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VEGETATION AND SOIL IN A DRENTHIAN BROOK VALLEY (THE NETHERLANDS)

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SUMMARY

The soil spectra, based on the higher levels of soil classification according to DE BAKKER & SCHELLING (1966), are not attuned to semi-natural vegetations in the study area, consisting of meadows. Only very general relations between soil- and vegetation spectra were found. It appeared that ground water fluctuation ranges were discriminating factors, the soil profile being especially related to water movements. Impermeable layers are very important in otherwise homogenous soil units. Ripening processes in different grades, recent or in the past, caused irreversible alterations and influenced the ground water regime.

The picture of the relationship between soil and vegetation is often confused by former agricultural use affecting both the soil profile and the plant communities.

1. INTRODUCTION

In 1972 the late Prof. D. Bakker introduced soil science into the current ecological research projects, being carried out in the Brook valley authority of the Drentse A in the pleistocene sandy areas of the northern Netherlands. Soil research was expected to give indications about those soil parameters, which are ecologically relevant not only to aspects of plant growth, but also to the specific changes, which result from different management practices.

The relations between vegetation and soil are not simply to interpret. ELLENBERG (1956), referring to the slogan that every plant community has its own soil profile, stated that every plant community reflects only those soil characteristics from which it is directly dependant, or which are working as an essential environmental factor. Only in a restricted climatic area under the same human management more indirectly working single value factors may also determine vegetation types. MEISEL (1956) investigated which soil factors govern the diversity in plant communities in addition to many other abiotic and biological factors. In the Ems valley he analysed whether thickness of soil horizons or depth of ground water tables were more decisive factors for variation than gley features or texture. He found out that fluctuation of ground water had the best relationship with vegetation. He pleaded for a soil survey with a legend generated from vegetation, instead of from agricultural use or pure morphological features. VAN DOBBEN (1970) stressed the narrow relationship between the vegetation and particulary the humus body of the soil, called the "humon" by BAL (1973). Devastation of the old succession climax is as a rule irreversible and thus many soil profiles must be regarded as fossils. In fact the application of fertilizers and hydrological changes may have disturbed a former balance between soil and vegetation. Both the direct application of fertilizers as well as the lowering of ground water tables with resulting nitrogen mineralisation (GROOTJANS 1979) have surpassed natural increments of soil fertility by inundations of loam-containing brook water.

ZONNEVELD (1966) discussed the causes of aberrations between soil boundaries and vegetation boundaries. Many different soil units are ecologically the same for the same standing vegetation. On the other hand in the standard soil description characteristics are not classified, though some have an ecological importance. VAN DEN BROEK & DIEMONT (1966) compared soils and plant communities in slope forests on chalk with a loess covering in the southern Netherlands. Following their own classifications for soil and vegetation, they found in oligotrophic environments of decalcified loess and coarse sands more soil units than vegetation types. In a richer environment on chalk were more vegetation types than soil units. Out of 99 possible combinations between 11 soil types and 9 vegetation units, there occurred only 28 combinations. Consequently there had to be some relationship between soil and actual vegetation.

A soil survey in the Netherlands traditionally includes vegetation in its mapping of correlative complexes. After the second World War the school of EDELMAN (1950) applied this method for mapping the soil of this country. Afterwards the idea was worked out in detailed mappings as of Rolde-Borger, an area in the neighbourhood of the Drentse A (DE ROO & HARMSEN 1959). The soils along the valleys were mapped in units as old arable land, land dunes, forest soil, heathland soils, grey oak soils, alder soils and meadow soils. Later on this landscape – vegetation – soil system was changed into a more morphometrical soil classification (DE BAKKER & SCHELLING 1966). Parts of the brook valley of the Drentse A are mapped in this system on a scale 1:50.000 (STICHTING VOOR BODEMKARTERING 1977).

Four approches have been practiced to relate vegetation and soil:

(1) Constructing soil spectra and vegetation spectra (KLOOSTER 1975, BOEDELTJE 1976, see also BOEDELTJE & BAKKER 1980).
(2) Determining the variation in soil units under some plant communities (EVERTS et al. 1978).
(3) Comparing the vegetation on unaltered and irreversibly changed soils (SCHIPPER & VAN DER WINDT 1979, SMIT 1979).
(4) Comparing the vegetation between homogeneous peat soils and peat soils including iron pans (BLOK & LANGBROEK 1980).

In this paper preliminary results of studies on vegetation and soil relations in a Drenthian brook valley are reviewed.

2. METHODS

Soils units are discerned according to the dutch soil classification (DE BAKKER & SCHELLING 1966). Soil was mapped with a density of ten augerings per ha to a depth of 1.20 m. Eleven soil units were distinguished (*fig 1*), belonging to four categories:

(1) 'Vlak' vague soil stands for wet sandy cover on top of peat deposits along the streams, as a result of regular spring inundations.

(2) 'Haar'-, 'Veld'-and 'Moer' podzol soils comprising a range of sandy soils with increasingly thick layer of raw humus in the topsoil and a thick infiltration layer of colloidal humus in the subsoil. Podzol formation is a result of deforestation and sheep grazing for centuries or of primary successions on fixed drift-sands.

(3) 'Goor'-, 'Beek'- and 'Broek' earth soils, standing for a range of increasing thicknesses of mineral humic to loamy earthened, peaty topsoil layers with increasing influence of eutrophic seepage water.

(4) 'Vliet'-, 'Vlier'-, 'Made'- and 'Bo' peat soils, standing for a range of peat soils with increasing thickness of the mucky topsoil and ripening in the subsoil.

Recent lowering of the ground water table causes shrinking of the peat. Shrinking was quantified by calculating the shrinkage factor 1, according to HOOGHOUDT et al. (1960):

$$1 = \frac{R_{max} - R_t}{R_{max} - R_{min}} \times 10$$

R_{max} = moisture content at pF 3 in g per 100 g of oven-dry soil (after centrifugation at 1000 × g) of unaltered peat,

R_{min} = moisture content at pF 3, after drying at 105°C and subsequent wetting and staying in water for 6 days,

R_t = moisture content at pF 3, of a sample after wetting and staying in water for 6 days.

As a reference for the degree of irreversible drying up, a sample of unaltered peat of the same botanical composition from the subsoil or from the nearestby locality is taken.

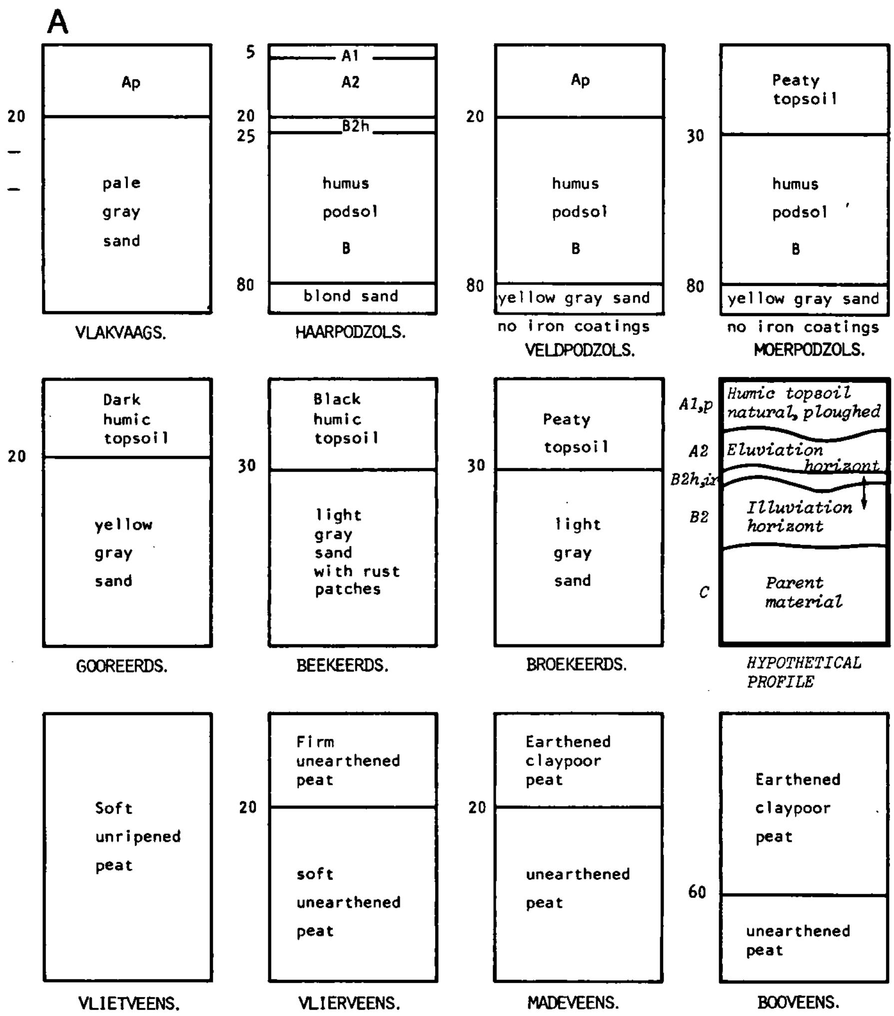
Plant communities have been distinguished according to species, composition and dominance. They were classified according to WESTHOFF & DEN HELD (1969) except for the *Cynosurion* (ELLENBERG 1978).

Ground water regimes were characterized through the fluctuation distance between the mean highest ground water table and the mean lowest table. In general the highest water-tables leave their spurs as a zone of rusty patches in the soil profile. The top of this zone is the base of a biologically mixed homogeneous topsoil layer. The lowest water-tables are characterized by "gley"-features of blue and grey colours, preserved roots and twigs, unaltered peat and sometimes a smell of H_2S. The ground water classes are given in *fig. 1*.

3. RESULTS

3.1. Soil spectra and vegetation spectra

KLOOSTER (1975) mapped an area on the slope of a cover-sand ridge parallel to the



B

CLASS	I	II	III	IV	V	VI	VII	VIII
MEAN HIGHEST GROUNDWATER TABLE	< 20	< 40	< 40	> 40	< 40	40/80	> 80	> 120
MEAN LOWEST GROUNDWATER TABLE (in cm minus surface)	< 50	50/80	80/120	80/120	> 120	> 120	> 160	> 160

Fig. 1a. Schematical soil profiles, b. Ground water classes, in the Drenthian A area.

brook valley in the neighbourhood of Schipborg.

Part of the ridge was recently covered with inland dunes, from a blowing sand area on the West side. The ridge sloped steeply down into the valley. The valley contains sedge peat, partly with a mucky topsoil. Alongside the stream sandy levees occur. The coversand ridge shows a *catena* of 'Haar' podzol soils with deep ground water levels to 'Moer' podzol soil. On the slopes downwards to the valley the soils were varying from 'Veld' podzol soils via 'Beek' earth soils to 'Made' peat soils. On the levees sandy "Vlak" vague soils occur. Classes of ground water regime were varying between VIII under the "Haar" podzol soils and I in the peat depressions behind the levees. The relationship between soil units, soil distinguishing factors, class of ground water regime, plant communities and management is shown in *table 1*. The thickness of the A1, the earthened layer, seems to be determining vegetation differences in peat soils. In general a peaty topsoil had a marked influence in wet areas, as well as a sandy topsoil over mineral soils in dry circumstances.

BOEDELTJE (1976) investigated a wet area in the lower course of the valley of the Drentse A. Most of the soil units distinguished by KLOOSTER (1975) were found again here. Discriminating soil factors are discussed in BOEDELTJE & BAKKER (1980).

One interesting soil-determining factor, caused by differences in management, may be mentioned here. As shown by Boedeltje, yearly dredging produced a loamy, fast nitrificating, mucky topsoil with a vegetation dominated by *Urtica doica*. Dredging once every four years caused a lower mean nitrogen level, leading towards a vegetation with *Lythrum salicaria* and *Filipendula ulmaria* dominating.

3.2. Variation in soil units under a plant community

EVERTS et al. (1978) compared the soil factors: earthening in peat soils and sandy admixtures in peaty topsoils in equal plant communities.

Earthening was determined by estimating the amount of still recognizable plant remains. Sand admixture was determined by weighing the mineral remainder after ignition at 700°C. These units were divided in wet, intermediate and dry moisture situations. In *figs. 2a* and *b* examples are given of soil variation under homogeneous vegetation types of *Senecioni-Brometum racemosi* subass. *Carex aquatilis* and of *Senecioni-Brometum racemosi* subass. *Carex nigra*. The factors earthening and sand admixture show a wide spreading in both vegetation types and are not discriminating.

3.3. Irreversibly changed peat soils.

SCHIPPER & VAN DER WINDT (1980) and SMIT (1979) investigated dry situations upstream, where ground water levels had been lowered by climatic influences in the past, or by recent anthropogeneous changes in hydrology. They found that the dry period at the end of the Subboreal (600 B.C.) caused oxidation of all kinds of peat to a depth of more than 1 m. Also at about 1200 A.D. the peat dried to an unknown depth. The most recent lowering of the water-table, in 1920, was

Table 1. Soil, vegetation and management in a part of the valley of the Drentsche A (after KLOOSTER 1975)

soil unit	discriminating factor	class of ground water regime	plant community	aspect	management
1. "Vliet"peat soil	A1 < 10 cm	I, II	Parvocaricetea	Equisetum fluviatile	mowed once a year, not manured, last three years abandoned
2. "Vliet"peat soil	A1 8–15 cm	I, II	Filipendulion	Glyceria maxima, Filipendula ulmaria	mowed once a year, not manured, last three years abandoned
3. "Vliet"peat soil	A1 15 cm	II	Caricion curto-nigrae	Juncus effusus	mowed once a year, not manured, last three years abandoned
4. "Made"peat soil	A1 30 cm	II	Calthion palustris	Rhinanthus serotinus	mowed once a year, not manured
5. "Vlak"vague soil	sandy cover > 40 cm	I, II, III,	Artemisietea vulgaris	Phalaris arundinacea, Urtica dioica	mowed once a year, not manured, last three years abandoned
6. "Moer"podzol -, "Made"peat soil	peaty topsoil	I, II	Agropyro-Rumicion crispi	Poa trivialis, Ranunculus repens	grazed and manured
7. "Made"peat soil	peaty topsoil	III	Molinietalion	Holcus lanatus	grazed and little manured
8. "Haar"pozol -, "Veld"podzol soil	sandy topsoil	V, VI, VII VIII	Poo-Lolietum	Lolium perenne	grazed and manured
9. "Haar"podzol -, "Veld"pozol	sandy topsoil	VII, VIII	Molinietalia	Holcus lanatus Agrostis tenuis	mowed once a year, not manured

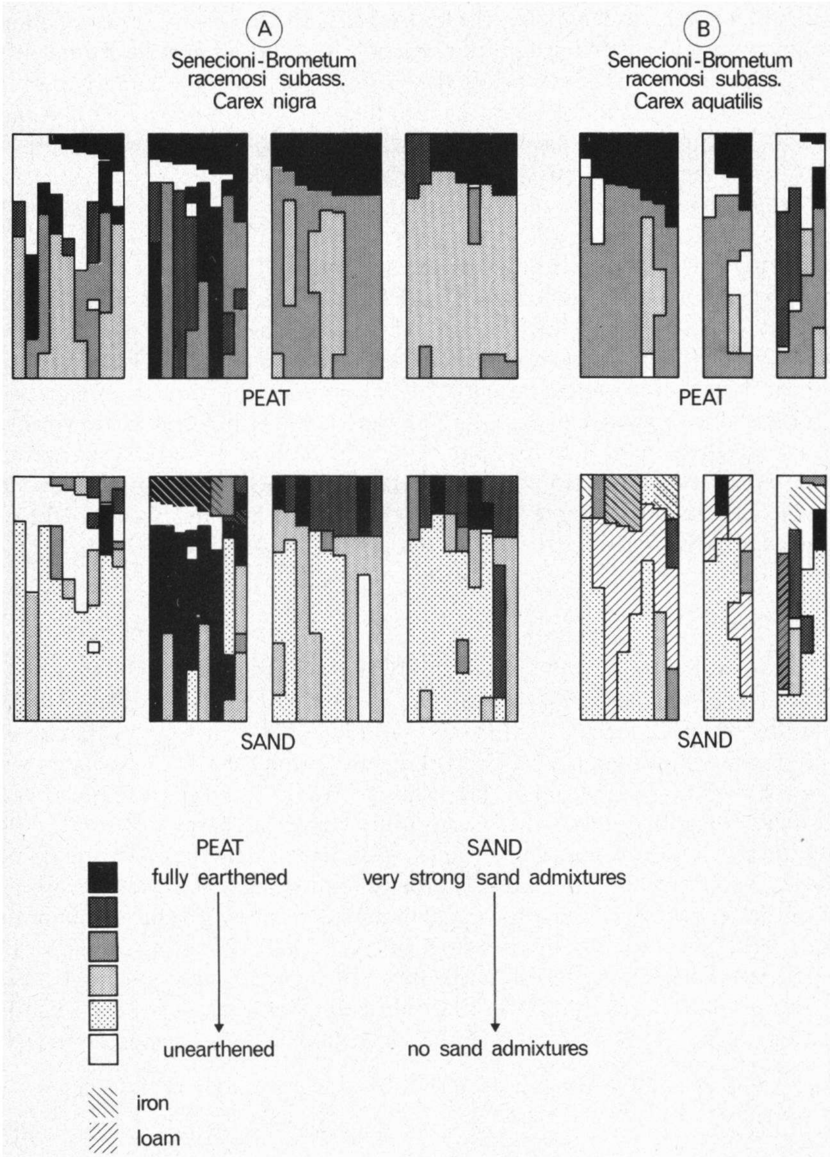


Fig. 2A. Earthening grade and % sand admixture in various samples on four localities with vegetation of *Senecioni-Brometum racemosi* with *Carex nigra* dominating.

Fig. 2B. As in fig. 2a: three localities with a vegetation of *Senecioni-Brometum racemosi* with *Carex aquatilis* dominating.

artifical as result of canalizing the brookbeds. In the loamy series of mucky topsoils pyramid-shaped structure elements of about 5 cm were found in the layers between 10 and 45 cm below the surface. The elements had coatings and roots followed them, not penetrating into the elements. In *table 2* the shrinkage factors are shown. A *Festuco-Cynosuretum* of the alliance *Cynosurion* (ELLENBERG 1978) was found on the irreversibly dried peat soil and a *Senecioni-Brometum racemosi* on the unaltered peat soil.

3.4. Peat soils including iron pans

Another phenomenon, studied by BLOK & LANGBROEK (1980), was an iron pan in the peat 10 to 15 cm below the surface. It was absent from seepage areas. Sometimes the iron pan was compact, in other cases it consisted of several layers. In general roots did not penetrate it. Only in communities with *Carex nigra* were the plants able to grow through it. There were no large holes of earth worms or arthropods in the pan. If an iron pan occurs the ground water table and ground water stream are deflected, these situations always coinciding with a *Carex aquatilis* community. Where a pan is absent seepage water wells to the soil surface and here *Juncus acutiflorus* communities are present.

4. DISCUSSION

From the investigations of KLOOSTER (1975) for a middle course area and of BOEDELTJE & BAKKER (1980) for lower course areas of the brook valley, using the soil units of DE BAKKER & SCHELLING (1966) (*table 1*), it follows that several plant communities may occur. Each plant community may be associated with, several soil units (*figs. 2a* and *b*). Thus soil spectra *versus* vegetation spectra only give few indications about the relationships between them. KLOOSTER (1975) noticed that on the level of single values, thickness of the mucky topsoil on peat soils, or peaty topsoils on sandy soils and pure sandy layers as well as classes of ground water regimes appear to be soil factors determining plant communities. BOEDELTJE (1976) (see also BOEDELTJE & BAKKER 1980), obtaining similar results as KLOOSTER (1975), could establish only very general relationships between vegetation and soil spectra, concerning only the higher levels of soil classification after DE BAKKER & SCHELLING (1966). The ground water is considered the most

Table 2. Shrinkage factors in peat samples from various depths in meadows with an unaltered and with a lowered water-table.

depth	peat after 2 years drying	wet peat
0– 5 cm	4.1	1.4
10–15 cm	4.6	1.1
35–40 cm	1.1	0
55–60 cm	0	–
70–75 cm	–	0.1
75–80 cm	0.2	–

important soil determining factor in this meadow area. Not only the class of ground water regime appeared to be determining, but especially variation within a class.

According to EVERTS et al. (1978), KLOOSTER (1975) and BOEDELTJE (1976), humidity related with the ground water regime is an important distinguishing factor in several plant communities. It serves to discriminate between a *Caricion curto-nigrae* and a *Magnocaricion* (BOEDELTJE & BAKKER 1980) in spite of their very different soil profiles. GROOTJANS (1980) and GROOTJANS & TEN KLOOSTER (1980) also indicated the principal influence of ground water variations. On the other hand it appeared that under homogenous plant communities very different soil types occur. Thus the relationship soil – vegetation is a very complex one. A new element from the investigations of BOEDELTJE (1976) are the various influences of the agricultural history on plant communities.

The structures found by SCHIPPER & VAN DER WINDT (1980) and SMIT (1979) were also described by KUIPER & SLAGER (1963) in the same region. The phenomenon of irreversible drying again emphasizes the influence of ground water regimes and their variation as vegetation determining factors. The presence of an iron pan in an otherwise homogeneous soil unit influences the ground water regime most strongly and hence greatly influences plant communities.

The investigations mentioned above may support the thesis of ELLENBERG (1956) stating that every plant community only reflects the soil factors on which it is dependant. EVERTS et al. (1978) found no recurring combination of soil features that characterizes their plant communities in a wet area. The only indications in this direction are found in the topsoil, such as an earthened layer, a sandy cover, or deposits of dredge material (KLOOSTER 1975, BOEDELTJE 1976, EVERTS et al. 1978). In general the importance of the humus quality in the topsoil as stated by VAN DOBBEN (1970), is confirmed. In addition the current research has revealed the effects on plant communities of disturbing layers for water movement such as iron pans, irreversibly dried peat structures or a simple discontinuity in the transition of peat to sand.

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REFERENCES

BAL, L. (1973): Micromorphological Analysis of Soils. Lower levels in the organization of organic soil materials. *Soil survey Papers no.* **6**. Soil Survey Institute, Wageningen, 174 pp.

BAKKER, H. DE & J. SCHELLING (1966): *Systeem voor bodemclassificatie van Nederland.* De hogere niveaus. Pudoc, Wageningen. 217 pp-

BLOK, D. & E. LANGBROEK (1980): *Onderzoek naar de relatie tussen Juncus soorten, grondwaterbeweging en bodem in de Drentse A.* Internal report Lab. voor Plantenoecologie, Haren (Gn).

BOEDELTJE, G. (1976): *De Kappersbult, bodem en vegetatie van het moerasgebied ten oosten van De Punt in het benedenstroomse dal van de Drentse A.* Mimeographed report Lab. voor Plantenoecologie, Haren (Cn). 114 pp.

— & J. P. BAKKER (1980): Vegetation, soil, hydrology and management in a Drenthian brookland (The Netherlands). *Acta Bot. Neerl.* **29:** 509–522 (this issue).

BROEK, J. M. M. VAN DEN & W. H. DIEMONT (1966): Het Savelsbos. Bosgezelschappen en bodem. *Land. Onderz.* **682.** Pudoc, Wageningen. 120 pp.

DOBBEN, W. H. VAN (1970): De terrestrische ecosystemen: de genese en de gevolgen van de menselijke technologie. In: *Biosfeer en Mens.* Pudoc, Wageningen, 29 pp.

EDELMAN, C. H. (1950): *Inleiding tot de bodemkunde van Nederland.* Amsterdam, 178 pp.

ELLENBERG, H (1956): Über die Beziehungen zwischen Pflanzengesellschaft, Standort, Bodemprofil und Bodemtyp. *Bericht über das internationale Symposium Pflanzensoziologie / Bodenkunde.* Stolzenau/Weser. 4 pp.

— (1978): *Vegetation Mittel Europas mit den Alpen.* Ulmer Stuttgart.

EVERTS, H., J. SWARTS & N. DE VRIES (1978): *Onderzoek naar de relatie bodem en vegetatie in de madelanden gelegen aan het Zeegser Loopje en de Drentse A.* Mimeograped report Lab. voor Plantenoecologie, Haren (Gn). 99 pp.

GROOTJANS, A. P. (1979): Some remarks on the relation between groundwater level, nitrogen mineralization and standing crop. *Acta Bot. Neerl.* **28:** 234–235.

— (1980): Distribution of plant communities along rivulets in relation to hydrology and management. *Berichte der Intern. Symposium der I.V.V. 1979:* 143–170. Cramer, Vaduz.

— & W. PH. TEN KLOOSTER (1980): Changes in ground water regime in wet meadows. *Acta Bot. Neerl.* **29**: 541–555 (this issue).

HOOGHOUDT, S. B., D. VAN DER WOERDT, J. BENNEMA & H. VAN DIJK (1960): Verdrogende veengronden in West Nederland. *Verslagen van Lanb. Onderz.* **66.** 23, Wageningen.

KUIPER, F. & S. SLAGER (1963): The occurrence of distinct prismatic and platy structures in organic soil profiles. *Neth. J. agr. Sci.* **5.**

KLOOSTER, J. (1975): *Samenhang tussen bodem en vegetatie in het dal van de Drentse A bij Schipborg.* Mimeographed report Lab. voor Plantenoecologie, Haren (Gn). 94 pp.

MEISEL, K. (1956): Vergleich zwischen Boden- und Vegetationskarte. *Bericht über das internationale Symposium Pflanzensoziologie/Bodenkunde.* Stolzenau/Weser. 12 pp.

ROO, H. C. DE & H. HARMSEN (1959): *De bodemkartering van een deel van de gemeente Rolde.* Intern rapport no. 441 van de Stichting voor Bodemkartering, Wageningen. 85 pp.

SCHIPPER, P. & H. VAN DER WINDT (1979): *Oecologische gevolgen van de ruilverkaveling Rolde Anlo.* Internal report Lab. voor Plantenoecologie, Haren (Gn).

SMIT, P. T. (1979): *Bewortelingsdiepte en grondwaterstandsdaling in de madelanden van de Drentse A.* Internal report Lab. voor Plantenoecologie, Haren (Gn).

STICHTING VOOR BODEMKARTERING (1977): *Bodemkaart van Nederland.* Blad 12 oost. Pudoc, Wageningen.

WESTHOFF, V. & A. J. DEN HELD (1969): *Plantengemeenschappen in Nederland.* Thieme, Zutphen. 324 pp.

ZONNEVELD, I. S. (1966): Zusammenhänge Forstgesellschaft – Boden – Hydrologie und Baumwuchs in einigen niederländischen Pinus – Forsten auf Flugsand und auf Podsolen. In: *Anthropogene Vegetation.* Ed. R. TÜXEN. Verlag Dr. W. Junk, Den Haag.