Summary of the case study on valuation of the forest ecosystem services

Title of the valuation study: **Avalanche protection by forests — A choice experiment in the Swiss Alps**

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Objectives of the study

One of the main ecosystem services of forests in mountainous regions is the protection of people and infrastructure against natural hazards. In Switzerland, about 43% of the forests mainly have a protective function. Since this service is a typical public good, information about its economic value is lacking. A monetary valuation of this ecosystem service could be helpful to provide efficient and effective protection to the local population and support decision-making processes between technical and silvicultural measures.

The paper showed results of a case study from the Swiss Alps. A combination of a choice experiment determining the willingness to pay for avalanche protection with risk-based evaluation techniques, virtual reality visualizations, and alternative cost estimations in a comprehensive interdisciplinary analysis was carried out. Hence, the benefit determination was based on stated preferences instead of avoided costs. Moreover, the outcomes were compared to the costs of alternative technical measures for natural hazard mitigation as well as with the results of the risk-based evaluation.

Scope of the study

The ecosystem service valuated in the study was a regulation service (avalanche protection). Moreover, a local geographical scope was covered.

The case study took place in the Swiss municipality of Andermatt with about 1250 inhabitants and up to 1500 tourists. The study area comprised the north facing slope of 'Gurschen' (24 ha) reaching an altitude of about 2000 m above sea level. The protection forest was dominated by Norway spruce mixed with European larch and Stone pine. The core area consisted of an about 300-year-old spruce forest surrounded by younger afforested areas.

Valuation method(s) applied

The protective function was determined by the damage potential of an avalanche event with a reoccurrence period of 300 years following **uniform procedure for risk analyses**. In addition to the classical risk analysis, this procedure of a GIS-based risk evaluation contained a classification of forest structures based on aerial photographs, the calculation of potential avalanche release areas within the forest and the prediction of avalanche run-out distances using the two-dimensional numerical avalanche dynamics **program RAMMS**. Furthermore, the damage assessment included the identification of endangered objects located in the run-out areas of the simulated avalanches.

The choice experiment (CE) aimed at determining which factors or attributes were most important for the choice decisions of residents. For a concise wording of the online questionnaire, expert interviews, focus groups and pre-tests were conducted. In the basic scenario, it was assumed that a windthrow has damaged about 1 ha of the protection forest. Thus, alternative measures to restore avalanche protection were presented to the respondents and described by five different attributes: type of measure, starting time, duration, damage avoidance and costs. Different level labels were assigned to the same attribute in order to reflect particularities of the respective technical measures. The payment vehicle was designed as a one-time (lump-sum) payment added to the households´ income tax bill. Different combinations of attribute levels

were combined in ten choice sets consisting of three options in a short-cut-design (Table 1). Because of a small sample size and the relatively low response rate (n=129) a **multinomial logit model** was applied for the data analysis. The statistical analysis has been conducted by using the 'BIOGEME'-software.

Table 1: Example of a choice set.

Attribute	Option A	Option B	Option C
Type	Steel bridges	Wooden grills	Wooden logs
Start	in 3 years	in 5 years	in 1 year
Duration	70 years	30 years	20 years
Damage avoided	80%	60%	70%
Cost per hh	500 USD	150 USD	250 USD
Choice	☐	☐	☐

The authors integrated **virtual reality visualizations** (3D landscape visualization) to increase respondents' familiarity with the basic scenario and the alternative protection measures. A digital elevation model, orthophotos, technical construction models and current land-cover data were used in the software package 'Visual Nature Studio' and 'Google SketchUp Pro'.

The estimation of the **costs of alternative protection** measures was calculated by the **alternative costs** of constructing and maintaining technical protection (completed by reforestation) on the one hand **and avoidance costs** of silvicultural measures taken to maintain the existing forest and to reduce vulnerability on the other hand. Current investment costs and future maintenance costs were then **discounted to the present** and assigned to all households, assuming that the municipality has to bear 25% of the overall costs.

Key results

- A windthrow damage of about 1 ha of the protection forest raised the damage potential from 20.5 million USD to approximately 29.5 million USD. This resulted in annual collective risk of approx. 98,500 USD instead of 68,500 USD.

- All selected attributes (type of measure, starting time, duration, damage avoidance, costs) had a significant influence on the result. Discounted risk reduction was positively related to utility, while increasing costs had a negative impact on the derived utility.

- The estimated willingness to pay (one-time payment) varied between 110-390 USD depending on the combination of attributes irrespective of the type of measure. WTP for risk reduction and the collective risk caused by the hypothetical wind throw area had about the same level.

- The age structure of the participants had remarkable influence on the results.

- WTP for risk reduction was substantially higher than the costs of wooden measures against avalanches (logs and grills). Costs of steel bridges and nets would not have been covered by WTP. Therefore, the combination of wooden constructions and reforestation measures was regarded as an adequate solution, when disturbances would create new avalanche release areas within forested terrain.

- The maintenance of the existing forest was the desirable solution from an economic, ecological and aesthetic point of view. Forests provides protection at the lowest costs.