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Gravitational natural hazards: Valuing the protective function of Alpine forests

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ABSTRACT

Forests produce significant non-market benefits by protecting residential and commercial real estate as well as all kinds of infrastructure (e.g. rail tracks, highways, power lines) against gravitational natural hazards such as avalanches, mudslides, and rockfall. The Austrian Federal Forests (Österreichische Bundesforste – ÖBf) recently commissioned a research project on the valuation of this ecosystem service by means of the replacement cost method and the hedonic pricing approach.

Based on the international literature, this paper focuses on a careful and realistic design of the baseline scenario with which the "marginal change" in ecosystem services can be assessed and valued. While the (current) management scenario is rather clear and reflects the approach pursued by the ÖBf (reasonably labeled as multifunctional forestry), the design of the baseline scenario (intensified commercial forestry) assumes a reduced protective function of the forests which, however, would still have to be in line with strict legal frameworks such as the Austrian Forest Act or European nature conservation directives.

Given these strict frameworks, the potential leeway for commercial forestry is rather limited; still, the current multifunctional forest management secures ecosystem services worth up to EUR 14.7 m per year (valued at replacement costs of technical measures to substitute the protective function of forests), which corresponds to EUR 268 per hectare and year. The result of the hedonic pricing approach for property in hazard zones protected by forests is substantially lower: The ecosystem service is valued at EUR 2.9 m per year (which corresponds to an annual per-hectare value of EUR 53). The results in general underline the importance of multifunctional forestry and of the ecosystem services function sustained especially in state-owned forests.

1. Introduction and background

Forests and their function of protecting residential and commercial land as well as infrastructure from gravitational natural hazards (e.g. avalanches, mudslides, and rockfall) are of significant importance in Alpine regions. Especially in France, Italy, Switzerland, and Austria, large areas would not be suitable for economic activities without protective forests. In Austria, forests cover about 46% of the surface (another 10% of the land are high-alpine areas such as rocks and glaciers). Total forest land in Austria amounts to about 3.9 m hectares, of which protective forests have a share of about 25% (Perzl and Huber, 2014). Protective forests are defined under the Austrian Forest Law as forests that (potentially) protect residential and industrial areas, agricultural land and all kinds of infrastructure against gravitational natural hazards. In some Austrian regions (e.g. in the federal provinces [*Bundesländer*] of Tyrol, Vorarlberg, and Salzburg), up to 47% of forests are classified as protective forests (Perzl and Huber, 2014). In an international perspective, protective forests for avalanche control, of course, only make up a minor share of the total forest cover worldwide. Only few countries (including Switzerland and Austria) have large shares of their forests designated as avalanche control forests (Miura et al., 2015).

The high share of protective forests in specific regions thus points to their enormous importance for everyday human life in the Alps; in fact, they facilitate settlements, infrastructure, and productive economic activities in mountainous areas. The protective function of forests, and their future significance, is highlighted by the substantial damage caused by gravitational events such as avalanches, rock- and mudslides, and rockfall (e.g. Brang et al., 2001; Dorren et al., 2004; Teich and Bebi, 2009; see Dupire et al., 2016 for a recent study on indicators of such natural hazards). In general, the regulating function of mountain forests may even be the single largest value of all ecosystem services provided

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by Alpine forests (e.g., Häyhä et al., 2015). The Austrian Disaster Relief Fund (*Katastrophenfonds*) compensates losses of households, municipalities, and other owners of affected land, and invests in disaster prevention, such as technical measures against avalanches and floods; the fund has paid about EUR 400 m on average per year in compensation and for preventive technical measures (BMF, 2016). In some years with severe events (e.g. the floods in 2002), compensations are significantly higher.

Given this perspective on the function of forests, the ÖBf (Austrian Federal Forests [*Österreichische Bundesforste, ÖBf*]) commissioned a research program to value the ecosystem services provided by forests to the authors of this paper. Among other ecosystem services, such as drinking water provision and local climate regulation, the ÖBf asked the authors to value the protective function of forests on ÖBf land.

The ÖBf manages forests and other land (e.g., high-alpine areas, pastures, lakes) owned by the Republic of Austria; the company was set up by law, is organized as a public limited company (Bundesforstegesetz, 1996), and has to manage the land efficiently based on sound management principles, and to 'optimize the economic outcome' (i.e., provide profits to the central government's annual budget). However, in a day-to-day perspective, forestry is only one branch of activities, since the ÖBf focuses on 'multifunctional' forest management. Apart from timber production, large shares of the land are protected under national or international (especially EU) law (e.g., national parks [category II of IUCN management guidelines; cf. Dudley, 2008], nature conservation areas, Natura 2000 habitats, species, and bird habitats), while other parts of the land are high-alpine areas without any direct commercial use. In addition, the ÖBf has to conserve freshwater and groundwater resources and is increasingly engaged in the planning and managing of, and consulting for, nature conservation on its own land as well as in other areas.

The protective function of forests as such is included neither in the usual national accounting systems nor in specific forestry accounting, as the benefits accruing from this function are typical non-market goods and services for which no market prices, and thus no straightforward measures of scarcity, are available. Furthermore, the national forestry accounting systems in Europe are usually not easily comparable since the countries apply different measurement, statistical and valuation methods (Sekot, 2007).

Given the legal frameworks of forestry and nature conservation, and the aims and objectives of the ÖBf's multifunctional forestry approach, estimating the economic value of the protective function of Alpine forests is not straightforward but is embedded both in legal, economic, ecological, and institutional frameworks and contexts. Thus, this paper and the underlying study (Getzner et al., 2016) focus on the following research questions:

- Which economic value can be attributed to the protective function of forests on ÖBf land given the current management regime of multifunctional forestry?
- How can this value be ascertained by means of the replacement cost method as well as the hedonic price approach?

The first question relates to the definition of a baseline scenario in order to operationalize the marginal change of ecosystem services given by the protective function of forests. The "marginal change" in the current context of environmental valuation reflects the change of environmental quality brought about by a certain management (or environmental) program in comparison to a baseline scenario (Johansson, 1993). Therefore, a central part of this paper concentrates on a detailed description of this marginal change as the foundation of any economic valuation exercise. The purpose of this approach is to model the value of protective forests against the background of two plausible-realistic planning alternatives. Plausibility in the current context assumes logical and factual consistency between all defining parameters of a certain scenario, which is also realistic if the environmental program or management regime is within legal boundaries, and has been discussed as possible option and subject of debate by stakeholders such as policy makers. The second question refers to the valuation itself by means of two approaches; it will become clear that the two questions are linked insofar as the definition of the baseline scenario might also depend on the choice and operationalization of the respective valuation method.

The structure of the paper is as follows: Section 2 provides a brief overview of the literature on the assessment and valuation of the protective function of forests with a special emphasis on the Alpine region. Most of the studies presented are from Switzerland, Austria, and Italy. In Section 3, we discuss the baseline scenario for estimating the "marginal change" of the protective function. Section 4 presents the results of the economic valuation based on the replacement cost method, while Section 5 presents the (partially contrasting) results of the hedonic pricing approach. Finally, in Section 6, we summarize and discuss the results, and draw conclusions.

2. Valuing Alpine forests and their protective functions

As briefly outlined in the introduction, the protective function of forests is substantial in many parts of the Austrian Alps. Fig. 1 presents a map highlighting the total area managed and owned by the ÖBf as well as the protective forests on ÖBf land.

Many published papers on the value of the protective function of forests in Alpine regions concentrate on Geographic Information System (GIS) and risk-based planning (e.g., Teich and Bebi, 2009), on the replacement costs of and the willingness to pay for the conservation of protective forests (e.g. Notaro and Paletto, 2012; Olschewski et al., 2011), and on choice experiments for the valuation of different combinations of conservation scenarios (e.g. Olschewski et al., 2012). However, the range and spatial dimensions of these studies vary widely from small protective forests of 1 ha to large forests of many hundreds of hectares.

Starting with a study of a smaller spatial dimension, Fuchs et al., (2007) present two alternatives for valuing avalanche hazard mitigation strategies at Davos (Switzerland); they conduct a cost-benefit analysis for a patch of around 7 ha in four different scenarios and compare the results to those of a cost-effectiveness analysis (cf. also Gamper et al., 2006). The four scenarios range from single technical measures (snow fences) to a combination of technical measures with organizational and spatial planning policies. The results indicate that technical measures are rather economical when compared to the opportunity costs (hedonic prices) of preventive land use planning (i.e. designation of red zones in natural hazard maps that lead to construction bans). The paper also shows that partial avalanche prevention structures are less efficient than measures for the total hazard zone. For our paper, the results of Fuchs et al. (2007) are important insofar as the technical measures to substitute the protective function of forests have to be constructed over a wide area in order to secure the full protection of residential areas or infrastructures (cf. Brang et al., 2006).

Grasser (2009) studies the cost-effectiveness of several options for the management of protective forests in the canton of Schwyz in Switzerland. She shows that among the several options available to substitute or complement the protective function of forests, including natural regeneration policies, the most economical form of protection is a sustainably managed protective forest that is able to secure infrastructures and residential areas. Technical measures such as wooden or steel snow bridges are more expensive.

Notaro and Paletto (2012) basically address the same topic as we do. They apply the replacement cost method to a small patch of protective forests in the Valdastico valley (Italy). The replacement cost method itself is rather widely used for valuing forest ecosystem services, especially with respect to erosion control and soil conservation, watershed protection, and carbon control (Ninan and Inoue, 2013). However, results vary widely across these studies – even though the replacement cost method is usually considered a robust method. In this context, Ninan and Inoue (2013) emphasize that the local context is especially important when discussing the value of forest ecosystem services and