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Photointrpretation of the color infrared aerial photographs as a tool for the city tree cadastre establishment

Introduction

Trees in cities live in conditions which differ vastly from conditions in their natural habitats, a fact that has a serious impact on their lifespan. The longer the trees in cities live, the more valuable they are. However, they are subjected to a variety of unfavourable influences caused mainly by human activities (Kušan et al, 1999). Like other living organisms, trees, too, react to changes in their life space. These changes are contained in the ecological conditions in cities: air and soil pollution, changes in the water regime, increased temperature, less humidity in the summer, and frequent mechanical damage – trimming branches to protect electrical or telephone lines or retain the desired crown shape.
Such poor conditions give rise to physiological changes in a tree which are not noticeable immediately, but are only detected when irreversible changes set in, such as bud dieback, shoot decline on crown edges and partial or complete desiccation and loss of assimilative organs. A weakened tree is more susceptible to diseases and pest attacks; thus, Houston (1985) and Novak and McBride (1992) have established a positive correlation between the strength of an attack and the weakening of a tree's biological potential.

The estimation of a tree's health and damage status in urban environments has become indispensable for proper planning in urban forestry. One of the most important tasks is to determine the null condition of a tree. Research may be conducted in two ways: terrestrially (field observation) and/or by applying remote sensing methods, of which infrared colour (ICK) aerial photograph interpretation is particularly practical.

The main advantage of ICK aerial photographs is the possibility of detecting physiological changes in a plant organism much earlier, before they are visible to the human eye (Lillesand and Kiefer 1974).

This paper is aimed at assessing the health of trees in the centre of the City of Zagreb, a part with the most unfavourable life conditions for trees, by using ICK aerial photographs. The obtained data will be integrated into a comprehensive geographical information system (GIS). A database will be constructed for each individual tree; in other words, a tree cadastre will be set up.

Field of research

Research will encompass the central part of the City of Zagreb surrounded with parks in the Green or Lenuci's Horseshoe (Figure 1).

Methods of work

Aerial photographs of the central part of the City of Zagreb were taken from the plane Piper – Aztec, using the camera LEICA RC20 – 15/4 UAGA and CIR film KODAK Aerochrome Infrared 2443. Photographic coverage was made in two directions: east – west and west – east. The photographs were obtained in stereopairs with longitudinal overlaps of 60% and transversal ones of 30%. Consequently, stereopairs were visually interpreted with a Carl Zeiss Jena stereoscope with a zoom of 8x. Photographs 1219, 1220, 1221 and 1222 on an approximate scale 1:5,000 were used for the study area.

Tree damage was assessed for three different positions and conditions of tree growth (trees within building blocks, trees in parks and trees in streets). A total of 1,571 trees were processed, of which 866 were in parks, 242 in streets and 463 among buildings. Forty-four different tree species were identified. The degree of damage, tree species and tree position were determined on the CIR aerial photograph for each tree.

To represent the acquired results spatially, all interpreted trees were identified and mapped on an ortophoto of the central part of the City of Zagreb at a scale 1:5,000 using the programme ArcView 3.3. The X, Y coordinate was attributed to each tree and the tree cadastre was established.

A GIS makes it possible to apply protective measures to the affected trees more reliably and at lower cost. Trees with a damage degree of 3a are particularly interesting in practice, because damage to these trees is so high that protective measures are indispensable (trimming, fertilizing and similar). The goal is to convert trees from the 3a damage degree into a lower one. Trees with the damage degree of 3a mostly pass into the 4^{th} degree; therefore, in order to undertake timely replacement planting, it is particularly important to obtain information on the position and number of such trees. The practical application of the damage degree assessment method used in this paper lies in the possibility of predicting the number, the species and the future location of trees to be raised for purposes of replacing severely damaged and dry trees (Samardžija 2000).

Results and discussion

According to research, trees growing in streets had the least favourable position, whereas trees within blocks of buildings had the most favourable position (Figure 2).

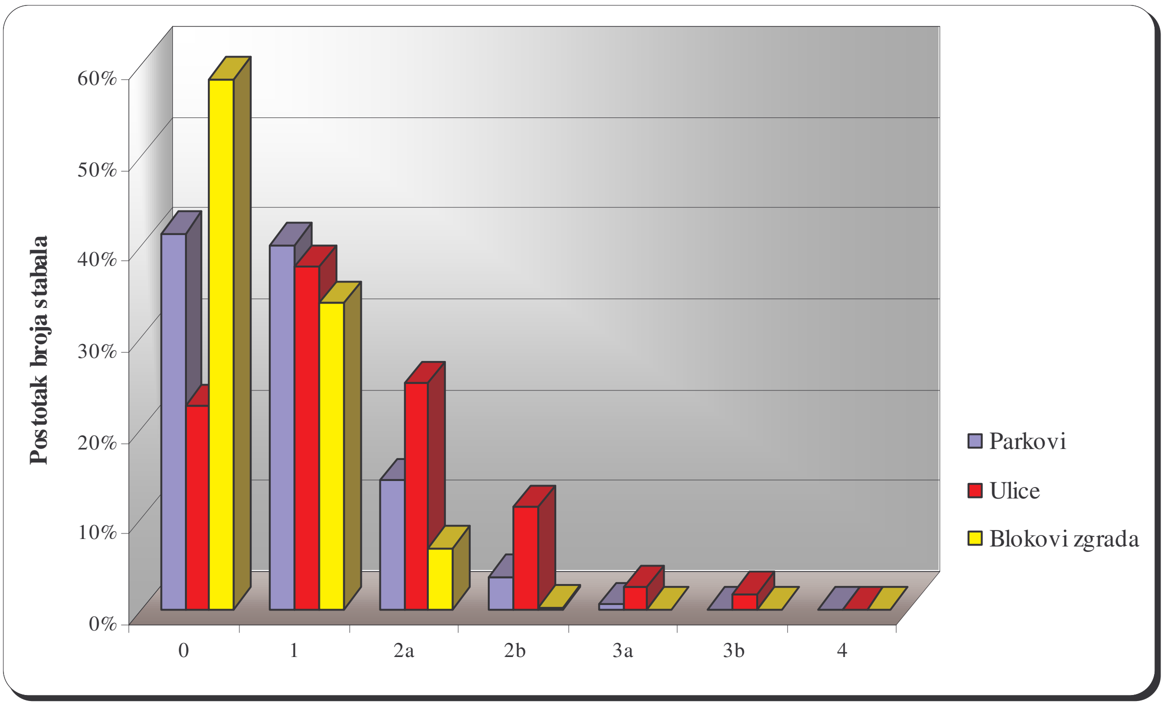

Figure 2 Percentage share of the number of trees by damage degree with regard to tree position

The poorer condition of trees in streets as opposed to trees within building blocks and parks is the result of planting methods (limited planting sites) and "exposure" to high atmospheric pollution caused primarily by combustion products (solid and liquid fuels).

By far the heaviest traffic passes through the streets commonly known as the "Green Wave", with about 72,269 motor vehicles per day (City of Zagreb Traffic Study, April 1999, data collected on 31 March, 1998).

Physiologically weakened trees are affected not only by their living conditions but also by phytopathological and/or entomological pests, which additionally afflict their health.
Consequently, the issue should be viewed in its full complexity, with an expert team involved in detailed research.

Two new layers were obtained by mapping the processed trees in the orthophoto:

1) spatial distribution according to the tree damage degree (Figure 3)
2) spatial distribution of tree species in the study area (Figure 4).

An attribute database was associated with each layer. All the acquired data within the GIS were geocoded and stored as separate layers, allowing undisturbed handling.

The cadastre of each tree provides the following data:

1) identification number
2) tree position
3) tree species – scientific (Latin) name
4) tree species – Croatian name
5) degree of tree damage
6) coordinates X,Y

The database may also be used by other users. It is possible to make any changes in the existing data or add new data (Pernar 1997).

Figure 3. Spatial distribution according to the tree damage degree

Figure 4. Spatial distribution of tree species in the study area

Conclusion

The null condition of trees in CIR aerial photographs was determined for a dual purpose: a) to link the existing field information and data from aerial photograph interpretation into a comprehensive information source and b) to generate new information to be used as a planning platform with the help of geographic information system (GIS) methods in urban environments.

The set goal, the conducted research and the obtained results allow for the following conclusions:

1) Future conditions of green plants in urban environments may be predicted by monitoring the acquired results over a period of time, which has a very positive effect on planning and managing such areas.
2) The results are spatially defined and as such available for other users. It is possible to make changes in the existing data or add new data, such as breast diameter, tree age, flowering time, pedological soil properties, vegetation period, phytopathological diseases and others.
3) A GIS is a useful means of integrating data from different sources, on condition that all data are georeferenced.
4) Recording and interpreting trees in the study area makes it possible to observe the condition and trends in the changing health of trees, as well as the quantitative and qualitative damage intensity that indicates the disturbed conditions in the city. This allows for adequate planning of green areas in the city, ranging from the choice of species to proper care undertaken for the permanent maintenance of green areas.

This paper is intended to acquaint urban horticultural experts with the possibilities of remote sensing methods and GIS in establishing a comprehensive tree cadastre in urban environments.

Without an insight into the spatial distribution of trees, it is not possible to fully utilise all the attributes that constitute a green entity.

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Abstract

The proper planning and managament of the city trees, in parks, tree rows and alleys should be based on the good and updated information about every tree. The most convenient way for the gathering information about spatial distribution and conditions of trees in urban areas are photointerpretation of color infrared (CIR) aerial photographs. They are also commonly used for monitoring urban trees and establishing their cadastre.

The aim of this research was to establish the tree cadastre for the part of the Zagreb center. For that purpose the orthophoto, prepared from the black and white aerial photographs was used, as well as color infrared aerial photographs. The information about species, trees condition and their position were checked by field investigation. The data were than incorporated in established GIS of trees as a base for tree cadastre.

Keywords: color infrared (CIR) aerial photographs, photointerpretation, orthophoto, tree cadastre, geographical information system (GIS)