IMPACT OF CLIMATE CHANGE ON RECREATIONAL URBAN FORESTS

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Abstract
The paper presents the results of a case study that was developed as a basis for decision-making processes in the context of the impacts of global climate change. It deals with a very important part of the urban environment, namely urban forests, which on the one hand are one of the main objects to mitigate the impacts of climate change (in the landscape and urban space), but are themselves at risk from the impacts of climate change in the first place. When planning measures in suburban forests, these two facts must always be addressed in parallel, so it is necessary to consider both measures to mitigate the effects of climate change on the forest complex and its use to mitigate the effects of climate change in its vicinity. The case study is addressed on the territory of the town of Mladá Boleslav. In addition, the forest park in question is the most important natural object in the municipality's intravilan in terms of its size and functions.

Key words: SCS-CN method, Rational method, runoff conditions

Introduction

The city parks represent the phenomena in the city urban structure. It's necessary for the good function of the city organism, which is a manmade space without any connection to the nature (Kulhankova, 2016). The service road network is a prerequisite for park access for citizens and management (Hrůza, 2014). Urban trees provide many ecosystem services to cities: alleviating the urban heat island effect, absorbing stormwater runoff, and contributing to residents' social and psychological well-being (Sonti, 2019). The construction of urban green spaces usually leads to the replacement of native species by alien species, resulting in the homogenization of species composition across cities in different climatic zones (Chen et al., 2021).
The case study is the basis for the preparation of the adaptation strategy of the city of Mladá Boleslav. Its purpose is to analyze the hydrological regime of Štěpánka Forest Park, and in the context of the current state of the site, especially in the context of tree communities that currently occur in the site and assess how this state would change in significant impacts of climate change (drought).

Materials and methods

The site of interest, Štěpánka Park, is located in the south-eastern part of the town of Mladá Boleslav, in the Central Bohemia Region (Czech Republic). The altitude ranges from 204 to 238 m above sea level and the total area is 31.02 ha. The locality falls into the climatic warm region, which is characterized by warm and dry summers and short and drier winters. The average annual air temperature is around 8˚C and the annual average precipitation is around 550-700 mm.
The Klenice River, a left-side tributary of the Jizera River, flows through the site at km 37.00. It is an extensive complex of vegetation, playgrounds and sports activities. The park was founded in 1881, and was revitalized in 2014. The subject of revitalization and reconstruction were paths, public lighting, furniture (benches, waste bins, bicycle stands and information boards), small river catwalk and gradings.
Although the site is not located on holdings intended for forest functions, it has the character of a mature forest stand and is thus still treated in this way. The field survey was focused mainly on the evaluation of the existing vegetation and runoff conditions at the site. Based on the field survey, it was decided that the calculation of the outflow from the site, resp. water retention at the site for two scenarios, for the current state and for the state of deforestation at the site, which would theoretically arise as a result of the cessation of forest functions of the site in connection with the impacts of global climate change.
The characteristics of runoff and water retention at the site for the current state and for possible deforestation of this part of the park were compared. This is a part of the park with steep wooded slopes, where significant changes in runoff conditions (water balance parameters) due to deforestation can be expected.
Hydrological modeling using a rational method of runoff calculation (UNMZ, 2012, TP 83) and DES-RAIN short rain intensity model (Kovář and Vaššová, 2011), was performed on interpolated data of a

digital relief model DMR 5G for the Czech Republic. The analysis and formulation of the target state of the vegetation area and the technological basis for planning the implementation of its restoration was prepared using GIS and CAD software.

Results

The threat of drought in the locality is mainly due to the lack of available water in the rhizosphere of woody plants forming the forest communities of the locality. The potential water shortage in the rhizosphere of woody plants is a function of two variables, namely the location of the locality in one of the warmest climatic regions of the Czech Republic and the progress of global change (increasing average annual temperature). In addition, the occurrence of some species or genera of woody plants, which are already on the border of their ecological optimum (especially conifers of the genera *Picea*, *Abies*, *Larix*, or the family *Cupressaceae*), or are in the phase of senescent maturity, is added as a consequent effect. with significantly limited ability to adapt to changing climatic conditions. If due attention is not paid to the care of the stands, then the potential risk of drought in the park in the medium term (approximately 30 years) is relatively significant. With adequate care, this threat can be reduced to a minimum in the context of current predictions of the development of global change parameters.

For the purpose of quantifying the change in the type of surface due to the simulated loss of forest cover, a separate forest segment on the left bank of the Klenice was distinguished. The area of the segment is 16.59 ha, the representation of forest stands is about 95%, the rest is roads and a negligible area is the built-up area. The mean value of the segment runoff coefficient at the current state of the forest stand is 0.11 (on the basis of the analysis of land use and runoff coefficient).

The simulation of the change in precipitation-runoff conditions based on the change in the condition of the forest stand is based on the assumption of a change in the value of the runoff coefficient. The simulation evaluates the condition of the site after the death of the forest stand, thanks to which such areas are more susceptible to surface runoff. The mean value of the runoff coefficient of the simulated state segment reaches the values 0.30 (Fig. 1).

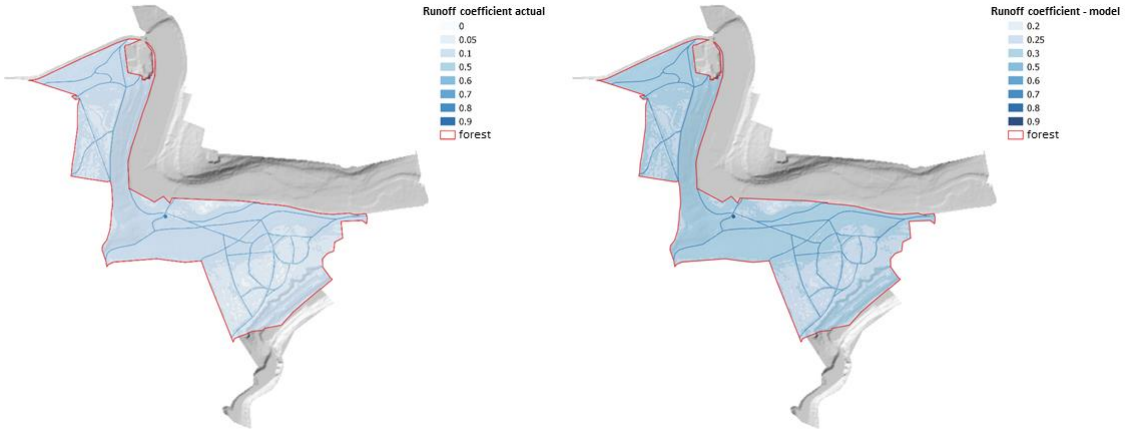

Fig. 1: The change of runoff coefficient due to potential deforestation

The results show that despite the relatively sloping terrain of the locality, the current forest stand has a high retention capacity (it retains about 90% of precipitation). This efficiency is, of course, reflected in absolute form, especially in extreme rainfall of lower intensities (longer durations) and higher probability of occurrence. Specific runoff in given hydrological situations can then be considered as a unit (hectare) quantity usable, for example, in simplified calculations of partial deforestation.

Graphically expressed ability of retention of rainwater of forest communities of the park in the current state and in the state after its potential destruction is presented in Fig. 2. The retention coefficient, so the closer it is to 1.0, the higher the potential retention. It is evident that the destruction of forest communities in the locality would reduce the retention by about one third.

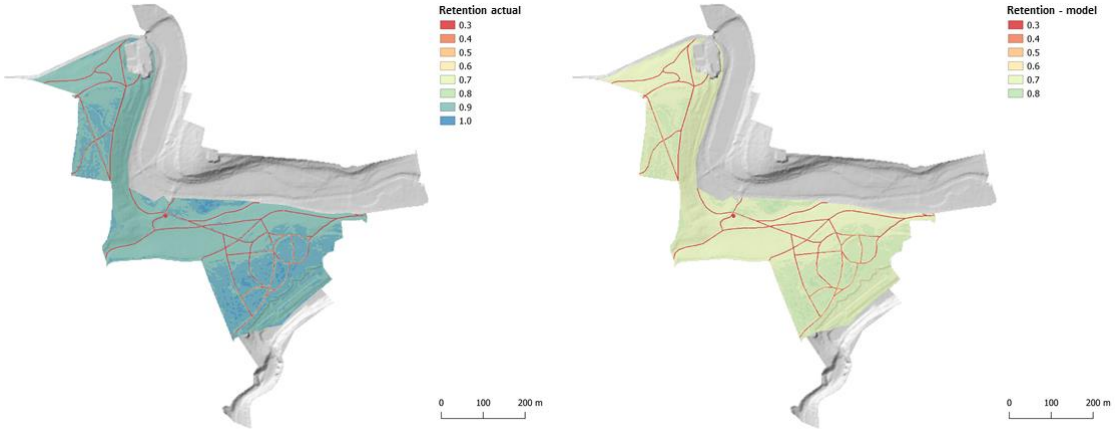

Fig. 2: The retention – current state and the model

Discussion

The park is of considerable social importance (recreational, social, historical, educational and aesthetic value) as well as important ecological functions that were not evaluated in this study (positive impact on the climate of the adjacent district, reduction of dust and noise, zoo and phytobiotic functions). For important quantifiable functions, which park, resp. especially its forest communities, significantly positively affects its surroundings, water retention can be marked (and thus ensuring quantitatively balanced outflows from the site and subsequently flows in the recipient Klenice) and soil erosion control. The related indicator is runoff coefficient with related rain analysis and water balance (UNMZ, 2012; Vaššová and Kovář, 2011). Potential deforestation would mean a triple value of runoff coefficient. This means that the hydrological efficiency of the site (in the sense of rainwater retention) will be reduced to about 70% in its originally forested part. The consequence of this phenomenon will be, in addition to the increase of specific runoff from the site in less extreme hydrological situations, approximately three times the peak flows in extreme hydrological situations than are potentially in the current state, i.e. in a fully functional forest stand at the site.

Basic management measures were formulated on the basis of a species-diverse stand composition since we can determine two characteristic categories of vegetation. Compared with natural forests, the tree species diversity of urban green spaces is greatly affected by human activities (Chen, 2021). First, there are stands of autochthonous species with an admixture of commercial woody plants and species, which can be described as invasive, however, they were introduced into the stands probably for economic reasons. The autochthonous species are represented by mainly oak, linden, maple, hornbeam, ash, beech, less alder and tree willows (*Quercus petraea, Tilia cordata, Acer platanoides, Carpinus betulus, Fraxinus excelsior, Fagus sylvatica, Alnus glutinosa, Salix alba*). The larch and pine (*Larix decidua, Pinus syslvestris*) represent commercial species. The spruce (*Picea abies*) was probably also found in the locality, but it was already removed from the stands after its death due to drought. The locust (*Robinia pseudoacacia*) is an invasive species, also Douglas fir (*Pseudotsuga menziesii*) can be found.

The other category of species are park trees, the function of which is primarily compositional and aesthetic. It is possible to include some of the above-mentioned species (fir, Douglas fir), but the red yew, various species of exotic firs and pines and representatives of the cypress family are especially important (Kupec et al., 2022).

Due to their ecological setting, the species of natural tree composition are still able to cope with the changed conditions (increasing temperature, changed rainfall distribution and reduced water reserves in the soil). Habitual symptoms of drought damage can be observed in older (resistant) individuals rather than in younger (resilient) individuals.

The cultivation of skeletal forest stands (except for park and aesthetic species in solitary or group plantings and compositions) corresponding in their ecological constitution to the original forest stands ensures the sustainable existence of forest stands. The goal of the spatial structure of the forest is the involved vegetation with lower density (fewer individuals in the area) and shorter forest restoration (rotation).

These aspects of skeletal forestry ensure its sustainability, in particular the sustainable water operation of trees in the context of lower water resources in the rhizosphere and the higher ability of relatively younger individuals to adapt to changing habitat conditions – replacing the resistant type of stress resistance with a resilient type (Kupec et al., 2022).

An important aspect is the good condition of the forest soil, resp. the state of humus as an essential attribute of retention and subsequent usability of rainwater by forest stands. During the restoration and maintenance of forest stands in the locality, it is necessary to avoid repeated movements of mechanization across the area and, in particular, to reduce the sliding and pulling of wood during the implementation of restoration or remediation timber harvest. It is appropriate to implement these methods of timber extraction only in slopes of up to 10% and to consistently use the existing road network for the movement of technology. The renewal of the forest stand of the park should be essentially continuous, since the simplified phasing is not desirable for maintaining forest cover at the site.

Conclusion

The study is the basis for the preparation of the adaptation strategy of the city of Mladá Boleslav. Its purpose is to analyze the hydrological regime of the Štěpánka forest park, especially in the context of tree communities that currently occur in the locality. The aim was to assess how this would change in the event of significant impacts of climate change (drought). Based on the analytical and synthetic part, management recommendations were set.

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Souhrn

Studie je podkladem pro přípravu adaptační strategie města Mladá Boleslav. Jejím smyslem je analyzovat hydrologický režim lesoparku Štěpánka, a to zejména v kontextu společenstev dřevin, která se na lokalitě v současnosti vyskytují. Cílem bylo posoudit, jak by se tento stav změnil v případě významných dopadů projevů klimatické změny (sucha).

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