BELLIGERENT LANDSCAPE CHANGE ANALYSIS USING REMOTE MAPPING OF VEGETATION COVER

Sergey A. Stankevich [(1)], **Tamara V. Dudar** [(2)], **Irina V. Loik** [(2)], **Natalia S. Neizmailova** [(2)]
[(1)] Scientific Centre for Aerospace Research of the Earth, Kiev, Ukraine
[(2)] National Aviation University, Kiev, Ukraine
st@casre.kiev.ua

Commission IV, WG IV-2

KEYWORDS: belligerent landscape, Donbass, remote mapping, vegetation cover, satellite imagery

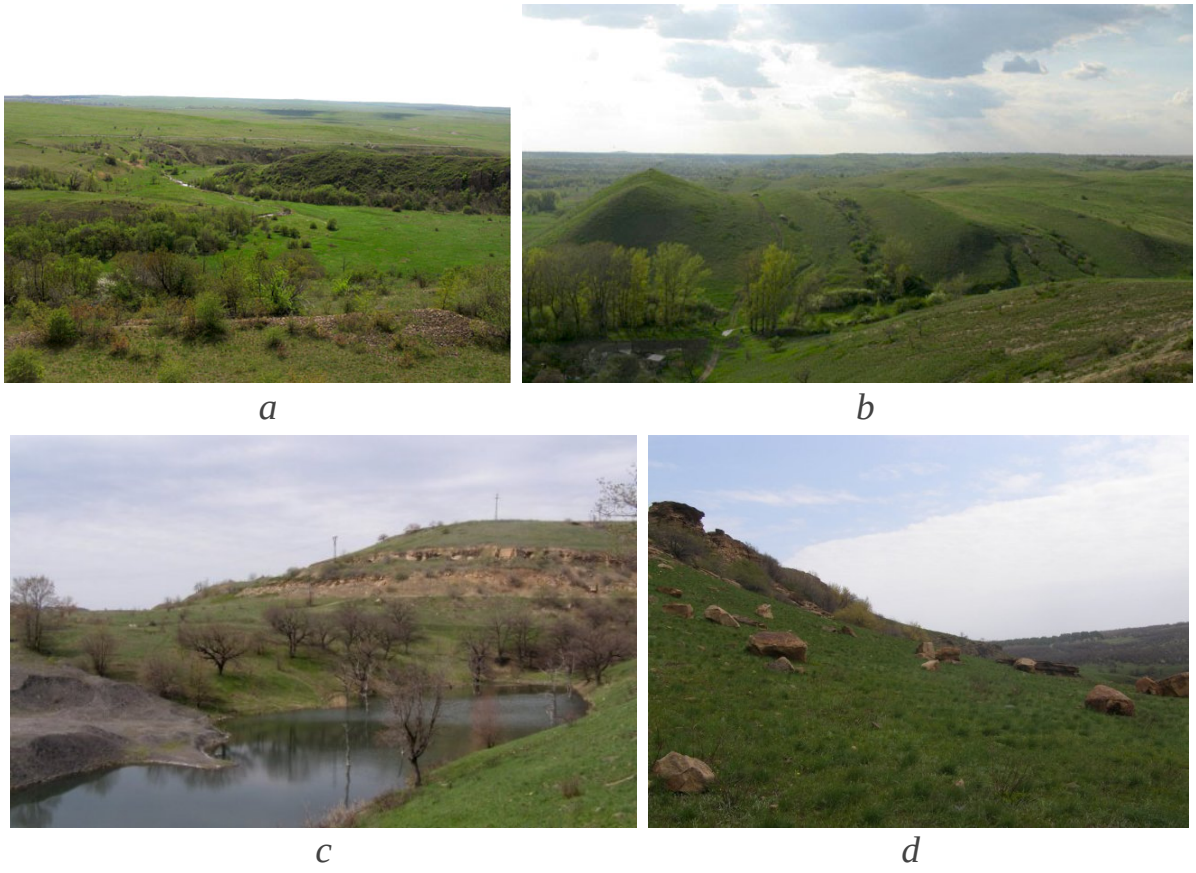
ABSTRACT
Analysis of indirect belligerent landscape changes using multitemporal high resolution satellite imagery is performed over the vicinity of the Popasna town, Ligansk region of Ukraine. Intensive forest cutting is detected, presumably due to proxy influence of warfare. The primary tool for landscape changes detection is the remote mapping of vegetation cover over study area.

1 INTRODUCTION

There is a growing interest in how geospatial processes and patterns affect ecosystems within zones of warfare impact. Many other questions about the interaction of features in landscapes and the effects of the warfare impact on the processes in ecosystems are best answered with satellite images and remote mapping.
Methods for vegetation change assessment using remotely sensed data allow for fast and spatial overview, quantitative vegetation assessment, land degradation mapping, etc. Evaluation of the static attributes of land cover on satellite image data may allow the types of change to be regionalized and the approximate sources of change to be identified.
Moreover, multispectral bands can provide increased spectral resolution that can be used to further analyze and classify environmental conditions, land cover and change detection, and how belligerent actions and associated transportation development impact these conditions. Landscapes of Donbass region (Ukraine) are under warfare impact now.

2 BACKGROUND

The Donbass landscapes are unique because of their nature diversity and contrasts. Here one can meet different types of the steppe landscape complexes: from cretaceous cleavage over the large river terraces to pure almost untouched ravine forests (Fig. 1). And what is more unique – all that is possible to meet within relatively small areas. In spite of the common stereotype there are more "wild nature" corners here than in the other Ukrainian regions.



a *b*

c *d*

Figure 1: Unique Donbass landscapes in the vicinity of the Popasna town (http://www.ostrovok.lg.ua):
a, *b* – Donetsk mountain range; *c*, *d* – stony remnants

In the Soviet times the landscapes of Donbass were severely overused. The increasingly tensions rising between society’s need for resources and space on the one hand, and the capacity of the land to support these needs on the other hand resulted in unprecedented changes in landscape configuration and hence in the environment. The high yield of crops and high rate of coal production had been achieved by any means available at those times leading to the demolishment of natural steppe landscapes. After the deforestation of natural oak-alder woods the territories were used for agricultural activities and later were replaced by homogeneous forests. The existing landscapes – pastures, hayfields and urban terrains – represent heavily transformed ecosystems that are under continuous anthropogenic-load. As a result, the majority of fauna and flora steppe species had disappeared and ruderals appeared instead.

The virgin landscapes can be only found on the gullies, ravines and steppe reserves because these territories are not suitable for farming. Nonetheless, these slopes are being used for grazing which leads to degradation and wind and water erosion. The adjacent steppes are used for agriculture, vegetable and livestock farming and viticulture. The lack of water resources in the area resulted in intensive irrigation practices. The main environmental spatial effect has always been associated

with degradation of arable lands because of water and wind erosion and due to high mineralization (salinization) caused by intensive irrigation.
The steppe territory is highly degraded in terms of the depth of transformation and the level of anthropogenic transformation is considered to be *highly significant*. All-in-all the landscapes are threatened by fragmentation of habitats, agricultural pressure and infrastructure development and subjected to the conflicting interests of environmental preservation and agricultural and forestry activities (Dudar, 2014).

3 STUDY AREA

Under belligerent landscapes we consider those formed owing to warfare impact. Belligerent complexes create specific group of anthropogenic landscapes. Their spatial location does not depend on natural conditions but on belligerent actions (Denysyk and Timets, 2010). There are directly and indirectly belligerent landscapes. Directly belligerent complexes are those created directly as a result of the war factor. These are road-belligerent complexes, defensive earthworks, belligerent badlands, destroyed irrigation complexes, belligerent calderas, ruined constructions, etc. (Fig. 2).

a *b*

c *d*

Figure 2: Belligerent landscapes of the Donbass region, February 2014 (http://www.wordpress.com)

All complexes formed in the vicinity of the warfare area are referred to indirectly belligerent landscapes. Indirect impacts are often longer-lasting than direct ones. In our case we can observe both but consider at a spatial level indirectly belligerent landscapes around and south-east the Popasna town of the Lugansk region (around 13.6 km west-east and 8.7 km north-south).

The region is located in the northern steppe landscape zone described above and characterized with uniqueness and diversity of landscape complexes on the one hand and with high level of anthropogenic impact on the other hand. The soil cover is mottled and heterogeneous and stony on the slopes. The topsoil layer is predominantly presented with ordinary chernozem of average humus content and fragmented vegetation of motley-feather grass content and ravine forests. At a relatively small area we can observe diverse complexes from large areas of crops and arable lands, and vineyards to cretaceous cleavage over the river terraces and remnants of ravine forests (Fig. 3).

4 DATA AND METHODS

As an input data, the satellite imagery of different time periods were used – high (submeter) spatial resolution QuickBird-2 (2010, Fig. 3*a*) and Worldview-2 (2014, Fig. 3*b*) of the Popasna town, Luhansk Region. The imagery was chosen from the times when vegetation was at its maximum.

a

b

Figure 3: Color-synthetic satellite images of study area:
a – QuickBird-2 (2010), *b* – WorldView-2 (2014)

The images were calibrated and converted into the land surface reflectance (Stankevich, Vasko and Gubkina, 2011). According to in-situ observations, the reference points with peculiar landscapes were chosen. Based on the latter, scene classification was performed (Stankevich, Levashenko and Zaitseva, 2014). The results of the classification are shown on the Fig. 4.

a

b

Figure 4: Land covers classifications of study area:
a – by QuickBird-2 (2010), *b* – by WorldView-2 (2014)

The list of the main land cover classes is given in Table 1.

Table 1. Land covers classes of study area

Code	Class [Color]	Percentage (2010)	Percentage (2014)
	Forest [Fern Green]	15.51	19.92
	Crops [Tea Green]	35.78	46.55
	Arable [Apricot]	21.11	15.38
	Barren [Pale Pink]	26.95	17.35
	Water [Air Blue]	0.65	0.80

The use of imageries of different dimensions enabled to detect the changes in indirect belligerent landscape near the Popasna town, covering the period from 2010 (peaceful times) to 2014 (active warfare time). The results of change detection are shown on the Fig. 5.

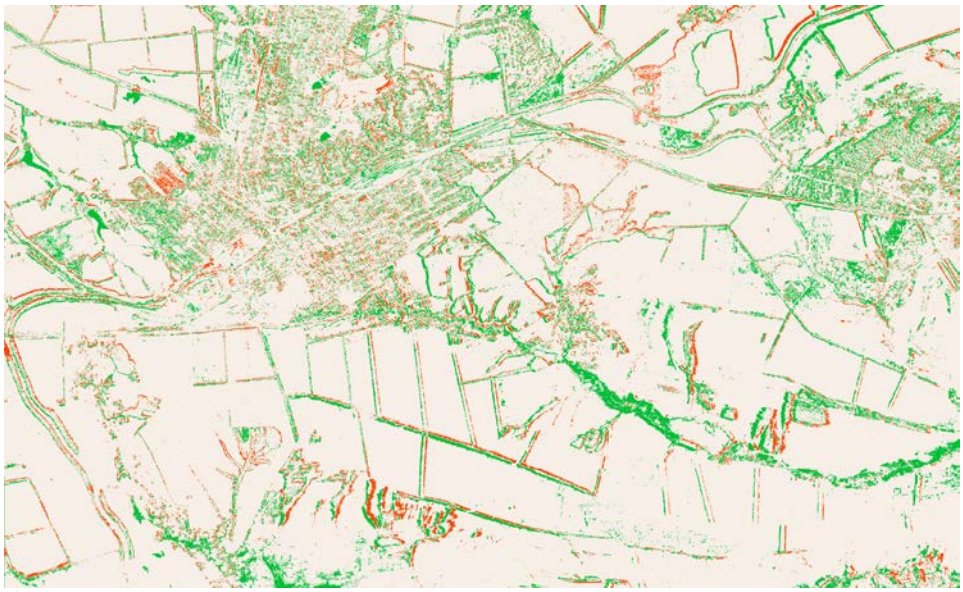


Figure 5: Land cover classes change (from 2010 till 2014)

The forest vegetation communities were mapped. The statistics of detected changes can be found in Table 2.

5 RESULTS AND DISCUSSION

The orange color signified disturbance with forest cover is made up of 4,77% which is quite high value for a relatively small area (Fig. 5). The forest cutting abruptly intensified after the warfare operations had started (in order to provide wood for building shelters and creating cooking fires, etc.) is a significant contributor to this factor. It is notable in the northern part of the town where wood clearance is observed around the large park pond. In the north-west part of the town the broken forest is reflected with dense orange spot. Deforestation and a high level of eutrophication are fixed in the vicinity of the Annenskiy pond (around 3 km north-west of the town). Alarm orange repeats the contours of the wooden massive south-east of the town, the railway and highways all over (right-of-way clearing), and also the vineyards south-west of the town. So, on the hand the wood clearance provoked vegetation change rate. And on the other hand, we can suggest deforestation as a result of natural processes within the ravine forests on the south behind the arable lands and also down the river Lugan valley.

Table 2. Forest change classes of study area

Code	Class [Color]	Percentage
	Rehabilitation [Pastel Green]	19.92
	Indifferent [Sea Shell]	46.55
	Deforestation [Alarm Orange]	0.80

6 CONCLUSIONS

Belligerent landscapes created due to warfare operations on the east of Ukraine are considered in this paper. The high resolution satellite imagery sets of the Popasna town, Luhansk Region were used to estimate the landscape changes during four year time period. Satellite imagery enabled to detect the changes in indirect belligerative landscapes, covering the period from 2010 (peaceful times) till 2014 (active warfare time). On the one hand, one can notice a direct correlation between woods clearance (intensified because of the warfare) and the forest change rate. On the other hand, long-term vegetation cover change is also observed within the remnants of virgin landscapes presumably as a result of natural processes.

The existing methods of warfare caused far greater devastation on the ecosystems which is yet to be investigated and overcome for many years after the war finishes. Remote methods introducing new dimensions into the study and understanding of long-term ecosystem processes will be of high priority then.

REFERENCES

Dudar T.V. Landscape Ecology / T.V. Dudar.– Kyiv: Publishing House of National Aviation University, 2014.– 244 p.

Denysyk G.I. Anthropogenic Landscape Science (in Ukrainian) / G.I. Denysyk, O.V. Timets.– Vinnitsa-Uman: Pavlo Tychyna Uman State Pedagogical University, 2010.– 165 p.

Stankevich S.A. Two-level model for land degradation mapping on multispectral satellite imagery / S.A. Stankevich, A.V. Vasko, V.V. Gubkina // Proceedings of the 8th International Conference on Digital Technologies (DT’2011).– Žilina: University of Žilina, 2011.

Stankevich S.A. Multispectral satellite imagery classification using fuzzy decision tree / S.A. Stankevich, V.G. Levashenko, E.N. Zaitseva // Communications.– 2014.– Vol.16.– No.1.– P.109-113.

Contact:

Dr. Sci. Sergey Stankevich
Scientific Centre for Aerospace Research of the Earth
National Academy of Sciences of Ukraine
55-B, Oles Gonchar St.
Kiev, 01601
Ukraine
Office/Fax: +380 (044) 482-01-66
E-mail: st@casre.kiev.ua