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# Digital general maps of tree stands as a basis for the creation of landscape units

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**Abstract.** General maps of tree stands are a valuable source of information for landscape analyses. There are border lines of subsections, and sometimes even forest sections, however they are usually difficult to field identification. These borders often serve only as tools. As a result of spatial analyses, e.g. aggregation of chosen areas from data basis, done with the use of geoinformation tools, other spatial units may be acquired, such as forest landscape units or forest age units. Such units characterise the analyzed area in some other way giving new information. On the basis of the analyses it may be stated that forest landscape units bring the division of a landscape area closer to the structure showed on topographical maps. Forest age units show better structural differences of an individual forest phytocenosis and allow to catch invisible differences among elements of forest ecosystems. Broader use of chosen units needs more detailed studies.

***Key words:*** landscape indices, landscape units, general maps of tree stands, aerial photographs, data integration, GIS

## Introduction

Most of Forest Inspectorates in Poland already have at their disposals the complete digital map which consists of a graphic part with a data basis. The forest digital map uses the standard for map creation and the structure of an attribute table, worked out in the form of the instruction after the pilot survey. Such a map allows to make analyses and their results may be thematical maps. The information registered in the data basis is used during the creation of such a thematical map. The created types of thematical maps depend on how the data basis is constructed. Examples of maps produced in this way are an exploitation map, an age structure map or a habitat map. This way, the other information about the analyzed area is acquired, and this information is spatially presented. The basic forest economical unit used in forestry is a forest subsection. This division has its detailed data-basis information, which describes its function-exploitation structure. Spatial analyses, e.g. data aggregation, make many operations possible. As the result of these operations we receive new information. The effect of the analysis may be separated spatial units, which were not earlier distinguished. The proposed units make it possible to use other than an economical-use approach to the analyzed area and to define its internal variability.

## Study area

Studies over proposed landscape units and their spatial structure were done within 5x5km square field situated in the Bory Tucholskie National Park (BTNP). The whole preserved area is situated in Chojnice administrative district and covers 4 789 ha, within it forest areas are 3 798 ha. The buffer zone,10 286 ha, is the part of the

Zaborski Landscape Park.
In the structure of study area land use forests (87,4%) and lakes (10,8%) have dominated in 2000. Green lands, marshlands, and arable areas were only 1,8% of the area. There were no forest settlements in the analysed area. The chosen area of the detailed analysis covers 75% of present forest sections which during 150 years of Prussian and Polish forest activities changed their shape, surface, and numeration. Taking into consideration a habitat, the analysed study area consists of 10 habitats of forest types, and fresh coniferous forest has the biggest share (almost 94%). The rest of forest habitats cover small areas and exist mainly along watercourses and around water basins. Taking into consideration species, pine is dominating with the share of almost 99%. Present treestands belong to 8 age classes, and the oldest class is 141 – 160 years old. The oldest, 153 years old pine tree stand exists in subsection 116a and 116f in the habitat of a fresh coniferous forest. Tree stands which are 21-60 years old (II and III class) are dominating in the age structure, and they cover almost 50% of the forest surface in the study area.

## Materials, goal, and methodology of studies

Comparative analyses have been done on the basis of tree stands general maps created in 1:20 000 scale in: 1952, 1966, 1976, 1987, and 2000. During analysis of those data, it has been observed that spatial structure presented on those maps is a clearly economical division, and it very often do not have anything common with the reality. Other data sources, such as aerial photographs and satellite images, visually characterize variability in the structure of this area, which cannot be observed visually on forest maps. Topographic maps are often additional information source concerning a landscape, but they are seldom (or never) updated, which makes them out of date, and consequently they are not used in comparative analyses for short periods (e.g. every 10-20 years). Figure 1 shows a part of the analyzed area on various data sources. Various mosaic structure of this forest landscape can be seen and it depends on the source of data.
The aim of the study was to check the possibility of the use of general tree stand maps in multitemporal and multisources studies. The analysis of the chosen units was made, and it was based on the comparison of the landscape structure worked out on the basis of the interpretation of general tree stand maps and newly created landscape units after the process of data transformation.
Studies were done with the use of tools and procedures of Geographical Information System (GIS). Geospatial system with graphical elements (geometry) and also complete data basis with attributes taken from Forest Inventory Books was created for the analyzed period (1952-2000). The procedure for creating the system for landscape studies and the use of multitemporal data was described by Kunz (1999, 2005, 2006 and 2006a). Forest subsection was accepted as the basic spatial element. On the created geoinformation system, aggregation of data was done according to criterion concerning the use and age of the subsection. In the process of aggregation done during analysis, rules proposed by Mitchell (1999), Petit and Lambin (2002) were used.
As the result of studies and data aggregation procedures new landscape units were acquired, and they were called: a forest landscape unit and a forest age unit. According to the concept of the studies (Kunz 2005), the forest landscape unit is defined as the part of a forest area covering neighbouring forest subsections which have their characteristic type of a land use. The forest age unit is acquired in the similar way, but it covers neighbouring forest subsections which have their characteristic similar age of tree stands. The main criterion for the determination of the first unit was the land use, and in case of the second proposed unit it was the age class defined on the basis of valuation activities, and registered in the forest management impact assessment. Forest landscape unit may be compared to a landscape patch chosen on the basis of topographic maps.
For produced in such a way new units of area division, a chosen indices of the landscape structure were calculated, e.g. the number of patches (NUMP), the total length of an edge (TE), a shape index (MSI), a fractal dimension (FD), and Shannon diversity index (SDI).
Theoretical basis considering indexes of landscape structure may be found in studies of McGarigal and Marks (1995) and Turner (1989). Gained results were compared with values acquired on the basis of the landscape structure analysis made on the basis of the traditional landscape division into forest subsections.

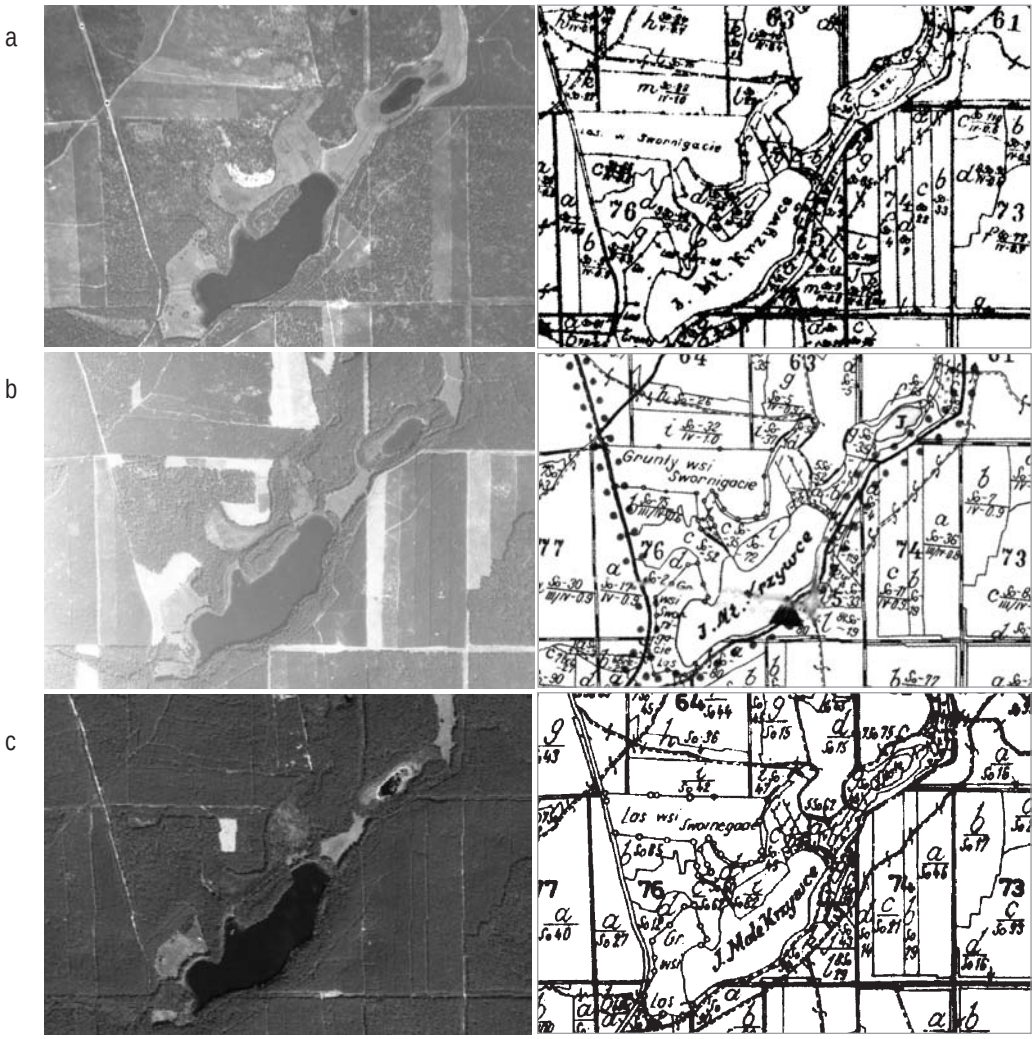


Fig. 1. Part of the analyzed area on: aerial photographs from 1951 (a), 1976 (b), IKONOS satellite imagery from 2003 (c), general map of tree stands from 1966 (d), 1976 (e) and 1985 (f)

## Results

Forest landscape units and forest age units acquired on the basis of spatial analyses are shown on figure 2. On the left side of this figure, there are forest landscape units, and on the right – forest age units. In this figure, there can be seen spatial change in functional and age structure of tree stands in the analyzed area, in the following stages of forest landscape development. In table 1, there is the list of calculated measures of a spatial landscape pattern for the proposed forest units and traditional forest subsections.

In the whole analyzed period the number of acquired forest age units is more or less twice smaller than the number of forest subsections shown on general maps of tree stands (fig. 3). The number of landscape patches is one-forth of the number of sub-sections. The results of counting landscape patches for 1952 and 1987 are very close to the number of patches chosen by Kunz (2005) on topographical maps from 1954 and 1985.

Similar tendency, and variability in time is characteristic for total edge index. Gained values of shape indicator and fractal dimension for forest landscape and age units are characteristic because of their time variation. Values gained for forest landscape units and also for forest age units are higher than for forest sub-sections.

Table. 1. Values of the chosen indices of spatial landscape pattern calculated with regard to various landscape units

| Landscape units | Year | NUMP | TE [km] | MSI | FD | SDI |
|---|---|---|---|---|---|---|
| forest subsection | 1952 | 388 | 418,29 | 1,49 | 1,32 | 0,88 |
| forest landscape unit | | 92 | 207,05 | 1,93 | 1,38 | 1,49 |
| forest age unit | | 209 | 317,51 | 1,58 | 1,33 | 1,71 |
| forest subsection | 1966 | 652 | 590,18 | 1,58 | 1,34 | 0,61 |
| forest landscape unit | | 72 | 172,43 | 1,91 | 1,38 | 1,43 |
| forest age unit | | 293 | 409,89 | 1,66 | 1,34 | 1,74 |
| forest subsection | 1976 | 441 | 507,81 | 1,65 | 1,33 | 0,48 |
| forest landscape unit | | 49 | 116,68 | 1,64 | 1,35 | 1,32 |
| forest age unit | | 223 | 375,61 | 1,74 | 1,34 | 1,67 |
| forest subsection | 1987 | 446 | 514,03 | 1,63 | 1,33 | 0,42 |
| forest landscape unit | | 49 | 114,29 | 1,78 | 1,30 | 1,20 |
| forest age unit | | 256 | 406,07 | 1,74 | 1,32 | 1,77 |
| forest subsection | 2000 | 489 | 536,65 | 1,66 | 1,34 | 0,42 |
| forest landscape unit | | 46 | 115,53 | 1,67 | 1,35 | 1,24 |
| forest age unit | | 279 | 420,04 | 1,74 | 1,36 | 1,85 |

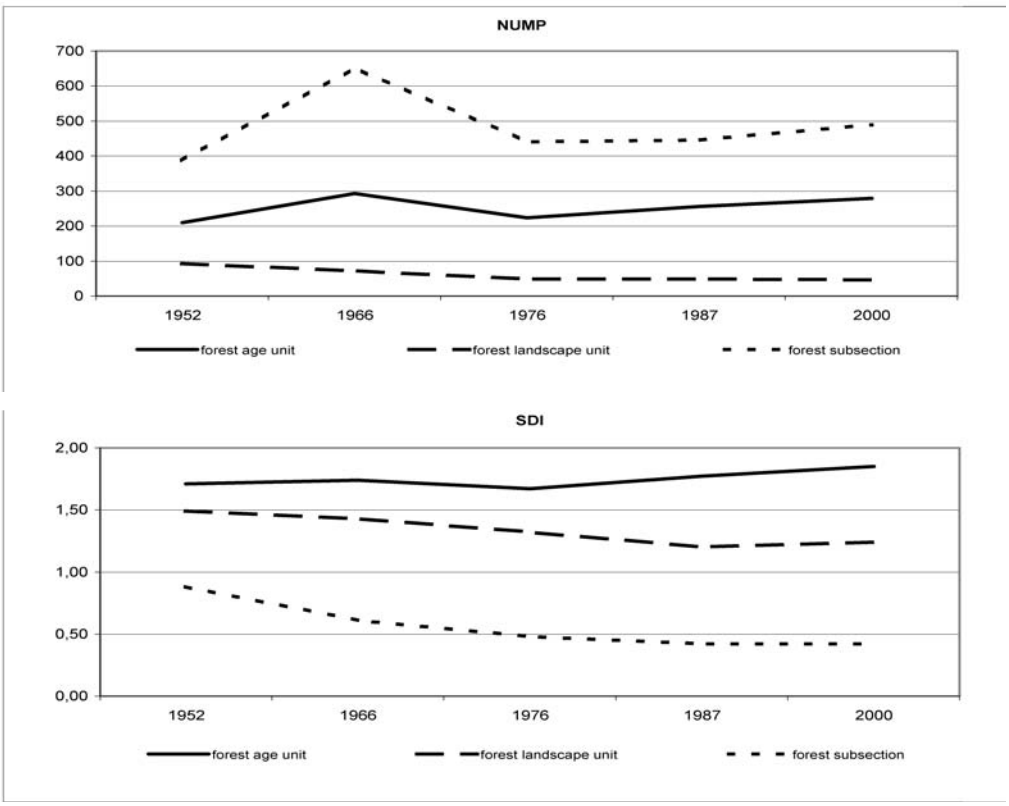


Fig. 3. The changes in number of patches (top) and Shannon diversity index (bottom) in 1952-2000 according to three types of landscape units

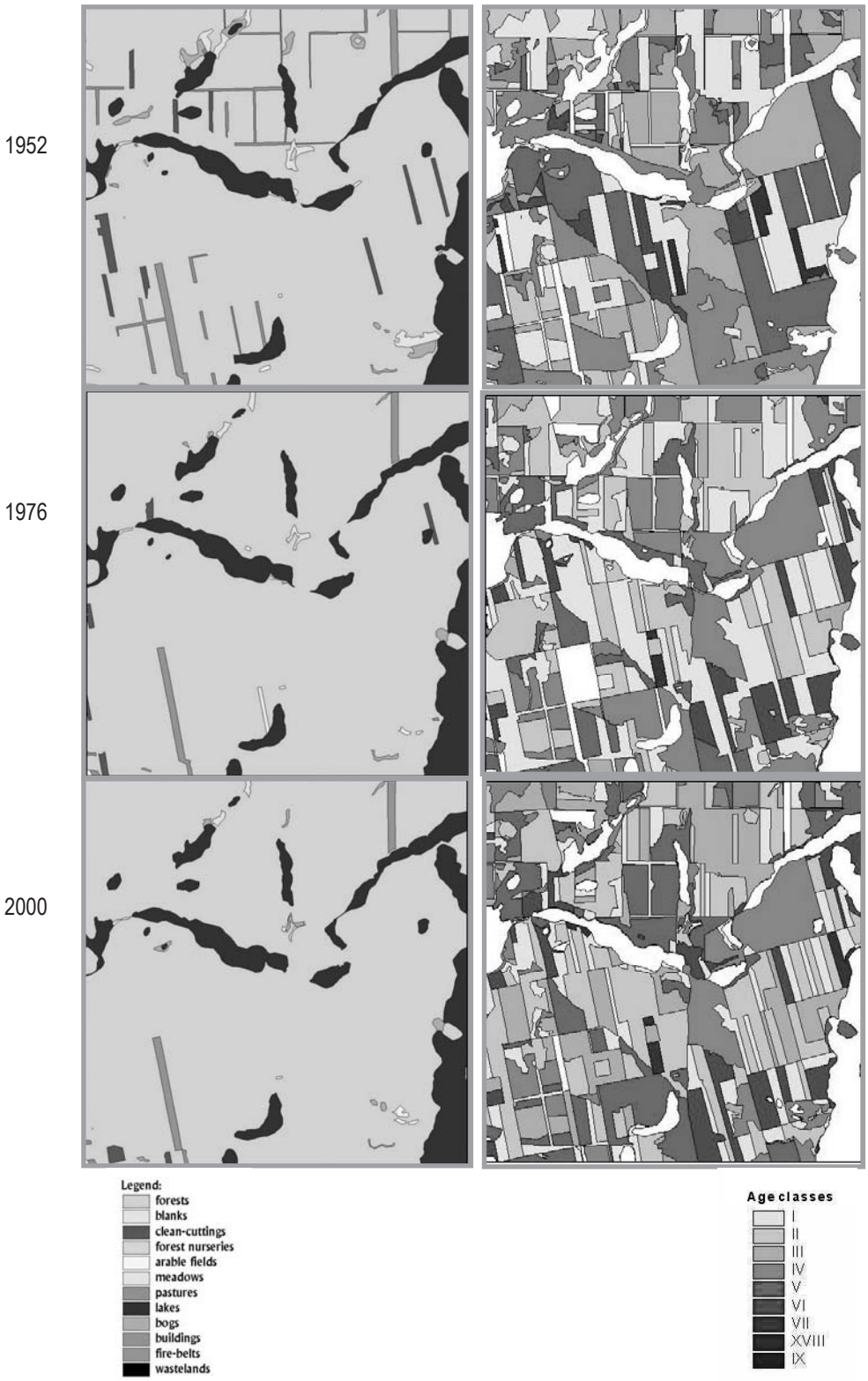


Fig. 2. Forest landscape units (left) and forest age units (right) in 1952-2000

This difference is very clear in the initial period (1952-56) and it gets smaller and smaller during the passage of time.

Shannon variability index is higher for the landscape composed of forest landscape and age units than composed of subsections (fig. 3). For the last landscape unit its value does not exceed 0.8 and it gets smaller, and at the same time for forest age units for the whole analyze period it increases and gains the value of over 1.7. This shows the increase in tree stands age variability in the analyzed time.

## References

Kunz M., 1999. System Informacji Geograficznej (GIS) Zaborskiego Parku Krajobrazowego. [W:] Barcikowski A., Boiński M., Nienartowicz A. (red.). Wielofunkcyjna rola lasu. Ochrona Przyrody-Gospodarka-Edukacja. UMK.

Kunz M., 2005. Wpływ zmian sposobu użytkowania terenu i zasad hodowli lasu na heterogeniczność krajobrazu leśnego (ocena w technologii Systemów Informacji Geograficznej). Praca doktorska. UMK. Wydział BiNoZ. Toruń.

Kunz M., 2006. Standaryzacja danych kartograficznych i teledetekcyjnych do analizy zmian struktury krajobrazu. Annals of Geomatics (Roczniki Geomatyki), IV (3), 119-127.

Kunz M., 2006. Rektyfikacja i standaryzacja historycznych oraz współczesnych danych kartograficznych do analizy zmian pokrycia/użytkowania terenu. [W:] Wołoszyn W. (red.). Problemy Ekologii Krajobrazu XVIII, 97-108.

McGarigal K., Marks B.J., 1995. FRAGSTATS: Spatial Analysis Program for Quantifying Landscape structure. General Technical Report PNW-GTR-351. United States Department of Agriculture Forest Service, Portland, OR.

Mitchell A., 1999. The ESRI Guide to GIS Analysis, Volume I. ESRI Press, Redlands, California.

Petit C.C., Lambin E.F., 2002. Impact of data integration on historical land use/land cover change: comparing historical maps with remote sensing data in the Belgian Ardennes. Landscape Ecology 17, 117-132.

Turner M.G., 1989. Landscape ecology: the effect of pattern on process. Annual Review of Ecology and Systematics 20, 171-197.