Judith Stagl

Ecosystems' exposure to climate change – Modeling as support for nature conservation management

SUMMARY

Climate change is projected to alter environmental niches for biota and exacerbate the effects of anthropogenic stress on biodiversity and ecosystems. Climatic changes will also affect river flow regimes as outlined in the natural flow paradigm for river conservation and restoration and, hence, the composition of riverine and riparian habitats. Thus, climate change raises new challenges for nature conservation management, especially in protected areas, which are the current core strategic areas for biodiversity management. Projecting the level of exposure of biodiversity to climatic changes is an integral part of assessing potential future risks and selecting appropriate adaptation strategies. The Danube river catchment is the most species-rich river basin in Europe and for many parts of the basin, little is known about the potential climate change impacts on ecology and hydrology so far. This thesis aims to provide insights into the potential future impacts of climate change on ecosystems' exposure, particularly in the Danube river catchment.

This thesis is guided by three research questions:

- How will climate change manifest in the Danube river basin under different global warming scenarios, and which direct impacts on ecosystems' exposure can be quantified?
- How will climate change impact the water cycle in the basin, and what are the impacts of climate change on ecologically relevant river flow characteristics and water availability?
- What are the implications of the results for conservation management in protected areas?

The impacts on ecosystems' exposure to climate change were quantified through the use of ecologically relevant hydro-climatic indicators, which were selected in a cooperative process with practitioners in order to account for the scientific limitations of climate (impact) modeling and to reflect the specific "user needs" of nature conservation planning at the same time. First, an ensemble of regional climate projections was evaluated by means of bio-climatic indicators. Second, a process-based, semi-distributed watershed model was set up, validated and applied for the entire Danube river catchment. By using the hydrological model coupled with climate scenario data, the potential impacts on regional water availability and river runoff dynamics were projected for different levels of global warming. To gain insight into the impacts of climate change on riverine ecosystems, suitable eco-hydrological indicators were selected to link hydrological features to ecological processes in a descriptive way. Until the end of the 21st century, the results of this thesis robustly exhibit increasing surface temperatures, including a prolongation of the climatic growing season length as well as changes in precipitation patterns and in the climatic water balance. Furthermore, the findings show that, in the next 30 years, climate change is expected to cause moderate to severe river flow alterations in the Danube River and its main tributaries. The findings reveal a general trend towards a decrease in summer runoff for the whole Danube basin as well as in autumn runoff for the Middle and Lower Danube basins, aggravating the existing low flow periods. The projected impacts strongly accelerate if global mean temperatures rise more than 2°C compared to pre-industrial times, and may shift towards environmental niches to which native biota may be poorly adjusted. This thesis includes the first climate impact modeling studies with a regional hydrological model covering the entire Danube river basin and, hence, the Danube River until its delta. The findings of this thesis particularly help to understand the possible impacts of climate change among nature conservationists and stakeholders and serve as a basis to create robust adaptation strategies for protected areas in the Danube Region.