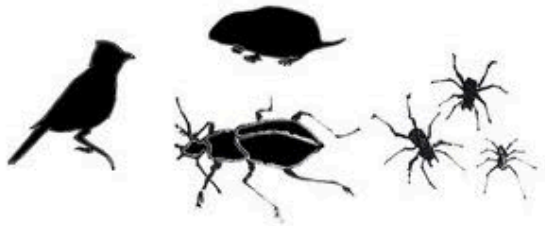

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Resilience in agriculture

<u>Dystopian scenario:</u>

Plowing big fields

= Exposed/killed soil fauna

= Food for birds

= Explosion of populations of sea gulls

= Less biodiversity, soil structure

= Compaction, desertification

= No more food production

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Actions for nature

- Biggest threat to biodiversity is loss of habitats
- **Permanent landscape elements** such as dirt roads, small biotopes, hedgerows and soil dikes make up the skeleton for life in agricultural land
- **Alternate cultivation systems**, such as agroforestry or holistic management
- Necessary to maintain food webs and for actions on field to have a positive effect
- Most farmland species are dependent on the border between farmed and unfarmed areas
- Optimally there is no more than 75 meters from the center of the field to the edge

Agroforestry

- Smaller fields with a variety of crops make it easier for wildlife to move through the agricultural area
- Also covers requirements for food sources and hiding places
- Plant **native** species that are from your geography
- Agroforestry provides many ecosystem services, and will attract beneficials to your fields.
- BEAT – project looking at the effect of agroforestry on biodiversity, in a Danish context
- Livestock, poultry, crops, climate, biodiversity, economics

Beetle Bank

- Split the field with permanent structures every 150 meters
- These structures can be flat, if you need to cross with machines, but function better if they have some height.
- Plow dirt ½ - 1 meter up from both sides
- Plant with tuft-forming grasses, such as: Timothy (timothé), creeping red fescue (rødsvingel)

- And something flowering, such as: Bird's foot trefoil (kællingetand), clovers, wild carrot
- Beetle banks require no / very little maintenance.
- Thistles may be present the first couple of years. If this pressure becomes too high, precision mowing should take care of it.

Hedgerow

- **GIVE THE HEGDEROWS FEET**

- 1-2 meters on either side of hedgerows allows more space for untouched, perennial vegetation
- Plant with tuft-forming grasses, such as: Timothy (timothé), creeping red fescue (rødsvingel)

- And something flowering, such as: Bird's foot trefoil (kællingetand), clovers, wild carrot
- The foot is important for birds, wildlife and overwintering insects.
- Acts as a buffer against agricultural activities, and require no maintenance.
- Should be dense, with tall vegetation that can provide cover year round. Avoid mowing.

Partridge patches (Agerhønefelter)

- Establishing patches for partridges and other wildlife can make a big difference towards rebuilding populations in the area.
- Provide nesting sites and a food source for chicks
- Easy to implement
- Square or rectangular, about 1 ha
- At least 20 m wide
- Foxes love straight lines!

Grazing of nature areas

- Grazing livestock such as cows and horses will improve biodiversity – especially if they can graze all year.
- Adjust grazing pressure, so fresh vegetation is available
- The perfect grazing for the benefit of biodiversity is at a pressure of 70-250 kg livestock/ha
- If higher than this, try to reduce pressure during summer, when plants are flowering.
- Also improves carbon sequestration

Hydrology/water sources

- If water is made available, species richness increase quickly
- Water expands the ecological space with habitats that generally are rare in agriculture, and that ALL species benefit from
- Recipe:
  - Keep livestock out. Their fecal matter contains high nutrient levels and will cause potentially dangerous algal blooms. This can lead to oxygen depletion or high levels of toxins
  - If your water source is over 100 m2, you need to apply for permission at the municipality
  - Water sources directly increase the potential for life on your farm. ”Approved” water sources instantly increase the nature value of a plot of land.

Summary:

1. Ecosystem resilience is the capacity of an ecosystem to thrive despite disturbance
2. High biodiversity = high functional redundancy = high resilience
3. Humans are the most impactful bringers of change. Everything we do has a consequence.
4. Increase complexity by bringing nature back.
5. Split big fields into smaller fields, with permanent structures between to ensure a stable operation in an unstable future.
6. The only thing that is permanent is change: Everything is in a state of constant change, even if we aren’t aware of it.

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Questions?