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Impacts and adaptation options of climate change on ecosystem services in Finland: a model based study

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At a global level, it is estimated that nearly two-thirds of ecosystem services have been degraded in just fifty years. The additional stresses imposed by climate change will require extraordinary adaptation. This paper synthesises main result of a large Finnish project studying the vulnerability of key ecosystem services to climate change and the possibilities for the individual sectors to adapt to these changes. The project based its work on data and infrastructures of nine intensively studied areas belonging to the Finnish LTER (Long-Term Ecological Research) network. The methods developed and used included remote sensing, derivation of impact scenarios, dynamic modelling, laboratory experiments, interactive workshops and expert judgement. The results clearly indicated not only complex interactions between the different ecosystem processes but also trade-offs between the ecosystem services. Climate change was predicted to have both positive and negative effects on key ecosystem services in Finnish conditions, the results being sector-specific and scenario-specific. Provisioning services like food and timber production would largely benefit from increasing temperatures and prolongation of the growing season in the cool Finnish conditions (with e.g. estimated increases in growth rates of trees up to 80% and the introduction of a wider selection of crops), although increasing occurrence of factors such as fungal diseases and insect outbreaks were estimated to cause increasing risks. On the other hand, climate change was predicted to pose a major threat to several endangered and valuable species, water and air quality, and tourism services dependent on present climate conditions. Goal conflicts between maximising service production and meeting environmental quality objectives were also identified. Adaptation options and impact thresholds identified together with local enterprises and experts are presented.

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Introduction

Ecosystems generate a range of goods and services important for human well-being, collectively called ecosystem services. Over the past decades, progress has been made in understanding how ecosystems provide services and how service provision translates into economic value. Nonetheless, the losses of ecosystem services continue more rapidly than ever [1,2••,3••,4•]. Efforts have been made to define 'planetary boundaries' for the major impacts and changes [5••]. Research in this field is also of great national science and strategic need regarding topics such as ecological restoration, ecological compensation and sustaining ecological security. It has still proven difficult to move from general pronouncements about the tremendous benefits nature provides to people to credible, quantitative estimates of ecosystem service values [6•,7]. Large efforts are currently devoted to develop methodologies for deriving spatially explicit values of ecosystem services across landscapes [8–11].

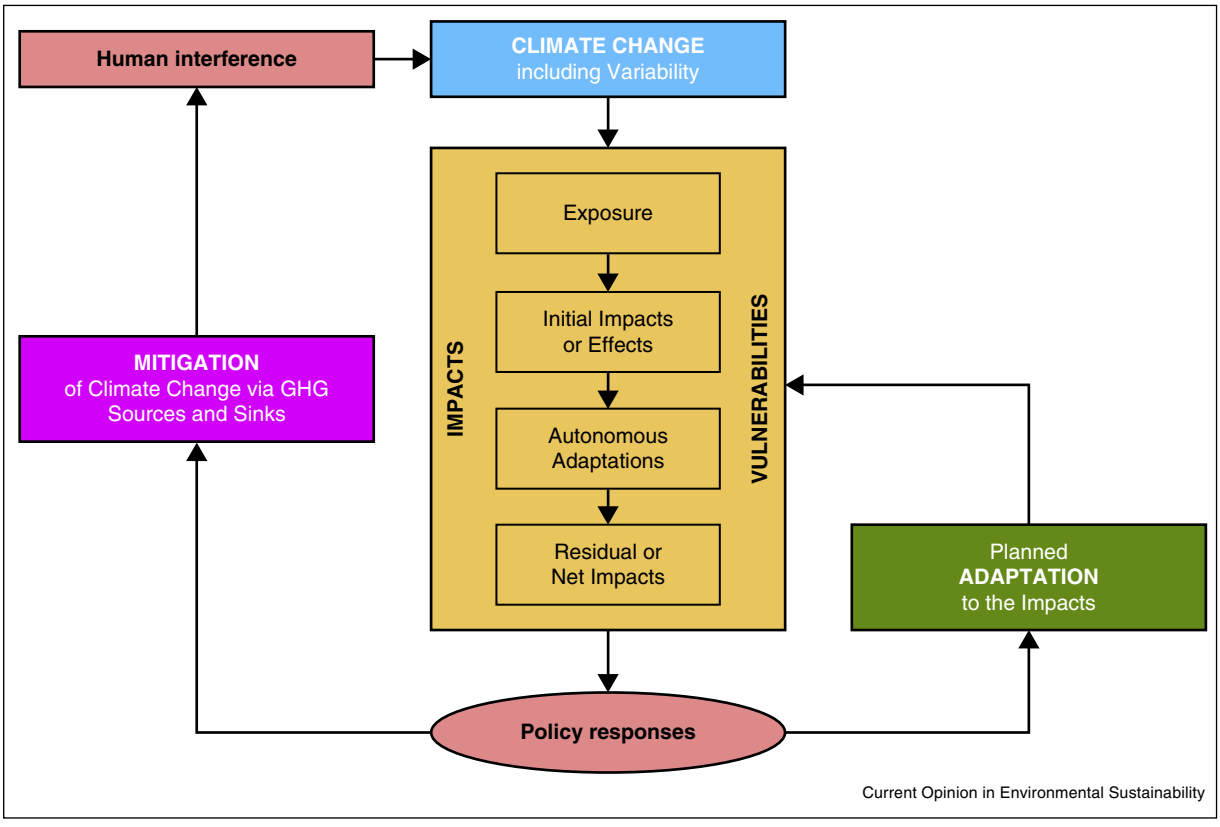
Climate change provides a major challenge for the sustainable management of the key ecosystem services [8,12•,13]. Climate change predictions for Finland indicate an increase in precipitation of 5–40% and in air temperature of 2–7°C by the 2080s, depending on the climate model and scenario used [14]. Changes in

seasonal patterns, for example, freeze-and-thaw periods, as well as in the frequency and intensity of hydrological episodes are also expected. Climate change also drives ecosystem structure and spatial pattern change affecting key processes such as carbon sequestration [15•], and which may induce the switch of some regional ecosystems from carbon sinks to carbon sources or vice versa by the end of the 21st century [16]. In many cases it is not only the mean climatic conditions but also the extreme events that influence ecosystem structure and function, and species diversity [12•,17].

Controlled adaptation to these changing conditions is needed in order to minimise the harm and maximise the benefits to society [18]. Already in present conditions, it is sensible to prepare for climatic variations and extreme events, because this expands the possibilities for adapting to increasing future changes and variability, with greater chances of success. These adaptation measures have to be based on the understanding of: first, the likelihood and speed of change; second, vulnerability of the specific ecosystem services to the predicted change; third, information about the trade-off relationships; and fourth, knowledge about the local-scale possibilities for adaptation (e.g. [19•]). There is thus the need for developing the process understanding, methodology and tools for obtaining detailed spatially explicit ecosystem service values, and for connecting the global/regional scale climate/global change scenarios to the landscape scale where the realistic adaptation measures can be planned and conducted (Figure 1).

The need for adaptation to climate change has also received increasing attention in the policy development. The European Commission's White Paper on adaptation [21] sets out a framework for reducing the EU's vulnerability to the impact of climate change. The importance of ecosystem services and biodiversity for climate change mitigation is also emphasised in the recently issued EU biodiversity strategy to 2020 [22]. This strategy is aimed at reversing biodiversity loss and speeding up the EU's transition toward a resource-efficient and green economy. In addition, at the national scale the adaptation issue is receiving increasing attention. The central aim of the Finnish climate change adaptation strategy of 2005 is the inclusion of climate change adaptation in the routine

Figure 1



Framework for climate change mitigation and adaptation. Society and ecosystems can to some extent adapt spontaneously to the effects of climate change. In many cases, however, policy decisions are needed for ensuring successful and effective adaptation. Policy actions are also needed for the implementation of feasible mitigation measures.
From [20].