Investigating sensitivity in a Central European landscape

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Studies of precipitation and biomass production in the Carpathian Basin indicate warmer summers in the next century.

In many parts of the world, global climate change strengthened by human activities has resulted in severe landscape changes. With rapidly changing environmental conditions and climate elements, many studies have focused on the causes and consequences of climate change. For at least 30 years, remote sensing has been used for the continuous monitoring of the Earth’s surface, providing opportunities for long-term evaluation of vegetation changes.

In our previous research, we focused on indicators that show and qualify processes such as vegetation, groundwater, and soil on the Great Hungarian Plain. We identified the connections between climate change (precipitation decrease), groundwater-table sinking, soil alteration, vegetation, and landscape changes in the Danube-Tisza Interfluve. Using Moderate Resolution Imaging Spectroradiometer (MODIS) vegetation indices (EVI or enhanced vegetation index and NDVI or normalized difference vegetation index), we analyzed the relationship between biomass and precipitation, which is one of the most important climate elements, over the Illancs microregion in Hungary (see Figure 1). It is located on the highest part of the Danube-Tisza Interfluve, which has been highly affected by groundwater-table sinking in the last decades. The reasons for this decrease are mainly the precipitation shortage caused by climate change and, to a much smaller extent, anthropogenic effects.

We investigated biomass production of conifer (pine, Pinus sylvestris) and deciduous (locust, Robinia pseudo-acacia) trees over a 10-year-period (2000–2009). We defined sequential periods for the precipitation sums in all possible combinations from

Figure 1. Location of the examined areas and the groundwater-table decrease on the Danube–Tisza Interfluve from the 1970s. This figure was published previously.1

Continued on next page
September in one year until months of the vegetation period the next year (such as September–April, September–May, September–June, November–April, November–May, and November–June). We analyzed their relation to the calculated biomass. To determine the appropriateness of vegetation indices for analyzing the climate sensitivity of various landscapes, we selected two control sites where vegetation is not solely dependent on rainfall variability, but also on other sources of water.

Based on vegetation index values of MODIS 16-day-composite images, we determined the close relation between forest biomass production and precipitation. In the forests that were studied, the annual distribution of precipitation proved to be an important factor. Furthermore, biomass produced by forests is influenced by precipitation over a short interval such as March–June (see Figure 2). When the control site on the edge of the Sandland had less groundwater-decrease, the close relation between biomass activity and precipitation can be defined (from December) because of nearby groundwater. In the other control site in the Danube valley, we detected no relation between the investigated parameters. In this case, the regular floods and continuous connection with the riverbed through the sandy, pebbly silt assure sufficient water for the trees.

Our research showed that water became a limiting factor in this landscape during the last 30–40 years. This bottleneck provides opportunities for detailed evaluation of biomass from the perspective of precipitation. Although heterogenic landcover and small resolution satellite data made the evaluation more difficult, the connection between environmental factors could clearly be identified.

In summary, we have discovered a narrow precipitation interval that shows the importance of water in the climate-sensitive Illancs microregion, which was predicted to be a critical area by the United Nations Food and Agriculture Organization. The climate scenarios for the Carpathian Basin predict warmer summers and a further precipitation decrease in the next century, which may intensify aridification. In climate-sensitive regions such as the one we examined, wildlife and humans will need to find ways to adapt to changing moisture availability. The results of these changing circumstances are clear, potentially leading to fewer wetlands, less water-dependent flora and bird life, abandonment of areas where water is severely lacking, and intrusion of invasive species. We are currently extending our measurements to other forest areas and further climate parameters. This process is expected to show the spatial extent of further sensitive areas in the Great Hungarian Plain.

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References