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THE IMPACT OF SOCIO-ECONOMIC CHANGES ON THE NATURAL PROCESSES AND TRANSFORMATION OF GEOECOSYSTEMS IN THE GORCE MOUNTAINS

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During the period 2011-2014, the Institute of Geography and Spatial Organization of the Polish Academy of Sciences worked on the project entitled "The impact of socio-economic changes on the natural processes and transformation of geoecosystems in the Gorce Mountains" (project No. NN 306 659940). Funded by the National Research Centre, this project headed by Anna Bucala involved a team comprising Anna Budek, Leszek Starkel, Łukasz Wiejaczka (IGSO PAS) and Maciej Kozak (Institute of Botany of the Jagiellonian University).

The aim of this project was to recognise and assess the impact of mechanisms leading to transformation in mountain geoecosystems, as influenced by land use and land cover, and forced by socio-economic processes. The study area was selected in the Jaszczce and Jamne catchments (areas of 11.39 km² and 8.95 km² respectively) at the Ochotnica

village in the Gorce Mountains. The latter are representative of the Beskid part of Poland's flysch Western Carpathians. Field studies combined with the application of pedological, sedimentological, palynological and chronostratigraphic methods, as supplemented by analyses of data from statistical registries and the interpretation of aerial photographs taken using a GIS system. Together, these techniques provided for the determination of changes that have occurred in the Gorce Mountains under anthropogenic impact from the beginning of human activity in this region through to the present day.

At the turn of the subboreal and subatlantic periods, climatic factors determined the development of relief, vegetation and soil in the Gorce Mountains. Evidence for the climate becoming more humid and cooler in this period is provided by the known expansion of fir at the expense of pine, spruce, alder

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and hazel, as well as the activation of landslides, as visible at the bottom of the peat sediments in Lake Iwankowskie, which date back to 790-410 BC (Bucala et al. 2014).

The earliest period of agricultural activity observed on a pollen diagram was probably associated with the period of early Slavic settlement in the context of the so-called 'Prague Cultural Province'. The age of the layer in which cereal pollen (*Cerealia*) appeared, and when a gradual increase in the mineral material delivery is observed, was dated using the radiocarbon method as older than 600-780 AD. However, more intensive agricultural use of slopes in the Ochotnica valley began in 1450-1640 AD. In this period, accelerated erosion related to deforestation of the Wallachian colonization of the Gorce Mountains and an increase in humidity during the Little Ice Age resulted in the replacement of peat organic sediments by mineral material in Lake Iwankowskie (Bucala et al. 2014).

A gradually increasing population forced to expansion of agricultural activity on to higher-altitude slopes, including even those of northern exposure. This led to an increase in the share of agricultural lands – to over 65% of the Ochotnica area between the mid-19th century and the 1930s. The introduction of tuber crops (mainly potatoes) increased slope wash, and aggradation in the river channels.

Data from statistical registries indicate that a gradual increase in forest area at the expense of farmland only occurred in the second half of the 20th century. The changes in land use which have been occurring since the 1970s, have been evidently accelerated by the political and economic transformation in Poland after 1989. Two main factors influencing the economic decline of farming in the Polish Carpathians following 1989 were: the cessation of a state subsidy to mountain farmsteads and the introduction of a law on private economic entities. As a result, forest areas increased by 14.64% and 23.98% in the period of 1954-2009 at the expense of agricultural areas in the Jaszczce and Jamne catchments, respectively (in 1981-2009,

the forest area increased by 10.76% and 18.59%, respectively for the two catchments). In the past few years, extra-agricultural activities (construction, services and agritourism) have become the leading means of support for local inhabitants. It gradually leads to a reduction in the recently predominant agricultural activity. The reduction in the share of the population employed in agriculture in the investigated area of Ochotnica was from 97.5% in 1950 to 32.1% in 2002. By 2013, only 25% of the population resident of the Jaszczce and Jamne catchments was still working in agriculture.

The past 50 years have seen the vegetation in all the areas investigated undergoing transformations associated with the abandonment of agricultural land use. The most significant change is marked reduction in the arable land and poor grasslands of the *Nardetalia* order (the *Calluno-Nardetum strictae* and *Hieracio-Nardetum* communities). These have been replaced by dense overgrowth, areas of floristically-poor uncultivated land and areas with bilberry scrub. If a high diversity of semi-natural communities (including those of high natural value) is to be preserved, adequate management will be required, with consideration needing to be given to active habitat protection measures (Kozak & Bucala 2014; Bucala et al. 2015).

Despite evident changes in land-use structure, the physical and chemical properties of soils in the Jaszczce and Jamne catchments under arable land or abandoned fields overgrown with grasses, differ only slightly in terms of the content of organic carbon and phosphorus, as well as sorption complex saturation. Moreover, changes in pH or the content of organic matter in the ploughing layer of soils were usually insignificant. Only micromorphological analysis were indicated that the development of aggregates of soil humus horizons under arable land (and thus associated with agriculture techniques) is better than that in soils under grasslands. However, the findings do not permit unequivocal determination of how often and in what way the arable lands were ploughed, and whether occur-

ring today grassland were plowed in the past (Bucala et al. 2015). It must therefore be concluded that the period of 10-30 years following the abandonment of cultivation is too short for significant changes in soil to have occurred.

Land-use changes leading to the increase of forests at the expense of arable land, as well as a reduction in the area of ditches and cart roads, have affected the intensity of geomorphological processes. During the period of intensive agricultural economy up to 1989, the slopes of the Jaszce and Jamne catchments were shaped by linear erosion, landslides, slope wash and tillage erosion, the last two of which were dominant on arable land. Present-day geomorphological processes reach their highest intensity during heavy rainfall in the range of 70 mm/day, on slopes with agricultural use, roads, and stream channels. On slopes with only a small proportion of cultivated land, linear erosion still causes the dissection of slope cover and the deepening of V-shaped valleys, at whose mouths alluvial fans build up. Steep ($\geq 20^\circ$) deforested slopes that are still cultivated or occupied by grasslands are most prone to transformation by fresh shallow landslides. The edges of agricultural terraces often disappear along sections several metres in length, owing to the geomorphic effects of shallow mass movements. Material in relict landslides is moved only during short-lived downpours, owing to the great thickness of colluvium. Reduced slope wash has greatly limited the amount of suspended load in the Jaszce and Jamne streams, this in turn interrupting aggradation processes on their floodplains. In both streams, channel incisions currently dominate. The mean annual rate of river-bed deepening increased from 0.24 cm and 0.32 cm in the years 1964-1968 in the Jaszce and Jamne streams respectively, to 1 cm annually in the period 1969-2014. The incision of the Jamne channel along its lower course resulted in the dissection of alluvia and the transformation of the alluvial

channel existing in the 1960s into a more-rocky channel. Lateral erosion is of ever-less significance. Despite an increase in the forest cover of both catchments, the concentration and structure of suspended material transported during floods remains diverse. In the Jamne catchment, which was characterised by intensive cultivation, the concentration of suspended material and the dominance of the fine fraction is still greater than in the Jaszce catchment.

The changes in land use over the past 25 years following the transformation in Poland from the Communist system to the free-market economy have been the greatest since the Wallachian colonisation of the Gorce Mountains in the 16th-17th century. These changes were primarily caused by socio-economic factors – lower profitability of agricultural activity that has led to a search for a new sources of income. The most rapid and evident transformations have concerned the vegetation, and are associated with the abandonment of agricultural land use. The properties of soils on arable land and grasslands are subject to slight, slow change which might reflect the short (10-30-year) duration of the period since cultivation was abandoned. Finally, contemporary geomorphological processes, accompanied by the gradual increase in forest area, only achieve greater intensity in periods of heavy rainfall on the slopes still used as a arable land, and along dirt roads and river channels, in which incision is predominant. The land-use changes described have ensured the better protection of slopes from erosion and soil degradation. With respect to erosion and flood control, the conversion of arable land into grassland is in accordance with the concept of sustainable management devised for the Carpathians in the 1970s.

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