The driving forces of landscape change in Europe: A systematic review of the evidence

Tobias Plieninger [a,*], Hélène Draux [a], Nora Fagerholm [a,b], Claudia Bieling [c], Matthias Bürgi [d], Thanasis Kizos [e], Tobias Kuemmerle [f], Jørgen Primdahl [a], Peter H. Verburg [g]

[a] Department of Geosciences and Natural Resource Management, University of Copenhagen, Rolighedsvej 23, 1958 Frederiksberg C, Denmark
[b] Chair of Societal Transition and Agriculture, University of Hohenheim, Schloss Museumsflügel Ost, 70593 Stuttgart, Germany
[c] Department of Geography and Geology, University of Turku, 20014 Turku, Finland
[d] Swiss Federal Research Institute WSL, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland
[e] Department of Geography, University of the Aegean, University Hill, Mytilene 81100, Greece
[f] Geography Department, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany
[g] Institute for Environmental Studies (IVM), VU University Amsterdam, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands

ARTICLE INFO

ABSTRACT

Over the past decades, landscapes worldwide have experienced changes (e.g., urbanization, agricultural intensification, expansion of renewable energy uses) at magnitudes that put their sustainability at risk. The understanding of the drivers of these landscape changes remains challenging, partly because landscape research is spread across many domains and disciplines. We here provide a systematic synthesis of 144 studies that identify the proximate and underlying drivers of landscape change across Europe. First, we categorize how driving forces have been addressed and find that most studies consider medium-term time scales and local spatial scales. Most studies assessed only one case study area, one spatial scale, and less than four points in time. Second, we analyze geographical coverage of studies and reveal that countries with a non-European Union/European Free Trade Association membership; low Gross Domestic Product; boreal, steppic, and arctic landscapes; as well as forestland systems are underrepresented in the literature. Third, our review shows that land abandonment/extensification is the most prominent (62% of cases) among multiple proximate drivers of landscape change. Fourthly, we find that distinct combinations of mainly political/institutional, cultural, and natural/spatial underlying drivers are determining landscape change, rather than single key drivers. Our systematic review indicates knowledge gaps that can be filled by: (a) expanding the scope of studies to include underrepresented landscapes; (b) clarifying the identification and role of actors in landscape change; (c) deploying more robust tools and methods to quantitatively assess the causalities of landscape change; (d) setting up long-term studies that go beyond mapping land-cover change only; (e) strengthening cross-site and cross-country comparisons of landscape drivers; (f) designing multi-scale studies that consider teleconnections; (g) considering subtle and novel processes of landscape change.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

Landscapes have been shaped and maintained by people and their activities over millennia (Ellis, 2015; Farina, 2000) and have undergone fundamental changes, both today and in their history (Levers et al., 2016; van der Sluis et al., 2015; Verburg et al., 2010). Partly reflecting global trends, partly exhibiting regional particularities, multiple causes are influential in reshaping European landscapes, though their magnitude has not been quantified yet. Among the causes of landscape change are urbanization, agricultural intensification, land abandonment and forest expan-

* Corresponding author.
E-mail addresses: tobias.plieninger@ign.ku.dk (T. Plieninger), hedr@ign.ku.dk (H. Draux), ncf@ign.ku.dk (N. Fagerholm), claudia.bieling@uni-hohenheim.de (C. Bieling), matthias.buergi@wsl.ch (M. Bürgi), akizos@aegean.gr (T. Kizos), tobias.kuemmerle@geo.hu-berlin.de (T. Kuemmerle), jpr@ign.ku.dk (J. Primdahl), peter.verburg@vu.nl (P.H. Verburg).

sion, international commerce and trade, new demands of land for nature conservation, and development of renewable energy uses (Plieninger and Bieling, 2012). Depending on prevailing social-ecological conditions, these trends find strongly varying regional expression, exhibiting diverse directions and pace (Pinto-Correia and Kristensen, 2013). For example, hotspots of land abandonment occur in Eastern Europe (Estel et al., 2015), the Mediterranean parts of Europe (Sluiter and de Jong, 2007), and many European upland areas (MacDonald et al., 2000). In contrast, agricultural intensification is most expressed in those European regions where biophysical and structural conditions for agriculture are favorable, e.g. in many areas of Northwestern Europe (Pinto-Correia and Kristensen, 2013).

The magnitude of these changes has given rise to concerns that landscape sustainability – the capacity of a landscape to consistently provide long-term, landscape-specific ecosystem services essential for maintaining and improving human well-being (Wu, 2013) – is currently at risk (Selman, 2012). The understanding of the reasons behind landscape changes has been at the center of recent landscape research, and the "driving forces", i.e. the forces that drive changes in and of a landscape (Bürgi et al., 2004), have developed into a fundamental concept. Initially introduced in the late 1990s as an indicator framework for environmental policy (OECD, 1999), the concept of driving forces is now used as a framework for understanding the causes, processes, and outcomes of landscape change and has become indispensable for the evaluation of policy interventions (Klijn, 2004). Knowledge on drivers of landscape change is becoming more important, as attention is moving away from traditional sectorial policies toward integrated "landscape approaches" in natural resources management (Sayer et al., 2013). In the European context, this view has been reflected in the cross-sectoral approach of the European Landscape Convention that calls for the integration of protection, planning, and management of landscapes (Jones et al., 2007).

The concept of driving forces distinguishes between proximate and underlying drivers of change. Proximate drivers refer to human activities at the local level that result in landscape change, such as agricultural expansion or extension of settlements (Geist and Lambin, 2002). Underlying drivers comprise the fundamental social and natural processes (e.g. human population dynamics, agricultural policies, markets, or culturally embedded attitudes and beliefs) that underpin the proximate drivers and either operate at the local level or have a more indirect impact from the national or global level (Geist and Lambin, 2001; Geist and Lambin, 2002). Underlying drivers can comprise political, economic, cultural, technological, and natural factors (Brandt et al., 1999; Bürgi et al., 2004).

Since the turn of the millennium, the number of case studies on driving forces of landscape change in Europe has grown (e.g., Bieling et al., 2013; Hersperger and Bürgi, 2009; Mottet et al., 2006; Serra et al., 2008), and important conceptual contributions have been made, e.g. directed towards enhancing the understanding of the interplay between driving forces and actors (Hersperger et al., 2010). However, the understanding of the drivers of landscape changes remains poor, among other reasons due to the strong variation of existing case studies over disparate spatial and temporal scales (Bürgi et al., 2004) and the current spread of landscape research across many domains and disciplines within the human, social, and natural sciences (ESF, 2010). Case study research at local level is on the one hand needed to foster a "place-based culture" in landscape ecology (Fischer et al., 2011), because the landscape is the most relevant scale to address real-world sustainability problems (Crumley, 2012). On the other hand, local-level studies are highly specific in contexts, actors, main processes, scale, and resolution (Bürgi et al., 2004). But despite the unique context of most local landscapes and their drivers, the application of a comparative framework can allow more generalized insight that can be transferred across places (Kinzig, 2012; Rindfuss et al., 2007). Systematic

review and meta-analyses techniques are particularly promising approaches to synthesize and upscale local-level insights on environmental changes to a more general level (Rudel, 2008). While recent years have brought significant developments in all corners of landscape research, these have hardly been synthesized, so that Pan-European perspectives on landscape change – as informed by local case studies – are under-developed (ESF, 2010).

Several meta-analyses have provided valuable insights into drivers and patterns of land-use change (Magliocca et al., 2015; van Vliet et al., 2015b). Previous studies reviewed individual land-cover changes (e.g., deforestation, Geist and Lambin, 2002; Robinson et al., 2014; or urban land expansion, Seto et al., 2011), land-use sectors (e.g., agriculture, Keys and McConnell, 2005; van Vliet et al., 2015a), or natural ecosystems (e.g., wetlands, van Asselen et al., 2013). However, studies that synthesize broader landscape change at continental scale, including the interactions among multiple change processes, have not been carried out.

The aim of this study is to provide a synthesis of the proximate and underlying drivers of landscape change across Europe. Our systematic review of the literature on landscape change identifies and catalogues the available knowledge from a wide variety of sources. In particular, our review has the following objectives: (1) to broadly characterize how proximate and underlying drivers of landscape change have been addressed in empirical case studies; (2) to examine coverage of particular socio-economic, biogeographical, and land systems attributes in the scientific literature; (3) to identify and classify the most important proximate drivers of change in European landscapes; and (4) to reveal the underlying drivers of landscape change and the interactions between proximate and underlying drivers. By this, we identify knowledge gaps that put barriers to the understanding and management of landscape change. We follow the understanding of the European Landscape Convention of landscape being "an area, as perceived by people, whose character is the result of action and interaction of natural and/or human factors" (ELC, 2000: 3).

2. Methods

Our method followed established guidelines for systematic review and systematic mapping (Centre for Evidence-Based Conservation, 2010) and was inspired by previous systematic review exercises in comparable fields (Geist and Lambin, 2002; Rudel, 2008; van Asselen et al., 2013; van Vliet et al., 2012).

2.1. Study selection

Scoping was performed to find useful keywords and to get a first overview about the availability of landscape studies. The scoping exercise was performed in the ISI Web of Science and revealed that many landscape studies did not use terms such as "driving forces", "drivers", or "causes" in the abstracts, though they offered explanations on these. Therefore, we decided to perform an inclusive search based on the following search string: "*Landscape change*" *OR* "*landscape dynamics*". To select only case studies from Europe, the search was refined by adding the names of each European country as search terms. We searched the following databases for relevant documents: ISI Web of Science, GEOBASE (Ovid), CABI: CAB Abstracts (Ovid), and Scopus. To locate grey literature, we additionally considered the first 50 pdf and word documents that were provided by the Google Scholar and Dogpile search engines. We stored titles and abstracts in a single reference database and removed all duplicates. Our review considered studies in English, French, and German language.

Building on Rudel (2008) and Geist and Lambin (2002), we specified the following four inclusion criteria: A study had to