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Ekológia (Bratislava) Vol. 32, No. 1, p. 95—103, 2013
doi:10.2478/eko-2013-0008

LAND COVER DYNAMICS IN WESTERN BIESZCZADY MTS BETWEEN 19TH AND 20TH CENTURY

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Abstract

Klich D., Gielarek, S., Antosiewicz M.: Land cover dynamics in western Bieszczady Mts between 19th and 20th century. Ekológia (Bratislava), Vol. 32, No. 1, p. 95—103, 2013.

The aim of this paper was to indicate the main directions in cover changes and land use in Western Bieszczady Mts. Two areas differing in altitudes, were taken into analysis: part of Bieszczady Wysokie Mts (for years 1852 and 2004) and Baligród Forest District area (for years 1938 and 1996). Changes in land cover were estimated based on map overlapping, and using indices of changes. Transformations related to almost 40% of Baligród Forest District area and insignificantly less in Bieszczady Wysokie Mts. Within the study areas, regions with considerable stability and also regions with intensive changes on vast areas appeared. The origin of differences in the land use of both study areas emerged not only from natural changes, but also from historical, social and economic changes.

Key words: land use, conversion, afforestation, forest regeneration, Carpathians, Poland.

Introduction

Landscape structure assessment is the essential aspect in landscape change analyses (Li et al., 2001) Landscape constantly evolve in space and through time (Zwoliński, 1998); its structure and composition development is a result of multiple interactions among environmental components (Xiao et al., 1990). All changes, qualitative and quantitative, display themselves as landscape physiognomic-esthetical quality transformations (Kistowski, 2003) and emerge from energy and matter supply disturbance (Horska-Schwarz, 2007).

Vegetation change is, historically, one of the oldest indicators of anthropopression. As a result of human activity, areas artificially devoid of vegetation or areas of substitute vegetation assemblages appeared. Those areas present the most visible forms of anthropopression, and they are defined as land cover or land use (Kistowski, 2003). Land cover is the observed physical cover of given area and indicates (Heymann et al., 1993), whether the area is covered by vegetation, water or human constructions (Di Gregorio, Jansen, 1996; Di Gregorio, 2005). Land use is based upon function, and can be defined as a series of human activities (Di Gregorio, 2005; Lambin et al., 2006), thus land use should be regarded as a dynamic category (Kistowski, 2003). In light of these definitions, land use is a result of land cover exploitation in relation to determined purposes (Jakkola, Mikkola, 1999; Lambin et al., 2006).

Detection of the directions and dynamics of land cover and land use change creates difficulty, due to the complexity of the problem and the lack of proper cartographic materials (Drzewiecki, 2008). The possibility of recognizing a history of vegetation cover transformations depends on the accessibility of cartographic data (Orczewska, 2009). Land use and land cover analysis play the main role in the assessment of changes in anthropogenic landscape. Only a comprehensive analysis of anthropopression cause, processes and results reflects the full view of landscape transformation (Kistowski, 2003). A massive displacement of local people in Beskid Niski Mts and western part of Bieszczady Mts in the 1940s is an example of drastic reduction of anthropopression strength (Augustyn, Kozak, 1997; Augustyn, 2004; Kozak, 2004; Wolski, 2002, 2007, 2009). As a result, agricultural use of land stopped for several years (Kucharzyk, Augustyn, 2010). The areas of this category – changed by humans and then abandoned – tend to change into forested ecosystems (Ciurzycki, 2004a; Wolski, 2009). Such fast changes were observed not only in Bieszczady Mts (Wolski, 2007; Kucharzyk, Augustyn, 2010) or Beskid Niski Mts (Zajdel, 1997; Frączek, Zborowska, 2010), but also throughout the entire Carpathian range (MacDonald et al., 2000; Ciurzycki, 2004b; Kozak et al., 2007; Kuemmerle et al., 2008; Kaim, 2009; Kozak, 2010). Szwagrzyk (2004) suggests that the rate of forest increase in Poland seems to be higher than they supposed, and that secondary succession plays a main role in this process. The aim of this paper was the indication of the main directions in cover changes and land use in Western Bieszczady Mts and the assessment of the rate of change on the basis of available cartographic data.

Study area

Two areas in Western Bieszczady Mts, differing in altitudes, were taken into analysis to assess changes in all altitudinal zones in Bieszczady Mts. The first area, named Bieszczady Wysokie Mts, covered villages: Brzegi Górne, Nasiczne and Caryńskie (6 909 ha) (Wolski, 2007). The area covers a lower forest montane zone (500—1150 m a.s.l.) and characteristic for Bieszczady Mts – a mountain glades zone (>1150 m a.s.l.). The second area is delimited by the external borders of Baligród Forest District with areas of other properties (29 378 ha), covering a submontane zone (<500 m a.s.l.), and a lower forest montane zone (500—1150 m a.s.l.).

Methods

Analysis of Bieszczady Wysokie Mts was based on maps from Wolski (2007): a land use map from 1852 (cadastral map 1:2 880) and a map of land cover in 2004. Analysis of Baligród Forest District was based on tactical maps from 1938 (1:100 000) and a land cover map of Baligród Forest District in 1996 (1:25 000, unpublished data). All maps were digitalized and uniformed in scale. Identical borders of the areas were delimited. A grid cell of the area represented 0.25 ha in Bieszczady Wysokie Mts and 1 ha in Baligród Forest District (Gielarek et al., 2011). Grid cells were assigned to chosen cover types different for both areas. In Bieszczady Wysokie Mts five classes were assigned in the year 1852: forest, settlements, arable land, meadows, orchards and kitchen gardens. After years of transformation a class of orchards and kitchen gardens disappeared and a class of wasteland appeared in the year 2004. In Baligród Forest District five classes, for both maps of analysis, were assigned: forest, settlements, arable land, meadows and pastures.

Changes in land cover were estimated based on map overlapping and using the following indices of changes:

- proportion of each cover type in the area in comparative years (U);
- proportional change of chosen cover type between periods of time (ΔU):

$\Delta U[\%]=S\%_2-S\%_1$, where

$S\%_1$ – initial area of chosen cover type, showed as a proportion of the cover type area to the whole study area,
$S\%_2$ – final area of chosen cover type, showed as a proportion of the cover type area to the whole study area;

— area if changes in relation to initial area of each cover type (KZ) (Dec et al., 2009):

$$KZ[\%]=\frac{S_2-S_1}{S_1}\times 100 \text{ , where}$$

S_1 – initial area of chosen cover type,
S_2 – final area of chosen cover type;

— mean annual change rate of chosen cover type (δ_n) (Velázques et al., 2002), according to FAO formula:

$$\delta_n=\left(\frac{S_2}{S_1}\right)^{\frac{1}{n}}-1 \text{ , where}$$

S_1 – initial area of chosen cover type,
S_2 – final area of chosen cover type,
n – time period of changes (number of years).

Results

Cover type changes in Bieszczady Wysokie Mts

All changes covered almost 34% of the area. The most visible changes appeared in forest cover, which increased over 23%, mostly as a result of meadows and arable land conversion (Table 1). At the expense of these cover types, settlements are increased (from 0.04% in 1852 to

T a b l e 1. Cover type changes in Bieszczady Wysokie Mts during the period 1852–2004 (the table presents conversions in all cover types; the last column contains total area of each class in 1852, and the last line contains total area of each class in 2004).

	Land use/cover classes	Year 1852 [ha, (%)]					
		Forest	Settlements	Arable land	Meadows	Wastelands	**Total**
Year 2004 [ha, (%)]	Forest	3 324.00 (54.494)	0.00 (0.00)	0.00 (0.00)	32.75 (0.537)	1.25 (0.020)	**3 358.00 (55.051)**
	Settlements	0.75 (0.012)	0.00 (0.00)	0.00 (0.00)	1.50 (0.025)	0.00 (0.00)	**2.25 (0.037)**
	Arable land	545.75 (8.947)	2.00 (0.033)	19.75 (0.324)	543.00 (8.902)	0.75 (0.012)	**1 111.25 (18.218)**
	Meadows	919.50 (15.074)	3.75 (0.062)	20.00 (0.328)	682.75 (11.193)	1.50 (0.025)	**1 627.50 (26.682)**
	Orchards and kitchen gardens	0.50 (0.008)	0.00 (0.00)	0.00 (0.00)	0.25 (0.004)	0.00 (0.00)	**0.75 (0.012)**
	Total	**4 790.50 (78.535)**	**5.75 (0.095)**	**39.75 (0.652)**	**1 260.25 (20.661)**	**3.50 (0.057)**	**6 909.00 (100.00)**

T a b l e 2. Indices of cover type changes in Bieszczady Wysokie Mts during the period 1852–2004.

Land use/cover classes	Metrics				
	U (%) 1852	U (%) 2004	ΔU (%)	KZ (%)	δ_n (%)
Forest	55.05	78.54	23.48	42.66	0.23
Settlements	0.04	0.09	0.06	155.56	0.62
Arable land	18.22	0.65	-17.57	-96.42	-2.17
Meadows	26.68	20.66	-6.02	-22.57	-0.17
Orchards and kitchen gardens	0.01	–	–	–	–
Wastelands	–	0.06	–	–	–

Notes: U - proportion of each cover type, ΔU – proportional change of chosen cover type, KZ - area if changes in relation to initial area, δ_n – mean annual change rate

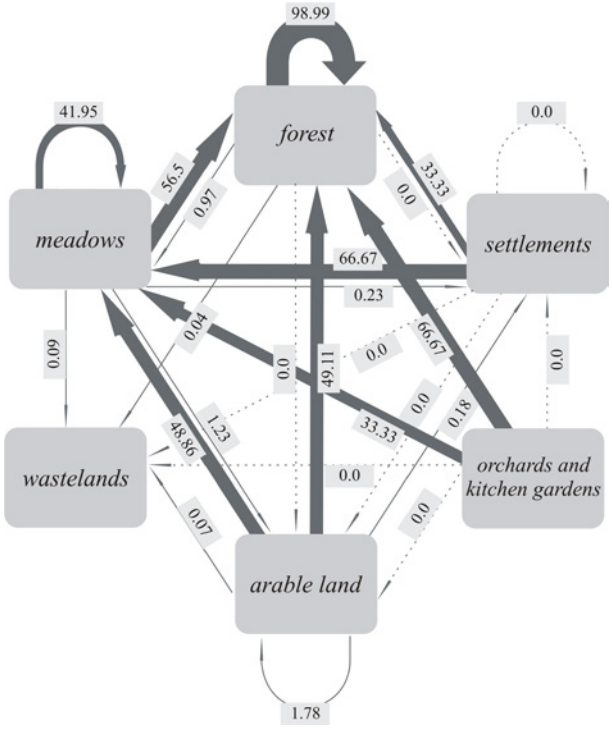

Fig. 1. The scheme of class change directions (in %) in Bieszczady Wysokie Mts between 1852 and 2004 (the thick arrows present the main directions of changes and the dashed arrows present the lack of changes).

0.09% in 2004). The area of meadows in both years exceeded 20% of the landscape area. As a result of patch conversion to wastelands and arable land, meadow class area decreased slightly. Arable land area drastically decreased during this period of time (from 18% to 0.5%) (Tables 1, 2). Orchards and kitchen gardens, that occupied an area of 0.75 ha disappeared totally. As a result of some parts of forest, meadow and arable land conversion, wastelands appeared.

Analysis within particular cover types presents similar results. Changes mostly proceeded in the direction of a conversion into forest class at the expense of meadows (56.5%), arable land (49%) or orchards and kitchen gardens (67%). Other changes mainly lead to a conversion into meadows (67% of settlements and almost 49% of arable land) (Fig. 1).

Settlements presented the highest increase, and reached an increase of one and a half times their original area. Forest class area increased about 42%, but the dynamics of changes were low. The highest rate of decrease appeared in arable land (δ_n = -2.17%) (Table 2).

Cover type changes in Baligród Forest District

All changes covered almost 38% of the area (Tables 3, 4). Forest presents a dominating class in the study area, and its area increased (from 48 to 75%) during the analyzed period of time mainly at the expense of meadows and arable land. Arable land area decreased from 46% in 1938 to 23.5% in 1996 to the benefit of settlements cover type, which also decreased similarly to other cover types (Tables 3, 4). Changes in class in the landscape frame differ from each class scale change. Forest represents the most expansive cover type, covering former pastures (on 86% of the area), meadows (on 81%) and arable land (on about 60%). Moreover, forest presents the most stable class as it mostly remained on areas it occupied initially. Only pastures converted on whole area during the analyzed time period (Fig. 2).
Generally, changes in landscape were dominated by high increase of forest and decrease of arable land (ΔU); other changes constituted a marginal proportion in landscape conversion (Table 4). Particular cover types underwent high changes. The pastures area changed the most out of all the classes, about 80% of its area underwent conversions. Change rates were positive only for forest. This class area increased by 0.77% annually. The highest change rate appeared in pastures (δ_n = 3.6%).

T a b l e 3. Cover type changes in Baligród Forest District during the period 1938–1996 (the table presents conversions in all cover types; the last column contains the total area of each class in 1938, and the last line contains the total area of each class in 1996).

Land use/cover classes		Year 1938 [ha, (%)]					
		Forest	Settlements	Arable land	Meadows	Pastures	**Total**
Year 1996 [ha, (%)]	Forest	12 915.00 (43.961)	7.00 (0.024)	1 158.00 (3.942)	45.00 (0.153)	1.00 (0.003)	**14 126.00 (48.083)**
	Settlements	262.00 (0.892)	69.00 (0.235)	471.00 (1.603)	8.00 (0.027)	1.00 (0.003)	**811.00 (2.760)**
	Arable land	8 057.00 (27.425)	140.00 (0.477)	5 111.00 (17.397)	70.00 (0.238)	24.00 (0.082)	**13 402.00 (45.619)**
	Meadows	650.00 (2.213)	3.00 (0.010)	138.00 (0.470)	11.00 (0.037)	2.00 (0.007)	**804.00 (2.737)**
	Pastures	202.00 (0.688)	0.00 (0.00)	31.00 (0.106)	2.00 (0.007)	0.00 (0.00)	**235.00 (0.801)**
	Total	**22 086.00 (75.179)**	**219.00 (0.746)**	**6 909.00 (23.518)**	**136.00 (0.462)**	**28.00 (0.095)**	**29 378.00 (100.00)**

T a b l e 4. Indices of cover type changes in Baligród Forest District during the period 1938–1996.

Land use/cover classes	Metrics				
	U (%) 1938	U (%) 1996	ΔU (%)	KZ (%)	δ_n (%)
Forest	48.08	75.18	27.10	56.35	0.77
Settlements	2.76	0.75	-2.02	-73.00	-2.23
Arable land	45.62	23.52	-22.10	-48.45	-1.14
Meadows	2.74	0.46	-2.27	-83.08	-3.02
Pastures	0.80	0.10	-0.70	-88.09	-3.60

Notes: U - proportion of each cover type, ΔU – proportional change of chosen cover type, KZ - area if changes in relation to initial area, δn – mean annual change rate.

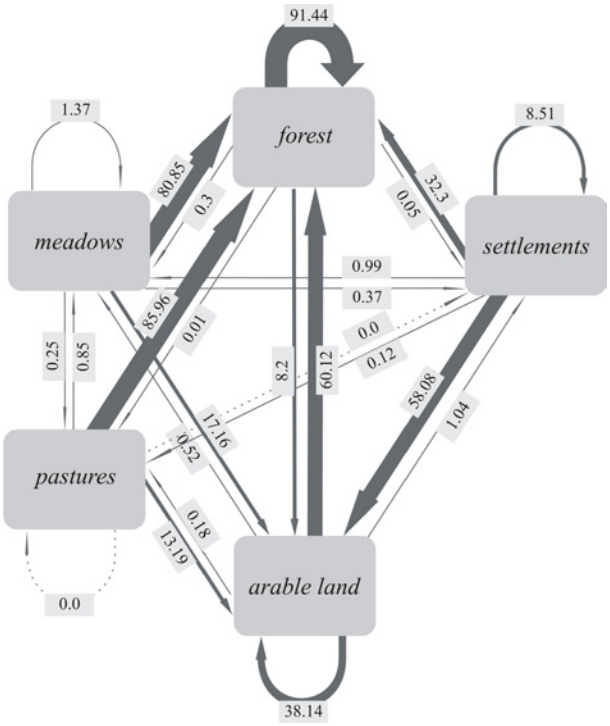

Fig. 2. The scheme of class change directions (in %) in Baligród Forest District between 1938 and 1996 (the thick arrows present the main directions of change and the dashed arrows present the lack of changes).

Discussion

Settlement disappearance, connected to massive depopulation (in the 1940s of the 20th century), was the main force that drove landscape changes (Augustyn, Kozak, 1997; Wolski, 2001; Augustyn, 2004; Szwagrzyk, 2004). Quantitative and qualitative changes in land cover, as a reaction of anthropopression reduction, were similar to change directions in Western Biesz-

czady Mts observed earlier (Denisiuk, Korzeniak, 1999): arable land → meadows → shrubs → forest (Wolski, 2009). However, succession processes did not proceed at a similar rate in all areas.

Within Baligród Forest District over 90% of settlement area underwent changes, mainly into arable land and forest (Fig. 2). Although, settlements covered only 2% of the whole area, its influence on other classes was high and conditioned agrocoenoses existence, i.e., 50% of the whole area in 1938 (arable land, meadows, pastures; Table 3). A high rate of settlement disappearance (2.23% per year) influenced on cover structure by causing a high rate of meadow and pasture disappearance (over 3% per year) and moderate arable land disappearance (about 1% per year). Depopulated areas were taken over by State Agricultural Farm with the rearing of cattle and sheep as a main activity (Musiał, 2007). The arrival of biogenic substances as a consequence of pasturage involved changes in species composition on meadows (pasture area increased 4 times during 20 years) (Wolski, 2001). State activity stopped in the 1990s, and desagrarisation processes appeared (Musiał, 2007; Wolski, 2007). In an ecological sense the changes meant forest area increase, in consequence of shrubs and trees succession on abandoned rural areas (Musiał, 2007).

In Bieszczady Wysokie Mts, that represent the lower forest montane zone and mountain glades zone, settlements occupied less area than in Baligród Forest District (Tables 1, 3). The area of Bieszczady Wysokie Mts occupies a higher elevation; it was sparsely populated, and pasturage was the main human activity. In consequence, meadows, apart from forest, were the main cover type (mainly on the area of today's mountain glades zone). Pastoralism continued until the 1940s of the 20th century, and from this time processes of new assemblages creation proceed. Lower parts of the mountain glades zone, where pastures were abandoned earlier (at the turn of the 19th and 20th century) are occupied by shrublands now (Wolski, 2007). Enclaves on higher elevations changed into wastelands, and gradually were overgrown by lightweight seed trees and shrubs (juniper, hazel and willow) as a final stage of forest area increase. According to Wolski (2007), trees and shrubs secondary succession continues on clearings nowadays.

Arable land situated on lower parts of the study area showed the highest rate of changes in the landscape (2.17% per year; Table 2), and had almost disappeared by 2004 (Table 1). Other classes changed at a much slower rate, not faster than 1% per year. Changes within this study area are characterized by sinking class (settlements, orchards and kitchen gardens, arable land) transformations not only into forest, but also into meadows (Fig. 1). Thanks to this direction of changes, forest succession on over half of the meadow area was compensated in expanse to other cover types, and total meadow area did not change significantly (Table 1).

Conclusion

The results of landscape structure change analysis within the chosen period of time indicate significant dynamics of land use transformation in Western Bieszczady Mts, especially over a longer time perspective. Changes related to almost 40% of Baligród Forest District area and insignificantly less in Bieszczady Wysokie Mts. Within the study areas, regions with considerable stability and also regions with intensive changes on vast areas appeared. Generally,

changes led to an increase in forested area and a decrease in arable land area in the landscape. Transformation directions resulted from post-war social and economic processes related to the politics of abandoned land management. The migration of local people caused reforestation processes on former arable land. The origin of differences in Baligród Forest District area and Bieszczady Wysokie Mts area land use emerged not only from natural changes, but also from historical, social and economic changes during this period of time.

Translated by D. Klich
English corrected by T. Lee

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