A rapid ecosystem function assessment to promote basic and applied ecology

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A rapid ecosystem function assessment to promote basic and applied ecology
(1) Biodiversity - ecosystem functioning research

What is the functional importance of biodiversity?

Many open questions

Data on multiple functions from a large number of experimentally manipulated and natural sites needed

(2) Ecological conservation and restoration

Amelioration and/or protection of habitats
Traditional focus on species
More recently ecosystem functions became additional aim

Need to monitor different ecosystem functions following restoration and/or conservation efforts for both intact and degraded ecosystems

Based on 89 studies from which 526 quantitative measures were extracted.

(3) The science-policy interface

Ecosystem services as a critical concept to value nature for human well-being
(Millennium Ecosystem Assessment - Ecosystems and Human Well-being: Biodiversity Synthesis. 2005, Washington, DC: World Resources Institute.)

Provisioning functions used to link habitats or habitat properties and ecosystem service provision

Currently mapping is constrained by data availability at all spatial scales

Ecosystems and Human Well-being

Synthesis

Millennium Ecosystem Assessment 2005
Ökosystemdienstleistungen (nach MEA definiert)

Bereitstellende Dienstleistungen (provisioning services)

Regulierende Dienstleistungen (regulating services)

Unterstützende Dienstleistungen (supporting services)

Kulturelle Dienstleistungen (cultural services)
**Provisioning Services** are ecosystem services that describe the material or energy outputs from ecosystems. They include food, water, and other resources.

**Food:** Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems but marine and freshwater systems or forests also provide food for human consumption. Wild foods from forests are often underestimated.

**Raw materials:** Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species.

**Fresh water:** Ecosystems play a vital role in the global hydrological cycle, as they regulate the flow and purification of water. Vegetation and forests influence the quantity of water available locally.

**Medicinal resources:** Ecosystems and biodiversity provide many plants used as traditional medicines as well as providing the raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources.
Regulating Services are the services that ecosystems provide by acting as regulators eg. regulating the quality of air and soil or by providing flood and disease control.

**Local climate and air quality:** Trees provide shade whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.

**Carbon sequestration and storage:** Ecosystems regulate the global climate by storing and sequestering greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues. In this way forest ecosystems are carbon stores. Biodiversity also plays an important role by improving the capacity of ecosystems to adapt to the effects of climate change.

**Moderation of extreme events:** Extreme weather events or natural hazards include floods, storms, tsunamis, avalanches and landslides. Ecosystems and living organisms create buffers against natural disasters, thereby preventing possible damage. For example, wetlands can soak up flood water whilst trees can stabilize slopes. Coral reefs and mangroves help protect coastlines from storm damage.

**Waste-water treatment:** Ecosystems such as wetlands filter both human and animal waste and act as a natural buffer to the surrounding environment. Through the biological activity of microorganisms in the soil, most waste is broken down. Thereby pathogens (disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced.

**Erosion prevention and maintenance of soil fertility:** Soil erosion is a key factor in the process of land degradation and desertification. Vegetation cover provides a vital regulating service by preventing soil erosion. Soil fertility is essential for plant growth and agriculture and well functioning ecosystems supply the soil with nutrients required to support plant growth.

**Pollination:** Insects and wind pollinate plants and trees which is essential for the development of fruits, vegetables and plants. They also pollinate flowers for the production of seeds and nuts.
Habitat or Supporting Services underpin almost all other services. Ecosystems provide living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals.

**Habitats for species:** Habitats provide everything that an individual plant or animal needs to survive: food, water, and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements.

**Maintenance of genetic diversity:** Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots'.
Cultural Services include the non-material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits.

Recreation and mental and physical health: Walking and playing sports in green space is not only a good form of physical exercise but also lets people relax. The role that green space plays in maintaining mental and physical health is increasingly being recognized, despite difficulties of measurement.

Tourism: Ecosystems and biodiversity play an important role for many kinds of tourism which in turn provides considerable economic benefits and is a vital source of income for many countries. In 2008 global earnings from tourism summed up to US$ 944 billion. Cultural and eco-tourism can also educate people about the importance of biological diversity.

Aesthetic appreciation and inspiration for culture, art and design: Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science.

Spiritual experience and sense of place: In many parts of the world natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging.
The ecosystem function data gap

There is need for better data on ecosystem functions
Need arises from all three research areas

"Towards a standardized Rapid Eco-system Function Assessment (REFA)" TREE 30: 390-397.
How to close the gap?

There is need for better data on ecosystem functions
Need arises from all three research areas

Compilation of existing data
Heterogeneity due to various sources and methods
Bias towards some functions and study systems

Alternatively collection of new data
Aiming at important functions with standardized methodology

"Towards a standardized Rapid Eco-system Function Assessment (REFA)" TREE 30: 390-397.
REFA provides easy-to-measure approximations independent from local conditions independent from experience of the data collector

Methods proposed were specifically selected to be low-tech, easy to use, repeatable, cost-efficient.

REFA enables standardized and comparable measures for the potential of a site to provide functions of interest on a large scale.

REFA cannot measure functions in detail.

Rapid Ecosystem Function Assessment: Introduction | REFA | Case study | Summary

Which ecosystem functions?


- **Inorganic compartment**
- **Dead organic compartment**
- **Living compartment**
- **Transfer of organic material**
- **Transfer of inorganic material**
- **Important influence**
- **Edge of the ecosystem**
REFA methods

- Standing plant Biomass above & belowground
- Electric conductivity
- Abundance / Biomass heat extraction soil cores
- Decomposition Wooden sticks
- Soil texture
- Herbivory 0/1 Pathogens 0/1
- Seed removal
- Abundance / Biomass Pan traps
- Artifical caterpillars
- Abundance / Biomass suction samples

Rapid Ecosystem Function Assessment: Introduction | REFA | Case study | Summary
Callibrating Herbivory REFA

- Estimate damaged leaf area by eye
- Measure size of leaf with leaf area meter
- Calculate percentage herbivory:
  \[
  \text{Percentage Herbivory} = \left( \frac{\text{Damaged area}}{\text{Total leaf area}} \right) \times 100
  \]

\[F_{1,140} = 97.58, \ p < 0.0001\]
REFA – Case studies
Established in 2002 with 82 plots of 20 x 20 m

Experimental plant diversity gradient (1, 2, 4, 8, 16, 60 grassland species)

Large number of different ecosystem variables measured
Rapid Ecosystem Function Assessment: Introduction | REFA | Case study | Summary

Predation in the Jena Experiment

Hertzog, ..., Meyer (in preparation)

Significances based on likelihood ratio tests

**Larvae**
Month 2472.2***
Position 1315.3***
Species richness (SR) 0.0n.s.
Month:SR 11.8***
Position:SR 0.0n.s.

**Dummies**
Month 0.3n.s.
Position 310.2***
Species richness (SR) 9.1**
Month:SR 0.0n.s.
Position:SR 2.6n.s.

In vegetation

On soil surface
Degraded South Brazilian Grasslands

Primary grassland low intensity
- unburnt
- irregular grazed

Primary grassland medium intensity
- regularly burnt

Primary grassland high intensity
- seeded with fodder species
- fertilized

Secondary grassland after agriculture
- regenerating

Secondary grassland after sylviculture
- regenerating
Functions in Brazilian Grasslands

Primary grassland low intensity
- unburnt
- irregularly grazed

Primary grassland medium intensity
- regularly burnt

Primary grassland high intensity
- seeded with fodder species
- fertilized

Secondary grassland after agriculture
- regenerating

Secondary grassland after sylviculture
- regenerating

Leidinger, ..., Meyer (in preparation)
Ecosystem functions included into more and more research agendas

There is an ecosystem function data gap

REFA is a useful collection of methods to measure data on ecosystem functions on large scales

Added value because of standardized data being usable for large scale synthesis projects
REFA methods

- Standing plant Biomass above & below ground
- Electric conductivity
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Predation marks

Insect Morphotype 1

Insect Morphotype 3

Bird

Insect Morphotype 2
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