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Going beyond landscape change description: Quantifying the importance of driving forces of landscape change in a Central Europe case study

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ABSTRACT

Over the past decades, urban sprawl and agricultural intensification have enormously changed the traditional cultural landscape of the Swiss lowlands. This research aims to analyze the driving forces of urbanization, agricultural intensification, and greening in five municipalities of the periurban Limmat Valley, near Zurich, Switzerland. The main objectives of the paper are (1) to quantify the change in urbanization, agricultural intensification, and greening, (2) to determine the driving forces of landscape change, (3) to determine the relative importance of socioeconomic, political, cultural, technological, and natural/spatial driving forces, and (4) to establish from which administrative levels and spatial scales the most important driving forces originate. Changes for the periods 1930–1956, 1957–1976, and 1977–2000 are documented based on a comparison of cartographic maps. A list of 73 potentially relevant driving forces is established based on document analysis. Based on further document analysis and expert interviews, 52 of them were found to be relevant primary driving forces for the documented landscape changes. We found that in all three periods, urbanization was the most important process of change. Greening is steadily increasing in importance and surpassed agricultural intensification in the last period. Overall, as well as for urbanization, the economic driving forces, followed by political driving forces, are most important for landscape changes in all three periods. Cantonal driving forces are most important, followed by the national, local and international driving forces. By presenting an approach to quantify the contribution of major driving forces groups to landscape change this study contributes to method development in land change research.

Introduction

Over the past decades, periurban development and agricultural intensification have enormously changed the traditional cultural landscape of the Swiss lowlands (Bundesamt für Raumentwicklung und Bundesamt für Umwelt Wald und Landschaft, 2001) and many other regions in Central Europe (Kleyer, 1996; Antrop, 2004). Most landscapes in Central Europe are cultural landscapes. That means that they have been shaped over time, in an interactive process linking human needs with natural resources and features in a specific topographic and spatial setting. Whereas some human activities only left a short imprint on the scenery, others remain visible over thousands of years. Thus, only a historical perspective provides an appropriate understanding of the present land-use and land-cover (Russell, 1997; Marcucci, 2000).

Documentations of landscape change, often based on historical maps, have a long tradition (e.g. Ewald, 1978; Kienast, 1993; Seiffert et al., 1994; Konold, 1996; Petit and Lambin, 2002). However, landscape change studies have so far mainly focussed on the documentation and analysis of spatial patterns and have paid considerably less attention to landscape function and therewith processes. This bias is common to the entire field of landscape ecology (Wiens, 1995; Hobbs, 1997). Understanding landscape changes, however, requires a sound understanding of the underlying processes. In this context, the concept of driving forces is gaining increasing attention in landscape change research.

Driving forces are the forces that cause observed landscape changes, i.e. they influence the trajectories of landscape development (Bürgi et al., 2004). These forces have also been called keystone processes (Marcucci, 2000), drivers (Wood and Handley, 2001) or causal or causative factors (Geist et al., 2006). The study of driving forces of landscape change has a long tradition in geography and landscape research (Wirth, 1969; Wood and Handley, 2001) and has received increased interest with the recognition that land-use change is one of the major factors affecting global environmental change (Dale et al., 1993; Meyer and Turner, 1994).

Five major types of driving forces are identified: political, economic, cultural, technological, and natural/spatial driving forces

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(Brandt et al., 1999; Bürgi et al., 2004; Hersperger and Bürgi, 2007). The economic driving forces include consumer demands, market structure and structural changes, as well as governmental subsidies and incentives. Since economic needs and pressures are expressed and reflected in political programs, laws and policy, the economic and political driving forces are strongly interlinked. Culture unquestionably leaves a deep imprint on landscapes as culture structures landscapes while landscapes affect culture. For example, the landscape of any American's home is immediately interpreted for what it says about the owner. In turn, people make landscapes according to what they believe their neighbours will think (Nassauer, 1995). But also technology has shaped the landscape enormously (Grübler, 1994). Striking example is the technological modernization in agriculture. In the near future, information technology is likely to become an important driving force of landscape change (Kienast et al., 2004). For the natural/spatial driving forces we distinguish between site factors, such as spatial configuration, topography, and soil conditions, and natural disturbances. Site factors are short-range stable but long-term variable. Natural disturbances can be slow- or fast-acting and today, the major slow-acting natural disturbance is global change. Fast-acting natural disturbances are, for example, avalanches, mudslides, and hurricanes. Calamity or an extraordinarily grave event has also been proposed as a driving force (Antrop, 2005). We put natural disasters into the group of natural/spatial driving forces and regard other disasters as rarely big enough to affect an entire landscape. However, they might help to explain why certain spots developed differently.

Studies on the causes of landscape change have generally followed one of two approaches: broad scale cross-national statistical comparisons and detailed studies at the local scale (Geist et al., 2006). Many studies simplify reality and only focus on a small number of driving forces (Lambin et al., 2001). This clearly holds true for modelling approaches where statistical methods may limit the number of introduced independent variables (e.g. Alig et al., 2004). Many descriptive approaches and case studies also focus on a few driving forces (e.g. Baumgartner, 2003; Antrop, 2005). This approach can be appropriate if one is interested in the effect of, for example, a specific policy over time (e.g. Baur, 2002; Bürgi and Schuler, 2003). However, since we are interested in the causes of complex periurban landscape changes, we choose a comprehensive approach and include probable driving forces from the five types described above.

Driving forces originate and act on several levels. A driving force, for example a regulation, can originate from the local government, the canton, the nation or from an international body. In this study we are interested in driving forces originating from local to international levels, acting on the local scale of the study area. Since driving forces form nested systems, it is often appropriate to distinguish between primary, secondary, and tertiary diving forces (Bürgi et al., 2004). In order to reduce complexity, we limit our study to the primary driving forces, i.e. driving forces acting directly upon landscape features.

In order to better understand the driving forces of landscape change in the periurban Limmat Valley, the main objectives of this paper are to:

(1) quantify the change in urbanization, agricultural intensification, and greening,
(2) determine the driving forces of landscape change,
(3) determine the relative importance of socioeconomic, political, cultural, technological, and natural/spatial driving forces causing these changes,
(4) establish from which administrative levels and spatial scales (local, cantonal, national, international) the most important driving forces originate.

Materials and methods

Study area

The study area includes five municipalities of the Limmat Valley, namely Dietikon, Geroldswil, Oetwil a. d. Limmat, Spreitenbach, and Würenlos (Fig. 1). The study area is part of the periurban area of the city of Zurich, approximately 13 km from the center of Zurich and ranges from 390 to 640 m altitude. It covers 31.6 km^2 with roughly 42,300 inhabitants (census 2000) which yields a density of 1338 persons/km^2. It includes municipalities on both sides of the broad river Limmat and extends from alluvial plains to the adjacent hilltops. The steep slopes and the hilltops are mostly forested whereas the moderately steep slopes and the alluvial plains are in agricultural use. The towns are located at the edges of the alluvial plains. Today, the region is dominated by transportation infrastructure such as national and regional railway tracks, a national highway, and a large regional freight train station. The region is considered a prototype of the urbanized Swiss lowlands (Koch et al., 2003).

In 1930, four of the five municipalities have been small rural villages (Haller, 1957), with some industry in one municipality. The total population was 9063, which yields a density of 287

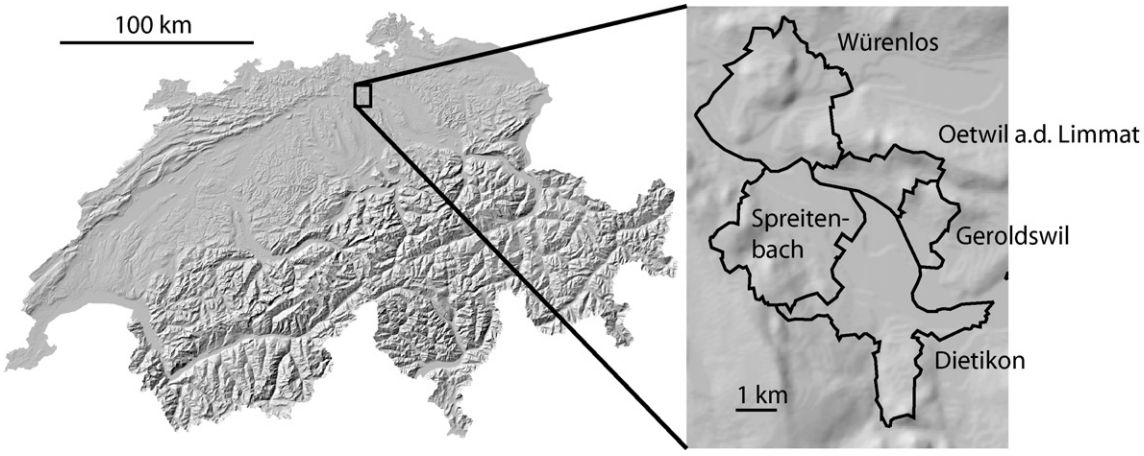

Fig. 1. Study area. Location within Switzerland and boundaries of the five municipalities.