Geomorphology 212 (2014) 4–15

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Geomorphic connectivity within abandoned small catchments (Stołowe Mts, SW Poland)

Agnieszka Latocha

University of Wrocław, Institute of Geography and Regional Development, Pl. Uniwersytecki 1, 50-137 Wrocław, Poland

ARTICLE INFO

Article history:
Received 30 July 2011
Received in revised form 15 November 2012
Accepted 16 April 2013
Available online 2 May 2013

Keywords:
Human impact
Land abandonment
Anthropogenic landforms
Sediment transfer
Slope–channel coupling
Sudetes Mts

ABSTRACT

Studying 5 small catchments (0.6–2.7 km^2) located in the central part of the Stołowe Mountains (SW Poland), which are partly or totally abandoned, has revealed the substantial changes of connectivity within the catchments. Field investigation (geomorphic mapping, morphometric analyses) and GIS based analyses of historical data show that slope–channel coupling is much less efficient than in the past, mainly due to the decrease of unpaved road network, especially roads linked directly with streams. Also land-use change with considerable loss of arable land does not support erosion from slopes. The general direction of geomorphic change due to depopulation and lack of maintenance of anthropogenic features tends towards higher stability and lower efficiency of morphological processes, connected with a sustained decrease in slope–channel coupling. This tendency is evidenced by relict landscape features (e.g. road gullies, abandoned roads) formed in the period of more intensive land use, for which higher dynamics of the morphogenetic system may be inferred. The evidence of contemporary erosion and mineral material transport is very local and spatially limited to a few roads which are still in use. Sediment transfer is additionally slowed down by the presence of numerous anthropogenic barriers within slope and valley-floor domains. Even though their total impact may seem only local and negligible at the catchment scale, their contribution to increase the diversity of morphological processes is significant. Especially the neglect of hydrotechnical constructions enhances trapping of material within the catchments.

1. Introduction

Human disturbance is usually associated with contemporary human activity, which often leads to considerable changes of the natural environment, including, among others, the development of new landforms and alternation of the intensity of morphological processes (Gregory and Walling, 1987; Goudie, 2000; Slaymaker, 2000; Szabó et al., 2010). However, in the European uplands and mountains, there are many areas which have witnessed a substantial decline of human impact, especially agriculture, in recent decades or a century. Most of the studies on the declined human impact focus on land-use and land-cover changes related to land abandonment and to the withdrawal of agricultural activity, especially on the ecological consequences, the increase of forest stands, renaturalization and also on the policy and management of the abandoned areas (Baldock et al., 1996; Wolski, 1998; MacDonald et al., 2000; Richter and Block, 2001; Lasanta-Martínez et al., 2005; Kizos and Koulouri, 2006; Gellrich et al., 2007; Reger et al., 2007; Zomeni et al., 2008). Less attention has been paid to the impact of land-use changes in the context of alteration of morphological processes (Burt et al., 1993; Asselmann et al., 2003; Bork and Lang, 2003; Szilassi et al., 2006; Wolski, 2007; Latocha, 2009). Within this scope the geomorphic effects of the reduction of human impact on mountain areas are often presented in the context of slope–channel coupling/decoupling due to various human activities in the catchments (Latocha and Migoń, 2006; Dotterweich, 2008; Houben, 2008). Special attention is paid to the role of roads as important routes of material transfer downslope. For example, in the forested areas which are usually considered stable as far as the downwash is concerned, the dense network of forest roads contributes much to a high extent of linear erosion (i.e. Luce and Black, 1999; Wemple et al., 2001; Arnáez et al., 2004). According to Froehlich (1982) and Froehlich and Słupik (1986), unpaved roads in the Polish Carpathians contribute up to 90% of the suspended material transported by rivers. Taking into consideration the role of unpaved roads as potential sediment sources and transfer routes, the amount and length of roads which have direct connection with streams are essential (Froehlich, 1982; Wemple et al., 1996, 2001).

The effects of former human activity, understood as landforms of anthropogenic origin, usually stay preserved in the landscape long after the area has been abandoned by people (Antrop, 2005; Mottet et al., 2006; Wolski, 2009). In this context, they still have the potential to modify the type and dynamics of morphological processes, at least at the local scale. Therefore, any catchment with previous intense human activity can be considered as human-disturbed as long as anthropogenic features are preserved, even if the general tendency of declining human impact can be observed within its boundaries. The investigation of human impact on changes of topography and morphological processes has been

E-mail address: agnieszka.latocha@uni.wroc.pl.

0169-555X/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.geomorph.2013.04.030

recently gaining more attention and seems to be developing into a separate discipline of anthropogeomorphology (Szabó et al., 2010). However, at the moment much more attention is given to direct human impact on landforms, while the indirect morphological changes triggered by human activity are somehow under-researched (Lóczy and Pirkhoffer, 2009).

This study tempts to add to the latter by presenting changes in slope–channel connectivity due to alternating human activity. It refers to 5 small catchments in a low mountain area (Stołowe Mountains in SW Poland) which have been subject to intense depopulation and land abandonment within the last 120 years. However, the legacy of former human impact remains preserved in the landscape in the form of various anthropogenic landforms and features. The main research question is as follows: Are pathways of geomorphic evolution altered due to the lack of maintenance of anthropogenic features in the context of slope coupling/decoupling? The special attention is given to the role of anthropogenic barriers in influencing contemporary morphological processes and the connectivity within catchments.

The question of connectivity within a catchment seems to be crucial for the proper management of mountain regions. The study area allows for detailed tracing of changes of slope–channel connectivity from the historical perspective, as the entire area is protected as a National Park, so the modern human impact is very limited and it does not obliterate relics of former anthropogenic activity. Knowing the settlement history of the region, one can assess changes of the morphogenetic system and human impact on the study area within the time span of around 150 years. Broader conclusions can be also drawn, referring to the question of the rate of the recovery of natural morphogenetic system (i.e. Wolman and Gerson, 1978) in mid-mountain areas after decline of human impact.

2. Methods

The study was based on detailed geomorphic mapping of areas which were subject to intense human impact in the past (areas of former settlements and adjacent land under previous agricultural land use, places of former intense forest economy, etc.). The geomorphic mapping of human-made landforms was based on the current topographic maps 1:10,000 (sheets: Karłów 1998, Kudowa Zdrój-Pstrążna 1998 and Łężyce 1998). Additionally, the historical topographic maps 1:25,000 ('Messtischblatt', sheets: Bad Reinerz 1884/1928 and Lewin 1883/1919) and other historical sources were used in order to identify the legacy of former human activity in areas of total abandonment. Field investigations included: (1) identification of the remains of anthropogenic landforms and their morphometric characteristics, (2) identification of morphological processes on the basis of resulting landforms, spatial distribution of erosional and depositional features, and using bio-indicators. The exact location and distribution of human-made landforms and the tangible evidence of contemporary processes was marked with the use of GPS and the morphometric analyses were conducted by the use of measuring tape and laser rangefinder (TruPulse 200 B). DEM and GIS (ArcGIS 9.0) were used for presentation of the results.

3. Study area

The Stołowe Mountains are a low mountain massif in the Middle Sudetes in SW Poland and they are a part of the Bohemian Massif (Fig. 1). The Stołowe Mountains are the only example of plateau relief in Poland and represent a typical structure-and-lithology-controlled landform unit (Migoń, 2008). The massif developed in Upper Cretaceous sedimentary rocks, such as sandstones, marls and – to a minor extent – mudstones (Wojewoda, 1997). Extensive flat surfaces are formed within marl/mudstone, while sandstone layers form isolated plateaus and mesas with very steep slopes, often of a rock-cliff type, and flat summit surfaces, which are the highest areas of the entire massif (Szczeliniec Wielki 919 m a.s.l., Skalniak 915 m a.s.l., Szczeliniec Mały 895 m a.s.l., Narożnik 851 m a.s.l.).

The climatic conditions of the Stołowe Mts are highly influenced by topography — there are differences in temperature at various topographic levels and between S and N aspect slopes. The eastern part of the massif experiences much lower precipitation due to orographic shadow effect (the dominating wind direction is from W and SW sectors). The average precipitation is 1100 mm per year in the most elevated parts of the massif and 650–850 mm/year at the footslope, with the maximum rainfall in summer months (100–120 mm in July). The maximum daily precipitation noted in the period 1976–2005 ranges from 85 up to 170 mm. The mean annual temperature in Karłów (in central part of the region) is 4.3°C. Throughout the winter (around 100 days) average daily temperatures are below 0°C. The snow cover in the higher parts of the massif occurs for around 100 days per year and is especially long-lasting in deep, narrow fissures. Thermal inversion is a common phenomenon (Dubicki and Głowicki, 2008).

In the period of maximum population, which occurred at the turn of the 19th and 20th centuries, there were 62 settlement units in the entire Stołowe Mountains, including colonies and hamlets. 12 settlements disappeared completely (19%) and 33 (54%) were subject to intense depopulation (based on Staffa, 1992). The process of land abandonment started as early as at the end of the 19th century and was intensified in the post-World War II period, which was a typical demographic process in the whole Sudetes (Miszewska, 1989; Ciok, 1995). Depopulation was usually followed by considerable changes in land use, with secondary vegetation succession on abandoned arable land and immense increase of forest stands (Salwicka, 1983; Latocha and Migoń, 2006; Latocha, 2009). However, in the Stołowe Mountains, the increase of forested areas was not as spectacular as in other parts of the Sudetes — for the central part of the massif it changed only from 53 km^2 (based on the Messtischblatt maps) to 57 km^2 nowadays. This phenomenon can be explained by natural environmental conditions of the area and its specific relief: rocky cliffs, numerous bedrock outcrops and very steep and debris-covered slopes did not support the development of agriculture. Therefore, the core area of the Stołowe Mountains remained forested for centuries and the agricultural land use and subsequent secondary vegetation succession were limited to the nearest vicinity of the villages. A much more widespread land-use change in the study area was the turn of arable grounds into hay meadows and pastures (Table 1).

The study was conducted in 5 small catchments (0.6–2.7 km^2) located in the central part of the Stołowe Mountains, which is under legal protection as the Stołowe Mountains National Park. All catchments represent areas of former settlements and their nearest surroundings which were subject to intense human activity, the legacy of which is still readable in the landscape as various types of anthropogenic landforms and features (Table 2, Fig. 2). The boundaries of the selected study areas usually follow both the watershed lines and borders of previously existing administrative units (villages). There were six villages within the study areas — two of them have disappeared completely (Karłówek, Januszów), three have remained in vestigial form (Ostra Góra, Łężno and Kociołek) and only one maintains its administrative status as a separate village (Pasterka), even though substantial depopulation was observed there as well (Table 1). All the villages were/are located in the upper parts of the valleys, usually in the source zones of streams (Fig. 1).

4. Results

4.1. Connectivity in the study catchments

Two main elements associated with human activity are crucial for influencing the level of connectivity between slope and valley floor domains: the type of land use and the network of unpaved roads acting as efficient conveyor belts. In the study areas both factors have considerably changed. The terrain is now dominated by forests and grasslands, with no arable lands. In the past, the situation differed substantially, as much of the area was cultivated (Table 1), with a high proportion of potato fields. Contemporary land use in all catchments does not