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THE MAP OF THE NAREW RIVER NATIONAL PARK ON THE SCALE OF 1:25,000 ELABORATED ON THE BASIS OF THE MERGER OF THE SATELLITE AND AERIAL IMAGERY

The increasing availability of various remote sensing materials encourages to look for the new and better methods of processing photographic images and of associating the information contained in them in order to obtain a new image of the Earth's surface, attractive from the point of view of interpretation possibilities. The present paper shows the methodology of elaboration of the satellite map of the Narew River National Park (NPN) along with its surrounding protective belt; an area of particular natural value. The source materials were constituted by the Landsat TM satellite data, with resolution of 30 m and the photo-map of the scale of 1:10,000, elaborated on the basis of the spectral-zonal aerial photographs having resolution of 0.5 m. By associating the satellite photographs with the aerial ones from the same part of the growing season (end of summer) the image on the scale of 1:25,000 was obtained in colours due to the satellite photographs and the resolution level characterising the aerial photography.

Narew river is characterised by a dense network of river channels, which occupy the entire valley of the river over numerous segments. Low gradient of the river (0.15‰ on the average), slow current, and flat, peaty terrain, cause that the flow of the surface and ground waters is hampered and dammed, and the entire valley is within the reach of the long lasting flooding by the river waters, distributed over the valley through the dense network of the riverbed branches. In the periods of spring and summer high discharges water fills the whole width of the valley (2 – 3 km). Consequently, the aquatic-swampy setting of the natural environment developed, featuring specific ecological conditions, different than in the other river valleys. This setting involves a rich mosaic of the ecosystems having emerged from the aquatic, aquatic-and-meadow, dryland-and-swamp, and dryland environments. The land improvement (drainage) undertakings from the 1970s and 1980s caused disadvantageous changes in the environment. The subsequent years brought a general improvement of the situation, owing to the economic crisis and the advancement of the re-naturalisation work. Presently, after the Narew

River National Park has been established, there exists a possibility of conducting work related to the protection and monitoring of the environment. The Department of Remote Sensing of the Environment of the Faculty of Geography and Regional Studies, Warsaw University, takes an active part in this work. Due to the studies having been conducted in the past, materials have been gathered, which are used to determine the directions of changes, taking place in the environment of the NPN.

This environmentally valuable area plays a significant role in the international system of migration of living organisms. Hence, the Narew River National Park was considered in the European programme ECONET to be one of the nodal areas of international significance (Liro, 1995).

The satellite map of the NPN was elaborated in order to obtain the detailed image of the land cover and the information on the state of the plant associations. This information was provided by the Landsat TM satellite imagery and the spectral-zonal aerial photomap.

Elaboration of the map was associated with the necessity of resolving a number of methodological problems and the questions related to the naturalist interpretation of the processed images. In order to obtain the images in colours similar to the natural ones an original method was applied of associating the composition of the colour satellite photographs, applied for the first time in the elaboration of the satellite map of the counties of Nowy Dwór and Lagionowo (Lewiński, Goljaszewski, 1999; Lewiński, 2000). The Landsat TM imagery was processed in such a way as to make it possible to obtain, after the merger with the spectral-zonal aerial photograph, a detailed colour image on the scale of 1:25,000, that would constitute the sum of information on vegetation, soils, and the remaining elements of the land cover.

The algorithm of processing of the aerial and satellite imagery here applied is shown in Fig. 1. This algorithm can be subdivided into three basic stages, corresponding to transformation of the Landsat TM satellite photographs in order to establish an appropriate colour composition, to the processing of the spectral-zonal aerial photographs, and to the association of the satellite and aerial images with the use of the IHS method.

The processing of the Landsat TM satellite imagery was started with the analysis of the RGB composition from the point of view of the colours representing the basic classes of the land cover. Two compositions were selected from the channels (2,4,3) and (3,2,1). The first of them maps out in the colours similar to the natural ones first of all forests and meadows, while the second — the agricultural areas. Thereafter, elaboration was started of the mask used in the process of pixel selection and linkage of the chosen compositions.

The mask, that is — the image having precisely defined properties — was produced through application of the Tasselled Cap transformation (Jensen, 1986). On the basis of six spectral channels of the Landsat TM image (the thermal channel not being accounted for) three new images were generated bearing the token names “Brightness”, “Greenness” and “Wetness”. In further analyses only the “Greenness” channel was used, since in this channel the

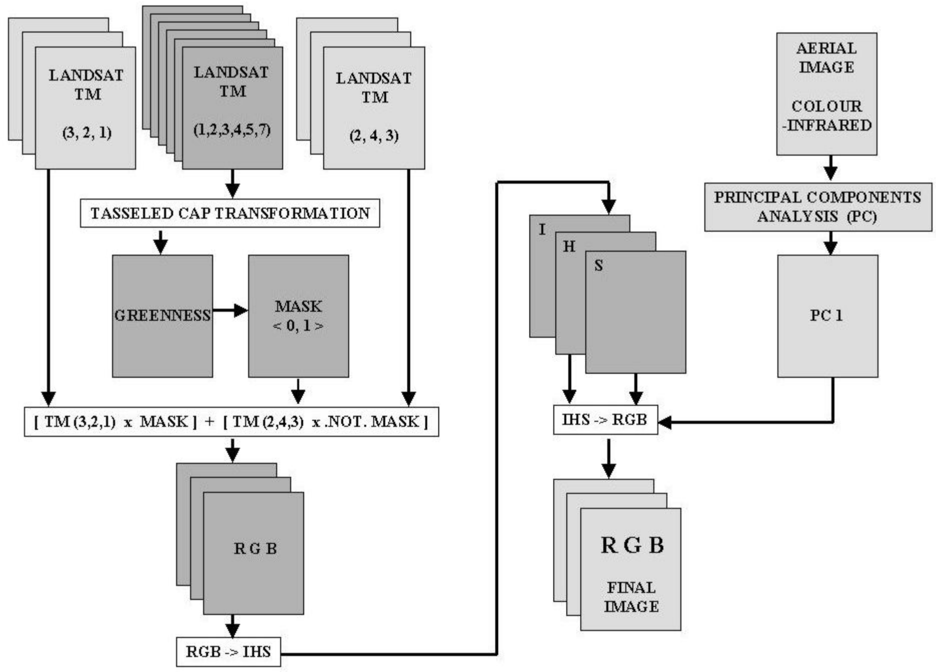

Fig. 1. The algorithm of processing of the satellite and aerial photographs.

pixel values are correlated with the appearance of vegetation on the image. On its basis the intervals of values of pixels were determined, connected with the colours similar to the natural ones in the composition (3,2,1) and (2,4,3). Then, the mask was formed, with values 0 and 1, corresponding, respectively, to the first and the second of these compositions.

The compositions (3,2,1) and (2,4,3) were multiplied, the first one by the mask, the second one by the inverse of the mask, and then added. In this manner the satellite image was developed, being the sum of two compositions, characterised by the appearance of two classes of land cover in colours similar to the natural ones.

In the work on this map use was made of the spectral-zonal photomap of the Narew River national Park, composed of ten parts. Individual sections were merged (joined), and the precision of the resolution of the image was lowered from 0.5 m down to 2.5 m, which was completely sufficient for printing of the map on the scale of 1:25,000. Then, the spectral-zonal aerial photograph was subject to the principal components analysis (PC). The first component obtained (PC-1), representing first of all the degree of detail of the imagery, was used in the last portion of the algorithm concerning the merging of the satellite photograph with the aerial photograph.

Colour composition produced on the basis of the satellite photographs was linked with the PC-1-based image via application of the transformation

Fig. 2. The RGB (3,2,1) composition of the Landsat TM photograph.

Fig. 3. The Landsat TM satellite image in conjunction with the aerial photograph.

between the colour systems RGB and IHS (Carper, Lillesand, Kiefer, 1990; Chavez, Stuart, Anderson, 1991; Gonzalez, Woods, 1993). First, on the basis of the RGB colour composition three channels were established: “Intensity”, “Hue” and “Saturation”. Thereafter, the “Intensity” channel was replaced by the PC-1 image and the return to the RGB colours was performed. In this manner the image was obtained having the colours of the satellite image and the level of detail of the aerial photograph.

Association of the photographs was connected with the necessity of carrying out several attempts meant to determine the optimum parameters of the image processing. This was not an easy task in view of the very big difference in the resolution levels. Each pixel of the satellite image (30 × 30 m) was divided up into 144 parts corresponding to the pixels of the aerial photograph (2.5 × 2.5 m). It turned out that in the first phase of the attempts an essential problem was constituted by the “visibility” of the boundaries of the thirty-metre satellite pixels on the resultant image. It was thus necessary to test various methods of dividing the pixels and of their filtration.

Fig. 2 presents the composition (3,2,1) of the Landsat TM image, while Fig. 3 shows the view of the very same fragment of the terrain obtained owing to the application of the previously outlined algorithm of processing of the satellite and aerial imagery. The photographs differ in an essential manner as to their resolution levels and the colours. The processed image shows the structure of forests, fields, local road network, settlements (a family housing estate is located in the lower right corner of the image), and even individual tree-tops can be observed on it.

Road network was overlaid on the processed satellite image, with distinction of four classes of roads (main roads, local roads, village roads, as

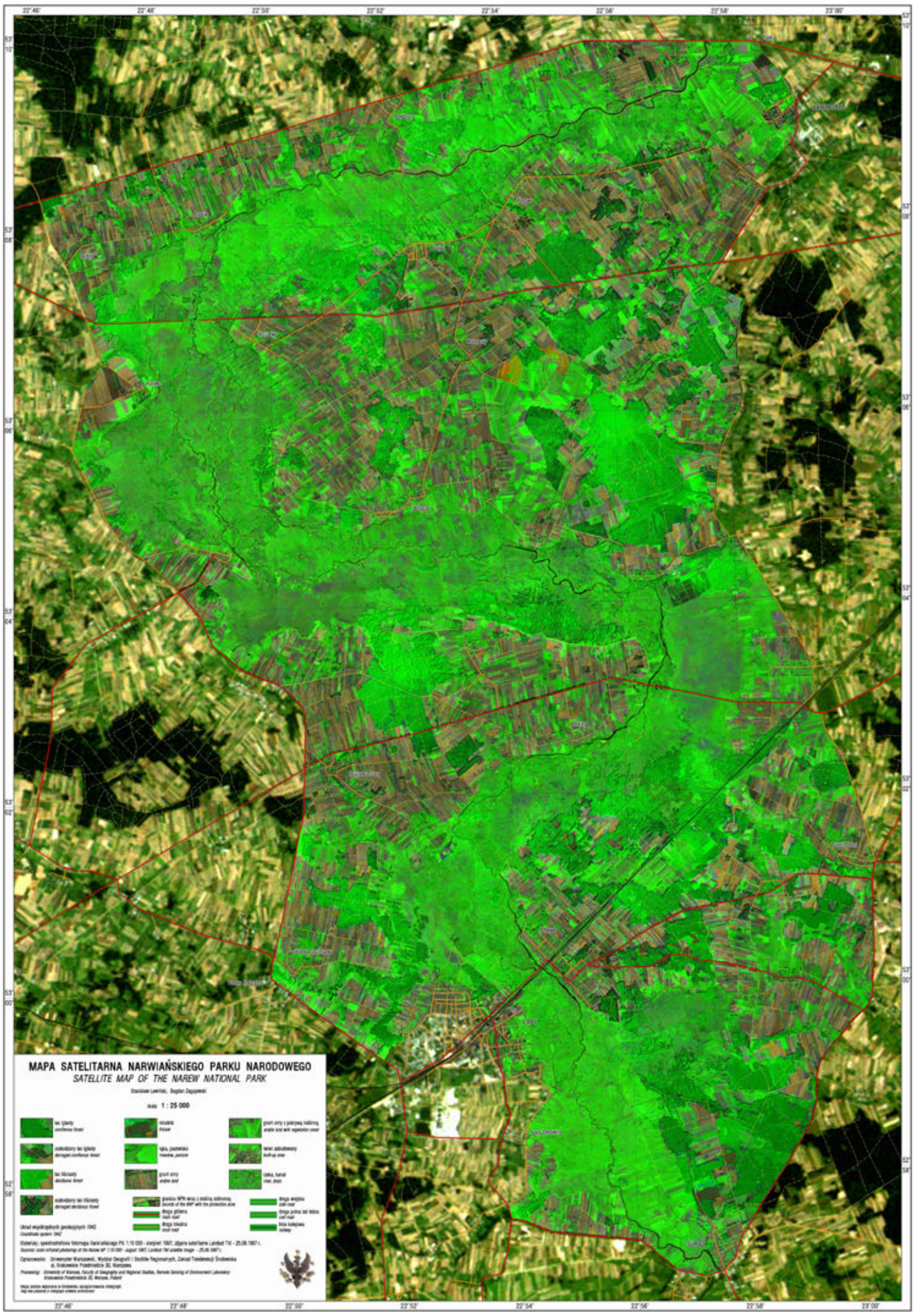

Fig. 4. The satellite map of the Narew River National Park, Lewiński St., Zagajewski B., 2001.

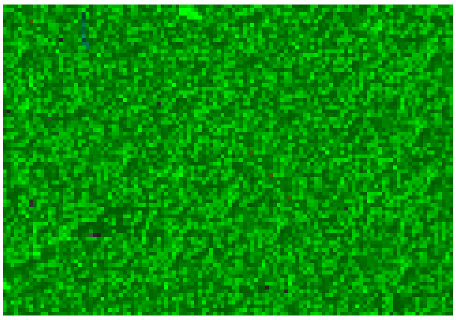

Fig. 5. Coniferous forest.

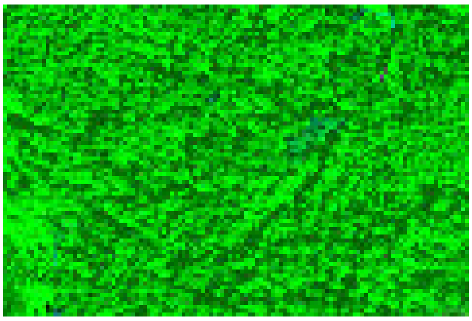

Fig. 6. Deciduous forest.

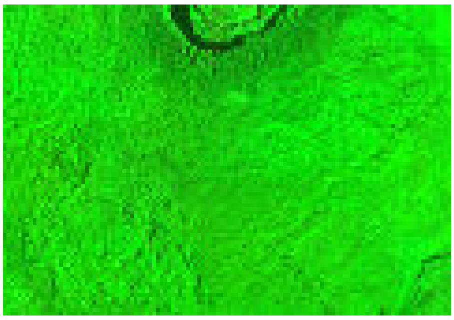

Fig. 7. Pastures.

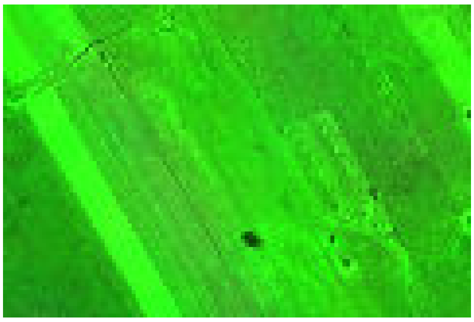

Fig. 8. Meadows.

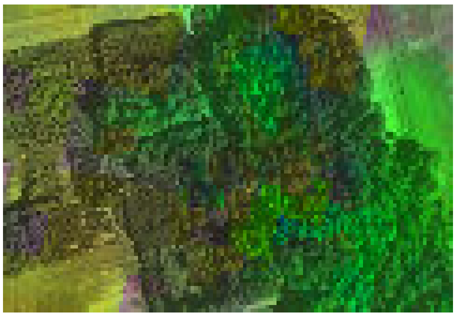

Fig. 9. Damaged coniferous forest.

well as in-field or forest roads), along with the railroad network, geographical grid (with the interval of 2'), and the names of bigger localities. The legend was elaborated presenting, in the form of small fragments of the image, ten basic classes of the land cover, namely the coniferous forest, the damaged coniferous forest, the deciduous forest, the damaged deciduous forest, the young forest, the meadows and pastures, the arable land, the arable land with vegetation cover, the overbuilt area, and the rivers and canals. Presentation of the areas outside of the boundaries of the NPN was made using the composition (3,2,1) of the Landsat TM image, which differs in an essential way from the image of the NPN with respect to the resolution level and colour, so that the boundaries of the Narew River National Park are well visible. The obtained satellite map of the Park is shown reduced in Fig. 4, while its fragment in the original scale of 1:25,000 is shown in Fig. 10 (Lewiński, Zagajewski, 2001).

As can be seen, identification of the land cover classes mentioned above was possible not only on the basis of the colour, obtained from the satellite photograph, but also on the basis of structure and texture from the aerial photograph.

Figures 5 and 6 present the fragments of image of the coniferous and deciduous forest. The green colour of the coniferous forest is clearly darker in comparison with the deciduous one, but this is not the only distinguishing feature. An additional characteristic, allowing for distinguishing the classes is their well visible structure and texture. The coniferous forest is characterised by the fine-grained structure, with the uniformly distributed small-dot texture, while the image of the deciduous forest has a grained structure with medium-dot and chaotic texture. Another example is constituted by the meadows and pastures, which, although distinguishable on the map of the NPN, are accounted for within just one class, conform to the habit proper for the majority of the satellite maps. The fragments of images of meadows and pastures are shown in Figures 7 and 8. Despite the uniform colour, classes can be easily distinguished on the basis of the structure and the texture. In case of pastures we deal with the amorphous and unordered texture, while meadows can be easily recognised through their linear structure forming stripes.

The influence of information on the condition of plants, originating from the spectral-zonal photograph, can be illustrated on the example of the coniferous forest. Fig. 9 shows a fragment of the map, where a limited complex of forest is seen. The healthy coniferous forest is shown in green colours, while the green-and-brown colours represent the damaged coniferous forest, appearing primarily close to the border of the stands.

The very first analyses of the image demonstrated that there is a proportional relation between the intensity of the green colour on the map and the condition of the vegetation. A similar relation, though difficult to determine in a precise manner, exists between the humidity of the meadows and the productive pastures on the one hand, and the green-blue-violet colours on the map on the other. This results from the fact that vegetation that is not mowed nor grazed remains in August (the period of execution of both the satellite and the aerial imagery) abundant, and the registered signal comes mainly from it (intensive green colour on the map). Then, in case of similarly good habitats, but under agricultural use, vegetation is shorter (mowing, pasturing), and hence the signal registered is the mixture of the spectral responses of plants, soil, and water. The increase of humidity of the uncovered arable land is expressed through the darker tones of the brown colour. It is also interesting that one can observe as well weeds, which appear spontaneously on the arable land. Their colour is intensively green, bearing an evidence of their good health condition.

Altogether, the effect of the undertakings here described ought to be considered very promising. It should be emphasised that the analysis of the joint image has shown that the aerial photograph enriched the satellite image

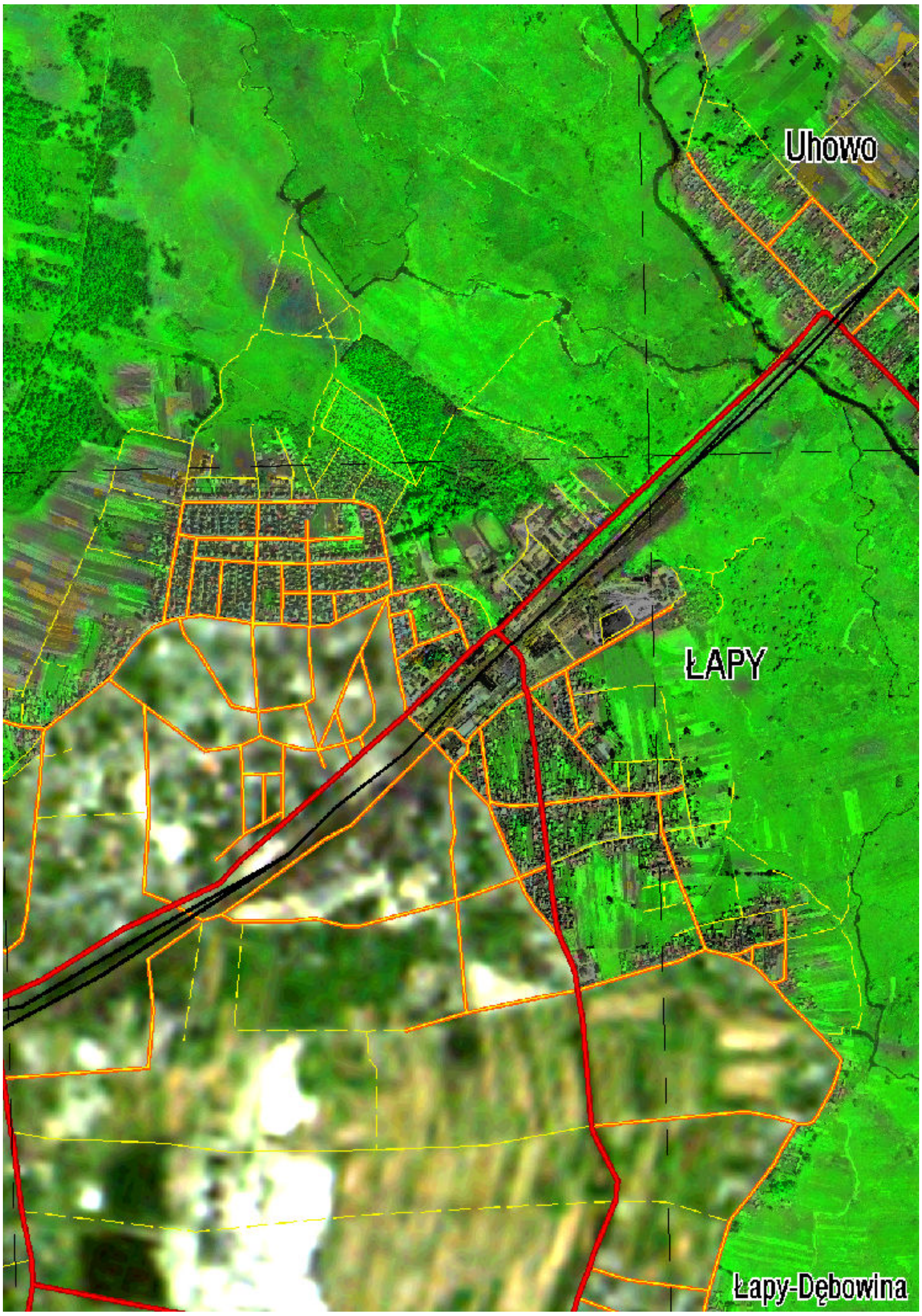

Fig. 10. A fragment of the satellite map of the NPN on the scale of 1:25,000.

not only with its resolution level, but also with many of the interpretation-related properties. The use of the spectral-zonal photograph broadened significantly the capacities of analysis of the vegetation. Complete interpretation of the image obtained is being carried out within the framework of the project entitled "Analysis of the condition of vegetation of the Narew River National Park".

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