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# PERSPECTIVES OF WATER MANAGEMENT IN A PROTECTED AREA OF THE KAMPINOS NATIONAL PARK

## INTRODUCTION

The intensive use of land and water in the past has caused substantial changes in the natural environment. The unwanted environmental effect of the human activity became evident. Humans have altered river corridors and lowland areas by over-engineering, pollution and over-abstraction. Land drainage schemes, construction of embankments and weirs, rivers regulations and expansion of agriculture modified considerable natural hydrological and ecological conditions. As a result natural ecosystems became increasingly threatened and restricted to relatively small remnant areas in a changing environment. In a such situation it has appeared a growing concern about importance of maintaining ecological processes throughout environment protection and restoration. In the process of sustaining natural and quasi-natural environments protected areas play a very special role which involves the necessity of innovative approaches to the monitoring and management of natural resources, including water resources. Effective water management practices are essential especially for the water-related ecosystems. However the answer to the question how to conduct restoration of damaged environments requires special knowledge how to manipulate environmental processes to achieve long-term aim of putting environments back to a better state.

This research centers on practical approaches to the water management in a protected area of the Kampinos National Park (KNP) situated in the central Poland on the Mazovian Lowland. The KNP is located at the confluence of major river valleys of the Vistula, the Bug and the Narew. Besides, it is a nodal element of the large-space system of protected areas in the central Poland and classified as international core area (*Strategia*..., 1998). As connected through a system of ecological corridors with all national areas of particular significance for the conservation and restoration of rare species, it is ranked as the environmental focal point of the special importance. The area has a status of the UNESCO MAB Biosphere Reserve. In the area valuable wetland ecosystems are present. They have been influenced in the past by land improvement practices, before the area gained the protection status.

The purpose of this research is to present selected aspects of water management from historic and contemporary perspectives, as referred to the ecological targets. Hydrological conditions are evaluated by precipitation income, groundwater depletion rate and linked to the soil water resources. The paper presents development of operational method for quantitative assessment of the impact of hydrological conditions on the development of soil water deficits. The research is a step towards managing soil water resources and re-development of vegetation.

## HISTORIC PERSPECTIVE

In the area of KNP first substantial human interference to the natural environment took place at the end of XIX century. In that time large areas of forests have been cut down. Drainage works were conducted at the beginning of XX century, in twenties. Construction of embankments along the Vistula river in fifties of the XX century had reduced the Kampinos floodplain inundation. For the past years attempts have been made to shape the area in such a manner that it meets requirements of agriculture and flood protection. The natural forested landscape has made a room for open cultural landscape.

Natural inundations of the Kampinos caused in the past by high levels of Vistula river that constitutes the north boundary of the area are no longer natural source of water income. Thus the only natural water income to the area is the precipitation recharging soil water resources and shallow groundwater levels. Declining quantity and quality of water resources has resulted in changes of ecosystem functioning, in some cases of irreversible nature. Large scale drainage and groundwater exploitation have led to the substantial changes in the groundwater regime and in the soil moisture conditions. Dynamic water resources are ranked here as one of the highest priority issue. The reconstruction of water retention in wetlands was specified as one of the most important problem. An approach to preserve and restore the nature that has appeared in last decades has definitively substituted an old approach aimed at drainage of the land.

The Protection Plan prepared for the Kampinos National Park has formulated a program of hydrotechnic works aimed at a control of surface and groundwater levels to slow down the runoff from the Park and to raise groundwater levels, especially in wetland zones (Kazimierski et al., 1995). Monitoring of groundwater levels and surface water levels has started in 1998 as a continuation of former investigations conducted in a region (Krogulec, Sikorska-Maykowska, 2001). The main aim is to monitor current state of hydrologic conditions and — in perspective — to increase retention in the shallow soil layers.

As a support to monitoring efforts within the KNP a monitoring of soil water resources has started in 1995. Much efforts was put into the study on the surface wetness conditions as a starting point for developing strategies to support water management decisions. The main objective was to provide an assessment of the general magnitude of the soil moisture resources stored in the upper soil layers. The purpose of such soil moisture monitoring was in this case the strong requirement to control dynamic water resources available for protected ecosystems. Diagnosis of a current situation was done on the base of measurements conducted in 1995 – 2000 period (Somorowska, 2001).

## ENVIRONMENTAL OBJECTIVES AND TARGETS OF CONTEMPORARY WATER MANAGEMENT

A review of existing expertise developed in the past decades for the KNP indicates that the main targets should be focused on the quantitative aspects of water management to overcome water shortage (Kazimierski et all., 1995). The general objective is that water management should meet requirements imposed by different ecosystems (Solon, 1995).

This hydrological research was conducted and aimed at quantifying these requirements. Evaluation procedure of the impact of different hydrological scenarios to predict development of soil water deficits is presented in Fig. 1. Historic data involved in the analysis comprises long-term precipitation records, groundwater levels and soil water resources derived from soil moisture

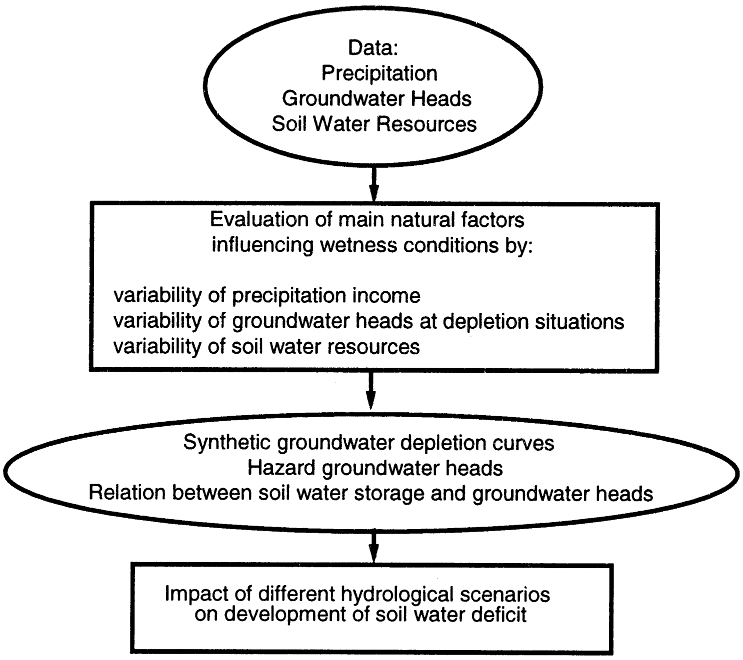


Fig. 1. Outline of approach to evaluate different hydrological scenarios and their impact on development of soil water deficits.

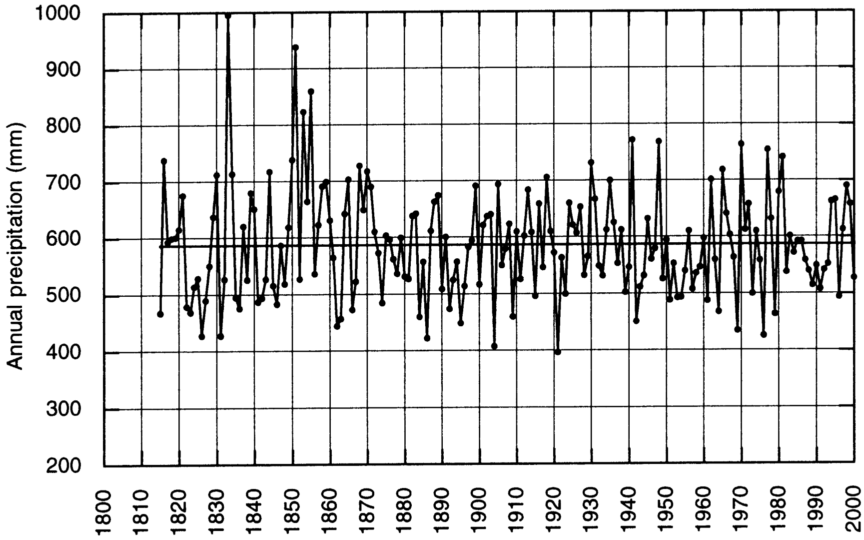


Fig. 2. Annual precipitation in the period 1815 – 2000 for the area of the Kampinos National Park reconstructed from instrumental series for Warsaw.

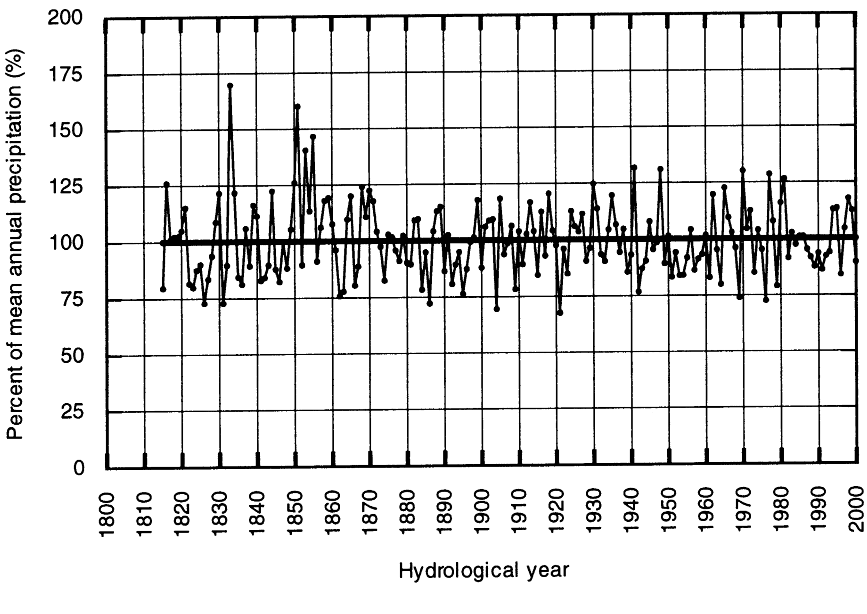


Fig. 3. Reconstructed annual precipitation as a percentage of a long term mean value in the period 1815 – 2000.

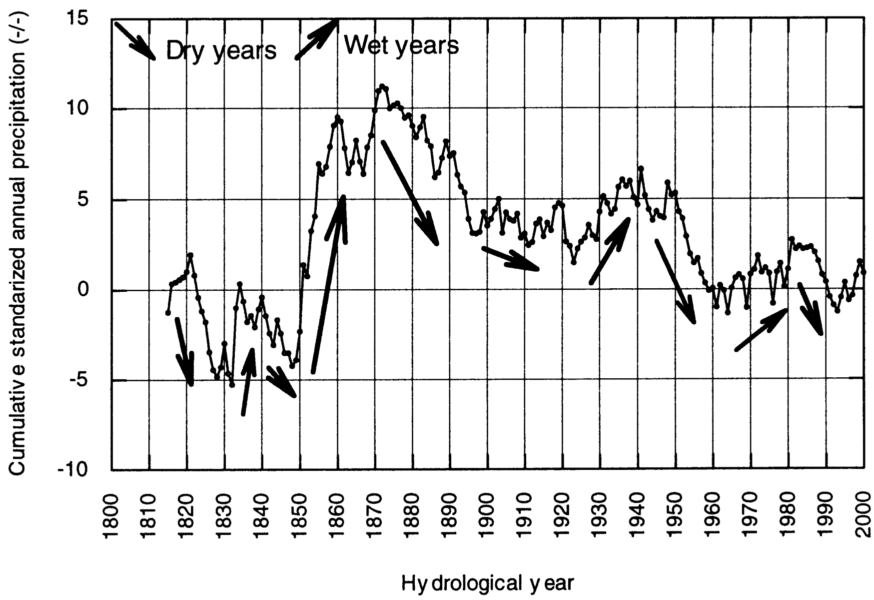


Fig. 4. Dimensionless curve of cumulative annual precipitation derived from reconstructed series for the area of the Kampinos National Park for the period 1815 – 2000.

measurements. First, an evaluation of historic hazard situations that influence hydrologic conditions was conducted. A long-term series of annual sums of precipitation was reconstructed for the KNP (Fig. 2) based on the long-term instrumental precipitation records available for Warsaw (Glasser, Szulakowski, 1959). The reconstructed series expressed as a percentage of the long-term mean annual value is presented in Fig. 3. Several periods of higher or lower than mean annual precipitation sum are observed during the years 1815 – 2000, within the range of 65 – 170%. To visualize a sequence of dry or wet years defined here as a those being lower or higher than long-term mean annual precipitation, the function of standardized cumulative annual deviation (SCAD) was applied. The course of calculated SCAD values is presented in Fig. 4. The positive slope indicates a period in which precipitation is above the mean, and a negative slopes — below the mean. It comes out that in the long historic period 1815 – 2000 sequence of dry years and wet years has occurred, both for the period before substantial human impact took place (till the turn of XIX and XX centuries) as well as in the past eighty years. This general picture of precipitation totals to the area in long term period visualizes that the natural recharge by precipitation incoming annually to the area has preserved its general character of a sequence of dry and wet years. The value of particular annual precipitation can vary substantially from year to year but this is observed in historic time as well as in contemporary conditions. Thus it comes out that the changes in natural environment can be

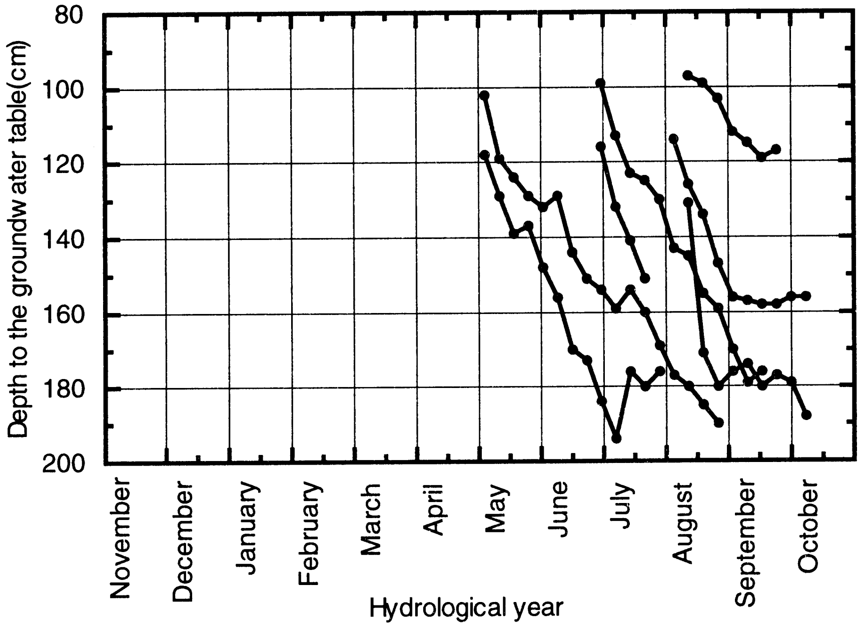


Fig. 5. Chosen groundwater depletion curves observed in the period 1956 – 2000 during months May – October.

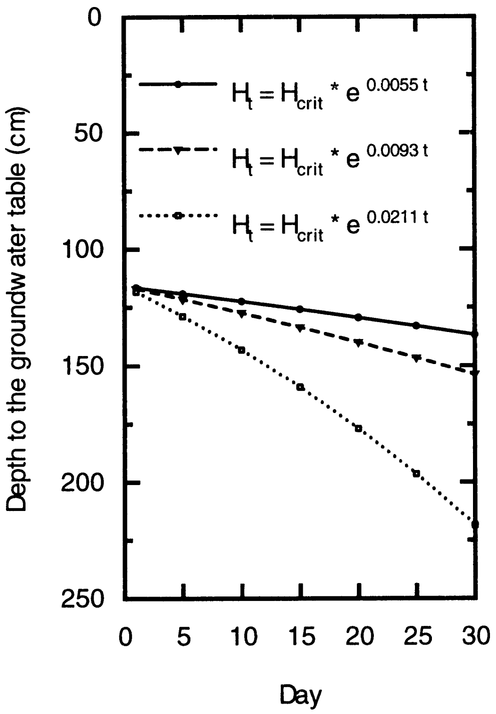


Fig. 6. Synthetic groundwater depletion curves characterized as dependant on the value of the depletion coefficient *K*.

attributed to the hydrotechnic works and drainage manipulations that has caused the symptoms of drying such as lowering of groundwater table. On the basis of observations of the shallow groundwater aquifers mean annual value of the groundwater level has been calculated for the period 1956 – 2000 for the station in Korfowe representing the wet zones conditions. This value is assumed to be critical for the occurrence of soil water deficits that can develop in the periods of the intense summer groundwater depletion. Selected groundwater depletion curves observed in the summer are shown in Fig. 5. On that base synthetic groundwater depletion curves have been derived using a recession function in the following form:

$$H_t = H_{crit}\ e^{-Kt} \quad (1)$$

in which $H_t$ is groundwater depth at a time $t$, $H_{crit}$ is the critical groundwater level, and $K$ is a fitting coefficient characterizing rate of the groundwater depletion. The value of $K$ has been determined by least squares fit for the summer depletion curves that have appeared in the periods without precipitation. Synthetic curves derived are shown in Fig. 6. Then water storage decrease function (Somorowska, 2001) was applied in the form:

$$\Delta R = \mu \Delta H \quad (2)$$

where $\Delta R$ is the change in water storage in mm, $\Delta H$ is the change in depth to the groundwater table in mm and $\mu$ is the storage coefficient. Substituting equation (1) to the equation (2) soil water deficits can be derived as follows:

$$\Delta R = \mu\ H_{crit}\ (\ e^{-Kt} - 1) \quad (3)$$

From the equation (3) it is visible that the soil water deficits directly depend on the duration of the dry period during which depletion of the groundwater table takes place and on the value of $K$ coefficient. The calculated values of the soil water deficits for the synthetic depletion curves those that start from the critical groundwater level $H_{crit}$ are presented in Fig. 7. In such a way impact of different hydrological scenarios characterized by variable rate of groundwater depletion can be evaluated as a development of soil water deficits. This development depends on the precipitation recharging shallow groundwater which is responsible for the value of the $K$ coefficient.

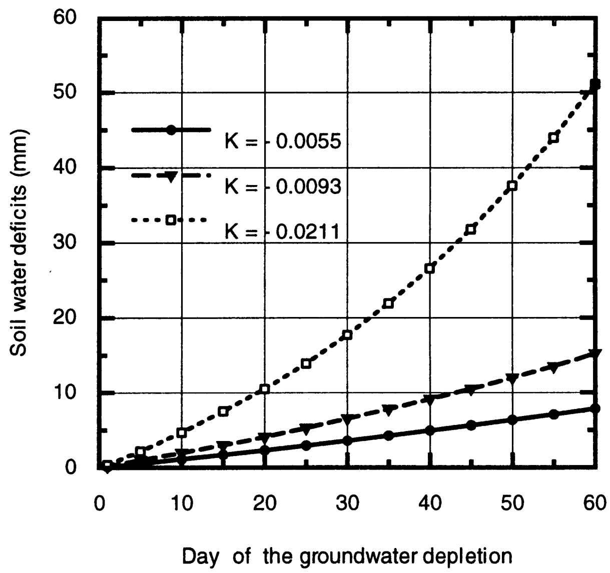


Fig. 7. Soil water deficits derived from synthetic groundwater depletion curves.

## CONCLUSIONS

In the long term period the objectives of the water management in the protected area of the Kampinos National Park have changed considerable from the historic approach aimed at drainage and flood protection towards contemporary efforts of complex environment restoration. The general contemporary objective of water management defined as meeting requirements imposed by different ecosystems can be approached by designing an optimal abiotic conditions that influence natural succession of vegetation. In the region the groundwater levels are critical for the constitution of abiotic conditions. The rise in groundwater levels is considered to be one of the key processes for the desired natural development. To counteract the development of water shortage in the shallow subsurface that is the source of moisture for vegetation, an evaluation method of the soil water deficits has been proposed. Synthetic groundwater depletion curves have been derived and coupled with the water storage decrease function. On that base the value of water deficits can be calculated during long dry periods that are the most dangerous for the development of water deficits. The proposed method is a support in water management practices to evaluate impact of groundwater levels on water availability/shortage for ecosystems. Further research should include spatial water requirements dependant on the type of ecosystem.

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