The vegetation of Clara Bog in relation to the hydrology and waterchemistry

M. Neefjes, 1989

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ABSTRACT
In raised bogs the presence of different vegetation types is probably determined by the surface flow and related to the waterchemistry. Hummock-hollow and other wet vegetation types are situated in flat areas where the waterflow is impeded by the small difference in hydraulic potential, caused by the small slope.
Most chemicals show a decline in concentration from the dry edge to the wet soak vegetation. This could be explained by the fact that decomposition is higher in dryer environments.
The low concentrations in the soak area are remarkable because of the apparently more nutrient-requiring vegetation. Perhaps the nutrients are only released in the spring and taken up by the plants immediately.

SAMENVATTING
In hoogvenen wordt de aanwezigheid van verschillende vegetatie-types waarschijnlijk bepaald door oppervlakte-stroming en heeft te maken met de chemische samenstelling van het water.
Bult-slenk complexen en andere natte vegetatie-types bevinden zich in vlakke delen waar de waterstoming vertraagd wordt door het kleine hydropotentiaalverschil, veroorzaakt door het kleine hoogteverschil.
De meeste chemische stoffen in het water vertonen een afname van de droge rand naar de natte soakvegetatie. Dit zou verklaard kunnen worden door het feit dat de decompositie hoger is in droge omgeving.
De lage concentraties in het soak-gebied vallen op vanwege de schijnbaar meer nutriënten eisende vegetatie. Wellicht komen de nutriënten alleen vrij in het voorjaar en worden dan onmiddellijk weer door de planten opgenomen.

INTRODUCTION
In all ecosystems the vegetation is not only determined by the type of substrate and the available nutrients, but also by the behaviour of water, the hydrology. This is not different in a raised bog. In bogs water plays a major role because a bog can only thrive when it is waterlogged. This stage is maintained by high rainfall and a low hydraulic conductivity (Ingram, 1987A).
Because on a yearly basis evaporation is less than rainfall (Streefkerk and Caspari, 1987) and not all the remaining water is stored in the bog, some water must be lost from the system in other ways: there must be an efflux.
Waterflux is described as a result of hydraulic potential. The water flows from a high to a low potential. However, a large difference in potential does not automatically mean a high flow rate, because a difference in potential can be maintained when
there is either a high resistance or a large slope. Only in the last case it means a high flow rate (Streefkerk, personal communication, 1989).

According to Streefkerk and Caspari (1987) surface flow is the main component of efflux. This can be explained by the fact that the hydraulic conductivity of the acrotelm is very high compared with the catotelm. Because of the large difference in this conductivity the flow through the acrotelm, the surface flow, is considered to be distinct from the bog itself (Ingram, 1983). Therefore it seems likely that the occurrence of the various vegetation types is determined by the varieties in the rate and chemical composition of the surface flow. Different aspects of waterflux in bogs have been studied but its relation to the vegetation on top of the bog still requires further investigation. The purpose of this study was to try to explain the position of vegetation types by examining the hydrology of the bog and the chemistry of the surface water.

STUDY SITE
Clara Bog is a raised bog in County Offaly in the Midlands of Ireland. Especially the western part of it is relatively undisturbed and has several well-developed hummock-hollow systems. A special feature, and therefore an important reason that the bog is now a nature reserve, is the soak-system: a system of lakes accompanied by a special vegetation that is dominated by plants that usually occur in fen situations where more nutrients are available than in a rain-fed raised bog. The soak is thought by some to be a kind of spring where rich water wells up from the mineral underground; others consider it to be a sink where water (with its nutrients) is collected from a large part of the bog. The eastern side of the bog is drained to a large extent; therefore this study was carried out on the western part. Of this part a certain area was chosen that was expected to be a hydrological unit, on grounds of a contour map of Bord na Mona (Irish Turf Board) (1982-83). The field work of this project took place in October and November of the year 1988.

METHODS
vegetation
The vegetation survey was performed by making 59 vegetation
relevés of 2 meters square. Each relevé contained percentages cover of vascular plants, mosses, the larger liverworts and lichens.

A classification was made of the resulting vegetation data using the computer program TWINSPLAN (Hill, 1979). The result of this classification was listed in a vegetation table.

A general vegetation-map of this area was made, based upon the vegetation-types that could be distinguished in the field. The nomenclature follows Heukels and van der Meijden (1983) for vascular plants, Smith (1980) for bryophytes, Watson (1981) for liverworts and Wirth (1987) for lichens.

**hydrology**

The hydrology was studied in 21 stations scattered over the western half of Clara Bog, including a transect of about 750 meters which went through the largest hummock-hollow complex. One station was situated in the soak area.

Each station consisted of at least three PVC-tubes. One was a dipwell, a tube 50 cm long with slits over the whole length. The lower end was shut to prevent peat from entering while inserting the tube. A dipwell is used to measure the depth of the watertable.

The other two tubes were piezometers: tubes, also shut, with slits only at the lower end and covered with a piece of nylon stocking to make sure only water would enter. Piezometers are used to measure hydraulic pressure at a particular depth (Ingram, 1987B), in this case 1 and 3 meters. At some stations a piezometer of 5 meters was present as well.

All tubes were covered with a cap protecting it from rain. The caps were loose fitted to prevent a build up of pressure.

The altitude of all the stations (in m. above Irish Sea Level) was measured with the aid of a level. After establishing these altitudes a convenient local datum surface lying within the bog could be chosen, in this case 54 m. above Irish Sea Level. The results of the altitude measurements were used to make a contour map. With the aid of the local datum surface it was possible to calculate hydraulic potential (Ingram, 1987B).

The results of the dipwell and piezometer measurements were drawn in a cross-section of the transect and a map of the total area. In these figures isopotentials (lines of equal potential) were drawn. Water flows normal to these isopotentials.

The watertable and hydraulic pressure were measured once a week, seven weeks in a row. This was achieved by inserting into the tube a flexible hose with the lower end straightened.
with a bamboo rod. Measurements were then taken by blowing through the tube and when the waterlevel was reached bubbles could be heard. The accuracy of this method lies within 0.5 cm.

chemistry
To get extra information about the differences between vegetation-types watersamples were taken at the dipwells at all the stations. The samples were filtered and in the field the pH was measured with a glass electrode. A few drops of CCl₄ were added to fixate the samples and they were analysed within five days in the laboratory in Amsterdam. Conductivity was measured with a Philips PW 9505 conductivity meter. Phosphor and nitrogen were measured colorimetrically with a Technicon II auto-analyzer, PO₄ as a molybdate-complex, NO₂ and NO₃ as an azo-complex at 550 nm, and NH₄ at 660 nm. Calcium, potassium, iron, manganese and aluminium were measured spectrophotometrically with a Perkin Elmer 1100B atomic absorption spectrophotometer.

The stations were divided into five vegetation areas: edge, dry, wet, hummock-hollow and soak vegetation. Per chemical the average was taken of all the stations of one area, and plotted in a bar diagram.

RESULTS

vegetation
The classification of the vegetation data has resulted in a vegetation table (table 1). On grounds of this vegetation table several divisions can be made in the relevés. The first division can be made into bog and soak vegetation. In the soak vegetation the *Myrica gale*-thickets that occur at several places on the bog are also included.

The bog vegetation can easily be divided into dry and wet on grounds of the presence of *Scirpus cespitosus* on one hand and high abundance of *Sphagnum cuspidatum* on the other. The wet section can in turn be divided again into wet areas with hardly any open water and areas with a considerable surface of open water defined by a very high abundance of *Sphagnum cuspidatum* and representing hummock-hollow vegetation.

In the soak area one can see several vegetation types that are dominated by one very conspicuous species. The remaining soak relevés can be described as "transitional" soak vegetation.

vegetation in dry areas
In the dry type *Scirpus cespitosus* is the most important
species. In the moss layer several species of the genus *Campylopus* occur: *C. introflexus*, *C. fragilis* and *C. pyriformis*. *Erica tetralix* and *Nartecium ossifragum* are present in relatively high abundancies.

**vegetation in wet areas**
In this type the abundancy of *Sphagnum tenellum* is comparatively high. In small wet depressions *S. cuspidatum* is present, but only in low abundancies.

**hummock-hollow vegetation**
This vegetation type is dominated by *Sphagnum cuspidatum* and several other *Sphagnum* species as *S. capillifolium* and *S. magellanicum*, representing respectively hollow, hummock and lawn.

**transitional soak vegetation**
As its name implies, this vegetation type has aspects of both the bog and the soak vegetation. It does have its own aspects though. It is the only vegetation type where *Pleurozium schreberi* and *Sphagnum subnitens* occur in the moss layer in relatively high abundancies.

**Eriophorum vaginatum** dominated vegetation
Between the *Eriophorum vaginatum* which dominates the appearance, *Oxyccocus palustris*, *Sphagnum capillifolium* and *Aulacomnium palustre* are found.

**Myrica gale** dominated vegetation
The only discriminating, but very dominant, species in this vegetation type is *Myrica gale* itself. It usually occurs in thickets near the pond or scattered on the bog.

**Betula pubescens** dominated vegetation
This vegetation type has a forest-like appearance due to the *Betula pubescens*. In the moss layer *Sphagnum palustre* is present. *Dryopteris carthusiana* occurs, and *Molinia caerulea*, though in low abundancies. *Pteridium aquilinum*, *Eurynchium praelongum*, *Vaccinium myrtillus* and *Sphagnum recurvum var. mucronatum* can be found in this vegetation type.

**Molinia caerulea** dominated vegetation
Between the *Molinia caerulea* some *Myrica gale* occurs and often *Sphagnum cuspidatum* and *S. palustre* are present.

On the vegetation map (fig. 1) these types are indicated. The
condensed table (table 2) gives the information in a more bite-size form.

**Hydrology**

The results of the hydrological measurements were processed by using the average per station. For fifteen stations this was the average of seven weeks; for six stations in the transect only of five weeks, because the tubes of these stations were put in later and took some time to fill up.

In fig. 2 the hydraulic potentials of the stations in the transect are drawn. The results of the dipwells were taken as the hydraulic potential at the watersurface (and thus at atmospheric).

The results of all the stations are illustrated in fig. 3-6. Fig. 3 is a contour map, fig. 4, 5 and 6 are maps of hydraulic potential, at the water table, 1 m. and 3 m. depth respectively. Contours and isopotentials were drawn with help of these results and field observations.

**Chemistry**

The results of the chemical analyses are shown in fig. 7.

**CONCLUSIONS**

As said, differences in potential are the result of both resistance and slope. Since it is known that the resistance is low in the acrotelm, difference in potential will very directly influence the flow rate. In fig. 2 one phenomenon draws the attention. In the flatter parts the potential does not change as rapidly as in steeper parts, which results in a lower flow rate in these flatter parts. From field observations is known that the areas around station 17, and station 19 & 13, are wet, the latter even a hummock-hollow complex. Putting the vegetation map and the water table map together (fig 1 and 4) also shows that wetter areas are situated in flatter parts of the bog.

It is likely that hummock-hollow complexes always occur in such flat areas where waterflow is impeded. This matches well with the experience that these complexes usually occur in the middle of a raised bog rather than at the steeper edges (V.d. Molen, personal communication, 1989).

In the diagrams in fig. 7 some aspects draw the attention. Firstly, most metals and some nutrients show a clear trend from high values in dry and low values in wet environment.

As explained earlier, dry vegetation types are determined by slope rather than level, so the high values can not be explained
by the high or low position of these areas on the bog. A possible explanation is that in dry situations the decomposition is higher. A dry environment means that the watertable lies relatively deep and therefore oxygen can penetrate deeper compared with a wet situation.

Another explanation could be that in wet situations the watersample is taken mainly from the acrotelm where water flows fast and is diluted by rainwater. For the dry edges there is an extra argument. The water flows in the direction of the edge (fig. 4) and thus nutrients are collected there.

The most remarkable aspect of these diagrams however is that the soak water has in most cases a very low value, where the nutrient-requiring vegetation would suggest otherwise. It is clear that the plants will have to get their nutrients in another way, either from another source, or at another time.

One can imagine that in spring when the weather grows warmer the rate of decomposition increases. But since this is also the beginning of the growth-season, the rate of uptake of the nutrients will be high as well. So perhaps the time between decomposition and uptake is so short that the nutrients cannot be measured in the water.

All these hypotheses leave the two anomalies, aluminium and ammonium unexplained. It must be stated that the samples were not taken during the growth season, during which they could give altogether different results.

RECOMMENDATIONS

When back from a field trip, one always comes up with a lot of things that should have been investigated also. In this case suggestions for further research would be in the first place to make a very dense grid of levelings, to get a detailed idea of the contours of the bog. The watersamples could be taken at regular intervals during the whole year and in many places, especially in the various soak vegetation types. For comparison it would be good to sample rainwater as well. To investigate the soak theories, samples could be taken at various depths and also of the water that comes from the esker which forms the mineral underground.

ACKNOWLEDGEMENTS

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REFERENCES


Hill, M.O. 1979. TWINSPLAN - A FORTRAN program for two-way indicator species analysis. Section of Ecology and Systematics, Cornell University, Ithaca, New York


Table 1  VEGETATION TABLE

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In this table the species that occur only once are listed at the bottom of the table.
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<th>GTC.</th>
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</table>

This table does not include the species that occur in only one relevé.

The information in this table consists of three parts:

The first part shows the presence (times present in total number of relevés).

- 0 - 20%
- 21 - 40%
- 41 - 60%
- 61 - 80%
- 81 - 100%

The second part is the average abundance of the total number of relevés.

The third part represents the lowest and highest occurring abundances.
VEGETATION MAP OF PART OF CLARA BOG

MYRICA GALE BUSH
POND
HUMMOCK-HOLLOW COMPLEX
WET
VERY WET AREA
MOLINIA CAERULEA JUNGLE
ERIOPHORUM VAGINATUM JUNGLE
BETULA PUBESCENS
CONIFEROUS TREES
OLD & NEW DRAINS
MOUND
STATION
RIDGE
ROAD
Fig. 2
CROSS-SECTION TRANSECT

SURFACE WATERTABLE
1 METER
3 METER
5 METER
Fig. 3

CONTOUR MAP
(cm. above local datum surface)
Fig. 4

WATERTABLE MAP
(cm above local datum surface)
Fig. 5

PIEZOMETER MAP 1 METER
(cm. above local datum surface)
Fig. 6

PIEZOMETER MAP 3 METER
(cm. above local datum surface)
CHEMISTRY OF DIPWELL WATER

EDGE_DRY_WET_HU-HO_SOAK

POTASSIUM

PHOSPHATE

CALCIUM

NITRITE

MANGANESE

NITRATE

ALUMINIUM

AMMONIUM

IRON

ELECTRIC CONDUCTIVITY

pH