

Hydrology and ecology: how Natura 2000 and Military use can match

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Abstract. The military domain of Houthalen is a shooting area and also a protected Natura 2000 site, with an alternation of dunes, fens and heathlands. Already years ago, it was determined that the groundwater table is lowered by digging deep canals. Intensive consultation and study work (ecohydrological modeling) has shown that recovery is possible, taking into account the military use. Specific attention was paid to the accessibility through the fire roads and the water level in the fens. Recovery is started up, as well as a monitoring programme.

Key words: ecohydrology, wet heath, groundwater flow modeling, monitoring, Natura 2000 aims and military use.

1. Introduction

In 1999, a protocol agreement between the Flemish Government and the Federal Government, recognized the importance of nature values in military areas. For every domain there is a local Nature and Forest Management Commission that regulates the management decisions (in relation to nature management) in consensus. The technical management of the shooting range is done by the Agency for Nature and Forest. During the period from 2004 to 2010 the management was carried out with financial assistance of the European LIFE project DANAH. This resulted in an integrated management plan, which set up a maximum development of the open landscape with open heathland ecosystems. In the management plan the dewatering of the area was detected as a bottleneck for ecolog-

ical restoration. Dewatering of the military site by means of an extensive network of drainage canals to improve the operability over the last decade has led to a permanent decrease of the groundwater table and to a deterioration of the protected habitats, as Northern Atlantic wet heath with *Erica tetralix* (code 4010), Depressions on peat substrates of the *Rhynchosporion* habitat (code 7150), Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoeto-Nanojuncetea* (code 3130), Transition mires and quaking bogs (code 7140) (Vandeberghe et al., 2010).

However, there was no agreement about the recovery measures. The Agency for Nature and Forest first needed to show that recovery does not have a negative impact on the military operational capability: more open water means a higher risk for the Ricochet and birdstrike and

a decrease in accessibility for fire trucks. Through cooperation between the military Government and the Agency for Nature and Forest a solution is found for the decline of the groundwater table in the wet heathland system. An extensive groundwater monitoring network, implementation of groundwater and ecological modeling and the design of monitoring system, helped to clear out the discussion on how accommodate Military use and Natura 2000 habitats. The hypothesis in the groundwater and ecological modeling is that the phreatic groundwater levels are reduced as a result of the further deepening of canals on and/or outside the shooting range.

The different keys for success are: groundwater measurements over a long period, detailed eco-hydrological modeling, systematic dialogue, make decisions with uncertainties and a good follow-up system.

2. The study area

The research area includes the military site “shooting range Helchteren” and the adjacent agricultural area around this military site (see Fig. 1).

The shooting range has an area of 2180 ha and is used by the 10th tactical Wing as target zone for aircraft. The military site is part of the Natura 2000 network. The main aspect of the landscape of the military site is: extremely nutrient poor, open wet heathland moorland (4010, 7150, 7140), surrounded by dry heathland (4030) and inland dunes (2330/2310). The dry heathland vegetation (4030,

2310, 2330) has an actual surface of about 900 ha. The wet heathland vegetation (4010, 7140, 7150) has an actual surface of about 254 ha. The total aim for wet heathland vegetation is 340 ha for the shooting range and requires an important quality improvement. In between there are lakes with amphibious short annual vegetation and pioneers in the land interface zones of lakes (3130). The shooting range is a major source area for many important rivers and lies on the divide of two river basins (van Wirdum et al., 2004). The area lies on the upper sand soils (formation of Diest) of the Campine plateau and consists mainly of humid to seasonally wet sandy soils with a naturally fluctuating water table. By the well drained sandy soils and the lack of an insulating layer of clay in the soil there are strong hydrological relationships between this heathlands and the adjoining agricultural area. The shooting range itself is the highest infiltration zone on the Campine plateau. There is only one groundwater layer, the phreatic aquifer. The water table in this phreatic aquifer, also called the phreatic surface, may be subject to significant fluctuations. That fluctuations can be caused by man (dewatering) or occur naturally. The height of the phreatic surface is determined by the amount of effective precipitation and the hydraulic conductivity of the sands. In wet, warm winters there will be an increase in the phreatic surface, dry summers will reduce the surface. Therefore, there can be significant differences during the year but also between different years.

As a result that the shooting range and the adjoining agricultural belong to the same groundwater system, changes

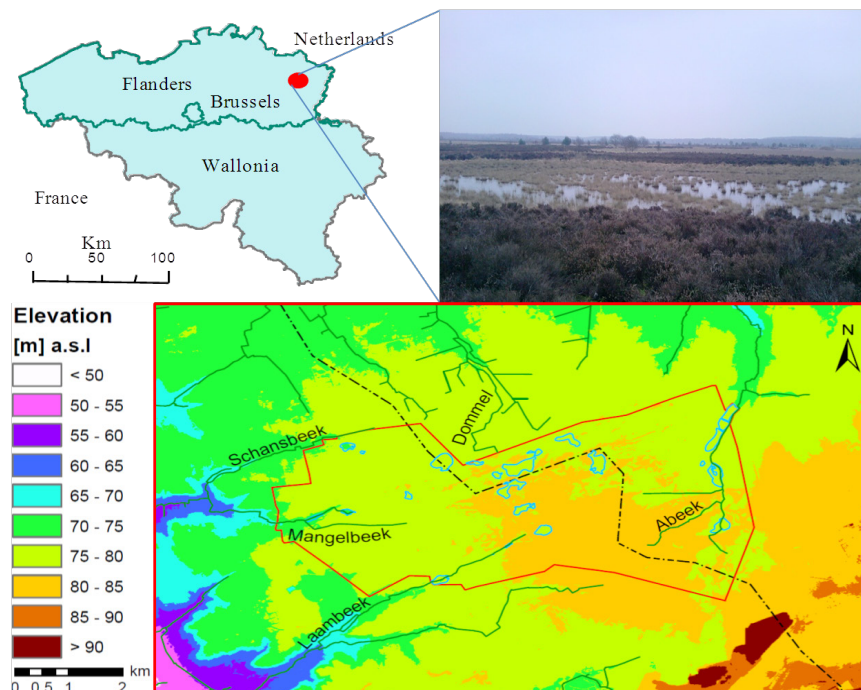


Figure 1. Situation of the study area

in groundwater management in the agricultural area can be quickly detected on the military domain and vice versa.

3. Research methods

To prove that Natura 2000 aims and military use for at least the groundwater component can match three steps are necessary:

1. long term measurement (data acquisition);
2. eco-hydrological modeling to understand the groundwater system and show the impact of recovery of the ditches ;
3. set up an signalization protocol based on monitoring during and after the period that the recovery measurements are realized.

The research method of step 2 is shortly explained.

To identify which interventions have caused the groundwater decline and which recovery can be realised, the Agency of Nature and Forest was decided to make a groundwater model, in relation with an ecological model.

The groundwater model was based on an extensive groundwater monitoring network operational at the military site since 2000. The network is operated by the Agency for Nature and Forest and the data are stored by the Research Institute for nature and Forest. Data are available through an online database. The data were used to calibrate the groundwater model.

The groundwater model (Batelaan et al., 2012) is transient and simulates time-dependent behavior on a monthly base from 1991–2010. On the basis of a number of simulation scenarios is examined how the adverse effects on groundwater-dependent vegetation can be reduced.

In a first scenario the actual state is modeled, this is used as reference for the other scenario's. As a first step the scope of the "maximum" effect of muting the canals in and around (200, 300, 500, 700 and 1000 meter perimeter) the shooting range is examined. Existing canals on and outside the shooting range were completely muted and the rivers to depth of 30 cm below ground level. These are the various MAX scenarios. As comparison, the effects of just muting canals outside the shooting range were studied. These are the different Scen 1–300 to 1000 scenarios. In scenario

2, all canals muted on the shooting range, but around the shooting area remains the state such as current. In the following scenarios of 3 to 6 are on and off the shooting range partially measurements modeled. For example, in scenario 3 within the perimeter of 300 m around the shooting range the canals are muted up to 50 cm depth and the watercourses to 1 m. In scenario 4, only a number of canals on the shooting range were muted. Through the various scenarios under 5 is searched for the individual contribution of each measurement individually.

All scenarios were simulated with the transient model. Partially muting or removal of drainage canals means that in each simulation the topography and/or the properties of the drain cells were changed. The water balance for each scenario, average, highest, lowest and spring depths to groundwater and the percentage of time that open water above ground level are calculated. In addition, there are 30 sandy road sections of which was analysed whether they maintain at all times a groundwater level below ground level. This road sections are fire roads and it is important for the operability of the military shooting range that these roads stay dry throughout the year (Vandeberghe et al., 2010).

The ecological study (Batelaan et al., 2012) looked at the relationship between the hydrology and findings and the spatial distribution of vegetation types in the open atmosphere. The studied habitats are: European dry heath (code 4030), Northern Atlantic wet heath with *Erica tetralix* (code 4010), Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoeto-Nanojuncetea* (code 3130), Transition mires and quaking bogs (code 7140).

The shooting area consists of sandy soils. It is assumed that the entire area is covered with Quaternary sand, poor in organic matter (Batelaan et al., 2012). The groundwater chemistry in the shooting range is uniform and is characterized by mineral groundwater, poor in nutrients with an electric of about conductivity $\leq 100 \mu\text{S}/\text{cm}$. These hydrochemical conditions are optimal for above mentioned habitats. Given the great uniformity of soil and groundwater chemistry on the shooting range groundwater dynamics is the steering location variable for the presence of these habitats.

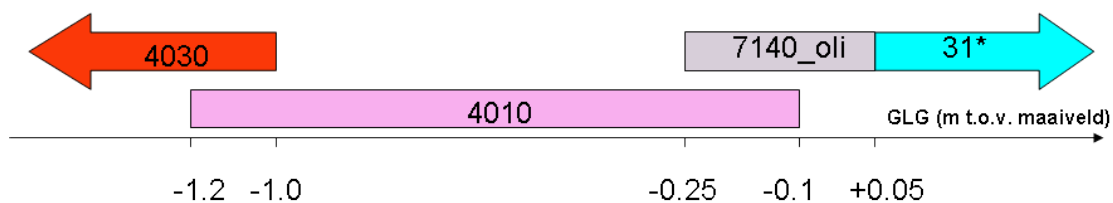


Figure 2. Link between groundwaterdynamic (mean lowest groundwater depth) and habitat (4010: atlantic wet heath, 4030 dry heath, 7140 peaty heath)

The decision rule on the shooting range to separate the habitat types is as follows (see Fig. 2):

When the mean lowest groundwater depth takes values between -1.2 and -0.1 meter (below ground level), then it will be in those locations the habitat type 4010.

Similarly, can the presence for the habitat type 7140_oli can be derived: -0.25 m (below ground level) and + 0.05 meters (above ground level). Between both types is a zone with overlapping mean groundwater depth, in particular where those situated between the -0.10 and 0.25 meters. In that area will develop a transition type. If the lowest ground water depth is deeper than one meter below ground level (sometimes up to several meters below ground level) then the habitat type 4030 will occur.

In the groundwater model several scenarios were calculated and compared. A first scenario is the actual state as reference for comparison with the other scenario's. As a first step in the groundwater modeling the scope of the "maximum" effect of muting the canals in and around (200, 300, 500, 700 and 1000 meter perimeter) the shooting range was studied. Existing canals on and outside the shooting range were completely muted and the rivers to depth of 30 cm below ground level. These are the various MAX scenarios. As comparison, the effects of just muting canals outside the shooting range were studied. These are the different Scen 1 – 300 to 1000 scenarios. This modeling showed that muting of canals for up to 300 m outside the military site had the most effect on restoration of the groundwaterlevel, and was used for further study in the ecological modeling. Besides that, another 13 scenarios were studied on the military site to see the impact of progressive muting the canals. In scenario 2, all canals muted on the shooting range, but around the shooting range re-

mains the state such as current. In the following scenarios of 3 to 6 are on and off the shooting site partially measurements modeled. For example, in scenario 3 within the perimeter of 300 m around the shooting range the canals are muted up to 50 cm depth and the watercourses to 1 m. In scenario 4, only a number of canals on the shooting site were muted. Through the various scenarios under 5 is searched for the individual contribution of each measurement individually.

4. Results and discussion

The outcome of the modeling (Vandenberghe et al., 2010) was:

- The scenarios show that as soon as a part of the drainage canals inside or outside the shooting range is removed the groundwater significantly increases (the drainage basis is increased).
- Result shows that measurements in groundwater (muting drainage canals and rivers) on more than 300 m from the shooting range does not lead to additional rise in the water table within the shooting range. Measurements on the shooting range and in a zone is a zone of 300 m around the shooting range are sufficient for obtaining optimal groundwaterlevels for the habitats.
- Restoration of the groundwater table leads to more open water than in the current situation, but the different scenarios affect only the remaining surface open water in summer.
- For some fire roads sections the groundwater level is near ground level.

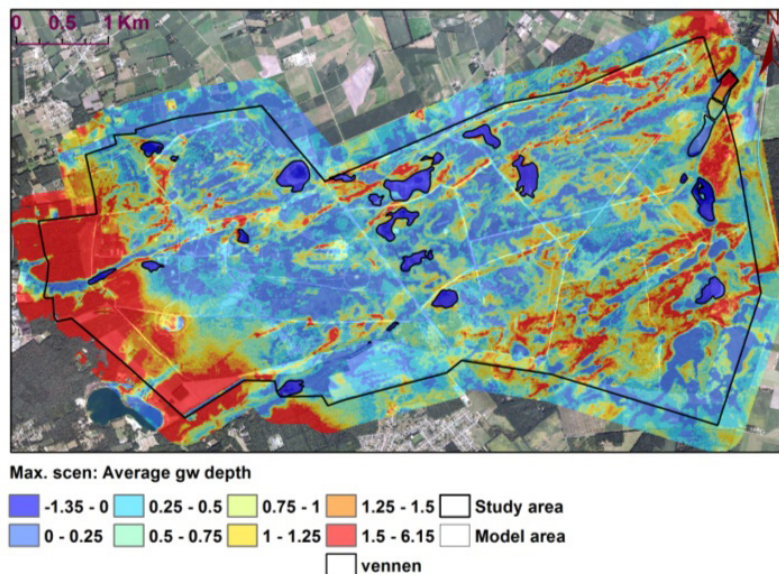


Figure 3. Mean groundwater depth for the 300 m scenario

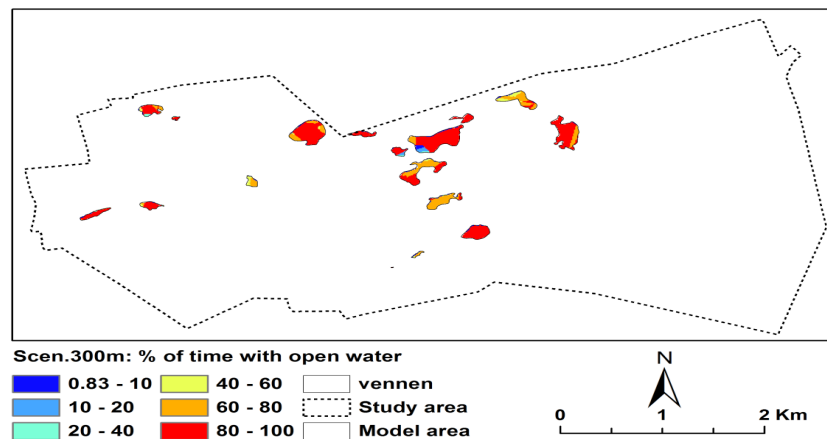


Figure 4. Percentage of time with open water in the fens for the actual situation

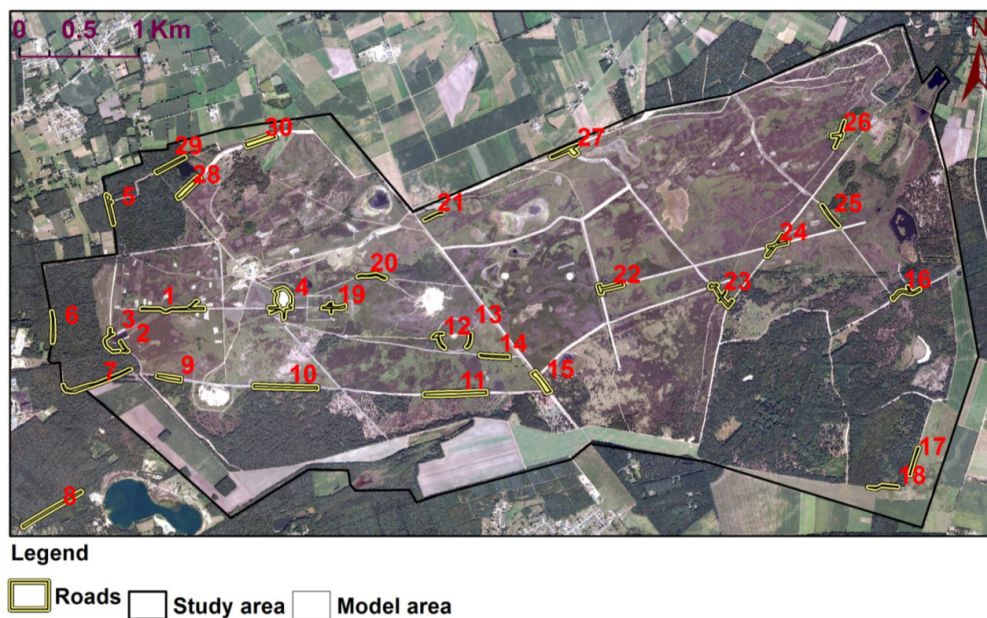


Figure 5. Studied road sections for the analysis of groundwater level changes

The habitat suitability on the shooting range increases significantly.

In the following result (see Fig. 3) of the transient model is shown the mean groundwater table for the 300 m scenario. In this case all the drainage canals are muted and the bottom of the rivers brought to 30 cm under ground level.

To make the results clear for the military operability for the 300 m scenario is shown how long the groundwater is above ground level in the different fens, as this was important for bird strike and Ricochet. Figure 4 shows the percentage of time that there is open water above ground level for maximum scenario with buffer zone of 300 m from April to September averaged over 20 years (1991–2010).

The average percentage of time that open water is above ground level in the fens is about 81.5%.

To know if there is a problem in the road sections with increase of the groundwater level, 30 sandy road sections were selected. Figure 5 shows 30 sandy road sections which analyzed whether they maintain at all times a groundwater level below ground level.

Figure 6 shows the result for scenario 300 m that the average groundwater depth (blue) for most sandy road sections are equal to the spring groundwater depth (black). The maximum groundwater depth is here to 6, while the shallowest groundwater levels under road sections 10, 12, 13, 14, 19, 24, 25, 30.

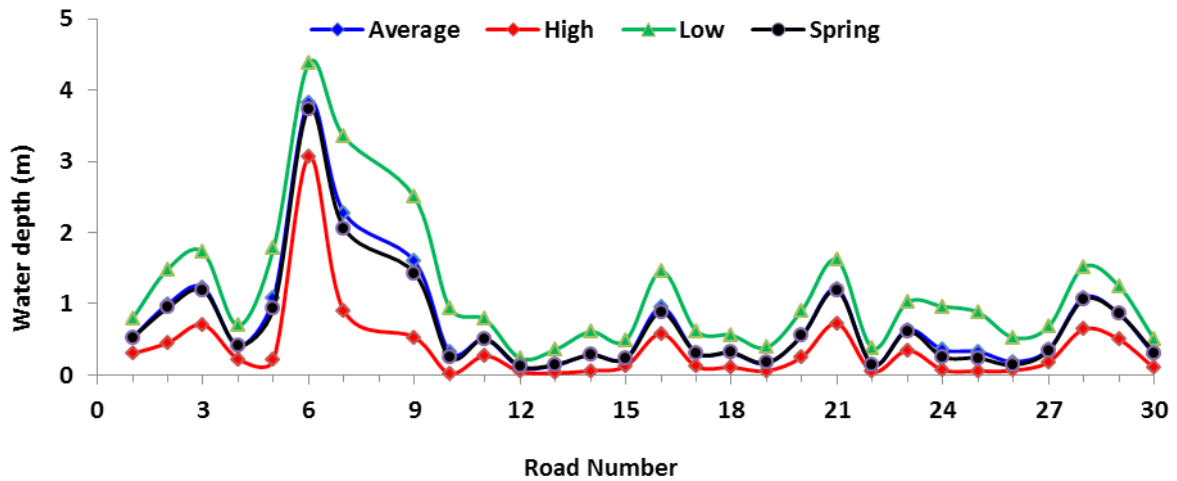


Figure 6. Average, high, medium, low and spring groundwater depth under the 30 road sections

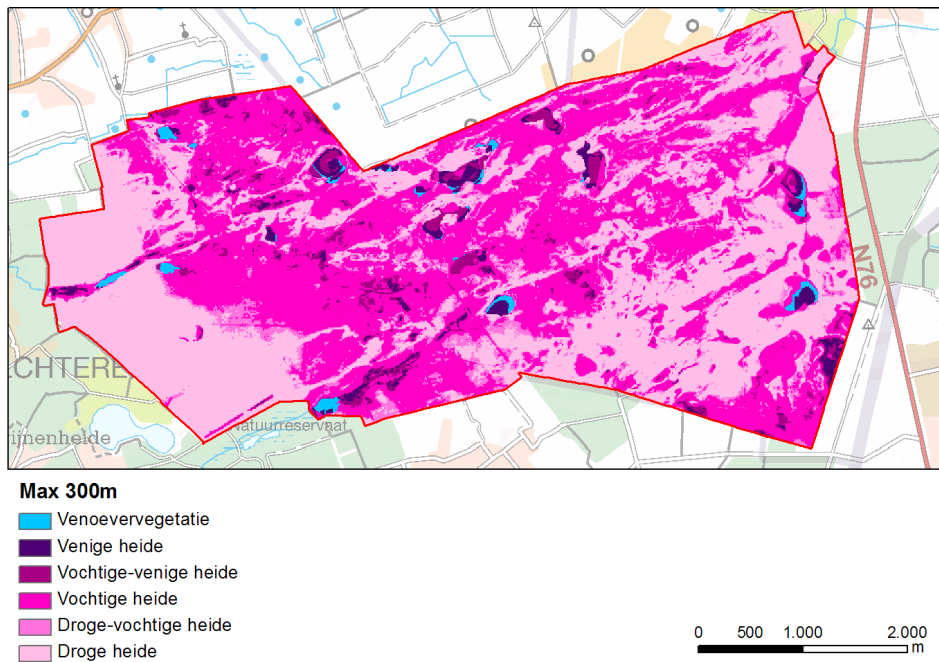


Figure 7. Habitat suitability for the 300 m scenario

The habitat suitability for the scenario 300 m is shown in Figure 7.

The scenario analysis, clear figures and quantification convinced the military government that the process of groundwater restoration could be started. It led to the decision that canals could be muted gradually, on condition of a monitoring study. The new monitoring study started earlier in 2015 for 3 years and aims to develop a protocol for signalization based on series analysis. This protocol

should help to draw conclusions about: effectiveness of recovery measures in function of favourable state of the habitats, the effects of the recovery measures on groundwater management outside the shooting range, the impact on the military operational capability on the shooting range. Criteria for this signalization protocol will be set up by the Military and by the Agency for Nature and Forest. Later on bird-monitoring will be started in function of bird control.

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