THE INFLUENCE OF DIFFERENT INVENTORY TECHNIQUES ON THE GEOMETRICAL ACCURACY OF FOREST GEOGRAPHIC DATA

Ina Bikuvienė
Lithuanian University of Agriculture
E-mail: ina_b@lvmi.lt

Abstract

This paper deals with the evaluation of the geometrical accuracy of Lithuanian forests compartments geographical data that has been developed using different forest inventory techniques. Geo-reference background database GDB10LT was used as the standard for comparisons. 2500 control points on clearly identifiable places – crossroads, dikes’ intersections, etc. – were selected randomly. The main finding was that the maximal positional root mean square error of clearly identifiable objects in forestry geographic data was 16.47 m (12.37 m and 10.87 m for X and Y coordinates respectively). However, such rather big errors refer to the techniques of GIS database development using paper topographic maps as a background for forest maps and manual digitizing. Enhancement of techniques for GIS database development was found to lead to significant increase in geometrical accuracy of the information.

Key words: forest inventory, geographic data, accuracy, geo-reference background.

Introduction

The first cycle of the stand-wise forest inventory using GIS was finished in 2006 in Lithuania. The technologies used for forest inventories were redesigned essentially during the last decade (Fig. 1) – e.g. the GIS database for the first GIS-inventoried Biržai forest enterprise in year 1995 was developed using manual digitizing from the paper topographic map with stand boundaries, transferred onto the maps from aerial photographs using photo-mechanical projectors. Since 1996, orthophotographic maps had been used as a map-base, however the manual digitizers were used to capture the geographic forest inventory data. Special color infrared aerial photography based orthophotos are used since 2002. These orthophotos are created specially for forest inventory and management planning purposes.

Lithuanian Forest Inventory and Management Planning institute introduced technologically new solution since 1999 in development of forest inventory GIS databases. This technology is based on the integration of all cartographical material using GIS and on-screen vectorization of orthophoto maps. The main points of this technology are (Kuliešis and Mozgeris, 2000; Kuliešis, 2002; Palicinas, 2007):

1. Collection of all available information to be used for possibly objective singling-out of the forest inventory units – forest stands (old forest maps, remote sensing data, general GIS databases and maps, measurements, etc);
2. Automatization and integration of all collected information (scanning and geo-referencing of paper maps);
3. On-screen interpretation of new forest compartment boundaries carried-out by forest inventory engineers. The same person will implement the field work and finalization of the compartment level GIS database later;
4. Development of initial version of forest compartment GIS database and printing-out of sketch maps for field surveys;
5. Conventional field survey;
6. Finalization of forest compartment GIS database, development of cartographic elements, calculation of some specific attributes (area), mapping, etc. using conventional techniques.
It is expected that this innovation has enabled to obtain more accurate data than using manual digitizing, however, this has never been tested. Even more, there is practically no information on the geometrical accuracy of geographic data, collected during stand-wise forest inventories. There are some publications on the quality of orthophotos used for inventory (e.g. Mozgeris and Dumbrauskas, 2003), but only theoretic accuracy assumptions are done in the technological descriptions of works. The instruction of forest inventory and management planning activities (Miškotvarkos, 2006) provides just the requirements for GIS data basis accuracies that are expected.

This paper introduces the first results of investigation of the geometrical accuracy of GIS database, created within the frames of Lithuanian stand-wise forest inventory. Different technological solutions to construct the database are compared. The main question to be answered is whether the technological innovations have had positive impacts on the quality of product being developed.

Material and methods

Identical object on two GIS databases – forest compartment GIS database at a scale of 1:10000, developed within the frames of stand-wise forest inventories and Lithuanian georeference background data base GDB10LT – are compared in this study. Five different technological solutions in development of the first database (Fig. 1) are compared in context of positional accuracy. Approximately 2500 of control points are located on both databases (Fig. 2). Clearly identifiable objects on both databases, such as road, dike intersections, sharp corners of forest tracts, etc., have been digitized. (Fig 3.)
Fig. 2 Locations of control points on the Lithuanian forest direktorate: ⊙ - Forest inventory GIS database; ▲ - GDB10LT database

Fig. 3 Example of a control point
Cartesian X and Y coordinates (National coordinate system LKS94 is used) of corresponding control points in regards of both databases are defined. Euclidean distances between points are calculated, as well as the distances in X and Y directions. GDB10LT is considered as the standard. Conventional accuracy estimates, such as bias, location root mean square error, including the ones in X and Y directions, standard deviations are calculated. Standard ArcGIS software is used for capturing the control points and calculating the accuracy estimates.

Results and discussion

Results achieved during this study are summarized in Table 1. One could easily observe rather large single errors to be present, reaching even 69 m, which is completely not acceptable for mapping at a scale of 1:10000. However, these deviations refer to the technologies used in the beginning of forestry GIS era. We can see that the largest root mean square errors (12.37 m and 10.87 m, for X and Y coordinates respectively) are found on a version of forest compartment GIS database, developed using manual digitizing of topographic maps, too. The overall root mean square error here is 16.47 and the bias – 13.2 m. The geometric accuracy of forest compartment GIS database seems to improve steadily with the introduction of more advanced techniques. By the way, introduction of color infrared orthophotos instead of panchromatic ones has resulted in slightly decreased geometrical accuracy of clearly identifiable forest objects. But this is what one could expect – color infrared orthophotos are focused on improvement of forest stand delineation but not the detecting topographic objects, such as rods and dikes. Visibility of topographic objects is obscured by the fact that color infrared aerial photography is acquired in summer season. And, finally, the geometrical accuracy of forest inventory oriented color infrared orthophotos is somewhat less than the one of panchromatic orthophotos (Mozgeris and Dumbrauskas, 2003).

Table 1. Geometrical accuracy of selected objects on forest compartments GIS database at a scale of 1:10000 (for all variant n=500)

<table>
<thead>
<tr>
<th>Technological variant of GIS database</th>
<th>X coordinate</th>
<th>Y coordinate</th>
<th>Distance between points</th>
</tr>
</thead>
<tbody>
<tr>
<td>I* - manual digitizing of paper topographic maps at a scale 1:10000 with the boundaries of forest compartments transferred from interpreted aerial photos</td>
<td>-45.75</td>
<td>68.69</td>
<td>-1.61</td>
</tr>
<tr>
<td>II* - manual digitizing of hardcopy outputs of panchromatic orthophotos at a scale of 1:10000 with the boundaries of forest compartments transferred from copies of interpreted orthophotos</td>
<td>-37.69</td>
<td>62.62</td>
<td>0.39</td>
</tr>
<tr>
<td>III* - on-screen vectorization of panchromatic orthophotos, assisted with numerous auxiliary information, including maps from previous forest inventories</td>
<td>-40.51</td>
<td>26.90</td>
<td>0.07</td>
</tr>
<tr>
<td>IV* - on-screen vectorization of color infrared orthophotos, assisted with numerous auxiliary information, including maps from previous forest inventories and georeference GIS databases</td>
<td>-30.4</td>
<td>30.06</td>
<td>-0.65</td>
</tr>
<tr>
<td>V*</td>
<td>-18.49</td>
<td>24.09</td>
<td>-0.07</td>
</tr>
</tbody>
</table>

RMSE** - root mean square errors
The results achieved may lead to a conclusion that forest compartments GIS databases, created a decade ago, fail to meet the requirements of mapping at a scale 1:10000. But all technological innovations, which took place later, have improved the geometrical accuracies well. For sure, we do not take into account other advantages of the new methods, like improved accuracies in stand boundaries, increased productivity, etc.

**Conclusions**

1. The geometrical accuracy of forest compartment GIS database at a scale 1:10000 developed a decade ago manually digitizing the paper topographic maps fails to meet the requirements for mapping at a 1:10000 scale – the root mean square error of well defined objects is 16.47 m.

2. Technological innovations in development of forest inventory GIS databases have had positive influence on the geometrical accuracy of well defined geographic objects.

3. The introduction of on-screen vectorization techniques has reduced the errors below the level required for mapping at a scale of 1:10000.

**References**


