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Trade-offs of ecosystem services provided by mountain hay meadows under land use change scenarios

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Abstract

Land use change has had a strong impact on Alpine land cover and might alter the ability of ecosystems to provide ecosystem services. Particularly affected have been high mountain hay meadows, which have often been subject to abandonment and consequently have become overgrown by dwarf-shrubs and young trees. This trend will have long lasting effects on the provision of ecosystem services. Analysis of possible trade-offs of ecosystem services may enable the development of best possible management strategies.

As study sites we chose a set of former mountain hay meadows representing various stages of succession, depending on the last time they were mowed. These sites are situated in the subalpine zone in the municipality of Brandberg adjacent to the nature park Zillertal.

Multi-criteria decision analysis (MCDA) is an important tool for environmental planning and decision making and is widely acknowledged to quantify possible trade-offs of ecosystem services. In order to carry out a MCDA we organised a workshop with local experts.

Preliminary results show that the six most important ecosystem services according to the ranking order were: biodiversity, aesthetic value/recreation, cultural heritage, fresh water, agricultural products, and protection from natural hazards.

Keywords

Trade-offs, MCDA, Land use change

Introduction

Human societies depend on goods and services they obtain from natural or semi-natural ecosystems. Fresh water, fertile soils, natural hazard regulation or recreation are just a few of these many services (MEA 2005). Over time, ecosystems and landscapes have been modified by man effecting the provision of multiple services. One characteristic feature of this modification in the Alps are mountain hay meadows. This labour intensive land use shapes the traditional cultural landscape of the Alps. In the past 50 years however, land use has changed; favourable agricultural sights have been intensified while, less favourable areas were subjected to abandonment (TAPPEINER et al. 2006). In the case of mountain hay meadows this has a significant impact on the vegetation cover, gradually becoming over grown by dwarf-shrubs, bushes and trees. This change might alter the capacity to provide ecosystem services. Yet which services might increase or decrease, in other words, which trade-offs might occur is not certain (RODRIGUEZ et al. 2006). On the one hand these open hay meadows, popular with walkers, might lose attractiveness and therefore get less frequented as a recreational sight. On the other hand natural hazard regulation might increase, as a dense tree cover provides higher protective functions. In order to facilitate best possible management strategies it is important to assess and value the provision of ecosystem services and weight possible trade-offs. Here multi-criteria decision analyses (MCDA) are useful, providing a tool to assist decision makers in finding an answer to which alternative is the best. For this study we used multiple ecosystem services as criteria to weigh which management alternative – labour intensive mowing or abandonment – is more suitable for mountain hay meadows.

In this context we aim at answering the following question:

1. Which are the most important ecosystem services provided by mountain hay meadows?
2. Are some of these ecosystem services considered more important than others?
3. To which extent are these ecosystem services provided under certain land use change scenarios and do trade-offs occur?

Study site

The study areas, situated around the Kolmhaus (1845m), are part of the municipality Brandberg and adjacent to the nature park Zillertaler Alps. The sites are located on a south facing slope of the Zillergrund, which is a tributary valley of the Zillertal. The annual precipitation of the municipality Brandberg amounts up to 1.365mm with an average annual temperature of 3,7°C.

Already in the 12th century extensive areas of the Brandberger forests were cut cleare in order to provide meadows and pastures. Because of the steepness, the secluded locations and lack of workers various mountain slopes were abandoned in the past century. However, until today mountain hay meadows represent a cultural heritage of traditional land use in the Zillertaler Alps (SCHACHNER 2005).

Images: Picture one shows a view of the hay meadows of Brandberg, which are still mowed. Picture two illustrates peasants at work and picture three shows an installation for hay transportation.

Method

General approach

Multi-criteria decision analysis (MCDA) is an important tool for environmental planning and decision making and is widely acknowledged to quantify possible trade-offs of ecosystem services. Generally the principle of this method is to arrange a preference ordering to a number of other options (STEELE et al. 2009). So a multi-criteria decision analysis helps to structure a problem and to investigate the decision-making process using multiple criteria. A clear definition of the alternatives as well as of the criteria is the framework of the decision-making process. Using multi-criteria decision analysis in ecosystem services research has the advantage (STEELE et al. 2009) that both quantitative and qualitative criteria are comparable, monetary and non-monetary attributes alike can be used and separate units can be obtained. The common process of the MCDA follows a set of successive steps (HOWARD 1991, KEENEY 1992 in SANON et al. 2012):

- Defining objectives
- Selecting set of criteria to measure the objectives
- Specifying the alternatives
- Transforming the criterion scales into commensurable units
- Pre-evaluating of the evaluation matrix
- Assigning weights to the criteria that reflect decision maker's preferences
- Selecting and applying mathematical algorithms for ranking alternatives
- Performing sensitivity analysis
- Choosing or recommending alternatives

Ranking of services (previous procedure)

We organized a workshop with local experts in order to:

i) determine the most relevant six ecosystem services provided by the study area in an open discussion,
ii) agree upon their relative ranking and
iii) identify suitable indicators to quantify these ecosystem services.

An extensive literature review helped to assign quantitative or qualitative values for the selected indicators. Only few references dealt with the valuation of the indicator group aesthetic value/recreation. Therefore an additional questionnaire was required. This questionnaire was set up in two parts: the first part consisted of manipulated landscape photos showing separate development scenarios to assess the aesthetic value. The aim of the second part was to investigate recreational values using a set of questions.

Preliminary results

Preliminary results show that for these mountain hay meadows of Brandberg the six most important ecosystem services according to the ranking order were: biodiversity, aesthetic value/recreation, cultural heritage, fresh water, agricultural products, and protection from natural hazards. According to these services (criterias) the following indicators were selected (see the table below):

CRITERIA	INDICATORS	REFERNCES
Biodiversity	Biodiversity	Botanical classification of plants
	Habitat diversity	Recording of habitats
Aesthetic value/Recreation	Perception	Questionnaire
	Structural diversity	Questionnaire with manipulated photos
Cultural heritage	Traditional land use	Land use register
	Identity	Data of the demographic structure
Fresh water	Runoff	Hydrological data
Agricultural products	Quality	Mountain hay certification
Protection from natural hazards	Erosion	Geomorphological mapping

Future steps

Further steps are 1) to analyse the questionnaire and to define values for the service group aesthetic value/recreation, 2) to quantify the selected six ecosystem services according to two management scenarios, 3) to evaluate benefits and disadvantages of these two management scenarios within the ecosystem services framework, and 4) to identify trade-off trends and to assess ecosystem services which directly compete.

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