Valuation of ecosystem services provided by habitat on the basis of biodiversity characteristics and the rate and sustainability of selected ecosystem functions

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Introduction

Increasing human impacts on ecosystems result in continuous biodiversity decrease; scientists´ task is to estimate the consequences in ecosystem functioning and ecosystem service (ES) provision under global change impact (Fig. 1). It is necessary to understand not only present functioning, described by function diversity (effect traits), but also its sustainability under environmental change conditions, described by response diversity. The aim of our work was to propose and verify the method enabling to determine response diversity for ecosystem functions performance in future. Our method reveals the resistance, resilience and adaptation potential of present habitats to environmental change to be able to predict subsequent potential changes in ecosystem service provision.

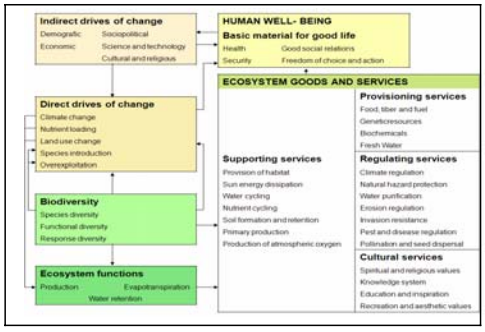

Fig.1. Biodiversity in the ecosystem service concept, modified according to MEA (2005) and CBD (2006).

Methods

Assessment of current habitat functions
Determination of the most important species for given function - „Ecosystem Service Providers“ - ESP (Kremen, 2005) based on their effect traits (Lavorel and Garnier, 2002).

Assessment of the sustainability of habitat functions
Estimation of the reaction of ESP to the environmental change – would they survive?

1) Forecast of environmental conditions (climate model).
2) Define the response traits of important ESP for abiotic factors, e.g. drought, changes in soil characteristics, pollution load (Lavorel and Garnier, 2002; Ellenberg, 1988).
3) Determine the dependence on and relationships with other organisms for major ESP, e.g. patogens, mycorrhizal symbionts, pollinators (Luck et al., 2009).

Major ESP will not keep their ecosystem functions.

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1) Looking for compensatory mechanisms for habitat (Kremen and Osfelt, 2005).
2) Determination of the response diversity (redundancy) for given ecosystem function (Walker et al., 1999).

The function will be performed by substitute species (new ESP).

Compensatory mechanisms are not present, the function will not be performed – ES will not be provided.

Results (example)

Production function to the habitat *Arrhenatherum* Mesophilic Meadow (T1.1) near Loděnice (Fig. 2) were estimated. Dominant and subdominant species (ESP) and their hard and soft traits for production function were determined, see Tab. 1.

Tab. 1. Species composition, function and response traits in *Arrhenatherum* Mesophilic Meadow - T1.1.

Dominant and subdominant species	Hard traits	Soft traits	Response traits
	yields (t/ha)	forage value	Ellenberg value for moisture
Festuca pratensis	7	1	6
Arrhenaterum elatius	9	1	5
Poa pratensis	7	1	5
Dactylis glomerata	8.4	1	5

Legends:
Yields are according to Fiala (2005). Forage crop value is determined by chemical properties, environmental complaints, returns and palatability of each species in terms of use for cattle. The best forage value is number 1, the worst is number 6. Ellenberg´s value for moisture expresses incidence in relation to soil moisture. Number 3 indicates the occurrence of plants on the drought soil, number 5 on fresh soils or "medium" conditions.

Fig. 2. Mesophilic meadow Arrhenatherum - T1.1 near willage Loděnice in Český kras (photo Richard Weinert).

DROUGHT

Determination of response traits using Ellenberg´s drought values for main ESP showed that they occur mainly on soils moderately stocked with water (values 5-6) (Tab.1).

In longer lasting drought the change in species composition for present species tolerant to dry soils (Tab. 2) will come through. New ESP with Ellenberg´s indicator values 2-3, occurring on dry grasslands (habitats T3.4 and T3.5), will take over the production function (Tab. Fig. 3).

Tab. 2. Species composition, function and response traits in dry grasslands - T3.4. and T3.5. Legends: viz Tab.1, Yields are according to Novotná and Kobes (2012).

Dominant and subdominant species	Hard traits	Soft traits	Response traits
	yields (t/ha)	forage value	Ellenberg value for moisture
Avenula pratensis	1.5	4	3
Pimpinella saxifraga	0.75	3	3
Trifolium arvense	0.3	3	2
Festuca ovina	0.5	4	3

It will result in a yield reduction.

Conclusion

If we know the prediction of climate change and response diversity of main „Ecosystem Service Providers“ (ESP), we can react to future changes by the application of appropriate management or changes in the biodiversity of the main ESP (seeding of relatively productive, drought resistant species, e.g. *Brachypodium pinatum, Bromus erectus*). After prolonged exposure to drought the production function of meadows belonging to the habitat *Arrhenatherum* Mesophilic Meadow will drastically reduce from 3-5 t/ha (maximum 6-10 t/ha) to 0.5-3 t/ha, which is the production of corresponding habitat dry grasslands T3.4 or T4.5 (Urban et al., 2003). Using above described adaptation measures we can manage the production function and thereby also relevant ES on maximum value under given conditions (3 t/ha).

Fig. 3. Dry meadow, near willage Milá in České středohoří (photo Ondřej Cudlín).

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