



Changes of Landscape Spatial Structure as a Result of Transformation of Land-Ownership

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Abstract. The aim of the research is to analyse the landscape structure changes from the end of the Soviet times in 1974–1986 until 2005 when market economy existed in Lithuania. The changes of landscape structure were observed in 100 sample areas (squares) each of them having 2.5 km² area and distributed in different landscape types. The changes in sample areas (squares) with determination of land cover structure transformations were observed using topographic photos and ortophoto images at a scale 1:10 000. More distinct manifestation of landscape re-naturalisation through land abandonment and conversion to forests, swamps and shrubs, also through transformation of arable land to meadows and pastures was the main direction of land cover changes. The opposite but lower scale conversion of forests, shrubs and other land use types to agrarian fields was also noticed. Acceleration of the conversion of landscape structure towards technogenisation through quick expansion of construction, recreational use and development of infrastructure was another important landscape structure conversion going on in the opposite direction of technogenisation. It manifested mainly as the change of agrarian fields, suburban gardens to built-up territories and as increase of percentage of other land use types related to them (ponds, streets and roads).

Keywords – deforestation, land cover structure, land use, spontaneous forestation.

I INTRODUCTION

Development of Lithuanian landscape is very dynamic with periods of evolution and sudden changes. It is related to the changes of social, economical, political conditions, of abundant socio-economical reforms which left their mark in present landscape structure. Current Lithuanian landscape contains reflections of various past social-economic reforms recorded in landscape mosaics and land use structure. Especially sudden, as seen from our modern perspective, are the landscape structure changes that have taken place in Lithuania after regaining the Independence and after approving certain programmes of land restitution. The latter stimulated the fragmentation of owned land, bringing our country somewhat back to the interwar period, only with the traces of Soviet land management and signs of some new elements in our landscape.

Observation of landscape state in Lithuania has been done since 1999 as State monitoring [1]. However, the transformations observed by analyzing CORINE Land Cover which is intended to track the changes of large areas (scale 1:100 000) do not allow to reveal detailed fragmentation of landscape which is especially specific to such landscape types as lake areas, river valleys, morainic hills. The analysis of landscape structure changes in a more detailed scale (1:10 000) proposed by us enables to reveal not only the small changes of landscape mosaic, but also the changes of linear or point objects. The knowledge about them is especially important for purposeful forming of the directions of state landscape protection and management, for preparing of documents

of different level territorial planning and for organising the activity for landscape forming and restoration.

II METHODS

The methodology of observation of landscape changes was described in detail during preparation of landscape monitoring program in previous article of the authors [2].

The changes of landscape were estimated in 100 sample areas each having 2.5 km² area (the length of the sides being 1581 m) which were distinguished in the main landscape types of Lithuania (Fig. 1) when analysing cartographic material at the scale 1:10000 (Soviet time aerial photographs of 1974-1986 and orto-photo views of 2005-2006) with the help of Arc/View 9.3 software. Thirty two land cover types were distinguished and their changes were observed during the above-mentioned period in each sample area. The statistical regularities of their distribution were determined for the whole territory of Lithuania. About 9000 plots with changes were distinguished which in total cover more than 4000 ha area.

The changes of land cover categories and the level of fragmentation were calculated and the main directions of landscape conversion were revealed. More detailed principle of evaluation of landscape structure changes has been discussed by the authors in another article [3].

III RESULTS AND DISCUSSION

After regaining the Independence, the fragmented small-scale land-ownership and land use structure was formed in Lithuania. Therefore it is normal that most of the changes are small: the average area of plot with

changes is about 0.5 ha and plots less than 0.5 ha area comprise almost 80 % of total number of plots with changes (Table 1). Especially small changes are observed in landscape types with the greatest fragmentation: lake areas, river valleys, morain hills.

Total changes of land cover in distinguished sample areas during the study period comprise even 17.4 % indicating great transformations of landscape in Lithuania. It should be noted that the fragmentation of land cover significantly increased during the study period (Table 2). This fact is proven by the marked increase of the number of land use type units in the study territory (from 3127 to 4813) and by the respective decrease of the

average area of land use plot (from 8 to 5.5 ha). The growth of landscape fragmentation is especially remarkable due to the increase of the shrubby areas and swamps both in the forested territories and in the agrarian fields, as well as due to growing extent of cuttings in the forested territories. The process of spontaneous forestation (conversion of arable land to shrubby meadows) is a characteristic phenomenon at the beginning of the period of the Independence it is manifested in the whole country, especially in those areas where according to other authors [4, 5] agriculture is weak due to poor soils.

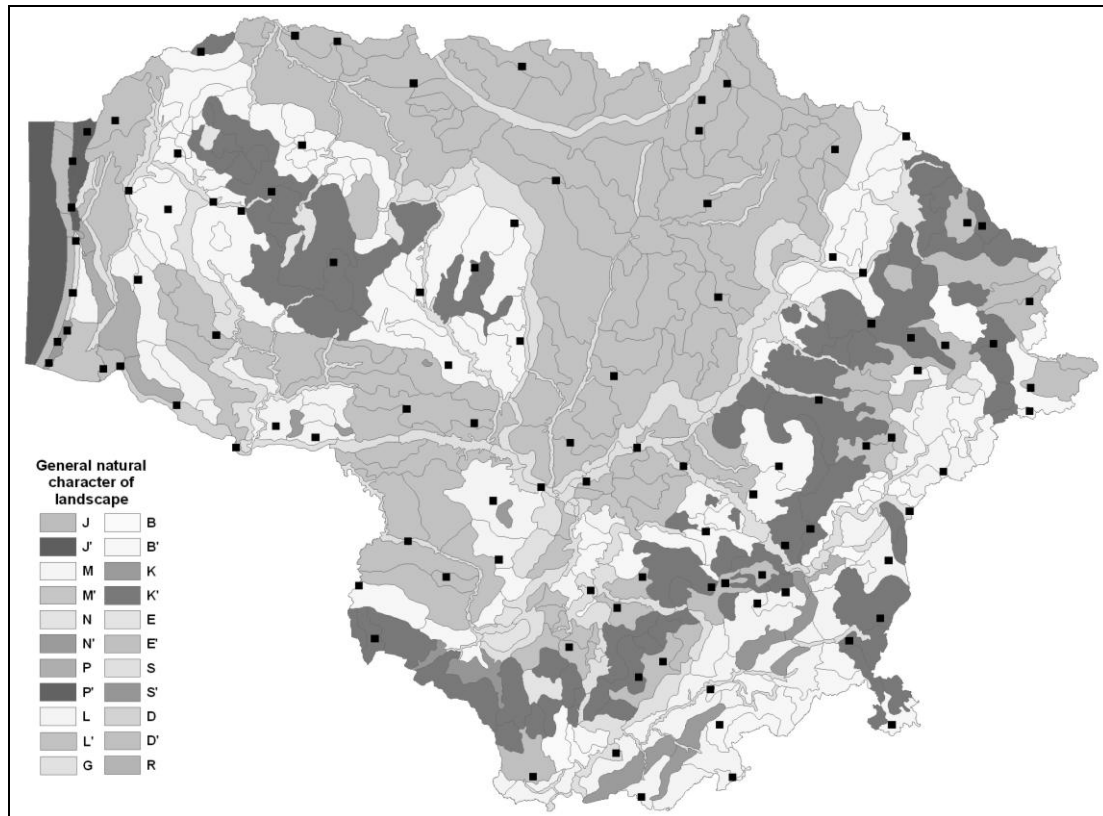


Fig. 1. Landscape sample areas (black squares) in different natural landscape types of Lithuania (map according to [6])

Natural character types of landscape: J – marine landscape in the coastal zone (at a depth of < 20 m); J' – underwater plateaus and troughs; M – shallow lagoon (at a depth of < 2 m); M' – deep lagoon; N – smoothed spit; N' – rugged spit; P – lagoon coastal plain; P' – sandy coastal plain; L – continental sandy plains; L' – clayey plains; B – sandy downy plateaus; B' – clayey downy plateaus; G – morainic hills; K – sandy hills; K' – morainic hills; E – troughs with lakes; E' – lake terrains; S – valleys; S' – old valleys; D – delta valley; D' – delta; R – erosion washes.

TABLE 1.
STRUCTURE OF CHANGES ACCORDING TO THE SIZE OF AREAS

Area (ha) of plots with changes	Number of plots with changes	% from total number	Area (ha) of plots with changes	% from total area
less than 0.1 ha	3933	45.2	129.8	3.0
from 0.1 to 0.5 ha	2975	34.2	717.1	16.5
from 0.5 to 1 ha	813	9.3	570.5	13.1
from 1 to 5 ha	870	10.0	1798.8	41.3
from 5 to 10 ha	71	0.8	502.3	11.5
more than 10 ha	40	0.5	634.9	14.6
Total	8702	100.0	4353.3	100.0

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TABLE 2.

CHANGES OF LAND COVER CATEGORIES.

1 – AT THE END OF THE SOVIET TIME (ACCORDING TO AERIAL PHOTOGRAPHS), 2 – IN 2005-2006 (ACCORDING TO ORTO-PHOTO VIEWS).

Land cover type (category))	Number of land use units			Area (ha) of land use type			% from total area		
	1	2	Change	1	2	Change	1	2	Change
Forests, swamps and schrubs	1340	2094	754	8196.6	9110.7	914.2	32.79	36.45	3.66
Forests	856	1001	145	7138.6	7441.6	303.0	28.56	29.77	1.21
Young forests	216	246	30	564.9	760.7	195.8	2.26	3.04	0.78
Forest cuttings	12	127	115	36.7	259.4	222.6	0.15	1.04	0.89
Schrubs	175	535	360	150.9	365.8	214.9	0.60	1.46	0.86
Swamps	81	185	104	305.5	283.3	-22.3	1.22	1.13	-0.09
Waters	325	392	67	1145.0	1135.3	-9.8	4.58	4.54	-0.04
Rivers	31	30	-1	313.8	307.4	-6.4	1.26	1.23	-0.03
Bars (in rivers)	10	16	6	33.2	3.5	-29.7	0.13	0.01	-0.12
Ditches and channels	2	9	7	3.1	9.2	6.1	0.01	0.04	0.02
Lakes	77	101	24	516.3	483.4	-32.8	2.07	1.93	-0.13
Ponds	195	226	31	48.9	102.9	54.0	0.20	0.41	0.22
Sea (and lagoon)	10	10	0	229.7	228.8	-0.9	0.92	0.92	0.00
Agrarian fields	1021	1430	409	15054.8	13819.6	-1235.3	60.23	55.29	-4.94
Arable land, meadows and pastures	501	725	224	14832.3	13128.0	-1704.2	59.34	52.52	-6.82
Schubby meadows	0	309	309	0.0	519.2	519.2	0.00	2.08	2.08
Gardens	520	396	-124	222.6	172.3	-50.3	0.89	0.69	-0.20
Built-up territories	305	756	451	308.5	690.9	382.4	1.23	2.76	1.53
Urban built-up	21	43	22	46.5	114.2	67.7	0.19	0.46	0.27
Village built-up	179	365	186	77.2	206.2	129.0	0.31	0.82	0.52
Industrial built-up	25	88	63	86.4	112.2	25.7	0.35	0.45	0.10
Garden allotment built-up	54	220	166	87.7	211.2	123.5	0.35	0.85	0.49
Country-houses built-up	0	16	16	0.0	34.9	34.9	0.00	0.14	0.14
Stadiums, hippodromes, athletic fields	6	7	1	3.1	4.0	1.0	0.01	0.02	0.00
Cemeteries	20	17	-3	7.6	8.2	0.6	0.03	0.03	0.00
Exploitable territories	53	25	-28	55.7	32.1	-23.7	0.22	0.13	-0.09
Quarries	51	22	-29	18.0	18.9	0.9	0.07	0.08	0.00
Peatbogs	2	3	1	37.8	13.2	-24.6	0.15	0.05	-0.10
Infrastructure territories	46	78	32	72.5	85.7	13.2	0.29	0.34	0.05
Infrastructure networks	3	2	-1	7.9	2.8	-5.1	0.03	0.01	-0.02
Streets and roads	28	50	22	61.8	78.0	16.2	0.25	0.31	0.06
Embankments	1	1	0	0.6	0.4	-0.2	0.00	0.00	0.00
Docks	10	19	9	1.1	1.2	0.1	0.00	0.00	0.00
Landfills	4	6	2	1.2	3.3	2.1	0.00	0.01	0.01
Other categories	37	38	1	157.7	116.6	-41.1	0.63	0.47	-0.16
Sands	29	29	0	152.0	100.5	-51.5	0.61	0.40	-0.21
Stony land	2	2	0	2.3	0.2	-2.1	0.01	0.00	-0.01
Heritage objects	4	5	1	1.1	13.7	12.6	0.00	0.05	0.05
Foreign territory	2	2	0	2.2	2.2	0.0	0.01	0.01	0.00
Total	3127	4813	1686	24995.6	24995.6	0.0	100.00	100.00	0.00

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TABLE 3.
MAIN CHANGES (TRANSFORMATIONS OF LAND COVER CATEGORIES)

Changes	Number of plots with change	% from total number	Area (ha) of plots with changes	% from total area
Renaturalisation. land abandonment and conversion to forests, swamps and shrubs				
Agrarian fields to forests and shrubs	2673	30.7	1328.7	30.5
Agrarian fields to shrubby meadows	269	3.1	336.2	7.7
Agrarian fields to swamps	133	1.5	63.2	1.5
Scrubs and young forests to forests	247	2.8	256.6	5.9
Quarries and peatbogs to forests to forests and shrubs	36	0.4	41.3	0.9
Conversion to agrarian land				
Shrubs to agrarian fields	208	2.4	30.5	0.7
Forests to agrarian fields	1042	12.0	305.4	7.0
Swamps to agrarian fields	43	0.5	66.6	1.5
Gardens to agrarian fields	335	3.8	56.2	1.3
Build-up territories to agrarian fields	143	1.6	42.7	1.0
Expansion of construction, infrastructure and recreational use				
Agrarian fields to build-up territories	717	8.2	397.8	9.1
Gardens to build-up territories	224	2.6	42.8	1.0
Agrarian fields to gardens	261	3.0	53.1	1.2
Agrarian fields to ponds	166	1.9	55.8	1.3
Overgrowth of swamps and lakes				
Swamps to forests and shrubs	120	1.4	69.3	1.6
Lakes to forests, swamps and shrubs	82	0.9	37.6	0.9
Other more important changes				
Forests to young forests and shrubs	257	3.0	351.7	8.1
Forests to forest cuttings	127	1.5	240.2	5.5
Forests to shrubby meadows	147	1.7	151.3	3.5

Though increase of forested areas due to decrease of arable fields is observed also in other European countries [7, 8], it is usually associated with expansion of planted forests but not with forests which are naturally occupying an abandoned land. It is possible to state that the increase of land cover fragmentation was first of all predetermined by land reform which allowed formation of small land-ownership and the latter in turn lead to the land use fragmentation. Besides that, such processes as increase of built-up territories, expansion of recreational use in suburban territories, and forestation or spontaneous forestation of agrarian fields had and still have great influence on the growth of landscape fragmentation. Though presently the tendency of enlargement of farms can be noticed (first of all in fertile plains). This process is going on slowly and with difficulties because small landowners refuse to sell their land of agrarian use. Thus farmers are forced to rent the greater part of agrarian land. Manifestation of landscape re-naturalisation as a result of land abandonment and conversion to forests, swamps and shrubs, as well as, transformation of arable land to meadows and pastures are the main directions of land cover changes during the study period. According to some foreign authors [9, 10, 11, 12, 13], land abandonment and its spontaneous forestation is qualified as rather negative

process, because of the losing of land value from a cultural viewpoint and from ecological viewpoint, because of decrease of biodiversity during succession period. However, in Lithuania this process should be qualified positively, because it helps to restore the landscape stability in the sense of structure optimum after high landscape homogenisation experience in Soviet period.

Transformation of agrarian fields to forests and shrubs can be considered as the main axis of landscape structure conversion (it comprises more than 30 % according to number of plots with changes and covered area). Though at the same time the conversion of forests and shrubs and other land use types to agrarian fields was also going on, but it had significantly lower scale and comprised only about 20 % from total number of all plots with changes (the conversion of forests to agrarian fields was somewhat more distinct and made up 12 % of the total number of plots with changes) (Table 3). Therefore in total, the part of natural land use types (forests, shrubs and swamps) increased by 3.7% during the study period, meanwhile the part of agrarian fields decreased by 4.9 % respectively.

Quick expansion of construction, recreational use and infrastructure is another important landscape structure conversion which is opposite to the first one, because it

goes towards technogenisation. It manifests mainly as the change of agrarian fields, suburban gardens to built-up territories resulting in the growth of the percentage of other land use types related to built-up territories (ponds, streets and roads). During the study period, the percentage of built-up territories increased more than twice (from 1.2 to 2.8 %).

It is possible to state that the processes of re-naturalisation were predetermined by the poor state in the villages and agrarian sector due to prolonged reform of agriculture, also by EU support for forestation of unproductive land. Very quick expansion of built-up areas began after Lithuania joined EU and the growth of large cities and employment of recreation areas, especially near lakes, rivers and seashore, intensified.

Increase of forestation of swamps and decrease of the lake areas due to implementation of melioration in Soviet times is also noticeable during the study period. Especially intensive forest cuttings (which increased 7 times and which are observed in sandy plains) can also be mentioned among other changes.

IV CONCLUSIONS

All traces of past social economical reforms are reflected in the present mosaic of Lithuanian landscape, but they are especially distinct when Soviet economy changed to market economy. Observation of landscape changes during the period from the end of the Soviet times to the middle of the second decade of the Independence using cartographic material of detailed scale (1:10000) enabled to determine the following main tendencies of landscape structure changes.

Significant increase of land cover fragmentation (mosaic) due to growth of the shrubby and swampy territories both in the forested territories and in the agrarian fields. The average area of land use plot decreased almost twice.

More distinct manifestation of landscape re-naturalisation through land abandonment and conversion to forests, swamps and shrubs, as well as through transformation of arable land to meadows and pastures. The conversion of forests, shrubs and other land use types to agrarian fields also takes place, but on markedly lower scale. Therefore in total the part of natural land use types (forests, shrubs and swamps) in land use structure increased by 3.7 % during the study period, meanwhile

the part of agrarian fields decreased by 4.9 % respectively.

Acceleration of the conversion of landscape structure towards technogenisation through expansion of built-up territories, recreational use and expansion of road infrastructure. The part of built-up territories during the study period increased more than twice (from 1.2 to 2.8%). The extent of forest cuttings increased 7 times.

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