операції та вплив фізико-географічних характеристик місцевості на організацію та проведення миротворчої діяльності військовими підрозділами.

Ключові слова: географічні умови, елементи місцевості, миротворча діяльність, миротворчі підрозділи, оперативно-тактичні властивості, фізико-географічні характеристики.

Bortnyk T. Yu., Olkhovaia J. **The impact of physical and geographical characteristics of the area and its peculiarities on peacekeeping missions**. This article details some of the basic elements to characterize geographical area and describes the nature of tactical peculiarities it offers. This article determines the dependence of peacekeeping missions on natural conditions of the area as well as the impact of physical and geographical characteristics of the area on the organization and support of peacekeepers.

Keywords: geographical conditions, elements of the terrain, peacemaking, peacekeeping troops, tactical and operational characteristics, geographical characteristics.

Бортник С. Ю., Ольховая Ю. И. **Влияние физико-географических характеристик местности и ее свойств на выполнение миротворческих задач.** В статье исследованы основные элементы которыми характеризуется местность, рассмотрено сущность ее тактических свойств. Определена зависимость выполнения миротворческих задач от природных условий зоны проведения миротворческой операции и влияние физико-географических характеристик местности на организацию и проведение миротворческой деятельности военными подразделениями.

Ключевые слова: географические условия, элементы местности, миротворческая деятельность, миротворческие подразделения, оперативно-тактические свойства, физико-географические характеристики.

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FOREST LANDSCAPE STABILITY IN THE HOLY CROSS MOUNTAINS (POLAND) IN THE LAST 200 YEARS

Keywords: forest landscape, landscape stability, forest cover changes, Holy Cross Mountains

Introduction. Forests are substantial elements in the landscapes of mountain areas, enhancing the view and terrain attractiveness. Particular role is played by the forests of high stability in the landscape. Landscape stability according to Richling and Solon (2011) describes its durability in the current state, therefore its resistance to inner and outer changes and ability to return to its initial state. Forest landscape stability can be analyzed using comparative cartography methodology. Starting point to delimit stable forest landscape areas is multi-temporal forest cover analysis, covering a large period of time, often being extended through hundreds of years. Recognition of spatial distribution of these stable areas is also essential in the analysis of durable habitats and ecological corridors (Gerlée 2011).

In recent years we could observe increased interest of European scientists in the analysis of land use/land cover changes, in particular in forest areas, considering big dynamics occurring in the natural environment. This problem in different spatial and temporal horizons has found its reflection in numerous publications describing many regions of Europe including Germany (Wulf et al. 2010), Italy (Di Fazio et al. 2011, Puddu et al. 2012) and Czech Republic (Skalos et al. 2012). In Poland it has been also a subject of many publications (Kozak 2005, Markuszewska 2005; Kozak et al. 2007a,b, 2008, Giętkowski 2009, Kozak 2010, Macias and Dryjer 2010; Szymura et al. 2010; Gielarek et al. 2011; Kunz 2012, Macias and Szymczak 2012).

Intense development of forest cover change analysis is a result of introducing GIS technology. It enables efficient and precise quantitative analyses of those changes in spatial divisions of different character (administrative, physico-geographical, hydrological et al.) and size, using various source materials of forest cover data. In these works archival cartographic materials play important role. They are often the only source of forest cover distribution data in past centuries and because of that they are still used by many authors (i.al. Więcko 1986; Kienast 1993; Petit and Lambin 2002; Kozak 2003). Except for archival cartographic materials, in forest cover change analysis also aerial and satellite imagery (m.in. Kuemmerle et al. 2007; Kozak et al. 2007a; Huang et al. 2008; Potapov et al. 2011; Baumann et al. 2012; Townshend et al. 2012; Griffiths et al. 2014) and dedicated databases, i.e. CORINE Land Cover are used (Heymann et al. 1994; Sifakis et al. 2004; Ciołkosz and Bielecka 2005; Bielecka et al. 2007; Traustason and Snorrason 2008; Pekkarinen et al. 2009; Ciołkosz et al. 2011, Trombik and Hlásny 2013).

Forests in the Holy Cross Mountains have been an object of interest described by many investigators already in the 19th century (Barański 1972). A review of available publications concerning spatial forest cover changes from the last 200 years was presented by Szymański (1979, 1993). This author points out big changes of forest cover in the region, caused by historical, economic, political and environmental factors. Despite many publications, an analysis concerning forest cover changes in the Holly Cross Mountains in addition to the landscape and its spatial and temporal stability has not still been made.

The aim of this work is to designate forest landscape spatial stability in the Holly Cross Mountains in the last 200 years, using multi-temporal analysis of forest cover changes.

Study area. The Holy Cross Mountains are, from the geological point of view, ones of the oldest mountains in Europe. According to Kondracki (2011), they create delineated physico-geographical mesoregion covering the area of 1825 km^2, being a part of the Polish Uplands (Figure 1). This region is characterized by almost parallel course of mountain ranges (Łysogóry, Jeleniów, Masłów, Klonów, Zgórsko, Posłowice, Wygiełzów, Orłowiny) with general directions WNW-ESE, directly referring to lithology and tectonics of the Paleozoic foundation of the region. Between these mountain ranges wide, flat-bottomed valleys are situated which, although traditionally called “valleys”, in fact have tectonic origin (Kielce-Łagów, Wilków, Dębno). Described mountains are relatively small. Ground absolute elevations reaches from 175 to 612 m a.s.l., while local terrain slopes rarely exceed 20°. Geology of the region is very diverse, being a mosaic of different types of rocks and periods of their creation. According to the soil parent material, rocky and skeletal soils are most common in the highest elevations. In lower parts of the area, there are fertile soils formed on loess, clays and fluvial dust, while river valleys feature soils formed on boggy and alluvial deposits.

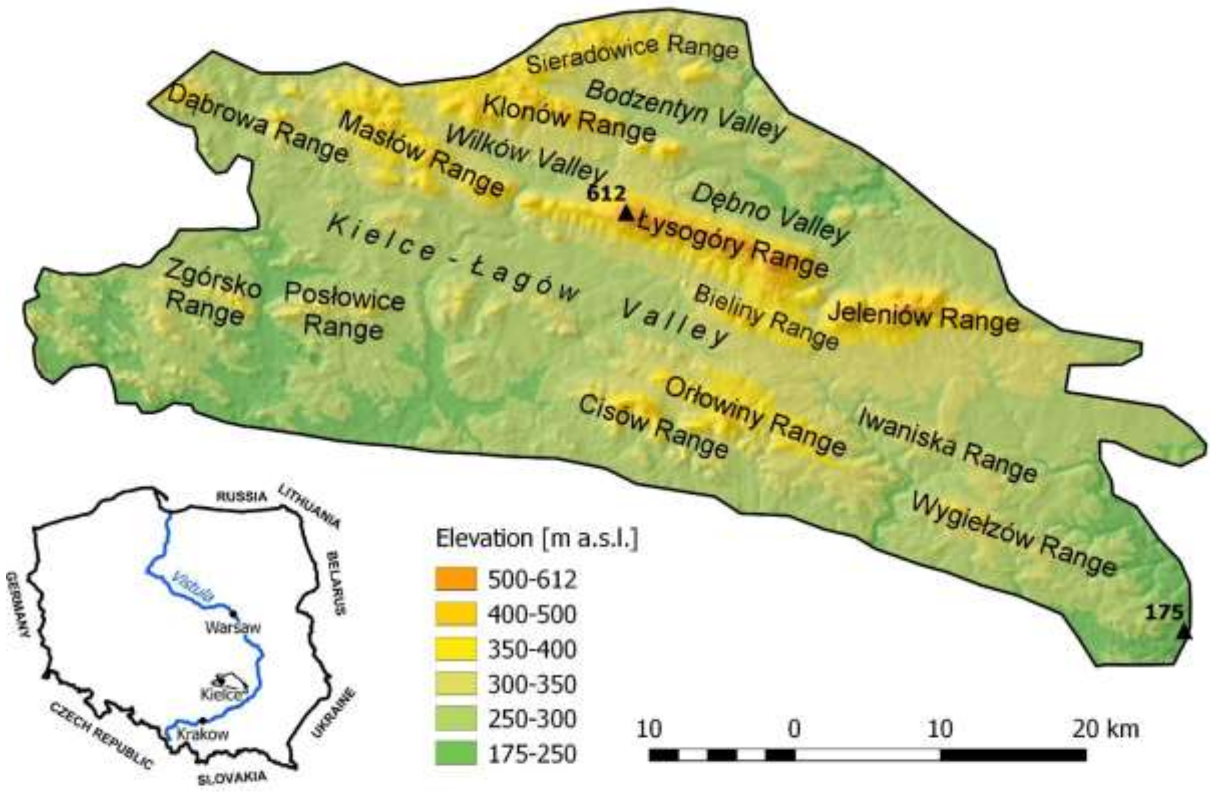

Figure 1 – **Location and hypsometry of the Holy Cross Mountains mesoregion**

Today the upper parts of the Holy Cross Mountains (above 350 m a.s.l. on northern slopes and 450 m on southern slopes) are covered by fir and beech mountain forests. Lower elevations are covered by pine and oak-hornbeam forests and in river valleys there are riparian forests. Continuous forest cover present on high elevations is the remnant of the old Holy Cross Forest (in Polish called Puszcza Świętokrzyska).

Intensive human impact on the Holy Cross forests dates back to the Roman Empire period. Here ancient mining and metallurgy were developing where wood was the only fuel to support technological processes (Bielenin 1992). In the early Middle Ages stable human settlements and agriculture came to the region, causing further deforestation on fertile and most accessible grounds in river valleys and on slopes covered with loess. Forest species composition was greatly influenced by glass production from 16th to 18th century, which consumed very big amount of beech wood. It has changed the natural tree species composition and nowadays we observe bigger contribution of fir over beech trees in existing tree stands (Żabko-Potopowicz 1954).

The analyzed area climatically differs from surroundings. In the topmost parts of mountain ranges, mean annual precipitation total exceeds 820 mm, while mean annual air temperature reaches 5,7°C. Annual precipitation totals are up to 200 mm higher than in surrounding valleys and air temperature is 1,5°C lower.

Materials and methods. The source materials used in the research consisted of high resolution scanned maps, both new and archived: (1) Map of Western Galicia by Col. Mayer von Heldensfeld in the scale of 1:28 000 (16 sheets published in the period 1801-1804), (2) Karte Des Westlichen Russlands in the scale of 1:100 000 (9 sheets published in 1914 and 1915), (3) Tactical Map of Poland published by Poland's Military Geographic Institute in the scale of 1:100 000 (9 sheets published in 1931 and 1934), (4) General Staff Map published by the Polish Army in the scale of 1:50 000 (14 sheets published in the period 1985-1988), Environmental Protection Map in the scale of 1:50 000 (14 sheets from 2011-2012). The analyzed time span in this study is conditioned upon available source materials. According to assumed maps field accuracy forest cover was analyzed in the following years: 1800, 1900, 1930, 1983, 2011 and four time periods between them.

Research task was performed using QGIS and SAGA GIS software, employing comparative cartography methodology – retrogression and elimination, both coming within the reach of cartographic research method (Stevens and Tree 1951; Wilson 2005; Podobnikar 2010). Furthermore, the use of GIS techniques enabled to create forest cover stability map for the whole analyzed time period.

Results. The performed analysis has shown that the forest cover area was the largest at the beginning of the analyzed time period – about the year 1800 and was of 772,5 km^2, which constitutes 42,3 % of the total analyzed area (Table 1, Figure 2).

Until 1900, the forest cover decreased to 510,8 km^2. Deforestation in the period 1800-1900 reached 41,5% of total forest area recorded in the year 1800 and afforestation was minimal – 7,6%. In 1930, forests covered only 499,7 km^2, while the areas of afforestation and deforestation between 1900 and 1930 were almost identical (Table 1). Therefore between 1800 and1930 the forest cover in the Holy Cross Mountains area was reduced by 35,3%.

The main reason of the 19th century deforestation in the Holy Cross Mountains was human activity. Lack of arable land, lack of forest supervision, poor legislation and ongoing industrialization were the main reasons of this process. Furthermore, the forests situated near human settlements were used as a source of fuel. All these reasons caused numerous and sometimes significant changes in the Mountains forest ecosystems, modifying their original character and leading to noticeable devastation of forest stands and decrease of their natural strength and vitality (Szymański 1993).

Since 1930 we could observe noticeable but slow forest recovery. This process is still ongoing, thus until 1983 the analyzed forest cover area increased to 554,7 km^2 (30,4% of the Holy Cross Mountains area), wherein afforestation covered 87,2 km^2 and deforestation 27,7 km^2. Accordingly, in 2011 forests covered 619,2 km^2 (33,9%) in comparison to contemporary Poland's woodiness – 29,3% which is also increasing (Forestry 2013). In the years 1930-2011, the forest cover area enlarged by 119,5 km^2, where afforestation was 163,9 km^2 and deforestation 44,4 km^2. In recent years we notice slow but clear process of tree succession in direct vicinity to larger forest stands. Despite ongoing afforestation, the forest cover in the Holy Cross Mountains has not yet reached its dimension from the beginning of 19th century.

Gathered cartographic materials allowed to perform particularly valuable analysis of forest landscape stability within more than 200 years. To achieve this, a raster with 100 m resolution was created, in which cell values indicate the number of maps with forest cover present in their spatial reach. As a result, there was a map created, with 5 classes of forest cover stability index (*SI*) which corresponds to a number of maps with forest cover present in the areas of one hectare respectively. For example, if in the reach of one particular raster cell, forest was present on one map only, value of the *SI* index will be very low (*SI* = 1), but if forest was present on all maps, the *SI* index value will be very high (*SI* = 5), indicating very high forest cover stability in this area (Figure 3).

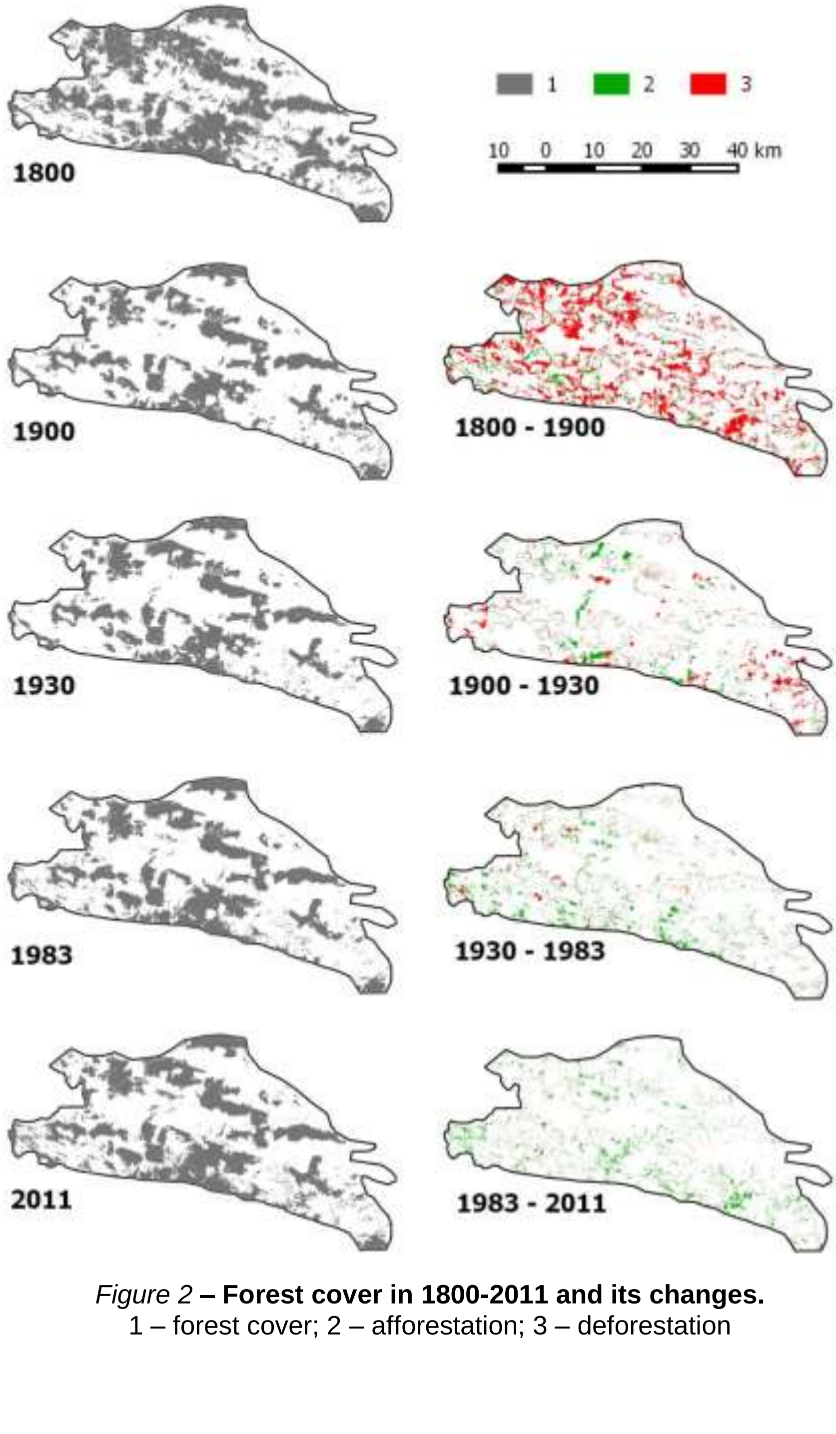

Figure 2 **– Forest cover in 1800-2011 and its changes.**
1 – forest cover; 2 – afforestation; 3 – deforestation

Table 1 – **Aerial forest cover changes in the Holy Cross Mts. between 1800−2011**

Feature		Year				
		1800	1900	1930	1983	2011
Forest cover - %		42,3	28,0	27,4	30,4	33,9
Forest area - km^2		772,5	510,8	499,7	554,7	619,2
		Period				
		1800-1900		1900-1930	1930-1983	1983-2011
change - km^2 (%)	deforestation	320,4 (41,5)		73,2 (14,3)	27,7 (5,5)	16,7 (3,0)
	afforestation	58,7 (7,6)		62,1 (12,2)	82,7 (16,5)	81,2 (14,7)

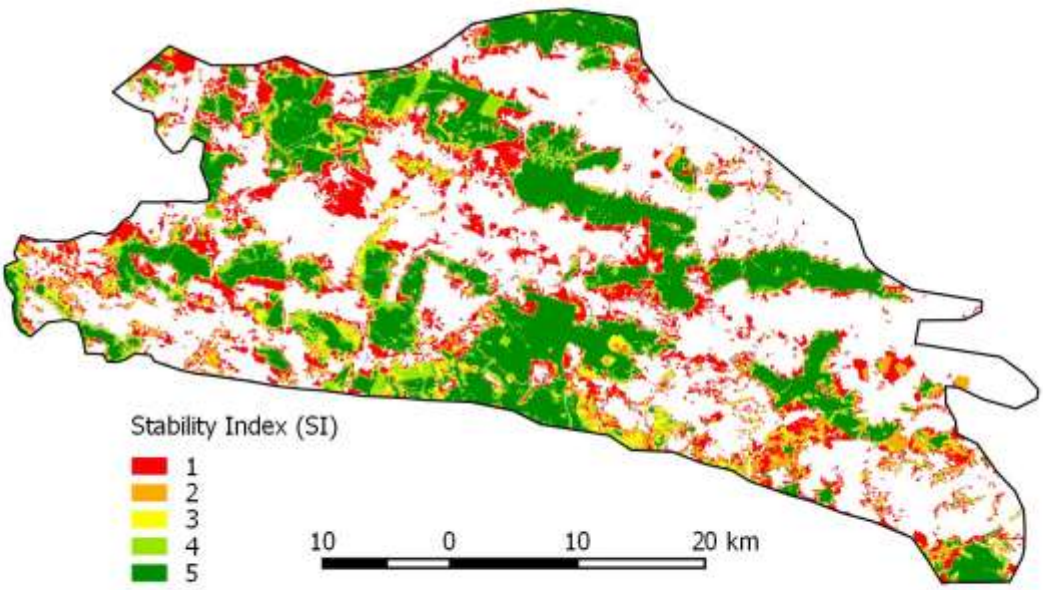

Figure 3 – **Forest landscape stability in the Holy Cross Mountains (on the basis of the cartographic data from 1800, 1900, 1930, 1983 and 2011).**
Stability Index: 1 – very low; 2 – low; 3 – moderate; 4 – high; 5 – very high

The analysis has shown that the most stable forest areas, defined as those that exist continuously since 1800, create a number of dense forest complexes that spatially correspond to the course of mountain ranges in the region. Their total area is of 382,6 km^2, which is 21 % of the total region area and 49% of the area covered by trees in time of the maximum forest cover reach in the analyzed period – at the beginning of the 19th century. Permanently forested are tops and upper parts of slopes of the highest mountain ranges: Łysogórskie, Jeleniowskie, Masłowskie and Klonowskie. Also very high stability (*SI* = 5) is observed in a number of lower but still distinguishing mountain ranges: Orłowińskie, Iwaniskie, Zgórskie, Posłowickie, Sieradowickie.

As the distance from the stable areas increases, forest cover stability lowers. Forests with very low stability (*SI* = 1) were documented on foothills of mountain ranges, in Kielce-Łagów and Wilkowska tectonic valleys and in larger river valleys. Their total area is of 269,5 km^2, which is 14,8% of the total Holy Cross Mountains area. These areas are situated near the villages where the 19th century need of land caused afforestation for agricultural, housing and energy-related purposes, and are still used in agriculture. Numerous land use changes took place, often in direct vicinity of the packed and most stable forest areas. Low stability of these areas is often a result of contemporary afforestation on hitherto agricultural used land, abandoned due to its low profitability. These areas are relatively small and unevenly distributed.

Figure 4 presents an image of forest landscape stability relations in the Holy Cross Mountains in three different categories – areas always covered by forests, periodically covered by forest and never covered by forest. Areas always covered by forest refer to the areas of very high forest cover stability (*SI* = 5).

Significant area of the Holy Cross Mountains (28,9% of its total area) was periodically covered by forest in the analyzed 200-year period. This indicates numerous land use changes which varied spatially. The biggest areas periodically covered by forest are situated on soils formed on clays and loess in lower parts of slopes of the highest mountain ranges, tops of the lower mountain ranges (Wygiełzowskie) and at the bottom of Kielce-Łagów valley. These areas are moderately good for agricultural purposes. Big continuous areas never covered by forest in the analyzed period are Dębno, Wilków and Bodzentyn valleys situated in the northern part of the Holy Cross Mountains. These areas feature the most fertile soils formed on loess and because of that they are invariably used for agricultural purposes from hundreds of years. Other areas where the forest cover has not been documented are situated in the axis of Kielce-Łagów valley and in the southern part of the region – in river valleys near human settlements. The total of the area never covered by forest in the Holy Cross Mountains in the analyzed time period is 50,1% of the regions area.

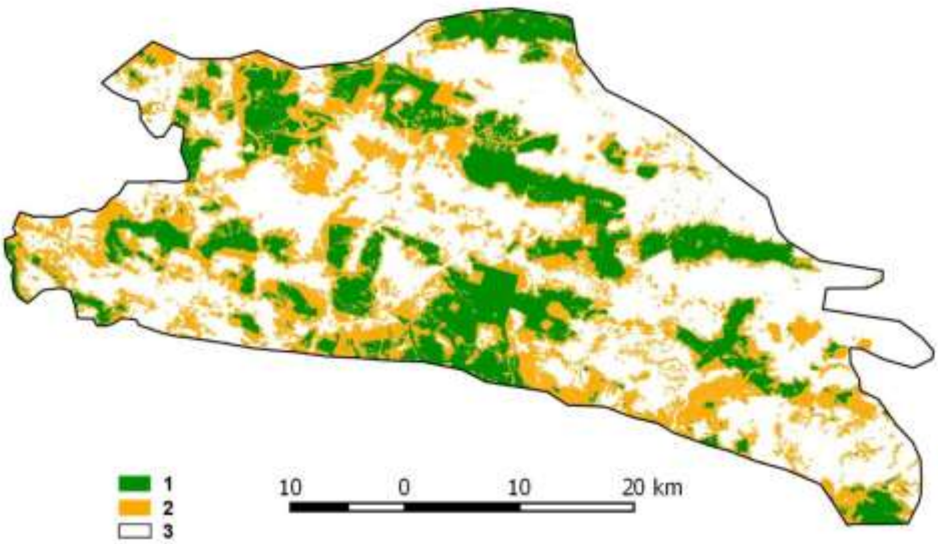

Figure 4 – **Forests in the landscape of Holly Cross Mountains from the beginning of the 19th century.** *Areas:* 1 - always covered by forest; 2 – periodically covered by forest; 3 – never covered by forest

Summary and conclusions. In the analyzed time period, the forest cover always played a major role in the landscape composition of the Holy Cross Mountains. From its largest coverage in 1800 (772,5 km^2, 42,3%), through the minimum in 1930 (499,7 km^2, 27,4%) till today (619,2 km^2, 33,9% in 2011), it endures invariably in a large part of the region. The area of the highest forest landscape stability, where the presence of forest was documented on every analyzed map (SI = 5), covers 21,0% of the Holy Cross Mountains. Half of the area of the region has never been covered by forest (50,1%) and 28,9 % of it was periodically covered by forest (*SI* = 1, 2, 3, 4). Forests in the Holy Cross Mountains are natural landscape dominants, covering mostly mountain ranges and hilltops which are obviously clearly visible from large distances. Stable forests cover areas characterized by low agricultural suitability resulting from existing natural conditions such as orographic and pedological determinants. On the other hand, stable forest areas in the analyzed region rarely cover valley bottoms which are agriculturally used from centuries.

Stable forests with the most valuable ecosystems in the region have been taken under the highest protection of law in the form of the National Park and of landscape parks (Ciupa et al., 2015). Here the oldest fir, beech and oak tree stands have more than 220 years. Over 100 years old trees cover 36% of the total forested area in the Holy Cross National Park.

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Цюпа Т., Суліґовскі Р., Валек Ґж. **Стабільність лісових ландшафтів у Свєнтокшиських горах (Польща) за останні 200 років.** Лісовий покрив є важливою частиною гірського ландшафту у Центральній Європі. Хоча багато гірських хребтів є відносно невеликими і доступними, деякі лісові ділянки існують сторіччями, будучи стабільною частиною ландшафту, тоді як інші категорії землекористування – зазнають змін. У роботі розглянуті питання про стабільність лісових ландшафтів у Свєнтокшиських горах - фізико-географічному мезорегіоні, розташованому в центральній частині Польщі. Проаналізовано часовий інтервал від початку XIX століття до 2011 р. Аналіз ґрунтується на основі порівняльного методу в картографії з використанням ГІС за допомогою чотирьох архівних і сучасної карт, які характеризують лісовий покрив у 1800, 1900, 1930, 1983 і 2011 рр. Представлені зміни в лісовому покриві за кожний проаналізований період з аналізом стабільності лісових ландшафтів. Найбільший лісовий масив був зафіксований у 1800 р. (772,5 км^2). На сьогодні лісові площі охоплюють 21% загальної площі регіону, і 49% площі, покритої деревами у 1800 році, в той час, як ділянки, періодично вкриті лісом протягом 200 років – 28,9%.

Ключові слова: лісовий ландшафт, стабільність ландшафту, зміни лісового покриву, Свєнтокшиські Гори.

Ciupa T., Suligowski R., Wałek G. **Forest landscape stability in the Holy Cross Mountains (Poland) in the last 200 years.** Forest cover is an important part of mountain landscape in central Europe. Even though many mountain ranges are relatively small and sufficiently well accessible, some parts of forests endure through centuries, being a stable part of the landscape while other land use categories change. In the present work we discuss the matter of forest landscape stability in the Holy Cross Mountains - a physico-geograraphical mesoregion situated in central Poland. The analyzed time span reaches from the beginning of the 19th century to the year 2011. The analysis is based on the comparative cartography methodology in GIS using four archival and one new, contemporary map showing forest cover in 1800, 1900, 1930, 1983 and 2011. We present changes in the forest cover in each analyzed time period followed by the forest landscape stability analysis. The largest forest area was recorded in 1800 (772,5 km^2). Today stable forest area covers 21 % of the total area of the region and 49% of the area covered by trees in 1800, while the area periodically covered by the forest within the analyzed 200 years is 28,9%.

Keywords: forest landscape, landscape stability, forest cover changes, Holy Cross Mountains.

Цюпа Т., Суликовский Г., Валек Гж. **Стабильность лесных ландшафтов в Свентокшиских горах (Польша) за последние 200 лет.** Лесной покров является важной частью горного ландшафта в Центральной Европе. Хотя многие горные хребты являются относительно небольшими и доступными, некоторые лесные участки существуют столетиями, будучи стабильной частью ландшафта, тогда как другие категории землепользования – измененчивы. В работе рассмотрены вопросы стабильности лесных ландшафтов в Свентокшиских горах - физико-географическом мезорегионе, расположенном в центральной части Польши. Проанализирован временной интервал от начала XIX века до 2011 г. Анализ основывается на сравнительном метода в картографии с использованием ГИС с помощью четырех архивных и современной карт, характеризующих лесной покров в 1800, 1900, 1930, 1983 и 2011 гг. Представлены изменения в лесном покрове за каждый период с анализом стабильности лесных ландшафтов. Наибольший лесной массив был зафиксирован в 1800 г. (772,5 км^2). На сегодня лесные площади охватывают 21% общей площади региона, и 49% площади, покрытой деревьями в 1800 году, в то время, как участки, периодически покрытые лесом в течение 200 лет, составляют 28,9%.

Ключевые слова: лесной ландшафт, стабильность ландшафта, изменения лесного покрова, Свентокшиские Горы.

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