Nature Conservation

Nature Conservation 55: 41–65 (2024)
DOI: 10.3897/natureconservation.55.111246

Research Article

A detailed assessment of the land cover development in a territory with dispersed settlement area (case study Hriňová – Snohy, Slovakia)

Katarína Švoňavová[1], Vladimír Falťan[2], Veronika Piscová[3], Vladimír Šagát[2], František Petrovič[4]

1 Department of Territorial Development and Conceptions, City of Trnava, Hlavná ulica 1, 91771 Trnava, Slovakia
2 Department of Physical Geography and Geoinformatics, Faculty of Natural Sciences, Comenius University in Bratislava, Mlynská Dolina, Ilkovičova 6, 84215 Bratislava, Slovakia
3 Institute of Landscape Ecology of Slovak Academy of Sciences, Akademická 2, 94910 Nitra, Slovakia
4 Department of Ecology and Environmental Sciences, Faculty of Natural Sciences and informatics, Constantine the Philosopher University in Nitra, Trieda A. Hlinku 1, 94901 Nitra, Slovakia

Corresponding author: František Petrovič (fpetrovic@ukf.sk)

Abstract

This study focuses on the development of the landscape during a period of significant social changes in Central Europe from the middle of the 20th century, and evaluates the impact of the selected natural factors on landscape dynamics in the Snohy dispersed settlement area (cadaster of Hriňová, Slovakia). During the periods of feudalism and the democratic Czechoslovak Republic after 1918, private ownership of land prevailed on the territory of Slovakia. After 1948, in the period of the socialist establishment, the municipality was one of the few localities without collectivisation. We focused on the state and changes to the landscape structure based on remote sensing data analysis (1949, 2003, and 2018), as well as field research and archive photographs inspection. The study area is a part of the proposed Special Area of Conservation SKUEV4026 Meadows of Poľana and is situated near the border between the transition and buffer zones of the Poľana Biosphere Reserve. The state of land cover and its changes have been evaluated using a CORINE Land Cover modification at the 5th level. Results showed that the influence of the slope on agricultural extensification, deforestation, and afforestation, was the most pronounced. Since 1949, more than half of the land cover has changed across the study area. The most extensive changes were recorded in the spatial structure and composition of forest communities.

Key words: Dispersed area settlement, georelief, Hriňová, land cover, Poľana Biosphere Reserve, Slovakia, soil conditions

OPEN ACCESS

Academic editor: Radosław Puchałka
Received: 16 August 2023
Accepted: 9 January 2024
Published: 14 February 2024

ZooBank: https://zoobank.org/CEB20ADC-D1FB-44BC-B714-78065E5B41E5

Citation: Švoňavová K, Falťan V, Piscová V, Šagát V, Petrovič F (2024) A detailed assessment of the land cover development in a territory with dispersed settlement area (case study Hriňová – Snohy, Slovakia). Nature Conservation 55: 41–65. https://doi.org/10.3897/natureconservation.55.111246

Introduction

Land use and land cover

Stamp (1931) conducted some of the earliest studies dealing with the inspection of land use, utilizing legends built upon a combination of several functional and physiognomic features. Other crucial works were released by Anderson et al. (1976) and Heymann et al. (1994). When identifying and interpreting different types of remote sensing images, physiognomic differences between the objects on the Earth's surface were emphasized by these authors. Similar objectives were aimed at by the CORINE Land Cover (CLC) programme, which established a technique for identifying land cover from satellite imagery with a resolution of 10–50 m, while including aspects of land use. With a scale of 1:100,000 and a minimum monitored area size of 25 ha, the CLC technique (Heymann et al. 1994; Büttner et al. 1998; Bossard et al. 2000) is appropriate for national or regional investigations.

The term land cover represents spatial objects on the Earth's surface, which are identified on the basis of morphostructural and physiognomic attributes (Feranec and Oťaheľ 2001). According to (Kopecká 2006), the term expresses the actual state of the landscape structure. By the term land cover change, Coppin et al. (2003) categorized change or gradual transition of one land cover class to another. Treitz and Rogan (2004), Rogan and Chen (2004), and Comber et al. (2005) all understand land cover as a physical formation of matter on the Earth's surface, which is represented by forests, grasslands, artificial surfaces, rocks, water, etc.

Oťaheľ and Feranec (1997, 2006) were among the first in Slovakia to focus on land cover changes identified from CORINE Land Cover data from 1970 to 2000. Analyses of landscape dynamics based on the spatial intensity of changes were published by Feranec et al. (2000), Feranec and Oťaheľ (2001), Boltižiar (2007), Oťaheľ and Feranec (1997) and Oťaheľ et al. (2011, 2017). Classifications of land cover changes were published by Čerňanský et al. (2003) and Kopecká (2006).

In recent decades, the topics of land use and land cover have been a relatively frequent part of historical, geographical, and landscape ecological research in Slovakia, as well as throughout the world. Some studies claim (Huba 1989; Petrovič 2006b; Hunziker et al. 2008; Bürgi et al. 2017), that landscape changes evaluation is largely linked to ongoing social processes. Land-use changes are increasingly being influenced by distant forces due to the globalization of many markets (Lambin and Meyfroidt 2011). Conversely, climate change can also influence land cover, resulting in a loss of forest cover from climate-related increases in disturbances (Flannigan et al. 2009), and the expansion of woody vegetation into grasslands (Kulmatiski and Beard 2013).

Dispersed settlement

In addition to Slovakia (Lauko 1985; Huba 2004; Petrovič 2006a; Petrovič and Petrikovičová 2021), dispersed settlement also occurs in many countries. As examples of studies of this type of settlement, we mention the following: Scandinavia (Norling 1960; Hansen 1972), Bulgaria (Hoffman 1964), Africa (Stone 1991; Donaldson and Boshoff 2001), Czechia (Löw and Míchal 2003; Vaishar and Šťastná 2019; Šťastná and Vaishar 2020), and the United States (Barnes and Robinson 1940). However, its occurrence in the aforementioned regions is spatially limited.

In Slovakia, dispersed settlement is a specific form of settlement, which is conditioned by specific historical and environmental factors. As a result of colonization waves in Slovakia, groups of irregularly-scattered settlements in different types of georelief were created. However, its genesis was rather diverse

(Huba 1989, 1990, 1997). The origin of dispersed settlements began in medieval times (Hoffmann 2014; Hanušin et al. 2020). Its basic function was soil cultivation in the marginal areas (Sitár 1967). The formation of dispersed settlements was linked to the three colonization waves: Wallachian (Chaloupecký 1947); Highlander and the "Kopaničiarska" (Petrovič and Petrikovičová 2021). Nowadays, in Slovakia, five different regions with scattered settlements and different land uses can be found (Verešík 1974).

Poľana Biosphere Reserve

One specific dispersed settlement was created in the Podpoľanie area. Within Poľana, as a part of the Western Carpathians Mountains, is one of the greatest European former volcanoes (original elevation at the time of its activity reached approximately 2500 m a.s.l.), and the highest volcanic mountain range in Slovakia. Elevation at the highest point is 1458 m a.s.l., while the lowest one reaches 460 m a.s.l. Poľana Biosphere Reserve (BR), established in 1990, is characterized by the common occurrence of both thermophilous and mountain plant species. Forests cover almost 85% of its area, with the moderate prevalence of coniferous forests (https://en.unesco.org/biosphere/eu-na/polana). To date, 1220 species of vascular plants have been described in the BR, out of which 80 species are in the categories of protection, threat, and rareness. With 174 species of birds, the Poľana BR has been recognized as an Important Birds Area of Slovakia. Besides biodiversity, land use dynamics is a crucial part of BRs research in Slovakia (Olah and Boltižiar 2009).

Historical evolution of Podpoľanie

The area of Podpoľanie is characterized by a specific type of homestead and colonization. In the initial phase of Wallachian colonization in the 13th–14th century, there were successive waves of settlement by inhabitants with a nomadic way of life, who were influenced by the political situation (Cojacaru 2014). Wallachian colonization was continuously followed by mining colonization (in some areas it overlapped it) from the 17th to 19th century (Petrovič and Petrikovičová 2021). Colonization affected not only sheep farming, but also culture, folklore, domestic production, and the very way of life in mountain and foothill areas. This area of Podpoľanie is characterized by high biodiversity and is connected mainly to the boundaries, which consist of the edges of field roads, original meadows, pastures, permanently grassy areas on former fields, or various waterlogged areas (Ružičková et al. 1999).

Koza (2018) evaluated the historical landscape structures with a focus on the agricultural landscape in the cadastral territory of Hriňová. Vašková (2015) analyzed the development of ecosystems in relation to forms of land use in Podpoľanie. Lapinová (2004) dealt with the development of dispersed settlements in the Detva dispersed area region, and together with Paučová (2014), they conducted research in the neighboring district of Detva. Paučová (2014) focused on preserved areas in Detva, specifically on the local part of Skliarovo. Private land ownership, however, was not encouraged after the establishment of socialism in 1948. The established regulations clearly delineated the limits of land that could have been used for farming by private farmers, and the remaining land was predisposed to collectivization. In the middle of the 20th century, through the process of collectivization, land was collectively pooled. And so, peasant families were left with only small areas up to 0.5 ha (Spišiak 2005).

The shift after 1989 resulted in the conversion of the central planned economy to a market-oriented economy. Despite the fact that farmers in the area once farmed as owners of the agricultural soil, many young people moved for employment to other nearby cities. The growth of Hriňová's population began to decline in 1998 (KPSS 2018). Since then, the city of Hriňová's demographics have taken a negative turn as fewer children are being born, the population is ageing, or the population is post-productive. Nowadays, the area of Podpoľanie is sparsely inhabited, including three settlements, one recreation center, several farms and forest houses (https://en.unesco.org/biosphere/eu-na/polana). Only a few of the 400 permanent residents work in forestry or agriculture, and the majority of them are retired. Those who are working commute to industrial facilities outside the area.

Objectives of the study

Our study provides a detailed description of the historical landscape structures development in the Hriňová – Snohy location. With the years 1949, 2002–2003 and 2018 under examination, the early period of socialism, entry to the European Union and current land use are represented. Landscape dynamics were evaluated on the basis of aerial imagery GIS-based expert classification, in accordance with the CORINE Land Cover methodology modification by Oťaheľ et al. (2017).

We introduced our approach to detailed research of land cover changes of dispersed settlement area in relation to soil and geomorphological conditions. In this paper, we also aim to emphasize any threats that could potentially endanger the future existence of dispersed settlements in Slovakia.

Materials and methods

Study area

The city of Hriňová is located in the Detva district in central Slovakia. Snohy is a local part of Hriňová, situated approximately 10 km north of the city center on the southern slopes at an elevation range 751–828 m a.s.l. The area under investigation is located in Snohy, with a size of 2.5 km^2. It belongs to a moderately cold, very humid district of a cold climate area with an average air temperature in July of 12 °C – 16 °C. The average air temperature in January is from -5 to -6 °C (https://app.sazp.sk/atlassr/).

This is a specific type of dispersed settlement (named „lazy"), where traditional farming has been preserved until today. Hriňová was one of the few municipalities where the collectivization of agriculture never took place, and the Unified agricultural cooperative was thus never established. To this day, it has preserved the traditional structure of land use, which is characterized by terraced fields (Fig. 1). While in the surrounding municipalities of Detva and Očová only a few fragments of agrarian historical structures have remained, compact historical farms have been conserved in the Hriňová dispersed area, being among the best preserved in Slovakia (Urban 2015). Historical landscape

Figure 1. Landscape structure of Hriňová with dispersed settlements and terraced fields (Photo: K. Švoňavová, 2019).

structures are represented by terraced fields and several farms. The study area is a part of the proposed Special Area of Conservation SKUEV4026 Meadows of Poľana with agricultural management (Figs 2, 3). Landscapes of the Poľana Mts. have been protected as the Poľana has been designated as a protected landscape area since 1981, as well as within the Poľana Biosphere Reserve from the UNESCO Man and Biosphere programme since 1990.

The volcanic relief of the Poľana mountain range was remodeled in the Quaternary, mainly by fluvial activity. The soil cover consists mainly of cambisols, andosols, and fluvisols. The territory is located at the upper borderline of a moderately warm climate zone. The region is covered mainly by woodlands (85% of the BR), the rest being agricultural land, including grassland and pastures, except for 50 ha of water reservoir. The forest habitats are diverse, from oak and beech forests to spruce forests growing on andesites, and are well-known for their southernmost occurrence within the Western Carpathians, covering the highest part of the mountain range. Many forests have the character of an old primeval forest. Throughout their history, the Poľana forests have been modified by various natural disturbances and human interventions (e.g., beech forests were replaced by spruce monocultures).

Data

For the purposes of our research, imagery from an aerial survey was used. For the year 1949, panchromatic aerial photographs from the archive of the Topographic Institute in Banská Bystrica with a resolution of 0.5 m (http://mapy.tuzvo.sk) were used. An orthophotomosaic of the Slovak Republic, provided by Geodis ltd. and Eurosense ltd. with a resolution of 0.5 m, was applied for 2003. As for 2018, the open-source Orthophotomosaic of the Slovak Republic was used, carried out by the National Forest Center and Cadastre Authority of the Slovak Republic (https://www.geoportal.sk/en/zbgis/orthophotomosaic).

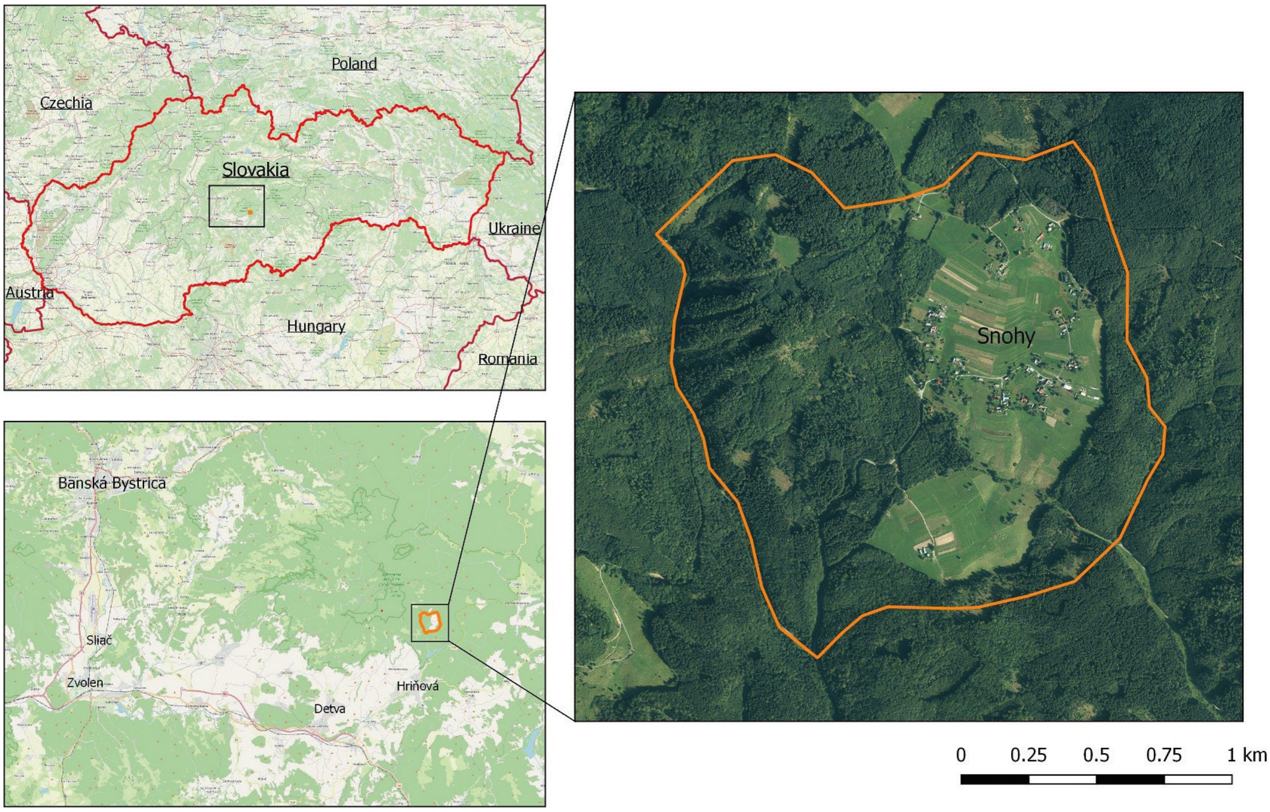

Figure 2. Location of the study area.

Figure 3. Landscape of the study area (Photo: K. Švoňavová, 2019).

Data for the soil maps creation (the map of certified soil-ecological units and forest soil maps) was provided by the Research Institute of Soil Science and Landscape Protection (http://www.podnemapy.sk/portal/verejnost/bpej/) and the National Forest Center (http://gis.nlcsk.org/ArcGIS/services/Inspire/PodneTypy/MapServer/WMSServer?).

The basemap of the Slovak Republic on a scale of 1:10,000 (https://zbgisws.skgeodesy.sk/ZMSR_wms/service.svc/get) and the digital elevation model (DEM) with a resolution of 25 m (https://land.copernicus.eu/imagery-in-situ/eu-dem/eu-dem-v1.1?tab=mapview) were used to create topographic and insolation outputs.

During the whole analysis, the coordinate system of the unified trigonometric network of the cadastral S-JTSK (5514) was used.

Analysis of land cover changes

The vectorization, as well as the following spatial analysis, were performed in QGIS 2.8.14. The creation of land cover layers was based on visual interpretation. Moreover, data for 2018 was verified by the field research. For identification of land cover classes, the modification of the CORINE Land Cover nomenclature on the 5th level at a scale of 1:10,000 by Oťaheľ et al. (2017) was used.

The method is based on the concepts of hierarchically higher classes (Heymann et al. 1994; Bossard et al. 2000). Most importantly, morpho-structural and physiognomic attributes distinguishing individual landscape objects were respected. The size of the least-identified and simultaneously-recorded area is identical with the study by Druga et al. (2015), who established it at 0.1 ha. It corresponds approximately to a square with a 31.5 m side, a circle with a 35.5 m diameter, or a 20 × 50 m rectangle (Falťan et al. 2020). The minimum area of change is set to 0.02 ha and the minimum width of a polygon to 10 m. Exclusion is made for polygons of linear elements – water courses, railways and road networks – which has a minimal width of 2 m and a minimal length of 50 m.

When mapping land cover for the years 1949 and 2003, the retrospective approach was applied (Feranec et al. 2004), meaning only areas with an interpreted change (larger than the size of the minimum area of the change) were edited. As a reference layer, the layer from the following analyzed year was used. The Change Detection Toolbox tool, which was created as a practical output in Lukáš Žubrietovský's diploma thesis (Žubrietovský 2016), was used in the analysis of the land cover. Classification of changes was carried out according to Feranec et al. (2010).

Temporal stability of each land cover class reflects the degree of its connection to the selected landscape natural components (Súľovský 2017).

The stability of the types of areas used for the land, or of the land cover, also shows the degree of their connection to the selected relevant natural components of the landscape (Súľovský 2017). Land cover stability maps were carried out in the ArcGIS 10.7.1, with land cover change data (1949–2003 and 2003–2018) being the input layers. These layers were overlaid using Intersect tool, and thus we selected unstable areas.

The Merge tool was applied when delineating neutral areas, by merging both layers of the land cover changes. Stable areas are defined as the territory outside any unstable and neutral areas, i.e., an area where no change was recorded.

Analysis of soil and georelief

Based on the underlying soil data, a map was created on a scale of 1:10,000 and the soils were classified according to the soil type and subtype. To unify soil names, a conversion table, which is freely available on the ForestPortal website about the forests of Slovakia, was used (http://www.forestportal.sk/lesne-hospodarstvo/hospodarska-uprava-lesov/Stranky/prevody-pody.aspx).

A map of morphographic-positional types of georelief according to Tremboš (Minár et al. 2001) was prepared on the basis of the Basic Map of the Slovak Republic in a scale of 1: 10,000 and DEM. When delineating the debatable areas, we used an extracted layer of slope, orientation to the cardinal points, and a layer of contours computed in ArcGIS 10.7.1. Auxiliary contours were created at intervals of 10 m and 5 m. To evaluate the relationship between relief forms and areas of stability, the aforementioned layers were overlaid, and their relationship was examined.

The slope of the soil is an important physical parameter that significantly affects the quality and method of use of the soil and the given location. Layers of slope and insolation were computed from the DEM. In the case of slope, we reclassified raster into six classes. For practical purposes and the needs of agricultural practice, it is possible to express the representation of the slope of agricultural land in the following classes: 0–1°, 1–3°, 3–7°, 7–12°, 12–17°, 17° – 25°, 25° and others. In the case of slope, we reclassified the data in degrees into these classes. Classes 12–17° and 17–25° were merged, as one of the classes was not represented.

Subsequently, raster was converted to the vector feature, while polygons with an area of less than 100 m^2 were merged with the nearest related area. A similar method was used to create the insolation layer: raster was reclassified into six classes, ranging from the minimum value up to 400,000, 400,000–430,000, 430,000–460,000, 460,000–490,000, 490,000–520,000 and 520,000–550,000 WH/m^2. Consequently, layers of slope and insolation were overlaid with the layer of land cover stability so that the underlying relationships could be analyzed.

Results

Analyses of land cover development

In the territory of the Snohy area (Fig. 4), a significant change of the land cover was observed (Table 1). During the period 1949–2003, 52.9% of the total area changed, while during 2003–2018, a change of 28.3% was recorded. In terms of land cover flows during both periods, the most prominent were other changes (61.1 ha = 23.6%), for example, changes in the species composition of stands in the forests or within settlement classes, followed by deforestation (28.0 ha = 10.8%), caused by forest harvesting, and extensification of agriculture (21.8 ha = 8.4%).

In 1949–2003, the most prominent changes were recorded in the structure and composition of forest communities (Fig. 5). The changes in the period of 2003–2018 were similar, however, the other changes had already reached lower values (25.7 ha = 9.9%), yet still being the highest among the others.

This was followed by changes in deforestation (20.8 ha = 8%) and afforestation (18 ha = 6.9%). Artificial areas, fields and meadows in Snohy have changed in all the observed periods (Fig. 6). Significant changes took place in forests under conservation of the Poľana protected landscape area and the

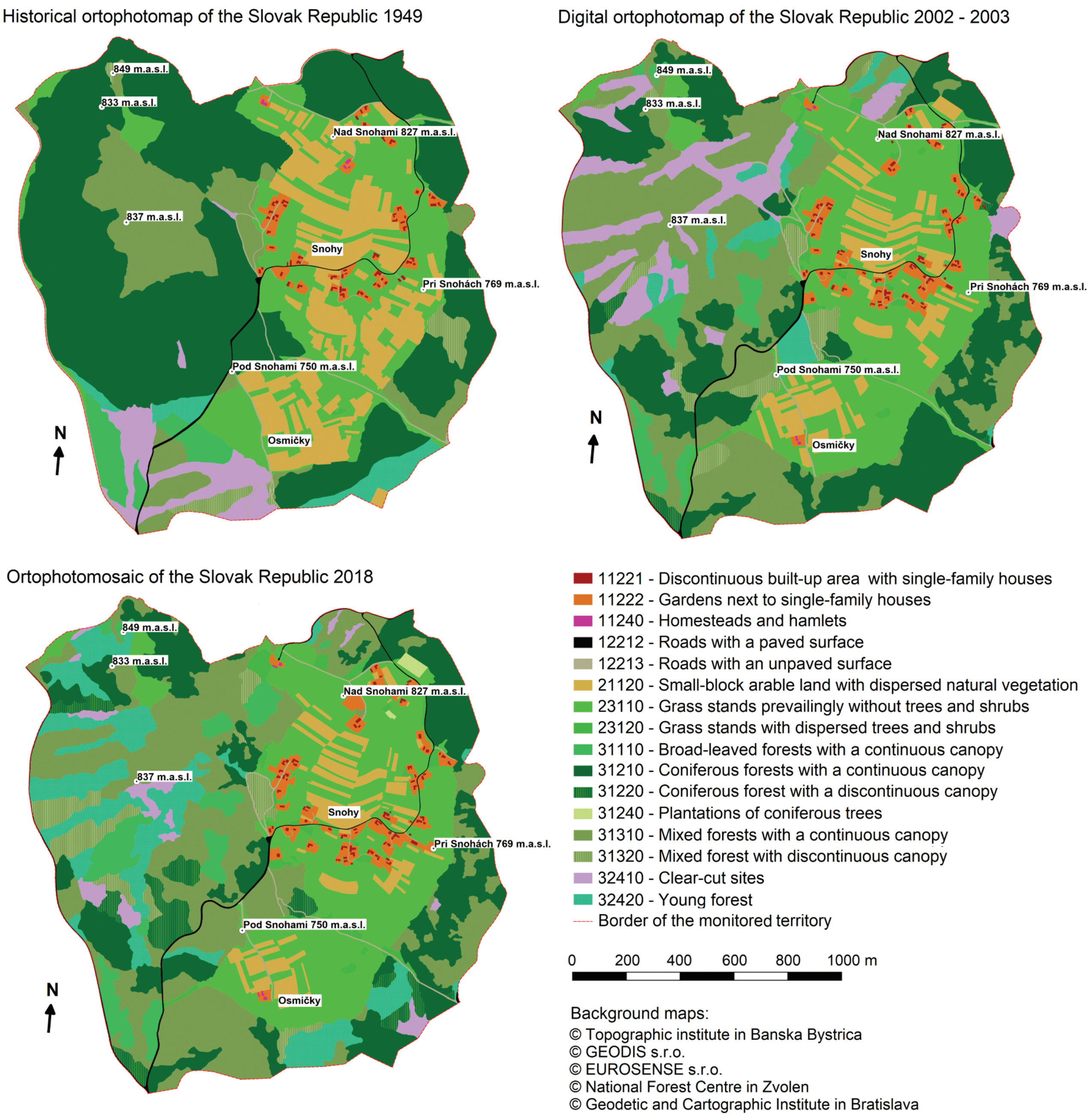

Figure 4. Land cover of the Snohy area in 1949, 2003 and 2018.

UNESCO Biosphere Reserve. It must be noted, however, that both active forest management and sustainable agriculture are not prohibited, and are thus encouraged in this zone.

The most stable land cover types are grasslands, followed by coniferous and deciduous forests with a continuous canopy.

Analysis of the influence of slope angle and insolation on the stability of the land cover areas

Unstable areas are connected predominantly to the slope angles 12–25° (19.1 ha) and 7–12° (17.0 ha), being associated with the increased values of deforestation in 1949–2003 (Fig. 8). Areas with a single recorded change are

Table 1. Land cover classes and its area (ha) in each observed time horizon.

Code	land cover type	1949	2003	2018
11221	Discontinuous built-up area with single-family houses	0.90	1.06	1.04
11222	Gardens next to single-family houses	3.78	5.75	6.59
11240	Homesteads and hamlets	0.08	0.05	0.06
12212	Roads with a paved surface	1.37	2.20	2.20
12213	Roads with an unpaved surface	1.99	1.18	0.91
21120	Small-block arable land with dispersed natural vegetation	31.86	15.84	12.05
23110	Grass stands prevailingly without trees and shrubs	46.78	64.69	65.30
23120	Grass stands with trees and shrubs	0.11	3.38	4.14
31110	Broad-leaved forests with a continuous canopy	6.74	8.02	11.51
31210	Coniferous forests with a continuous canopy	116.62	55.85	42.06
31220	Coniferous forests with a discontinuous canopy	0.23	1.51	8.43
31240	Plantations of coniferous trees	0.00	0.00	0.58
31310	Mixed forests with a continuous canopy	29.11	67.92	65.51
31320	Mixed forests with a discontinuous canopy	3.97	5.96	8.29
32410	Clear-cut sites	9.86	18.51	4.73
32420	Young forests	5.36	6.85	25.37

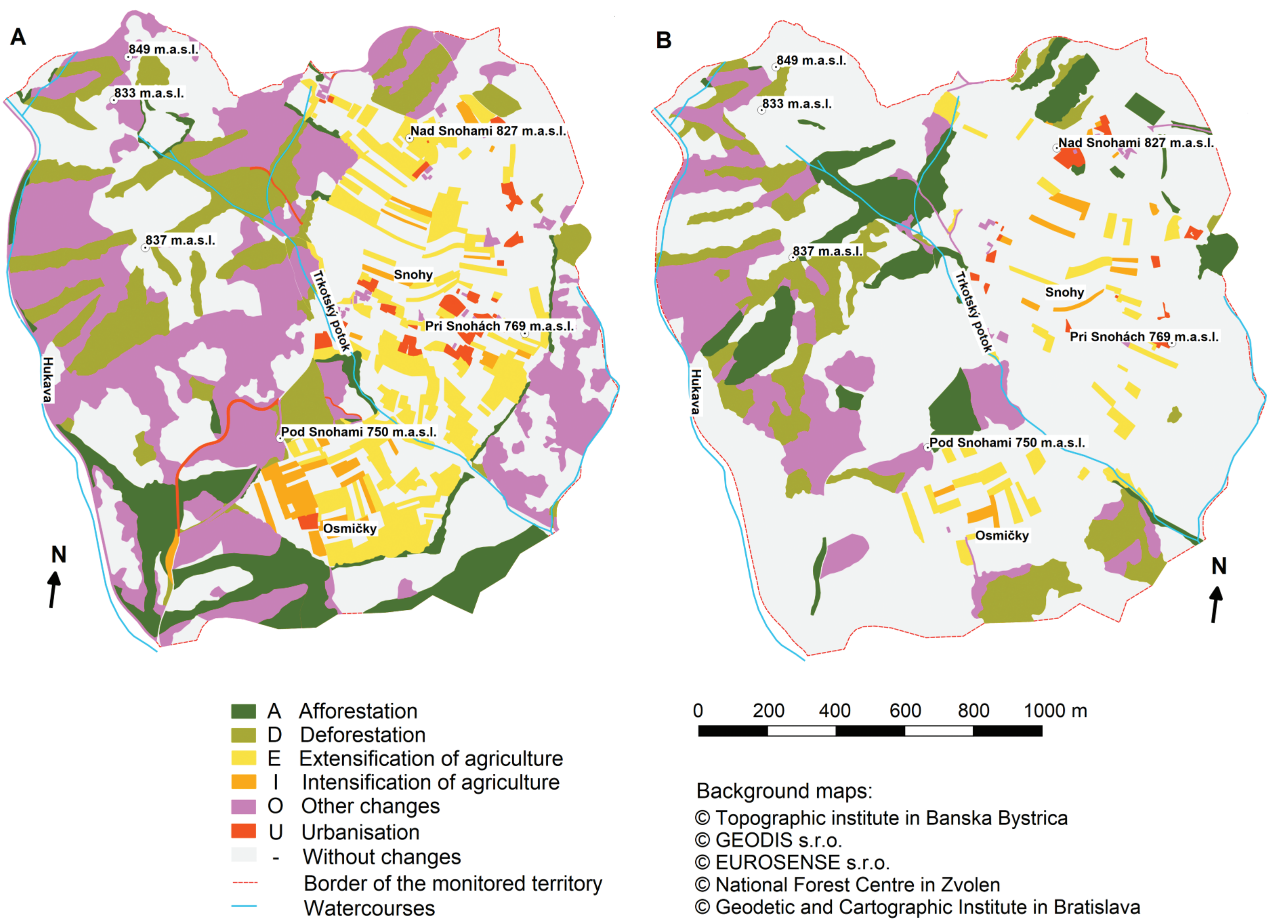

Figure 5. Land cover changes in the Snohy area in 1949-2003 (**A**) and 2003-2018 (**B**).

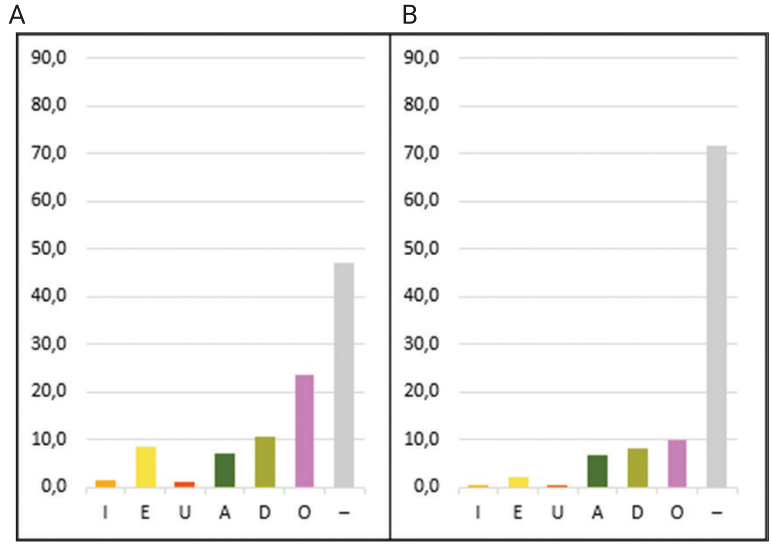

Figure 6. Proportions of individual types of land cover changes (%) in 1949–2003 (**A**) and 2003–2018 (**B**). Type of changes: I – intensification of agriculture, E- extensification of agriculture, U – urbanization, A- afforestation, D - deforestation, O – other change, - - without change.

linked to afforestation, significant extensification after 1950, and subsequent intensive deforestation between 2003–2018 (Fig. 8). Areas with steep slopes were marginally modified during 1949–2018, being covered mostly by forests.

The most significant category of the total insolation in the entire territory was 460,000–490,000 Wh/m^2 (104.5 ha = 40.4%). Moreover, the amount of insolation ranging from 490,000 to 520,000 WH/m^2 took place in the area of 69.3 ha (26.8%). The category of 520,000–536,300 Wh/m^2 was spatially detected in the area of 3.5 ha, being the highest value of insolation among dispersed settlements throughout the entire Hriňová region.

Unstable areas with higher insolation values showed the most significant processes of afforestation, deforestation, and other changes in the entire observed period of 1949–2018 (Fig. 7). Neutral areas in the sunniest parts of the territory were characterized by changes in deforestation, other changes until 2003, and increased extensification and other changes after 2003. The land cover in the areas with a higher insolation values was represented by forest communities, arable land, and grasslands.

The influence of georelief forms and soil types on the stability of land cover areas

In the study area, the predominant soil type is locally-andotermic cambisol (Fig. 7). In the floodplains, fluvisols take place, being characteristic for the areas modified by a single change type (mostly deforestation). In the areas with prevailing cambisols, the land cover types stability was influenced mainly by the forms of georelief. The most significant changes were linked to deforestation in the second half of the 20th century, as well as afforestation and extensification at the beginning of the 21st century. These changes took place on 46% of the transport slopes.

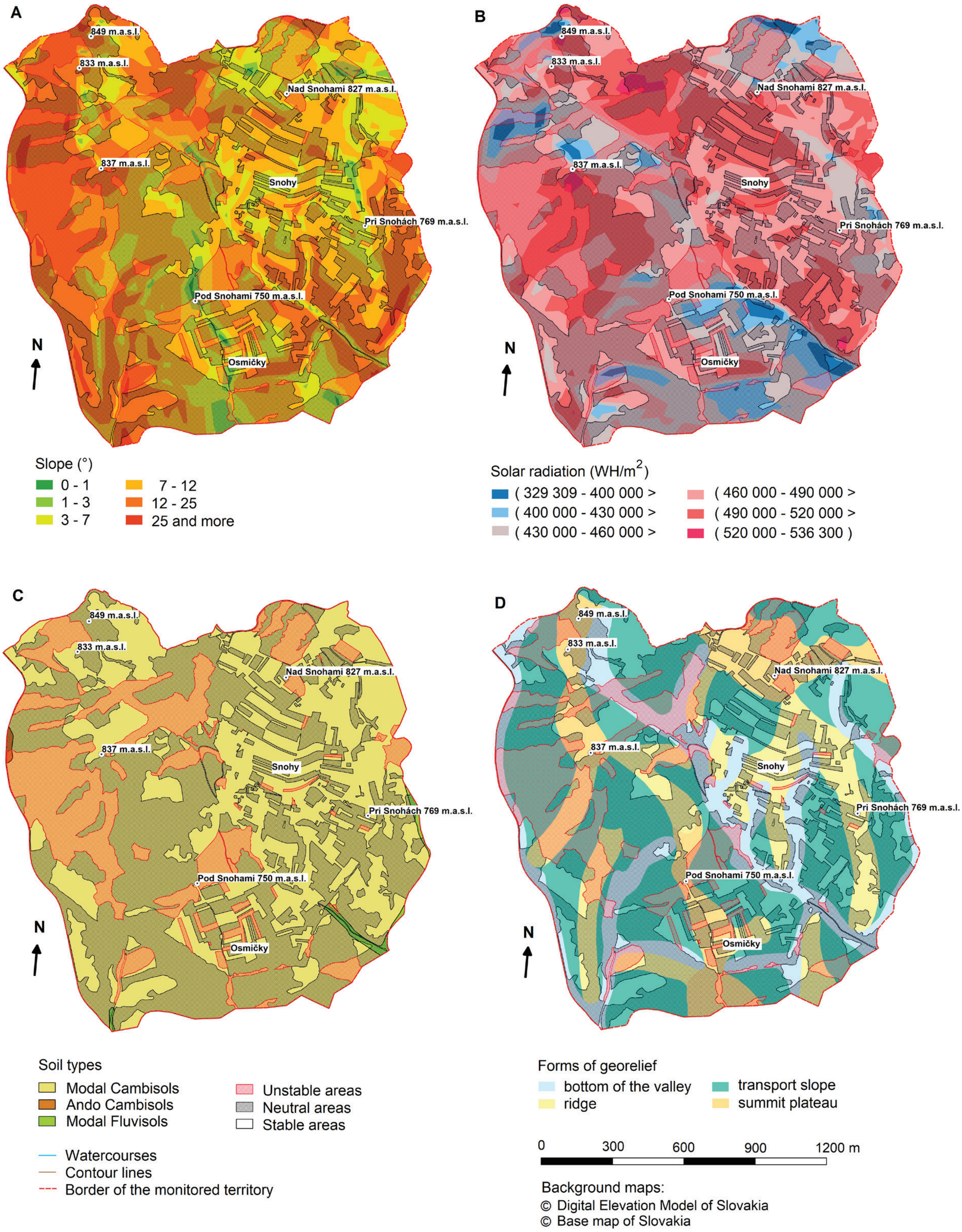

Figure 7. Stability of land cover areas in relation to the **A** slope angle **B** insolation **C** soil types **D** form of georelief.

Almost 20% of the valley bottoms and ridges has been modified by similar processes. However, stable areas are connected mainly to the transport slopes and not to the ridges and valley bottoms.

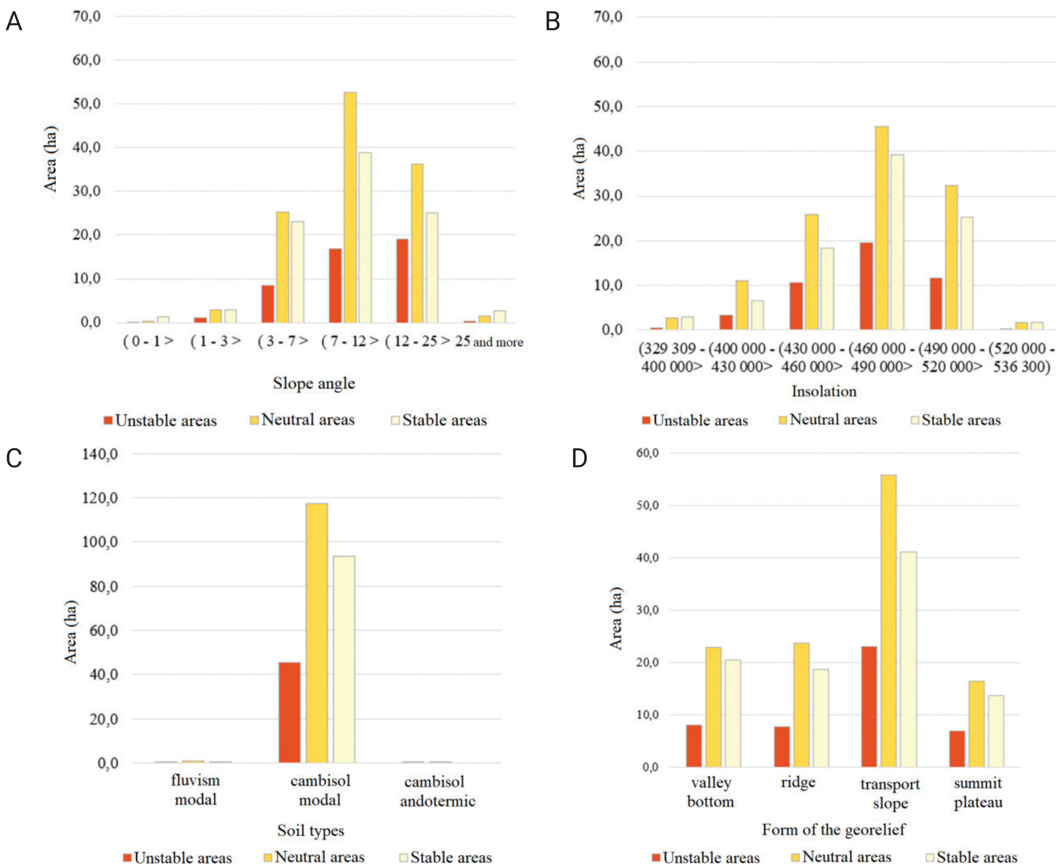

Figure 8. Stability of land cover areas in relation to the **A** slope angle **B** insolation **C** soil types **D** form of georelief.

Discussion

Long-term changes in land use also affect other environmental determinants, such as elevation, slope, insolation, or wetness of the soil (Druga and Falťan 2014). The drivers for the agricultural intensification and urbanization seem to be similar for both old democratic and post-socialist countries. In contrast, agricultural land abandonment in the old democratic countries was driven by technological, cultural and economic driving forces while in the post-socialist countries the political driving forces were mainly responsible (Skokanová et al. 2016).

According to several studies (Boltižiar and Olah 2009; Žigrai 2000), changes in the landscape and their spatial determinants are most intensively related to the most significant socio-political periods, namely socialism (1980–1990), post-socialism (1990–2000), accession to the EU (2000–2006), and EU membership (2006–2012). Pazúr et al. (2014) point to significant changes in the landscape management associated with institutional changes, especially in the post-socialist period. It was during this period that the protected landscape area of BR Poľana, established in 1981, was also included in the network of biosphere reserves in 1990, and until 2010, only its protective function was mainly ensured (Urban 2015). This was also reflected in a certain stabilization of the use of the territory and therefore roughly 70% of the territory was categorized as "no change" between 2003 and 2018 (Fig. 5B). The land cover changes in both evaluated periods took place mainly in forestry and agriculture, which, after the inclusion of Poľana in the network of biosphere reserves, are supported as close to nature forest management and sustainable agriculture, which is relevant also in our study area.

The territory that the Poľana biosphere reserve belonged to in 2014 was among the least urbanized protected areas in Slovakia. There were only three settlements (Iviny, Snohy and Vrchslatina) with a typical settlement (about 400 permanent residents in total) (Urban 2015). In 2016, Hriňovské lazy was also included in the transition zone. Scattered settlements were created in Hriňová due to the difficult availability of land from inhabited areas. In this area, horses and traditional agricultural tools are still used for agricultural work. This agro-ecosystem not only fulfils the function of a producer of food, feed and raw materials, but also supports a whole range of non-production functions of the country and thus becomes more sustainable (Prčík et al. 2019). The cadastral territory of Hriňová, as one of the few in Slovakia, was not affected by the collectivization of agriculture during the socialist period; it has preserved its unique landscape and traditional forms of farming. The preservation of these traditional forms of agriculture is mainly ensured by the work of the Coordinating Council of the Poľana Biosphere Reserve with stakeholders. In 2017, the Poľana Biosphere Reserve received the Michel Batisse Award for the Biosphere Reserve Management at the ceremonial event in the course of the ICC MAB, the highest possible award for the exceptional experience of man with nature.

Hanušin et al. (2020) claim that dispersed settlement with a residential or landscape area structure, significant building, and social and cultural peculiarities, create unique manifestations of material and spiritual heritage and genius loci. According to Woods (2005), a country with scattered population represents in most regions of Europe a specific type of rural landscape that has seen a significant change in recent times, predominantly during the twentieth and the beginning of the twenty-first century. Social and technological modernization has affected almost all areas of rural life. In Slovakia, regions with a dispersed settlement on mountain slopes have been changing their appearance and function for approximately the last 30–50 years. According to previous studies (Bezák and Halada 2010; Bezák and Mitchley 2014; Bezák and Petrovič 2006; Bezák et. al 2020), the main factors of changes were related to the onset of socialism after World War II, political and economic changes after 1989, and Slovakia's accession to the EU. Socialism led to the establishment of State Property (SP) and United Agricultural Cooperative (UAC); narrow-band fields were consolidated into larger blocks. Increase in production and decrease in agricultural landscape diversity were significant. UAC was a type of agricultural cooperative in the Czechoslovak Socialist Republic until 1990. UACs were responsible for most of Czechoslovakia's agricultural production. Any citizen could become a member after completing compulsory schooling. Upon joining the cooperative, a member of the cooperative handed over all the agricultural land he owned to the ownership and joint management of the cooperative. SPs were fully owned by the socialist state and they managed a smaller area of land than UACs in Slovakia.

After 1989 the population began to lose interest in agriculture, mostly in regions with dispersed settlements. The consequences for the landscape were thus significant: a large part of the agricultural land was abandoned, grassed-over, and overgrown with scrub. In Hriňová, due to the character of the landscape, there was no consolidation of offields during socialism. At the same time, the area of small-block, arable land with dispersed natural vegetation and coniferous forests with a continuous canopy managed by foresters gradually decreased in the Snohy study area from the middle of the 20th century. The area of gardens next to single-family houses, grass stands, and natural mixed forests has increased.

In the highly-fragmented agricultural patterns, which are typical of a traditional agricultural landscape, significant changes are not observable by conventional remote sensing approaches to land change measurement (Ellis et al. 2006). Specific research procedures included large-scale mapping based on aggregation data, such as historical records, field mapping combined with multiple level approaches that define land system – land cover – land use, cultural heritage features, and vegetation (Ellis et al. 2009; Kizos et al. 2010). Several detailed field investigations were carried out in the locality. The territory of the Hriňová dispersed settlement landscape became an object of interest for Mojses and Petrovič (2012, 2013). In addition to the changes in the land cover, they focused on other specific types of historical structures of the agricultural landscape, while the extensification of agriculture was recorded as the second most widespread type of change in the period from 1949 to 2010. The land cover changes recorded in this region were the result of several negative socioeconomic influences, such as unsuitable economic conditions, legislative and administrative obstacles, or the aforementioned loss of ties to the traditional way of farming. Krnáčová and Hreško (2014) came up with the suggested management and measures, which were based on the observed soil reaction of the management of agricultural biotopes, and described in detail the functions of vegetation and vegetational-anthropogenic elements of the agricultural landscape. With regard to the prepared site of NATURA 2000, it is necessary to preserve the agricultural management of meadows, gardens, and block fields in the Snohy area.

The development of mining and metallurgy in the 19th and 20th centuries caused significant logging and transformation of deciduous and mixed lowland forests into spruce monocultures (Urban 2015). The extracted wood was used in glassworks, in the production of charcoal or intended for export. More studies (Izakovičová 2013; Bezák and Mitchley 2014) link landscape changes with migration in Europe after World War II. The population tends to concentrate in bigger cities as a result of higher population density. This brings more opportunities for jobs, entertainment, and the social aspects of life (Antrop 2004). In the nearby surroundings of our study area, Detva and Hriňová, cities that attract the majority of the population, such as Zvolen, Banská Bystrica, or Brezno, can be found, which also provide better job prospects and improved cultural benefits while still being within reasonable distance of Poľana. A low population density without local services restricts viable employment opportunities (Lundmark et al. 2010). Generally speaking, the depopulation of dispersed settlements might have a serious effect on sustainable development of the region (Grau and Aide 2007). Although dispersed settlement has an irreplaceable ecological, cultural, and historical value, the interest of local owners in traditional farming is constantly decreasing in Slovakia (Pazúr et al. 2020). Olah et al. (2006) point out the impact of the decreasing number of farming inhabitants around Podpoľanie and the related reduction of the area of the managed permanent grasslands. Young people from Snohy also often left to work in nearby towns. The ecologically most stable areas lie in the lowest, southern, and south-western slopes in the region of the Poľana Biosphere Reserve (Olah 2003, 2006). Gallayová (2009) showed that overgrowths above 75% are clearly linked to the slopes higher than 15° in the territory of Poľana, which was also confirmed in previous research. It was similar in the analysis of soil types, where modal cambisol reached increased values in areas with a higher intensity of change or overgrowth. Galalyová registers overgrowth of over 75% in the areas oriented to the northwest, north and west. The smallest overgrowth was identified on the southern and eastern slopes. According to Žigrai (2000), distance plays an important role in the assessment of the relevant socioeconomic element.

Huba (2009) focused on the transformation of the dispersed settlement area on the example of Poľana. One type of secondary resettled population is the descendants of the original owners who decided to settle in this region and start farming. Another type are people who are looking for a second home or cottage, while at the same time carrying out agricultural and economic activities around the property. Nowadays, we can register a third type of residents, i.e., the descendants of the original owners, who live in either the original or newly-built houses, but are not interested in agricultural activities. This phenomenon is described also by Štefunková (2019). Therefore, land use changes are gradually taking place — overgrowth, conversion to recreational land, etc. This process is also evident by a slight increase of a discontinuous, built-up area with single-family houses in Snohy in recent years. Several authors have also reported changes in agricultural activities, which could create risks to the preservation of the traditional cultural landscape (Agnoletti 2007; Špulerová 2008; Van de Velde et al. 2010; Jakab and Petluš 2012). Another factor that potentially endangers the continuity of such areas is depopulation (Elbakidze and Angeltram 2007). Therefore, it is of utmost importance to find solutions to these problems, because research results confirm the irreplaceable role of HSAL (Deckers et al. 2005).

In the study of land cover changes around the villages of Malachov and Podkonice in Central Slovakia west of the Podpoľanie region, Druga and Falťan (2014) also confirmed a reduction of arable land during last century. Elevation and higher slope angle were related to the classes with lower intensity of use, such as forest land and extensive grassland, which is in our study too. Steep areas with a slope of more than 12°, despite having a higher amount of insolation, have been predominantly used for forestry after 1949. The trends of extensification of agriculture and afforestation have manifested more than urbanization in dispersed settlement localities. Löw and Míchal (2003) recorded fields from one settlement as having a maximum diameter of 1.2 km. In several studies (Hietel et al. 2004; Bárek et al. 2009; Martínez 2011; Tárnik and Igaz 2015), it has been stated that soils have minor or average influence on land cover changes. In our study, stability of land cover has been influenced more by georelief.

An interest in maintaining the integrity of traditional landscapes is also present in the European Landscape Convention (CETS No. 176 2000), because there are real threats of losing traditional landscapes and their genius loci. The recent CAP approach does not sufficiently reflect the specific local physical conditions of Slovak TALs. For example, small, remote meadows, and narrow fields with terraces and stone walls, typical for Podpoľanie area, are not included in the support system (insufficient size, difficult access). The system is financially demanding and inaccessible for many rural farmers. Administrative tasks are a huge barrier, especially for older people. This challenge of maintaining traditional agricultural landscapes is addressed to individuals, as well as to those politicians who make decisions on development policy (MRI).

Due to its location, Snohy and its wider surroundings have long been part of the Protected Landscape of Poľana, specifically falling into the transition zone. Logging is not prohibited in this zone, but practices of sustainable management of natural resources are promoted and developed in it. Compared to the unprotected forest land in the vicinity, the share of deciduous forests is gradually being restored here. The territory of Snohy is included in the upcoming part of the NATURA 2000 network, Special Area of Conservation SKUEV4026 Meadows of Poľana, which is supposed to protect valuable meadow biotopes: species-rich Nardus grasslands, on siliceous substrates in mountain areas and submountain areas in continental Europe, lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*), transition mires and quaking bogs and a species of European importance, *Campanula serrata* (https://www.minzp.sk/uradna-tabula/eu-uzemia/skuev4026-luky-polany.html). In 2021, negotiations began with the owners, managers, and tenants of the affected lands. According to Article 6(3) of the Habitats Directive 92/43/EEC1 (HD), any projects and plans within these sites or in their vicinity require an appropriate assessment to ensure that they will not have any significant impact on the integrity of the Natura 2000 site (Mockel 2017). This process is complicated in the territory of Podpoľania by the number of owners and users of the agricultural landscape. This region is very interesting from the point of view of landscape preservation, as well as for the monitoring and research of other connections.

Some studies have shown that the impact of settlement on landscape fragmentation in biosphere reserves has been more significant (Compas 2007; Liang et al. 2014; Li et al. 2023), and the interactions between settlement landscape patterns and natural ecosystems have been more complex (De Castro-Pardo et al. 2021). The area, number, density, connectivity, shape similarity, and spatial organization of patterns of settlements have had a significant impact on the size of biological communities and the species richness in biological reserves (Heider et al. 2018; Lu et al. 2018; Onilude and Vaz 2020; Wang et al. 2020). Woodland landscapes in mountainous areas have been characterized by high biodiversity and contain rich populations of plant and animal species (Bailey et al. 2002), so the influence of woodland landscape fragmentation is more complex, as compared to other types of landscapes (Pavlacky and Anderson 2007).

Our proposed methodology can be used in other Central European countries. Data for the soil maps creation is available in the portals of the forestry and agriculture research institutes. Digital elevation models, as a data for GIS georelief analyses, can be obtained according to the possibilities of state geodetic and cartographic authorities in different countries. Land cover mapping is realisable with the use of actual open remote sensing data and historical orthophotographs with interpretation procedures and nomenclature designed in the work Oťaheľ et al. (2017). The use of the CLC at the 5th level is methodologically possible throughout the European Union. The legend is usable in Central Europe, but of course, it can be expanded by adding specific types of areas (e.g. coast, forest-steppe, tundra, etc.). However, it should be noted that the process itself is more time-consuming compared to the use of satellite images for the CLC program and it is not very suitable for larger regions. The output of our work will be further used in the landscape management of the PLA Poľana, as the staff of the PLA administration requested them.

We perceive that globalization leads to the creation of a uniform society, as well as to the loss of the specificity of regions to varying degrees. This is gradually reflected in the formation of the landscape and scattered settlements. The landscape is changing into homogeneous units — peripheral settlements that had an agricultural and manufacturing function in the past are disappearing. Forms of anthropogenic relief in a traditional agrarian landscape are an important part of cultural heritage and, at the same time, a source of biodiversity. They were created over many centuries to improve the quality of the relief soil of agricultural land and contain specific features as a result of the local agrarian culture and specific natural conditions. The benefit of the research is a detailed evaluation of the development of the land cover of the territory with scattered settlements in the location of Snohy, which points to significant changes in the use and transformation of the landscape.

Conclusions

The area of Podpoľanie with the „lazy" dispersed settlement under the Poľana Biosphere Reserve, thanks to a specific method of management, has preserved several valuable historical landscape structures (e.g. terraced fields and fragments of non-forest woody vegetation). Our study introduced a new approach to deatiled research of land cover changes of dispersed settlement area in relation to soil and geomophological conditions. Since 1949, there has been a significant change in the land cover in more than half of the Snohy territory, mainly in the structure and composition of the forest communities. The relief factors were significantly dominated by the influence of the slope on land cover changes. Stable areas of forests were linked to slopes higher than 25°, transport slopes with a slope angle of 12–25° represented habitats with deforestation in the 20th century and afforestation in the 21st century. At the same time, the gradual extensification of agriculture was promoted. Research did not show any effects that would clearly indicate changes related to areas with very low insolation intensity. We can confirm the biggest changes occurred in the modal cambisol, and that the land cover areas linked to the fluvisol and andosol was more stable, regarding the soil types.

The city of Hriňová, in cooperation with the Poľana Biosphere Reserve, has implemented several arrangements to prevent the loss of diversity in this region. In 2016 the inclusion of the Hriňová dispersed settlements in the Biosphere Reserve marked another step forward in the sustainable development of the region. In 2016, Hriňovské lazy was also included in the reserve transition zone, where horses and traditional agricultural tools are still used for agricultural work. The main goal is to direct investments into the creation of new job offers, as well as into the creation of regional products and projects that will help preserve the customs and landscape character of the Podpoľanie region. The establishment of Special areas of Conservation (SACs) Meadows of Poľana, including locality Snohy, can significantly help preserve biodiversity in this area.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

This research was funded by the Scientific Grant Agency of The Ministry of Education, Science, Research, and Sports in Slovakia and The Slovak Academy of Sciences by project VEGA 1/0217/23, The Cultural and Educational Agency by project KEGA 043UKF-4/2022 and by the Operational Programme Integrated Infrastructure (OPII) under the FOMON project ITMS2014+ 313011V465 contract from EFRD.

Author contributions

All authors have contributed equally.

Author ORCIDs

Vladimír Falťan https://orcid.org/0000-0002-2840-3982
Veronika Piscová https://orcid.org/0000-0003-4375-9490
Vladimír Šagát https://orcid.org/0009-0004-7467-5112
František Petrovič https://orcid.org/0000-0002-2364-3610

Data availability

All of the data that support the findings of this study are available in the main text.

References

Agnoletti M (2007) The degradation of traditional landscape in a mountain area of Tuscany during the 19th and 20th centuries. Implications for biodiversity and sustainable management. Forest Ecology and Management 249(1–2): 5–17. https://doi.org/10.1016/j.foreco.2007.05.032

Anderson JR, Hardy EE, Roach JT, Witmer RE (1976) A Land Use and Land Cover Classification System for Use with Remote Sensor Data, Geological Survey Professional Paper 964, Washington, 28 pp. https://doi.org/10.3133/pp964

Antrop M (2004) Landscape change and the urbanization process in Europe. Landscape and Urban Planning 67(1–4): 9–26. https://doi.org/10.1016/S0169-2046(03)00026-4

Bailey SA, Haines-Young RH, Watkins C (2002) Species presence in fragmented landscapes: Modelling of species requirements at the national level. Biological Conservation 108(3): 307–316. https://doi.org/10.1016/S0006-3207(02)00119-2

Bárek V, Halaj P, Igaz D (2009) The Influence of Climate Change on Water Demands for Irrigation of Special Plants and Vegetables in Slovakia. Bioclimatology and Natural Hazards 271: 271–282. https://doi.org/10.1007/978-1-4020-8876-6_23

Barnes AJ, Robinson HA (1940) A New Methods for the Representation of Dispersed Rural Population. Geographical Review 30(1): 134–137. https://doi.org/10.2307/210453

Bezák P, Halada L (2010) Sustainable management recommendations to reduce the loss of agricultural biodiversity in the mountain regions of NE Slovakia. Mountain Research and Development 30(3): 192–204. https://doi.org/10.1659/MRD-JOURNAL-D-10-00023.1

Bezák P, Mitchley J (2014) Drivers of change in mountain farming in Slovakia: From socialist collectivisation to the Common Agricultural Policy. Regional Environmental Change 14(4): 1343–1356. https://doi.org/10.1007/s10113-013-0580-x

Bezák P, Petrovič F (2006) Agriculture, landscape, biodiversity: Scenarios and stakeholder perceptions in the Poloniny National Park (NE Slovakia). Ekologia (Bratislava) 25(1): 82–93.

Bezák P, Mederly P, Izakovičová Z, Moyzeová M, Bezáková M (2020) Perception of ecosystem services in constituting multi-functional landscapes in Slovakia. Land 9(6): 195. https://doi.org/10.3390/land9060195

Boltižiar M (2007) Štruktúra vysokohorskej krajiny Tatier (veľkomierkové mapovanie, analýza a hodnotenie zmien aplikáciou údajov diaľkového prieskumu Zeme). Nitra: Fakulta prírodných vied Univerzity Konštantína Filozofa, Ústav krajinnej ekológie SAV Bratislava, Pobočka Nitra, Slovenský národný komitét pre program UNESCO Človek a biosféra, 248 [ISBN 978-80-8094-197-0].

Boltižiar M, Olah B (2009) Krajina a jej štruktúra (Mapovanie, zmeny a hodnotenie), Prírodovedec,372, Univerzita Konštantína Filozofa Nitra, 150 pp.

Bossard M, Feranec J, Oťaheľ J (2000) CORINE Land Cover technical guide- Addendum. Technical report No. 40. European Environmental Agency, Copenhagen, 105.

Bürgi M, Bieling C, von Hackwitz K, Kizos T, Lieskovský J, Martín MG, McCarthy S, Müller M, Palang H, Plieninger T, Printsmann A (2017) Processes and driving forces in changing cultural landscapes across Europe. Landscape Ecology 32(11): 2097–2112. https://doi.org/10.1007/s10980-017-0513-z

Büttner G, Steenmans CH, Bossard M, Feranec J, Kolář J (1998) The European CORINE land cover database. In: Bűttner G (Ed.) ISPRS Commission VII on Resource and Environmental Monitoring 1996–2000. Budapest: International Society for Photogrammetry and Remote Sensing, 633–638.

Čerňanský J, Kožuch M, Stanková H (2003) Sledovanie a hodnotenie zmien vysokohorskej krajiny s využitím ortofotomáp. Zborník z 15. kartografickej konferencie „Geoinformatizácia kartografie". Zvolen, 93–101. https://doi.org/10.1080/0953732032000046079

Chaloupecký V (1947) Valaši na Slovensku. Praha: Slovanský ústav.

Cojacaru T (2014) Valasi na Slovensku a Poľsku, predbežné úvahy. In: Marza E, Syrný M (Eds) Valašská kolonizácia na Slovensku a Slovenská kolonizácia v Rumunsku (20–26). Bratislava: Slovak Academy of Sciences.

Comber A, Fisher P, Wadsworth R (2005) Comparing statistical and semantic approaches for identifying change from land cover datasets. Journal of Environmental Management 77(1): 47–55. https://doi.org/10.1016/j.jenvman.2005.02.009

Compas E (2007) Measuring exurban change in the American West: A case study in Gallatin County, Montana, 1973–2004. Landscape and Urban Planning 82(1–2): 56–65. https://doi.org/10.1016/j.landurbplan.2007.01.016

Coppin P, Lambin E, Jonckheere J, Muys B (2003) Digital change detection methods in natural ecosystem monitoring: a review. World Scientific. https://doi.org/10.1142/9789812777249_0001

De Castro-Pardo M, Azevedo JC, Fernández P (2021) Ecosystem Services, Sustainable Rural Development and Protected Areas. Land 10(10): 1008. https://doi.org/10.3390/land10101008

Deckers B, Kerselaers E, Gulinck H, Muys B, Hermy M (2005) Long-term spatio-temporal dynamicsof a hedgerow network landscape in Flanders, Belgium. Environmental Conservation 32(1): 20–29. https://doi.org/10.1017/S0376892905001840

Donaldson S, Boshoff E (2001) Household linkages in dispersed settlement around Pietersburg and implications for household resources management. Journal of Family Ecology and Consumer Sciences 29: 20–27. https://doi.org/10.4314/jfecs.v29i1.52797

Druga M, Falťan V (2014) Influences of environmental drivers on land cover structure and its long-term changes: A case study of the villages of Malachov and Podkonice in Slovakia. Moravian Geographical Reports 22(3): 29–41. https://doi.org/10.2478/mgr-2014-0016

Druga M, Falťan V, Herichová M (2015) Návrh modifikácie metodiky CORINE Land Cover pre účely mapovania historických zmien pokrývky na území Slovenska v mierke 1: 10 000 – príkladová štúdia historického k. ú. Batizovce, Geographia Cassoviensis IX.

Elbakidze M, Angeltram P (2007) Implementing sustainable forest management in Ukraine's CarpathianMountains: The role of traditional village systems. Forest Ecology and Management 249(1–2): 28–38. https://doi.org/10.1016/j.foreco.2007.04.003

Ellis EC, Wang H, Xiao HS, Peng K, Liu XP, Li SC, Ouyang H, Cheng X, Yang LZ (2006) Measuring long-term ecological changes in densely populated landscapes using current and historicalhigh resolution imagery. Remote Sensing of Environment 100(4): 457–473. https://doi.org/10.1016/j.rse.2005.11.002

Ellis EC, Neerchal N, Peng K, Xiao SH, Wang H, Yan Z, Li SC, Wu JX, Jiao JG, Ouyang H, Cheng X, Yang LZ (2009) Estimating long-term changes in china's village landscapes. Ecosystems12(2): 279–297. https://doi.org/10.1007/s10021-008-9222-4

Falťan V, Petrovič F, Oťaheľ J, Feranec J, Druga M, Hruška M, Nováček J, Solár V, Mechurová V (2020) Comparison of CORINE Land Cover Data with National Statistics and the Possibility to Record This Data on a Local Scale—Case Studies from Slovakia. Remote Sensing 12(15): 2484. https://doi.org/10.3390/rs12152484

Feranec J, Oťahel' J (2001) Krajinná pokrývka Slovenska. Veda, 124.

Feranec J, Suri M, Otahel J, Cebecauer T, Kolar J, Soukup T, Zdenkova D, Waszmuth J, Vajdea V, Vijdea A, Nitica C (2000) Inventory of major landscape changes in the Czech Republic, Hungary, Romania and Slovak Republic. International Journal of Applied Earth Observation and Geoinformation 2(2): 129–139. https://doi.org/10.1016/S0303-2434(00)85006-0

Feranec J, Oťaheľ J, Cebecauer T (2004) Zmeny krajinnej pokrývky – Zdroj informácií o dynamike krajiny. Geografický časopis. č. 56.

Feranec J, Jaffrain G, Soukup T, Hazeu G (2010) Determining changes and flows in European landscapes 1990–2000 using CORINE land cover data. Applied Geography (Sevenoaks, England) 30(1): 19–35. https://doi.org/10.1016/j.apgeog.2009.07.003

Flannigan M, Stocks B, Turetsky M, Wotton M (2009) Impacts of climate change on fire activity and fire management in the circumboreal forest. Global Change Biology 15(3): 549–560. https://doi.org/10.1111/j.1365-2486.2008.01660.x

Gallayová Z (2009) Podklady k hodnoteniu zraniteľnosti trávnych porastov voči zarastaniu na území CHKO Poľana. In: Environmentálne indexy a indikátory analýzy a hodnotenia krajiny (terénny prieskum, modelovanie a diaľkový prieskum Zeme ako alternatívne zdroje údajov). Zborník z vedeckého seminára 5.11.2009. Výskumný ústav pôdoznalectva a ochrany pôdy. Bratislava, 34.

Grau HR, Aide TM (2007) Are Rural–Urban Migration and Sustainable Development Compatible in Mountain Systems? Mountain Research and Development 27(2): 119–123. https://doi.org/10.1659/mrd.0906

Hansen JCH (1972) Regional Disparities in Norway with Reference to Marginality. Transactions of the Institute of British Geographers (57): 15–30. https://doi.org/10.2307/621551

Hanušin J, Huba M, Ira V (2020) Changes of dispersed settlements in rural cultural landscape from the strategic perspective (with special attention to the village Hrušov in central Slovakia). Folia Geographica 62(2): 106–132.

Heider K, Lopez JMR, Aviles JMG, Balbo AL (2018) Land fragmentation index for drip-irrigated field systems in the Mediterranean: A case study from Ricote (Mur-

cia, SE Spain). Agricultural Systems 166: 48–56. https://doi.org/10.1016/j.agsy.2018.07.006
Heymann Y, Steenmans CH, Crossille G, Bossard M (1994) CORINE Land Cover: Technical Guide. Luxembourg: Office for Official Publications of the European Communities.
Hietel E, Waldhardt R, Otte A (2004) Analysing land-cover changes in relation to environmental variables in Hesse, Germany. Landscape Ecology 19(5): 473–489. https://doi.org/10.1023/B:LAND.0000036138.82213.80
Hoffman GW (1964) Transformation of Rural Settlement in Bulgaria. Geographical Review 54(1): 45–64. https://doi.org/10.2307/213029
Hoffmann RC (2014) An Environmental History of Medieval Europe. Cambridge: University Press. https://doi.org/10.1017/CBO9781139050937
Huba M (1989) O niektorých otázkach genézy a súčasného stavu kopaničiarskeho osídlenia na území Slovenskej socialistickej republiky. Geograficky Casopis 41(2): 138–155.
Huba M (1990) O perspektívach kopaničiarskeho osídlenia a kopaničiarskej krajiny na území Slovenskej republiky. Geograficky Casopis 42(2): 113–130.
Huba M (1997) Kopaničiarske osídlenie, životné prostredie a trvalo udržateľný spôsob existencie. Životné prostredie 31(2): 61–66.
Huba M (2004) Historické štruktúry krajiny v kontexte súčasnej reality. Životné prostredie 38(2): 86–89.
Huba M (2009) Transformácia krajiny s lazníckym osídlením na príklade Poľany a Podpoľania. Slovenský národopis 57(3): 312–330.
Hunziker M, Felber P, Gehring K, Buchecker M, Bauer N, Kienast F (2008) Evaluation of Landscape Change by Different Social Groups: Results of Two Empirical Studies in Switzerland. Mountain Research and Development 28(2): 140–147. https://doi.org/10.1659/mrd.0952
Izakovičová Z (2013) Evaluation of the changes of landscape types of Slovakia. Georeview 22(1): 1–10. https://doi.org/10.4316/GEOREVIEW.2013.22.1.71
Jakab I, Petluš P (2012) Development of a program tool for the determination of the landscape visual exposurepotential. In: Jordan F, Jorgensen SE (Eds) Models of the ecological hierarchy: from molecules to the ecosphere (375–390). Amsterdam, NL: Elsevier. https://doi.org/10.1016/B978-0-444-59396-2.00022-5
Kizos T, Dalaka A, Petanidou T (2010) Farmers' attitudes and landscape change: evidence from theabandonment of terraced cultivations on lesvos, greece. agric Hum Values 27: 199–212. https://doi.org/10.1007/s10460-009-9206-9
Kopecká M (2006) Identifikácia a hodnotenie zmien krajiny vo veľkej mierke (na príklade okolia Trnavy). Geografický časopis. č. 58.
Koza M (2018) Historická krajinná štruktúra vybraného územia Podpoľania. Bakalárska práca, Fakulta prírodných vied Univerzity Mateja Bela v Banskej Bystrici.
KPSS (2018) Komunitný plán sociálnych služieb mesta Hriňová 2018–2023, s. 12–14.
Krnáčová Z, Hreško J (2014) Ekologický manažment v tradičnej agrárnej krajine ako základný predpoklad ochrany kvality krajiny a životného prostredia. In: Acta Environmentalica Universitatis Comenianae (Bratislava), Vol. 22, 1(2014): 14–24 [ISSN 1335-0285].
Kulmatiski A, Beard KH (2013) Woody plant encroachment facilitated by increased precipitation intensity. Nature Climate Change 3(9): 833–837. https://doi.org/10.1038/nclimate1904
Lambin EF, Meyfroidt P (2011) Global land use change, economic globalization, and the looming land scarcity. Proceedings of the National Academy of Sciences of the United States of America 108(9): 3465–3472. https://doi.org/10.1073/pnas.1100480108

Lapinová M (2004) Analýza vzťahov medzi prírodnými danosťami krajiny a jej hospodárskym využívaním na príklade modelového územia v katastrálnom území Detvy. In: Turisová I, Prokešová R (Eds) Ekologická diverzita Zvolenskej kotliny. Zvolen: Lesnícky výskumný ústav, 31–33 [ISBN 80-88853-77-X].

Lauko V (1985) Vývoj a transformácia kopaničiarskeho osídlenia Myjavskej pahorkatiny. Acta FRNUC, Geographica Nr. 25, Bratislava, 35–52.

Li B, Ouyang H, Wang T, Dong T (2023) Coupling Relationship between Rural Settlement Patterns and Landscape Fragmentation in Woodlands and Biological Reserves—A Case of Nanshan National Park. Land 12(4): 741. https://doi.org/10.3390/land12040741

Liang J, Liu Y, Ying LX, Li P, Xu Y, Shen ZH (2014) Road impacts on spatial patterns of land use and landscape fragmentation in three parallel rivers region, Yunnan Province, China. Chinese Geographical Science 24(1): 15–27. https://doi.org/10.1007/s11769-014-0652-y

Löw J, Míchal I (2003) Krajinný ráz. Lesnická práce, Kostelec nad Černými lesmi, 552.

Lu H, Xie HL, He YF, Wu ZL, Zhang XM (2018) Assessing the impacts of land fragmentation and plot size on yields and costs: A translog production model and cost function approach. Agricultural Systems 161: 81–88. https://doi.org/10.1016/j.agsy.2018.01.001

Lundmark LJT, Fredman P, Sandell K (2010) National parks and protected areas and the role for employment in tourism and forest sectors: a Swedish case. Ecology and Society 15: 19. https://doi.org/10.5751/ES-03175-150119

Martínez JÁ (2011) Modelling the risk of land cover change from environmental and socio-economic drivers in heterogeneous and changing landscapes: The role of uncertainty. Landscape and Urban Planning 101(1): 108–119. https://doi.org/10.1016/j.landurbplan.2011.01.009

Minár J, Barka I, Bonk R, Bizubová M, Čerňanský J, Falťan V, Gašpárek J, Kolény M, Kožuch M, Kusendová D, Machová Z, Mičian Ľ, Mičietová E, Michalka R, Novotný J, Ružek I, Švec P, Tremboš P, Trizna M, Zaťko M (2001) Geoekologický (komplexný fyzickogeografický) výskum a mapovanie vo veľkých mierkach., Geografické spektrum 3, Prírodovedecká fakulta Univerzity Komenského Bratislava: Geografika.

Mockel S (2017) The European ecological network “Natura 2000” and the appropriate assessment for projects and plans under Article 6(3) of the Habitats Directive. Nature Conservation 23: 1–29. https://doi.org/10.3897/natureconservation.23.13599

Mojses F, Petrovič F (2012) Vplyv zmien využitia zeme na diverzitu krajiny. Životné prostredie 46(1): 23–27.

Mojses F, Petrovič F (2013) Land use changes of historical structures in the agricultural landscape at the local level – Hriňová case study. Ekologia (Bratislava) 32(1): 1–12. https://doi.org/10.2478/eko-2013-0001

Norling G (1960) Abandonment of Rural Settlement in Vasterbotten Lappmark, North Sweden, 1930–1960. Geografiska Annaler, Vol. 42, No. 4, Advance and Retreat of Rural Settlement: Papers of the Siljan Symposium at the XIXth International Geographical Congress, 232–243. https://doi.org/10.1080/20014422.1960.11880948

Olah B (2003) Vývoj využívania Podpoľania – starostlivosť o kultúrnu krajinu prechodnej zóny BR Poľana. Vedecké štúdie, TU Zvolen.

Olah B (2006) Vývoj osídlenia a využívania krajiny južného Podpoľania. In: Figurová T (Ed.) Detva – Tradície premeny a súčasnosť. Zborník príspevkov z konferencie: Tradície, premeny a súčasnosť (Od rurálneho k urbánnemu?). Detva.

Olah B, Boltižiar M (2009) Land use changes within the slovak biosphere reserves’ zones. Ekologia (Bratislava) 28(2): 127–142. https://doi.org/10.4149/ekol_2009_02_127

Olah B, Boltižiar M, Petrovič F (2006) Land use changes' relation to georelief and distance in the East Carpathians Biosphere Reserve. Ekologia (Bratislava) 25(1): 68–81.

Onilude OO, Vaz E (2020) Data Analysis of Land Use Change and Urban and Rural Impacts in Lagos State, Nigeria. Data 5: 72. https://doi.org/10.3390/data5030072

Oťaheľ J, Feranec J (1997) Rural landscape assessment in environmental planning: case study – part of Záhorie Lowland. In: Munzar J, Vaishar A (Eds) Rural Geography and Environment. Brno: Geoekonfin, 89–96.

Oťaheľ J, Feranec J (2006) Výskum a mapovanie využitia krajiny: Minulosť a súčasnosť v kontexte Slovenska. Geograficky Casopis 58(2).

Oťaheľ J, Oťaheľová H, Pazúr R, Hrivnák R, Valachovič M (2011) Spatio-temporal changes in land cover and aquatic macrophytes of the Danube floodplain lake. Limnologica 41(4): 316–324. https://doi.org/10.1016/j.limno.2011.01.005

Oťaheľ J, Feranec J, Kopecká M, Falťan, V (2017) Modifikácia metódy CORINE Land Cover pre identifikáciu a zaznamenávanie tried krajinnej pokrývky v mierke 1:10 000 na báze príkladových štúdií z územia Slovenska. Geografický časopis. č. 69(3): 189–224.

Paučová M (2014) Výskum krajinnej pokrývky okolia Detvy v kontexte zmien využitia zeme. Diplomová práca, Prírodovedecká fakulta Univerzity Komenského v Bratislave.

Pavlacky Jr DC, Anderson SH (2007) Does avian species richness in natural patch mosaics follow the forest fragmentation paradigm? Animal Conservation 2007(10): 57–68. https://doi.org/10.1111/j.1469-1795.2006.00067.x

Pazúr R, Lieskovský J, Feranec J, Oťaheľ J (2014) Spatial determinants of abandonment of large-scale arable lands and managed grasslands in Slovakia during the periods of post-socialist transition and European Union accession. Applied Geography 54: 118–128. https://doi.org/10.1016/j.apgeog.2014.07.014

Pazúr R, Lieskovský J, Bürgi M, Müller D, Lieskovský T, Zhang Z, Prishchepov AV (2020) Abandonment and Recultivation of Agricultural Lands in Slovakia—Patterns and Determinants from the Past to the Future. Land 9(9): 316. https://doi.org/10.3390/land9090316

Petrovič F (2006a) The changes of the landscape with dispersed settlement. Ekologia (Bratislava) 25(1): 65–89.

Petrovič F (2006b) Vzťah rozptýleného osídlenia k morfometricko-polohovým vlastnostiam reliéfu. Acta Environmentalica Universitatis Comenianae (Bratislava) 14(1): 105–113.

Petrovič F, Petrikovičová L (2021) Landscape tranformation of small rural settlements with dispersed type of settlement in Slovakia. European Countryside 13(2): 455–478. https://doi.org/10.2478/euco-2021-0027

Prčík M, Kotrla M, Hauptvogel M (2019) Udržateľný rozvoj – aktuálny prehľad a vybrané problémy. Vydavateľstvo Slovenskej pedagogickej univerzity Nitra, 131 pp.

Rogan J, Chen DM (2004) Remote Sensing Technology for Mapping and Monitoring Land-Cover and Land Use Change. Progress in Planning 61(4): 301–325. https://doi.org/10.1016/S0305-9006(03)00066-7

Ružičková H, Dobrovodská M, Valachovič M (1999) Landscape -ecological evaluation of vegetation in relation to the forms of anthropogenic relief in the cadastre od Liptovská Teplička village, the Nízke Tatry Mts. Ekologia (Bratislava) 18: 381–400. https://doi.org/10.1016/S0735-2689(99)00372-X

Sitár E (1967) Kopaničiarske osídlenie na Slovensku (niektoré otázky súčasného stavu). Vlastivedný časopis 16(3): 125–135.

Skokanová H, Falťan V, Havlíček M (2016) Driving forces of main landscape change processes from past 200 years in Central Europe - differences between old democratic and post-socialist countries. Ecology (Bratislava) 35(1): 50–65. https://doi.org/10.1515/eko-2016-0004

Spišiak P (2005) Základy geografie poľnohospodárstva a lesného hospodárstva. Univerzita Komenského, Bratislava.

Špulerová J (2008) Land use changes in the Veselovianka river catchment in the Horná Orava region. Ekologia (Bratislava) 27(3): 326–337.

Stamp DL (1931) The land utilization survey of Britain. The Geographical Journal 78(1): 40–47. https://doi.org/10.2307/1784994

Šťastná M, Vaishar A (2020) Values of rural landscape: The case study Chlum u Třeboně (Bohemia). Land Use Policy 97: 104699. https://doi.org/10.1016/j.landusepol.2020.104699

Štefunková D (2019) Prepojenie tradičných agrárnych krajín s pamiatkovo hodnotnými sídelnými štruktúrami – príklady a možnosti zachovania biokultúrneho dedičstva. Životné prostredie 53(1): 3–11.

Stone GD (1991) Agricultural Territories in a Dispersed Settlemet System. Current Anthropology 32(3): 343–353. https://doi.org/10.1086/203967

Súľovský M (2017) The climatic and topographic potential of Little Carpathian Region for viticulture: a proposal for regionalization [Klimaticko-topografický potenciál Podmalokarpatska na vinohradníctvo: návrh regionalizácie]. Acta Environmentalica Universitatis Comenianae (Bratislava) 61(1): 45–64.

Tárnik A, Igaz D (2015) Quantification of soil water storage available to plants in the Nitra river basin. Acta Scientiarum Polonorum. Formatio Circumiectus 14(2): 209–214. https://doi.org/10.15576/ASP.FC/2015.14.2.209

Treitz P, Rogan J (2004) Remote sensing for mapping and monitoring land-cover and land-use change-an introduction. Progress in Planning 684(4): 269–279. https://doi.org/10.1016/S0305-9006(03)00064-3

Urban P (2015) História ochrany prírody na Poľane (Stredné Slovensko) – 1. Časť (od najstarších čias do vyhlásenia biosférickej rezervácie). Quaestiones rerum naturalium, č. 2., Fakulta prírodných vied UMB v Banskej Bystrici, 8–89.

Vaishar A, Šťastná M (2019) Sustainable Development of a Peripheral Mountain Region on the State Border: Case Study of Moravské Kopanice Microregion (Moravia). Sustainability: n. pag. https://doi.org/10.3390/su11195540

Van de Velde L, Van Eetvelde V, Antrop M (2010) A multistep method for historical characterisation of rural settlements in Belgium, results for the province of Antwerp. Proceedings of the Latvian academy of sciences, ser. A, 66(3): 93–104.

Vašková K (2015) Vývoj vybraných ekosystémov vo vzťahu k formám využitia krajiny. Dizertačná práca. Fakulta ekológie a environmentalistiky Technickej univerzity vo Zvolene.

Verešík J (1974) Vidiecke sídla. In: Plesník P, et al. (Eds) Slovensko – Ľud 3 (463–521). Bratislava: Obzor.

Wang YH, Li XB, Lu D, Yan JZ (2020) Evaluating the impact of land fragmentation on the cost of agricultural operation in the southwest mountainous areas of China. Land Use Policy 99: 105099. https://doi.org/10.1016/j.landusepol.2020.105099

Woods M (2005) Rural geography: processes, responses and experiences in rural restructuring. London: Sage.

Žigrai F (2000) Význam časopriestoru pri transformácii kultúrnej krajiny (Vybrané teoreticko-metodologické aspekty). In Acta Fac. Rer. Nat. Univ. Math. Belli, Geografické štúdie, 6. Banská Bystrica: FPV UMB, 2000, 51–60.

Žubrietovský L (2016) Vývoj nástroja na automatickú identifikáciu a hodnotenie zmien krajiny v prostredí ArcGIS, Diplomová práca, Prírodovedecká fakulta Univerzity Komenského v Bratislave.