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Spatial distribution of heathlands in Zaborski Landscape Park

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ABSTRACT: Today's plants of the Bory Tucholskie region and the Zaborski Landscape Park, which is located there, is the result of strong anthropogenic transformations that have been taking place in the natural environment for the last few centuries. Already in 19th and 20th century, on large areas of the today's park, which had been deprived of trees and used as pastures, heathlands developed. In Bory Tucholskie, four landscape parks constitute the main places with protected and rare plant communities and species. One of them is the Zaborski Landscape Park situated in the central part of this region. Today, the area of the park is mainly covered by the monoculture of Scots pine. The aim of the study was to define contemporary places of heathlands and changes in the surface area with this kind of land-cover/use during the last 200 years. Satellite imagery was applied in the analysis of distribution and monitoring of changes in the heathlands conditions. To define areas with heathlands in the Zaborski Landscape Park, satellite imageries Landsat MSS, TM and ETM+ from 1975 to 2003 and fieldwork from 2003 were used. To present spatial changes of heathlands, cartographic archival and historical materials as well as aerial photographs were analysed. These materials made it possible to show time changes in the occurrence of heathlands during the last two centuries. The value of electromagnetic radiation reflection for selected scanners of Landsat satellite was defined for the contemporary existing heathlands.

1 INTRODUCTION

Plant cover changes all the time, which is mainly the effect of human activities. Today's plants of the Bory Tucholskie region and the Zaborski Landscape Park, which is located there, is the result of strong anthropogenic transformations that have been taking place in the natural environment for the last few centuries. Already in 19th and 20th centuries, in large areas of the today's park, which were deprived of trees and used as pastures, heathlands developed. Ecosystems and plant communities of this kind are particularly

valuable due to their natural as well as historical reasons. In the European Union countries, heathlands, as essential landscape and bioculture elements, are included in programs of nature protection and intensive scientific studies.

Anthropogenic communities, such as heathlands in Poland, survive only in conditions of the constructive, and often planned human activity (Kaland 2001). Dry heathlands of an Atlantic type have been created in the place of a forest. The main factors were traditional pasturage together with the exploitation of heathlands as a form of fertilizer for poor soils (Bobrowicz 2003), and regular fires (Boinski 1999). Functioning of such communities is the result of balance among human and animal activities, and plant successions. About 100 years ago in Europe (also in Bory Tucholskie) there was the disappearance of one factor which conditioned the existence of this kind of communities – defined as a human activity. As a result of the change in soil exploitation techniques, animal breeding disappearance, and environmental pollution, over 80% of European heathlands have been transformed into arable fields, meadows, and forests (Kaland 2001).

The problem of decreasing heathland areas has especially been noticed in Great Britain and the Netherlands. European heathlands reached the most considerable range in about 1800 (Diemont 1996). To preserve this precious plant formation, which is also cultural element, various projects and preservation programs have been worked out, e.g. Heatcult, European Heathland Workshop or Natura 2000 research initiatives.

2 STUDY AREA

The research was made in Zaborski Landscape Park (created in 1990), situated in southern part of Pomerania Province, on west from Brusy town. Bory Tucholskie is a vast territory located west of the Lower Vistula, in the catchment area of its two major tributaries – the Brda and the Wda. This subregion covers about 5000 km^2, which makes ca. 1.6% of the whole territory of Poland. The subregion is characterised by immense richness of geomorphologic forms the origin of which is related to the last Baltic glaciation. The vast outwash plain at the foreland of terminal moraines from the Pomeranian stage of the above glaciation period constitutes here the dominating geomorphologic form. Surface of the outwash plain is dissected by post-glacial gullies, which are filled with numerous lakes and rivers.

The Zaborski Landscape Park is one of z four landscape parks in Bory Tucholskie which are the main places with protected and rare plant communities and species. In 1996, Bory Tucholskie National Park was created in southern part of Zaborski Landscape Park, which belonged to Chojnice district. National Park area is not big, because councils of other districts did not agree to cover their areas with this form of nature protection. Vast forest complexes in the area under study are part of Przymuszewo Forest Inspectorate (Przymuszewo and Laska forest districts) and Rytel Forest Inspectorate (Klosnowo forest district), which is subordinate to the Regional State Forest Management in Torun.

Today, the area of the park is mainly covered by the monoculture of Scots pine, *Pinus sylvestris*, which is a buffer for many lobelia lakes and peatbogs existing here. At present,

heathlands cover a small area of the park. However, they are also mainly within fire belts and on margins of forest complexes. They make the landscape more mosaic, just like aquatic ecosystems do.

The predominant vegetation formation on the soils developed mainly from poor sands are fresh and dry pine forests, classified as *Leucobryo-Pinetum*, *Peucedano-Pinetum* and *Cladonio-Pinetum.* Smaller areas are covered with other types of pine forests: ericaceous pine forest *Calluno-Pinetum*, wet pine forest *Molinio-Pinetum* and marshy pine forest *Vaccinio uliginosi-Pinetum* on organogenic soils. The deciduous species had greater contribution in forest stands in the past. Oak-hornbeam forests, oak forests and beech forests dominated there, but lasting for several centuries anthropopressure transformed them into agricultural fields and heathlands, or replaced them by pine monocultures. The most serious changes in the forest canopy took place on the turn of the 19th century, when Prussian forest administration planted the cleared grounds with pine. After 1920, when most of the Bory Tucholskie region was included in the reborn Polish State, heathlands, fallow lands, degraded pastures and waste lands were afforested. The subsequent afforestation period of formerly arable lands and waste lands took place after the Second World War, when the Polish Communistic Government took a decision, within the frame of so called land reform, to afforest some of the largest estates. Afforestation of formerly arable lands takes place also today, as unprofitableness of farming on small mid-forest plots causes that people taking on lease those fields from state forests resign leaseholds and turn them over for afforestation (Kunz *et al.* 2000; Nienartowicz *et al.* 2002). Studies and cartographic and remote sensing analyses have taken place in the whole area of the Zaborski Landscape park. Limitations were connected with availability of historical cartographic materials. Territorial studies covered the northern part of the park and the area of the Bory Tucholskie National Park.

3 MATERIALS AND METHODS

The aim of the study was to define contemporary places of heathlands and changes in the surface area with this kind of land cover and land use during the last 200 years. Satellite imagery was applied in the analysis of distribution and monitoring of changes in the heathland conditions. This technology enabled a fast and precise definition of location, area, and evolutionary tendencies of this specific land cover type.

To define areas with heathlands in the Zaborski Landscape Park, satellite imageries Landsat MSS, Landsat TM and ETM+ from 1975 to 2003, and fieldwork from 2003 were used. To present spatial changes of heathlands, cartographic archival and historical materials (Table 1) as well as aerial photographs were analysed. These materials made it possible to show time changes in the occurrence of heathlands during the last two centuries.

The value of electromagnetic radiation reflection for selected scanners of Landsat satellite was defined for the contemporary existing heathlands. Moreover, values of NDVI (according with formula [IR − RED] / [IR + RED]) were defined for these areas in relation to the time of satellite registration.

Table 1. List of used cartographic materials.

Description	Year	Scale
Topographic maps PUWG 1965	1985	1:25 000
Topographic maps WIG	1936	1:25 000
Messtiscgblatt	1874	1:25 000
Schrötter-Engelhard maps	1800	1:50 000

Territorial studies were connected with detailed spatial localization of heathlands interpreted on maps. Moreover, contemporary localization of this class landcover was defined.

The research study was performed with GIS technology, applying the software for satellite data transformation. The Global Positioning System was applied for precise localization of heathlands areas.

4 RESULTS

Spatial variability of heathlands in 1800–2003 has been worked out on the basis of available cartographic materials (Figure 1). Because of the fact that collected materials did not cover the whole area of the Zaborski Landscape park, the area of 3156 ha localized in the northern part of the park was chosen to the comparative analysis. The assumption was taken into account that poor arable pastures were the areas of former heathlands. This assumption was concluded from the fact that heathland had started to appear on poor sandy soils and that there were data which prove that in the past in these area of Zaborski Landscape Park there had been poor sheep pastures (Dziadowiec and Bednarek, 1993). Such a class of landcover is not included into contemporary topographic maps. Heathlands share in the landscape in this area was 14.4% in 1800, 19.0% in 1874 and 0.3% in 1936. In this area present heathlands cover less than 0.1% of the area.

The difference in a spatial distribution of heathlands may be stated on the basis of analysed cartographic materials, especially on the basis of Schröetter-Engelhardt map. In 1800 as many as 81% of heathlands were in the northern part of the Zaborski Landscape park. Probably, it has been the result of neighborhood of Bruska island and settlement centers which were connected with intensification of agricultural activities in these areas. Terrain studies have shown the existence of small heathlands in the area of the whole Park. In its northern part their existence is connected with the present heather coniferous forest *Calluno – Pinetum*. Moreover, heathlands found good living conditions in fire belts (ploughing and fires guarantee good conditions for preserving the domination of the species in phytocenosis), sandy roadsides, and forest margins.

Landsat satellite imageries have been used for a spectral analysis of the today's heathlands. Two heathlands were analysed – one in the fire belt, the second in the area of a former airport (Figure 2). The highest values of DN radiation reflection in the mean infrared and in the range of blue radiation. It relates to all isolated satellite imageries. Higher values of radiation reflection for heathlands in the whole range of electromagnetic spectrum are for May and the lowest ones are for July.

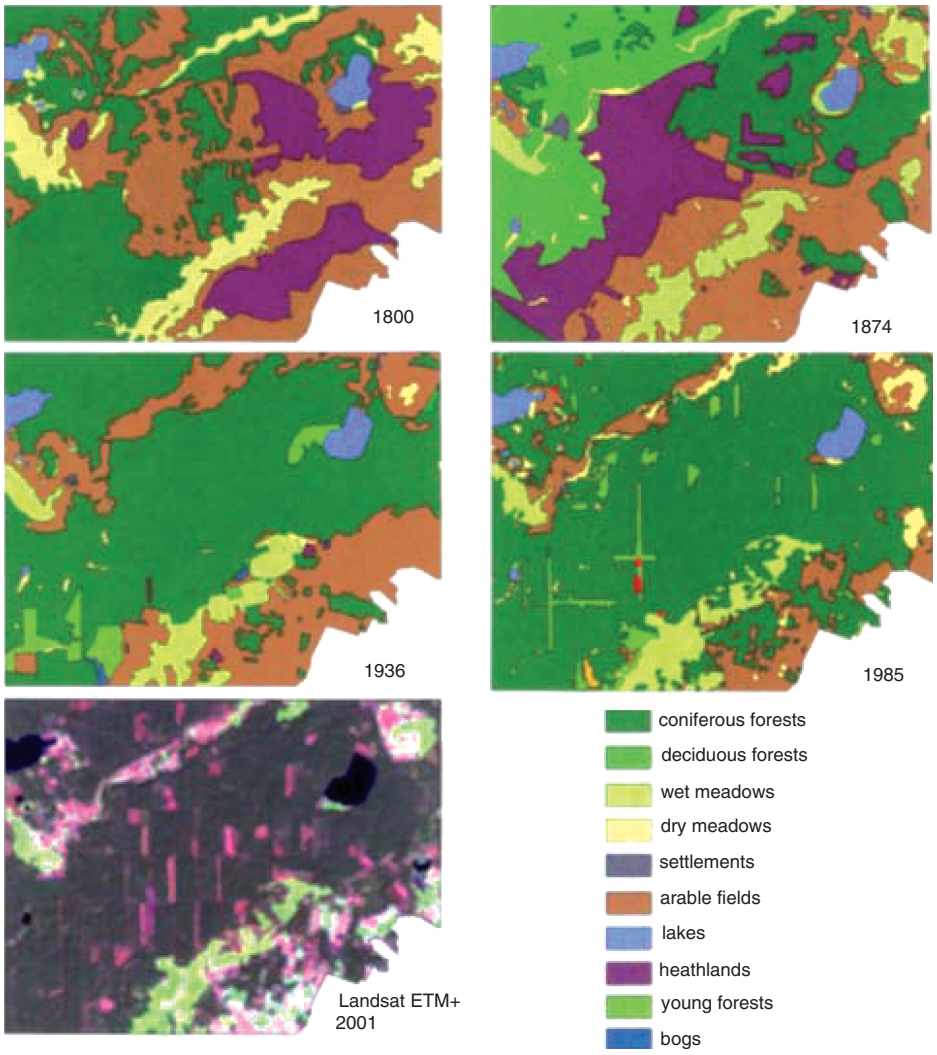

Figure 1. Landcover/landuse in the northern part of Zaborski Landscape Park in 1800–2001.

Analysing NDVI value for the area of two chosen heathlands, it should be noticed that it has lower values than NDVI value for the whole Zaborski Landscape Park or the Bory Tucholskie National Park (Table 2). In 2003 the value of this index for the heathland in the fire belt was 0.26, and in the area of the former airport it was 0.38. The heathland localized in the area of the former airport has lower mean NDVI values than the heathland localized in the fire belt. This heathland has characteristic lower values of maximum NDVI, which is 0.20 for July 1990, and 0.25 for June 2003. In the same period maximum NDVI for the heathland in the fire belt is 0.77 and 0.35, respectively. Considerable number of trees and

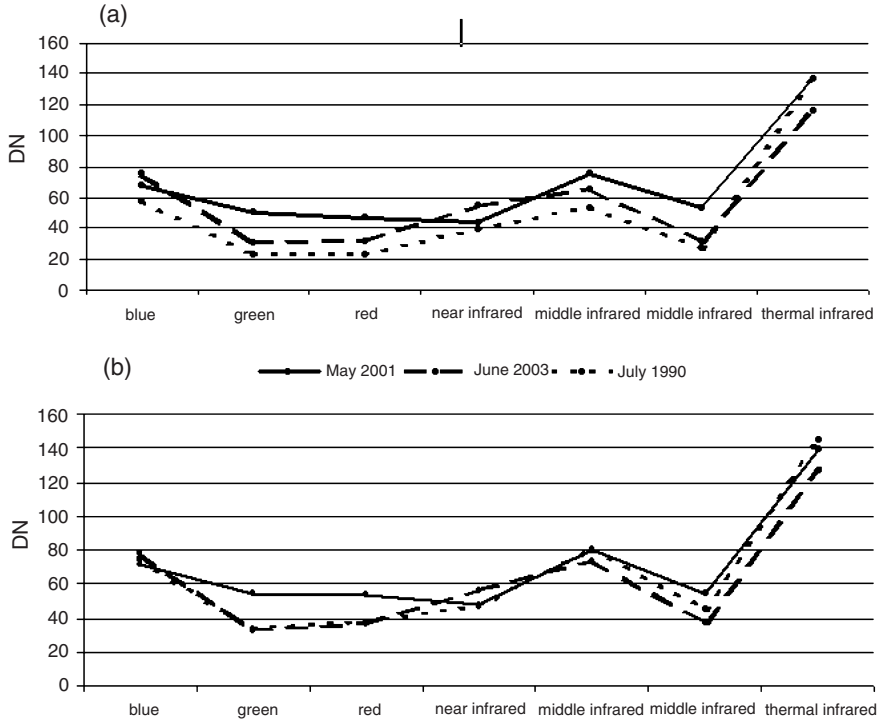

Figure 2. The value of the radiation reflection for heathlands situated in: a) fire belt, b) former airport.

Table 2. Mean NDVI value for heathlands in the fire belt and former airport, and for whole Zaborski Landscape Park and Bory Tucholskie National Park.

Area	Mean NDVI			
	August 1979	July 1990	May 2001	June 2003
Heathland – fire belt	0.1004	0.2608	−0.0278	0.2626
Heathland – former airport	0.0985	0.1198	−0.0518	0.2181
Zaborski Landscape Park	0.1939	0.4126	0.1030	0.3805
Bory Tucholskie National Park	0.1929	0.4100	0.0985	0.3844

bushes in this area has an influence on the higher value of NDVI. In the area of the former airport there are remains of concrete and asphalt among tufts of heathers. Described relations consider all analysed satellite imageries.

5 CONCLUSION

On the basis of analyses and terrain studies, it should be stated that today's heathlands in the Zaborski Landscape Park are of residual character and exist only on some areas such

as fire belts, areas under energetic wires, roadsides. Maximum area of heathlands in contemporary Zaborski Landscape Park existed in the middle of XIX century (19%), and later reduction of this area took place because of sheep-farming reduction and afforestation of arable areas. Strong cuttings in this area is also proved by the presence of *Empertum nigrum*, which very often grows in secondary forests today in the northern part of the Zaborski Landscape Park.

On contemporary topographic maps there is no heathland category mentioned, this is why there are difficulties with the evaluation of today's spatial range of this element of landcover. Remote sensing control methods are very helpful in this situation. They make a remote identification of this formation possible. Admittedly, this class of landcover has already been mentioned on the third level of CORINE Land Cover base, created on the basis of data from Landsat TM satellite, but minimum size of such a division is at least 25 ha. Such large-area heathlands are in Poland. The examples may be Kłominskie or Przemkowskie heathlands described by Bobrowicz (2003). Smaller heathlands are very precious from ecological and cultural point of view. In the future, they will be under the programs of detailed studies and preservation. Main emergencies for today's heathlands are arable crops, natural forest succession, forest breeding, pollutions (heathlands are sensitive to atmospheric pollution mainly of nitrogen, the results are similar to the ones of artificial fertilization – heather is displaced by other plants, mainly grasses) and mortification of dwarf shrubs because of the heather beetle (Gloaguen 1993; Kaland 2001).

In Poland, heathlands have characteristic considerable dynamics of seasonal changes of electromagnetic radiation reflection. Because of the development stages of heather, satellite imageries from July and August should be used, because then there is the period of dwarf shrubs blooming. According to Emery and Milton (1998), the period of green shoots, April has characteristic lower values of electromagnetic radiation reflection. The lowest values of reflection are characteristic for the period of brown heather shoots. In our climate this happens in November.

Satellite imageries may be used in studies over localization and variation of heathlands. It needs many studies and terrain verifications. To identify smaller heathland areas, satellite imageries with higher resolution should be used. It is also advised to make ground radiometric measurements together with satellite registering.

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