



## Assessing ecosystem impacts on health: A tool review



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### ABSTRACT

In the past decade, interest in the impacts of ecosystem change on human health has strongly increased. The ecosystem–health relationship, however, is characterized by several complexity aspects, such as multiple and diverse health impacts – both positive and negative – and a strong interaction with socio-economic factors. As these aspects strongly determine the outcomes of the ecosystem–human health relationship, they should be accounted for in assessments. We identified 14 ecosystem services and six ecosystem disservices with a direct impact on human health. An extensive search and selection procedure yielded eleven computer-based tools that we evaluated regarding their suitability for assessment of the ecosystem–health relationship. Nine of 14 health-related ecosystem services are addressed by one or more of these tools. However, most tools do not include the final step of actually assessing the associated health outcomes such as mortality or disease incidence. Furthermore, the review shows that each complexity aspect is addressed by several of the evaluated tools, but always in an incomplete way. We recommend that further tool development should focus on improved integration of socio-economic factors and inclusion of ecosystem disservices. This would allow better assessment of the net contribution of ecosystems to human health.

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### 1. Introduction

Following the Millennium Ecosystem Assessment (MA, 2005d), the past decade has seen a growing interest in the impacts of ecosystem change on human health. The MA aimed to assess the consequences of ecosystem change for human well-being, with health as one of its main components. This is especially apparent through MA chapters with a dominant focus on health (such as Corvalan et al., 2005; Levy et al., 2005; MA, 2005c; Patz and Confalonieri, 2005). The MA concluded that, of all the examined services ecosystems provide, approximately 60% were being degraded or used unsustainably, including services that relate to human health such as air and water purification and the regulation of natural hazards. Furthermore, the MA pointed out that the health-related Millennium Development Goals on hunger, child mortality and disease are particularly dependent on sound ecosystem management, and that public health costs associated with damage to ecosystem services can be substantial (MA, 2005d).

Hence, the MA has contributed significantly to the emerging awareness that, expressed in public health terms, ecosystem conditions should be understood as important determinants of

human health, operating at a higher hierarchical level of causality and shaping the context in which more direct health determinants operate and develop (Huynen et al., 2005). One of the three overall main problems highlighted by the MA experts was the established but incomplete evidence that changes being made in ecosystems have important consequences for human well-being and health (MA, 2005d). More recent work highlights the same issue, more specifically for health: the report of The Rockefeller Foundation–Lancet Commission on planetary health states as key message that within the concept of planetary health, human health depends on natural systems, which are being degraded to an unprecedented extent (Whitmee et al., 2015). Furthermore, the World Health Organization's review on biodiversity and human health summarize that the continued decline of biodiversity (being a key environmental determinant of human health) is reducing life-sustaining ecosystem services, often leading to negative outcomes for health (WHO and CBD Secretariat, 2015). Consequently, there is a need for research and policies to start accounting for ecosystem impacts on health as well as for the associated drivers of ecosystem change, such as climate change and land use change.

A growing number of health researchers calls for such broader approaches towards health, using various terminologies such as 'ecological perspective on health' (McLaren and Hawe, 2005), 'social-ecological systems perspective on health' (McMichael, 1999), 'ecosystem approach to public health' (Arya et al., 2009), 'ecological public health' (Morris, 2010; Rayner and Lang, 2012) and 'eco-epidemiology' (Sokolne and Broemling, 2002; Susser and Susser, 1996). The importance

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**Box 1**—Definitions of key terms

**Ecosystem:** “a dynamic complex of plant, animal, and microorganism communities and the nonliving environment, interacting as a functional unit. (...) A well-defined ecosystem has strong interactions among its components and weak interactions across its boundaries” (MA, 2005d)

**Ecosystem services (ES):** “the benefits people obtain from ecosystems” (MA, 2005d).

**Ecosystem disservices (EDS):** “functions of ecosystems that are perceived as negative for human well-being” (Lyytimäki and Sipilä, 2009).

**Ecosystem-related human health outcomes:** the final health endpoints impacted by both beneficial and adverse effects of (changes in) ecosystems, using the same categories as the WHO’s global burden of disease study (Mathers and Stevens, 2013). Examples of what we considered as health outcomes in our review are: diseases, injuries, behavioral disorders and mortality. Proximal health determinants (e.g., access to clean air or clean water, shelter and availability of sufficient nutritious food) were not considered health outcomes.

**Health-related ecosystem services (or disservices):** ecosystem services (or disservices) that positively (or negatively) affect health outcomes, either directly or indirectly.

**Human health:** “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 2006). The MA (2005a) defines human health similarly and adds “The health of a whole community or population is reflected in measurements of disease incidence and prevalence, age-specific death rates, and life expectancy”.

**Human well-being:** “a context- and situation-dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience” (MA, 2005a).

**Tools:** (semi-)automated aids in conducting an assessment of ecosystem impacts on human health. In practice, this concerns digital, computer-based tools, such as models, interactive maps, databases and toolkits. We restricted our review to ecosystem-based tools, i.e., tools using qualitative ecosystem characteristics or quantitative parameters (e.g., type, state, area) as inputs.

**Box 2**—Key aspects of the complexity of the ecosystem–human health relation.

- 1. Multiple drivers of ecosystem change:** Changes in climate, land use and resource availability drive ecosystem changes and the impacts of these drivers on ecosystem services can also change over time (Forget and Lebel, 2001; Huynen et al., 2005; Myers et al., 2013; Reis et al., 2013).
- 2. Long and complex cause-effect chains:** The cause-effect chains between driver, ecosystem condition and human health are often long, long-term and complex, due to non-linearity and feedback loops (Briggs, 2008; Corvalan et al., 2005; Coutts et al., 2014; Forget and Lebel, 2001; Hartig et al., 2014; Huynen et al., 2005; Jackson et al., 2013; MA, 2005c; Myers et al., 2013; Webb et al., 2010).
- 3. Multiple and diverse health impacts:** Degradation of a specific ecosystem type can produce several very different health outcomes (Briggs, 2008; Corvalan et al., 2005; Hartig et al., 2014; Myers et al., 2013). Forest conversion for example, can cause an increase in infectious diseases, malnutrition and mental disorders (Myers et al., 2013).
- 4. Ecosystem services as well as disservices:** Ecosystems providing a health service preventing one particular disease can at the same time provide a health disservice enhancing another disease. Moreover, whilst some ecosystems provide a health service concerning a particular disease, other ecosystems could provide a health disservice for the same disease (Briggs, 2008; Hartig et al., 2014; Myers et al., 2013; Reis et al., 2013). This is illustrated in Fig. 2.
- 5. Spatial heterogeneity and multi-scalarity:** The health outcomes associated with a particular ecosystem change (or a driver of change) can differ from location to location, and the underlying mechanisms as well. Some of these health impacts can be observed across one or several regions of the world, whilst others occur only locally. Moreover, global drivers of ecosystem change can have local health impacts and vice versa (Briggs, 2008; Corvalan et al., 2005; Forget and Lebel, 2001; Keune et al., 2013a; MA, 2005c; Myers et al., 2013).
- 6. Interaction with socio-economic factors:** Socio-economic factors are not only important health determinants themselves, but can also buffer or enhance the impact of ecosystems on human health (Briggs, 2008; Coutts et al., 2014; Forget & Lebel, 2001; Hartig et al., 2014; Huynen et al., 2005; Myers et al., 2013; Reis et al., 2013; Webb et al., 2010).

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