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Deforestation as a primary cause of the recent flood peaks in the Pannonian Basin? - Counter-evidences from the Upper-Tisza catchment

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Introduction

After the regulation of the Tisza River (Pannonian Basin, Hungary), the water level of the preceeding floods shows a continuous rise. There is a long debate on the role of the different environmental and human factors on this rise: besides the classic cause, the decrease of the river channel conductivity due to the narrower floodway between the dykes, the deforestation of the upper catchment is often cited, although not evidenced.

It is obvious that after the deforestation of a river catchment – primarily in the upspring area – the water of the heavy rains reaches much quicker the trunk stream, causing significantly higher floods than it would occur with undamaged forests (recently eg. Mount *et al.*, 2005). In our work the forest cover changes on the Upper Tisza catchment are analysed using older forestry and topographic maps and present medium and low resolution satellite imagery as well. Hydraulic data of the upspring reaches is also analyzed in order to draw conclusions about the effects of the forest cover ratio on the flood characteristics.

The upspring part of the Tisza drainage system is analyzed; this part is connected to the Tisza River above the estuary of the Szamos River at Vásárosnamény. The extents of the study area is about 12600 km^2. The area is divided into nine sub-catchments, analyzed here systematically.

The average annual precipitation of the whole study area is 900-1000 millimeters (Réthly, 1947). The maximum annual precipitation occurs on the Hoverla-Svidovec zone (1600-2000 millimeters), higher than in the Radnai Mts. (1200-1600 millimeters). In the higher-altitude zones the significant part of the annual precipitation occurs in snow, the main snowmelt is in April. Heavy, sometimes catastrophic showers produce the precipitation maximum in June but they can occur at any time from March to November causing flood peaks on the upspring reaches and the whole upper Tisza river section, as in 1947, 1998 and 2001. Early, warm spring showers, melting the snow cover quickly, could produce the most catastrophic floods (Gauzer & Bartha, 2001).

The natural vegetation cover is represented almost fully by the forests. Conifer forests cover the higher ridges (except their top levels) above 1100-1200 meters (Medzihradszky, 1996). The less high mountains are covered by beech (above 4-500 meters), the hills, the studied part of the Great Hungarian Plain and also the bottom of the trunk valley by elm forests. The upper limit of the forest zone is about 1800 meters; subalpine meadows and pastures dominate above this altitude.

Data and methods

The extents of the forests has been calculated on the base of older maps, such as

- The 'Map of all forests of the Hungarian state' by chief forest master Albert Bedő (1896; henceforth referred to as 'Bedő-map'), scale of 1:1 million, depicting not only the forest-covered areas but indicating also the dominative tree species (*Pinus*, *Fagus*, *Quercus*) of the different disctricts. To integrate this map to a geographic information system (GIS), it has been supposed that its projection is the Budapest-centered stereographic one. Using this assumption, the fitting of the map content has been made with significant but tolerable horizontal error of about one kilometer. For the details of the used fitting method to a different map and projection, see Timár *et al.* (2003a).

- Sheets of the 1:25000 scale military survey of Hungary, surveyed in the beginning of the 20th century, re-ambulated between 1940-44 can be used for more precise mapping of the forest extents. The GIS-integration of these sheets is described in details by Timár *et al.* (2003b).

- The 1:100000 scale Russian military topographic maps show the forest cover changes after 1947. Their GIS-integration can be easily made using their Russian Gauss-Krüger coordinates.

Besides the maps, ten-year-old, now freely distributed Landsat TM satellite images (7 channels, 30-meter physical horizontal resolution have been used along with own-received NOAA-AVHRR satellite data (5 channels, 1-km horizontal resolution; Ferencz et al., 2003). Their GIS-integration is based on the Space Oblique Mercator projection. After georeferencing all the maps and satellite imagery, these data have been converted into an equal-area projection. For the combination of the forest extents data with the elevation, the GTOPO-30 and SRTM global elevation models have been used.

Concerning the estimation of the forest extents on the Bedő-map, different colors sign the different forest types. These color zones have been identified by simple image processing selection methods and corrected manually where the map texts and signs cover them. It has to be underlined that the reliability of this map is somewhat questionable – but there is no better data source from that time, meanwhile forest statistics data from the end of the 19th century supports well our estimations. The total historical forest cover data for the complete study area (52%) occurred to be equal to the figure provided by Bogdánfy (1906).

Using the satellite images, a standard classification method, the supervised (minimum distance) classification has been applied. The reliability was marred by the fact that we have no real ground truth data for training sites. The training sites for the deciduous and coniferous forests have been assigned using the false color composite. Standard vegetation indices have been tried to decrease the shadow effect, but the robust classification using the original images and large training sites containing light and shadow too, led to better results. In case of the low resolution AVHRR data, the best, cloud-free image contains snow that covers mainly the mountaintops with no forests but a few percents of error can be caused by this effect, too.

Results and conclusions

The results are the following: the total forest cover ratio of the Upper Tisza catchment has fallen from 52% (1896) to 48% (2002). This means an 8% decrease of the forested area. Although it seems a high figure, it should be underlined that the decrease occured neither on the higher areas nor on the steep slopes of the catchment. Concerning the nine sub-catchments, four of them show decrease while on the other five ones, no significant forest cover changes have been detected.

The detected small decrease of the forest cover does not support the concept that the increased discharge fluctuations and the catastrophic upstream floods as the ones of 1998 and 2001 are because of a major deforestation process. As the deforestation seems to be limited to the lower parts of the sub-catchments and the most sensible woods on the steep slopes are almost untouched, it seems to be an evidence that the real cause of the mentioned floods is mainly the climate change (with the increase of the weather – and precipitation – variability) while the deforestation plays only a secondary role.

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