ISSN 2078-6441. Вісник Львівського університету. Серія географічна. 2014. Випуск 48. С. 87–94
Visnyk of the Lviv University. Series Geography. 2014. Issue 48. P. 87–94

UDK 911.52 (477.75)

CONTEMPORARY LANDSCAPE PATTERN OF THE SOUTH-WESTERN CRIMEA AND ITS ANTROPOGENIC TRANSFORMATION FOR THE LAST 40 YEARS

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An article introduces results of perennial field landscape survey at the territory of Crimea geologic polygon. The role of traditional landscape approach is demonstrated as an efficient method of environmental studies. Changes in contemporary landscape patterns from 1974 to 2013 for the four different landscape regions are considered and discussed.

Key words: landscape approach, contemporary landscapes, land cover/land use conversions.

Introduction. Landscape science provides an efficient and holistic approach to the revealing and spatial analysis of present-day environmental issues both at a regional and at a local scale. Local environmental studies based on well-developed methods of landscape mapping and analysis can more effectively reflect all the natural, economic and historic features of the region in the form of integral and hierarchic models with explicit spatial location [3, 8]. The aim of the current study concludes in investigation of local environmental issues of the south-western part of Crimea peninsula and the environmental history of this territory from the 1970-s by means of traditional landscape approach.

Study area. Area in study is Crimea geologic polygon located at the south-west of Crimea highlands in Bakhchisaray region in the vicinity of Prokhladnoe settlement. From the 1950-s Crimea polygon has been well-known and popular place for field scientific and educational investigations of geologists from many universities of Ukraine and Russia. Though there is excellent provision of the territory with base small scale topographic maps and detailed remote sensing data local landscape and environmental studies were insufficient here. Authors of this paper conduct field landscape studies at the territory of Crimea polygon for the last 10 years as supervisors of long-lasting field course for the students of Moscow State University specializing in environmental science [2].

In spite of the rather small area (about 70 sq. km) the territory of Crimea geologic polygon clearly represent natural landscape and physiographic diversity of the south-western Crimea, f.e. cuestas of Inner ridge of Crimea mountains, folded highlands of Main Crimea ridge and intercuestas depressions [2]. High contemporary landscape diversity is resulted from long-lasting and complicate history if its anthropogenic transformation: the major part of the polygon is covered with secondary broad-leaved (mainly oak) forests and pine plantings, plantations of essential oil cultures were replaced with uneven-aged fallows and abandoned lands; among technogenic landscapes one can meet open-cut mines and dumps.

Methods. Main method used in our study is field small-scale landscape survey. Conventionally such survey consists of three steps: preparatory pre-field, field and terminal. Our innovative approach at the preparatory step is based on structural paradigm of landscape science [8]. According to this approach preliminary map of terrain faces and edges is prepared at the pre-field step. Terrain faces are patches with uniform slope and are bordered with edges (i. e. lines or curves with gentle or steep slope gradient). All the points of a single terrain face have equal orientation in space to solar radiation, gravity field and other fluxes of substance and energy [8]. For the territory of Crimea polygon we separate several types of terrain faces: vertex faces (downward and convex), slope faces (according to different slope degree) and bottom faces (floodplains and terraces of river valleys; bottoms of broad erosion forms, big and small ravines).

At the field step of landscape survey the preparatory map of terrain faces is filled with landscape content i. e. field survey and depiction of landscape components. This process is complemented with the field visual interpretation of detailed remote sensing data and expert assessment of current environmental state for different lands.

At the terminal step of landscape survey obtained field data about landscape components compile in common database for terrain faces. Such simple approach demonstrates the leading role of terrain in landscape differentiation of the study area and allows to extrapolate data to the polygons with lack of field survey. As a result of depiction and comprehension of spatial regularities of landscape component one can reveal local landscape complexes (called "urotschistsche" in conception of the Moscow school of landscape science [5, c. 218]). Different spatial patterns of these local complexes determine individual structure of landscape region ("mestnost" in conception of the Moscow school of landscape science [5, c. 128]). For the territory of Crimea polygon four different landscape regions are separated: classical cuesta; weakly armored cuesta, hilly depression, steep-sloped highlands.

Analysis of contemporary landscape pattern and history of its anthropogenic transformation has conducted by means of high resolution remote sensing data: aerial photos of 1974 and space images from satellite Ikonos (2013). Visual interpretation of remote sensing data allows to create map of land cover and land use types and their changes between two time periods. Different land cover and land use types associating with the terrain facets can fracture or on the contrary unify the primary natural structure of local landscapes and create new patterns of contemporary landscapes [4, 7]. This mapping approach reflects spatial peculiarities of anthropogenic transformation within natural landscape regions and determines contributions of natural and human factors to the contemporary landscape pattern of the Crimea polygon.

Comparative analysis of remote sensing data has resulted in separation for the territory of Crimea polygon of 28 land cover/land use types grouped in 8 categories: industrial lands, built-up areas, agricultural lands (croplands, essential oil plantations, orchards), grasslands, forests and artificial forest stands, invaluable lands and barren grounds. These categories can be easily coincided with technogenic, anthropogenic, secondary and quasi-primary contemporary landscapes [4]. From 1974 to 2013 large scale areas of 11 land cover/land use conversion types were revealed and mapped for the Crimea polygon (figure 1).

Original maps were converted to GIS layers for the spatial analysis of several landscape metrics and degree of anthropogenic transformation among different landscape regions for the two time period. All the computations are conducted by means of GIS software ArcGIS Desktop and its extension for spatial pattern analysis Patch Analyst [10].

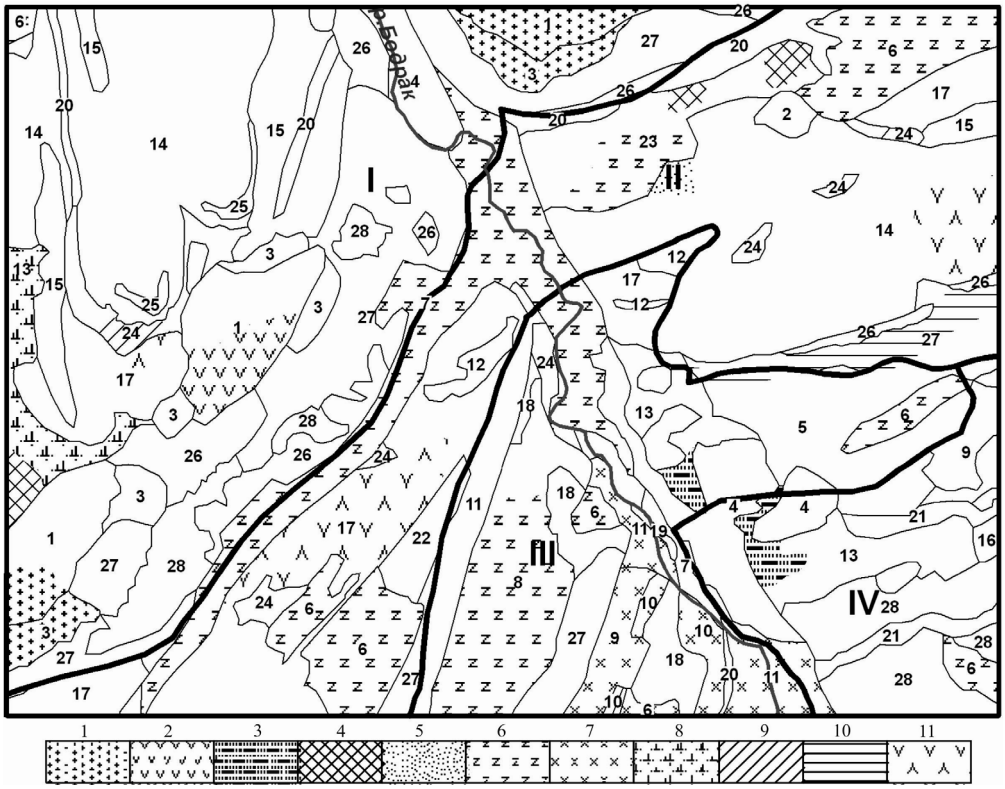

Figure 1. Contemporary landscape pattern of area in study and its changes from 1974 to 2013. Original scale 1: 25 000. Bold lines and roman figures indicate the landscape regions: I – classical cuesta; II – weakly armored cuesta; III – hilly depression; IV – steep-sloped highlands. Simple lines and arabic figures indicates different land cover and land use types: 1 – open-cut limestone mines; 2 – open sand mines; 3 – dumps; 4 – residential built-up areas; 5 – agricultural built-up areas; croplands at the gentle slopes; 7 – croplands at the bottom of broad erosion forms and the terrace of Bodrak river valley; 8 – rose plantations at the gentle slopes; 9 – orchards at the gentle slopes; 10 – orchards at the artificially terraced steep slopes; 11 – orchards at the bottom of broad erosion forms and the terrace of Bodrak river valley; natural grasslands at the bottom of erosion forms; 13 – post-forest meadows with shrubs; 14 – open broad-leaved woodlands with Quercus spp., Carpinus orientalis and Cornus mas at the gentle slopes; 15 – closed forests with Quercus spp. and Carpinus orientalis at the steep slopes; 16 – closed forests with Quercus spp. and Cornus mas at the steep slopes; 17 – open oak forests with Cotynus coggigria at the steep slopes; 18 – ash-oak forests at the slopes of middle steepness; 19 – willow woodland at the floodplain of Bodrak river valley; 20 – oak forests at the bottom of small ravines; 21 – elm forests at the bottom of big ravines; 22 – pine plantings at the gentle slopes; 23 – weed barren grounds with shrubs; 24 – young clear-cuts; 25 – face of cuestas; 26 – steep slopes and cliffs lack of vegetation; 27 – steep slopes and cliffs with single shrubs; 28 – steep slopes and cliffs with rare groups of Carpinus orientalis. Hatched areas are land cover/land use changes from 1974 to 2013: 1– natural overgrowth of open-cut mines; 2 – recultivation of open-cut mines (afforestation with Pinus pallasiana); 3 – sprawl of residential built-up areas; 4– appearance of mine dumps; 5 – new croplands from grasslands; 6 –fallows and grasslands from cropland and plantations; 7 – orchards degradation; 8 – shrublands from grasslands; 9 – afforestation of gentle slopes with Pinus pallasiana; 10 – terracing and afforestation of steep slopes with Pinus pallasiana; 11 – changes from broad-leaved to mixed forests

Results and discussion. Landscape region of classical cuesta occupies about 40% of study area. It represents massive of the Inner ridge of Crimea mountains divided by the Bodrak river valley. Gentle and long north-western slopes of cuesta dissected with vast erosion forms. Narrow barren faces of cuesta descent to vertical cliffs. Organogenic limestone abdicating the cuesta represent valuable construction material that's why this landscape region is notable for open-cut mines and dumps. From 1974 several mines were abandoned or recultivated. This region is also characterized with rather high diversity of land cover/land use types both in 1974 and 2013.

In the absence of any faces or cliffs weakly armored cuesta is characterized with downward vertexes and steep southern slopes with large debris streams. The network of broad erosion forms are developed within this landscape region. Land use structure has more irregular and fragmented pattern comparing to the structure of natural landscapes (f.e. landscape fractionality in natural state is 10,6 patches per sq.km against 13,6 and 14,9 in contemporary landscape pattern of 1974 and Shannon;s diversity index is only 1,67 versus 2,03 respectively). This landscape region leads in number of different land cover/land use types.

Natural landscape features of hilly depression region (predominance of gentle slopes and broad bottoms of erosion forms) are the most favorable for agricultural activities. The region possesses the greatest share of croplands, orchards and grasslands as residential built-up areas and the most insignificant areas of forests and barren grounds.

Region of steep-sloped highlands has rather homogenous natural landscape pattern with low diversity but high degree of natural landscape fractionality. Among local landscapes densely forested steep slopes dissected with small ravines are abundant. This region is characterized with the great share of barren grounds because of easily denuded flysch deposits. The presence of rather large areas under residential built-up areas and associated grasslands can be explained by the Crimea tatars traditional adaptations to living and farming in dissected relief [1].

Revealed changes in land cover/land use types from 1974 to 2013 in the first place reflects full breakdown of conventional agricultural system of Crimea highlands with its accent on essential oil plants and fruits production (table 1). This system were historically highly adaptive to the natural landscape structure of the south-western Crimea and environmentally friendly [6]. Lands which are in 1970-s widely and effectively used as croplands and essential oil plantations are now abandoned and transformed in fallows of different age and type. Near settlements these lands are often undergone with pastoral digression. Abandoned fruit orchards are degraded and gradually substituted with shrublands and grasslands.

Significant tendency in land cover/land use changes is connected with artificial afforestation of barren grounds at the steep slopes. Large scale planting of Pinus pallasiana was intrinsic feature of land use conversion in 1970-s and 1980-s throughout the south-western Crimea highlands. Environmental advantages of such activities can be argued because of poor regeneration and unfavorable present-day condition of pine stands and their negative influence on local biodiversity [1].

According to table 1 and figure 2 the largest areas of land cover/land use conversions from 1974 to 2013 are marked for the landscape region of weakly armored cuesta and hilly depression. The coincident changes in contemporary landscape pattern for these two regions are characterized with the expansion of secondary landscape at the expense of anthropogenic ones. As indicated above it reflects the tendency of abandonment croplands, plantations and orchards. Landscape region of classical cuesta is also characterized with the growth of secondary landscapes but at the expense of technogenic ones (figure 2). This region was also undergone with the most diverse set of land use conversion types (table).

Table 1

Land cover/land use conversions from 1974 to 2013 by landscape regions

Land use/land cover change, %	Landscape regions			
	I. Classical cuesta	II. Weakly armored cuesta	III. Hilly depression	IV .Steep-sloped highlands
1. Natural overgrowth of open-cut mines	6,3	–	–	–
2. Recultivation of open-cut mines	2,4	–	–	–
3. Sprawl of residential built-up areas	–	–	1,1	3,9
4. Appearance of mine dumps	0,7	1,1	–	–
5. New croplands from grasslands	–	0,6	–	–
6. Fallows and grasslands from croplands and plantations	4,0	25,6	24,3	3,4
7. Orchards degradation	–	0,1	14,0	3,5
8. Shrublands from grasslands	3,3	–	–	–
9. Afforestation of gentle slopes with Pinus pallasiana	0,6	–	–	–
10. Terracing and afforestation of steep slopes	–	2,9	0,9	–
11.Changes from broad-leaved to mixed forests	0,4	10,3	–	–
Total	***17,7***	***40,6***	***40,3***	***10,7***

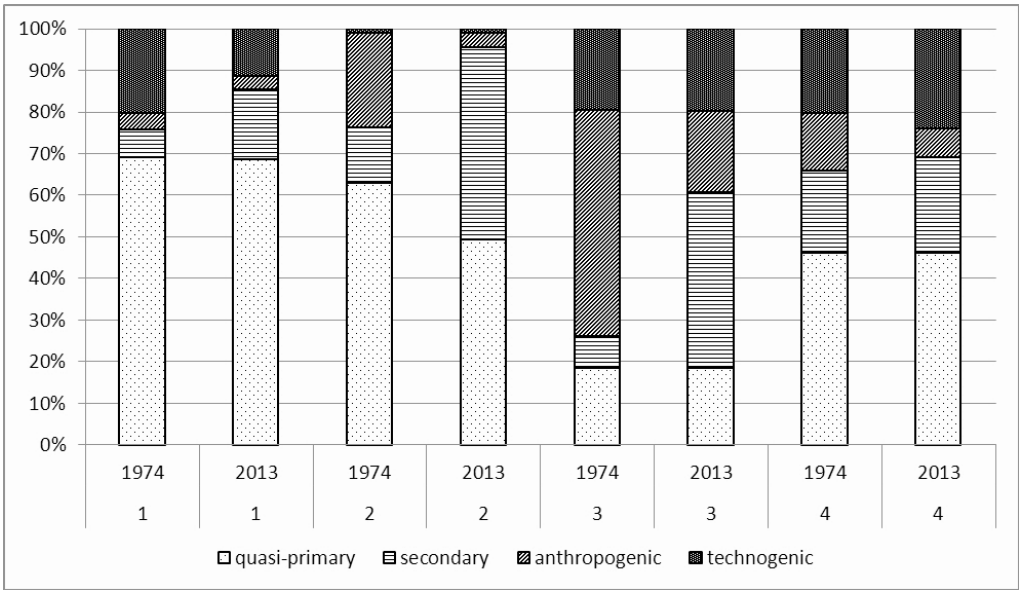

Figure 2. Distribution among the categories of contemporary landscapes in 1974 and 2013 for different landscape regions: *1* – classical cuesta; *2* – weakly armored cuesta; *3* – hilly depression; *4* – steep-sloped highlands.

Slight redistribution among different categories of contemporary landscapes along with stable share of quasi-primary landscapes are peculiar for the changes in anthropogenic transformation of steep-sloped highland region.

Changes in spatial pattern metrics of contemporary landscapes from 1974 to 2013 presented in table 2 reveal the common decline of landscape fractionality and edge density for the all landscape regions. These indexes can be correlated with the degree of landscape fragmentation which are lowered coincidently the declining levels of anthropogenic loads on landscapes [9]. The decline in mean shape index represent that contemporary landscape patterns of the all landscape regions besides classical cuesta become more irregular in 2013 than in 1974 [9]. Only for the region of classical cuesta contemporary landscape diversity has grown up in 2013 according Shannon's diversity index.

Table 2

Changes in spatial pattern metrics by landscape regions from 1974 to 2013

Landscape region	Landscape fractionality (number of patches per sq.km)		Patch size coefficient of variance		Mean shape index		Edge density		Shannon's diversity index	
	1974	***2013***	***1974***	***2013***	***1974***	***2013***	***1974***	***2013***	***1974***	***2013***
I.Classical cuesta	13,6	12,3	140,9	134,5	1,79	1,9	79,8	77,0	2,32	2,36
II.Weakly armored cuesta	14,9	11,6	189,7	188,9	2,07	1,8	62,8	53,5	2,03	2,03
III.Hilly depression	19,4	17,9	120,0	129,5	1,74	1,7	49,3	47,5	2,42	2,42
IV.Steep-sloped highlands	25,1	24,0	104,8	111,7	1,54	1,5	22,8	22,0	2,02	2,02

Conclusions. Heterogeneous character of contemporary landscape dynamics among different landscape regions of the Crimea polygons is determined with their uneven degree of anthropogenic transformation in 1970-s and different levels of natural landscape diversity. Revealed tendency of decline in share of anthropogenic and technogenic complexes at the expense of secondary landscapes expansion testifies reduction in current anthropogenic loads on the territory on the one hand. But on the other hand positive environmental impact of these changes is rather ambiguous.

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Стаття надійшла до редакції 05.03.2014 р.
Доопрацьована 15.04.2014 р.
Прийнята до друку 26.06.2014 р.

СУЧАСНА ЛАНДШАФТНА КАРТИНА ПІВДЕННО-ЗАХІДНОГО КРИМУ І ЙОГО АНТРОПОГЕННОЇ ТРАНСФОРМАЦІЇ ПРОТЯГОМ ОСТАННІХ 40 РОКІВ

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Описані результати багаторічних польових досліджень ландшафтного геологічного полігону на території Криму. Роль традиційного ландшафтного підходу репрезентовано як ефективний метод екологічних досліджень. Розглянуто й обговорено зміни в сучасних моделях ландшафтів з 1974 по 2013 роки для чотирьох різних ландшафтних регіонів.

Ключові слова: ландшафтний підхід, сучасні ландшафти, наземний покрив/земля перетворення**.**

СОВРЕМЕННАЯ ЛАНДШАФТНАЯ КАРТИНА ЮГО-ЗАПАДНОГО КРЫМА И ЕГО АНТРОПОГЕННОЙ ТРАНСФОРМАЦИИ В ТЕЧЕНИЕ ПОСЛЕДНИХ 40 ЛЕТ

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В статье описаны результаты многолетних полевых исследований ландшафтного геологического полигона на территории Крыма. Роль традиционного ландшафтного подхода демонстрируется в качестве эффективного метода экологических исследований. Рассматриваются и обсуждаются изменения в современных моделях ландшафтов с 1974 по 2013 года для четырех различных ландшафтных регионов.

Ключевые слова: ландшафтный подход, современные ландшафты, наземный покров/земля, преобразования.