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Applying the Delphi method to assess impacts of forest management on biodiversity and habitat preservation

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ABSTRACT

This study applied a structured expert elicitation technique, the Delphi method, to identify the impacts of five forest management alternatives and several forest characteristics on the preservation of biodiversity and habitats in the boreal zone of the Nordic countries. The panel of experts consisted of a number of scientists in the field. The data was collected using a semi-structured questionnaire distributed via e-mail in two rounds. Our findings demonstrated that an increase in management intensity for timber production is likely to have a negative effect on the biodiversity and habitats with intense management alternatives such as a "clear-cutting system" resulting in the strongest adverse impact. The presence of deadwood, mixture of trees of different sizes and increase in stand age were expected to promote preservation of biodiversity and habitats. However, there was little agreement between experts regarding the functional form that relationships between preservation of biodiversity and forest characteristics take. The Delphi method was found useful in investigating the existing knowledge base and capable of contributing to a more comprehensive assessment for decision support as a valuable addition to on-going empirical and modeling efforts. The findings could assist forest managers in developing forest management strategies that generate benefits from timber production while taking into account the trade-offs with biodiversity goals.

1. Introduction

Despite a growing body of literature addressing impacts of different land uses on the provision of ecosystem services (e.g. Foley et al. 2005; Nelson et al. 2009; Burkhard et al. 2010; Raudsepp-Hearne et al. 2010; Scolozzi et al. 2012), analysis of ecosystem services to support land use decisions still faces challenges related to a limited understanding of their flows and how they are affected by management (Carpenter et al., 2009; de Groot et al., 2010; Filyushkina et al., 2016; Kettunen and Vihervaara, 2013). These difficulties in assessment and quantification of ecosystem services arise from challenges in linking ecological processes with services, dealing with the complex dynamics of the relationships between management and provision of ecosystem services, and accounting for multiple spatial and temporal scales. Moreover, since many ecosystem services are challenging to monitor, researchers often have to rely on a variety of indicators (indirect and composite) (Egoh et al., 2012; Layke et al., 2012), for most of which the strength of evidence for the relationship has not been determined (Gao et al., 2015). The choice of indicator(s) for ecosystem services affects revealed trade-offs and impacts (Harrison et al., 2014) and thus it is important to determine a comprehensive and robust set of indicators to inform decision-making (Filyushkina et al., 2016; van Oudenhoven et al., 2012).

Forests and forest management is an example of land use, where multi-functionality and service provision is an inherent feature (FAO,

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2016; Hytönen, 1995). However, provisioning services such as timber production have been dominating in the past while in recent decades the demand for other (non-provisioning) services (e.g. recreation, carbon sequestration, biodiversity, and soil and water protection) has been increasing (Berg et al., 2007; Kriström & Boman, 2001; Norman et al., 2010). In the Nordic countries, there is a growing interest in managing forests as a so-called multi-functional land use, e.g. to simultaneously provide high-value timber, biodiversity, opportunities for recreation and game habitat from forests to meet societal preferences and demands (Boman et al., 2010; Ezebilo et al., 2015, 2012; Löf et al., 2016). Elsewhere, this is also reflected in the vast number of studies devoted to decision support tools that integrate non-provisioning services (e.g. Mendoza & Martins 2006; Diaz-Balteiro & Romero 2008) and revealing impacts of forest management on them (e.g. Spiecker 2003; Torras & Saura 2008; Paillet et al. 2010; Gustafsson et al. 2010). However, the majority of existing studies included only one or two management alternatives or forest characteristics, and applied growth simulations and ecological modeling to assess impacts on the provision of ecosystem services (e.g. Duncker et al., 2012b; Biber et al. 2015; Frank et al. 2015). At the same time, a review of existing decision support tools concluded that the majority of these tools do not include non-provisioning ecosystem services (Segura et al., 2014). Thus, there is a need for better understanding of impacts from various forest management regimes on delivery of non-provisioning ecosystem services in order to make more informed decisions (Duncker et al., 2012b; Filyushkina et al., 2016; Kuuluvainen et al., 2012; Trivino et al., 2016).

In this study we used the Delphi technique – a structured expert assessment method, to deal with a large degree of uncertainty and complexity (MacMillan and Marshall, 2006; Martin et al., 2012). Previously, the Delphi technique has been extensively applied in healthcare, technological and environmental forecasting and other fields since its development in the 1950 s. Applications of the Delphi in natural resource management include studies such as deriving habitat suitability models (e.g. Crance 1987; Uhmann et al. 2001; MacMillan & Marshall 2006), estimating potential of different land uses in provision of ecosystem services (e.g. Geneletti 2007; Scolozzi et al. 2012), selecting focal species in open space wildlife planning (e.g. Gobbi et al., 2012; Rubino and Hess, 2003), and valuation of global ecosystem services (e.g. Strand et al., 2017). Others include development of indicators for identification of forest restoration projects (e.g. Orsi et al. 2011) and biodiversity conservation (e.g. Oliver 2002; McBride et al. 2012). However, few such studies have focused on forest ecosystems in the Nordic boreal zone (e.g. Kangas and Alho, 1998; Edwards et al., 2012).

The objective of this study was to determine the effects of five forest management regimes on preservation of biodiversity and habitats in the Boreal zone of the Nordic countries using expert assessment technique. The study involved experts assessing the potential of five forest management alternatives along a continuum of management intensity levels. The relative importance of forest characteristics for preservation of biodiversity and habitat as well as functional forms of their relationship were explored. Findings from this study could complement on-going empirical and modeling efforts in quantifying the effect of forest management on provision of ecosystem services and provide further insights for decision support.

2. Methods and materials

2.1. Delphi methodology

Expert elicitation techniques are associated with a range of advantages such as ability to work with a large degree of uncertainty and data-poor environments (Martin et al., 2012). They are often relevant in cases when there is a need for generalization while still being able to capture the complexity of the system. However expert judgments have been criticized for being subjected to cognitive, motivational, subjective and other biases (e.g. framing, overconfidence, anchoring, halo effects, dominance), poor calibration and self-serving (Hasson and Keeney, 2011; Kynn, 2008; Tversky and Kahneman, 1974). Structured elicitation processes are meant to minimize these biases (McBride et al., 2012; Waldron et al., 2016). The Delphi technique is a multi-interaction structured group communication process that seeks to provide a group expert opinion on the defined question(s), forging a consensus through anonymous deliberations whenever possible. In each round experts (participants) are asked to fill out questionnaires individually and anonymously. After each round all responses within a panel are summarized by the moderator and reported back to the panelists, who then have an opportunity to revise their answers in the light of others in the group. The process continues until a set level of stability in answers is reached (Linstone and Turoff, 2002; Novakowski and Wellar, 2008).

Apart from advantages common to all expert elicitation techniques the Delphi method is associated with reduction of negative issues related to group dynamics due to anonymity of participants (e.g. social pressure and desirability, domination, halo effect), increase of robustness of opinion gathering due to structured and repeated nature of inquiry, possibility of engaging geographically dispersed experts and lower costs (Jolson and Rossow, 1971; Landeta, 2006; Linstone and Turoff, 2002; McBride et al., 2012; Novakowski and Wellar, 2008; Waldron et al., 2016). These characteristics, as well as previous applications in complex and multi-faceted issues with a high degree of uncertainty and poor data environment, make the Delphi method suitable for addressing questions related to impacts of land use on the provision of ecosystem services.

2.2. Data collection procedure

The data for this study were collected using a Delphi survey following the protocol described in Novakowski & Wellar (2008) and used in Eycott et al. (2011) and Edwards et al. (2012). The process comprised six steps as illustrated in Fig. 1.