13 THE USE OF PEAT SOILS FOR GRASSLAND

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13.1 Introduction

Already some thousand of years ago men penetrated by boat and in some higher places on foot the peat-district in the Rhine delta.
Besides hunting and gathering products of the vegetation in the field, they started grazing cattle in open places between the wooded peat land. By burning, cutting down and digging small drainage ditches a more regular grassland husbandry system was developed. However, this caused lowering of the sod surface, so a marsh forming process.
Therefore a more organized system of reclamation was developed. In this way a system of polders came into being in which the water was removed by a system of ditches and canals with the farm-houses situated in the higher parts on the river sides. The grassland lies in long narrow fields behind the farm-houses towards the centre of the polder.
The water was pumped up by wind mills from the ditches in the then low lying centre part of the peat regions into canals with a higher water level and from those canals into the rivers. Because in rainy periods like in autumn and winter the pumping capacity of the wind mills often was too small, the low lying centre parts of the polders became extremely wet. Often the watertable rose above the soil level. Also in some polderdistricts the ditches were made very wide, so that the watersurface was one third of the total surface. This opened a possibility to store more water after heavy rains. But in the low lying centre parts, this usually was not a guarantee for the grassland to obtain a somewhat lower ground-watertable.

The grassland in the centre parts was in the top layer of the soil free from saturation with water only in summertime. This caused a slow start of the growth of the plantcover in springtime. Mostly actual growth started at the beginning of June.
Together with the great distance from the farm-houses, this grassland was only cut and the hay with the minerals absorbed from the soil by the herbage was transported to the farm. Near the farm the grassland was always grazed by cattle and also the farmyard manure from wintertime was brought on to the grassland nearby.
Throughout the centuries this has caused great differences in mineral availability to the herbage. Together with the effect of use differences this brought about a high diversity in plant communities from *Molinietum; Nardetum; Lolio-Cynosuretum* to *Poa-Lolietum*. About 25 years ago this zonation could still be seen on vegetation maps.

13.2 Grassland vegetation and production in former days

The grassland near the farm, which was always grazed and was regularly fertilized with stable manure, consisted of a plant community with *Lolium perenne* as a dominant species (*Poa-Lolietum*). Together with this species we found *Phleum pratense, Poa trivialis, Poa pratensis, Agrostis stolonifera, Trifolium repens*. We always find a low percentage of *Alopecurus geniculatus* and *Ranunculus repens* indicating the high humidity state of the organic rich clay on peat soil underneath the pastures. If these pastures received less dung which was possible if they were situated at a further distance, species like *Cynosurus cristatus* partly replaced *Lolium perenne*, and there would be less *Poa trivialis*, but more *Agrostis stolonifera (Lolio-Cynosuretum)*.
Because of the migration of minerals during centuries from the hayfields via the cows and their dung to the pastures a rather high phosphate and potash level in the soil was achieved and therefore a good production was possible. By changes in the humidity of the organic matter during the year, nitrate mineralization was possible and also influenced a relatively good production level. The yield from year to year fluctuated by differences in the weather. With a cold and wet spring and autumn the yield was decreased. A dry summer in those districts fa-

voured the production on these humid soils with a good capillarity from the ground water.

In cutting experiments on those pastures, which are still there, during many years, without adding fertilizer nitrogen and optimal phosphate and potash, we found an average gross production of ± 6 tons per hectare. This means that the pastures could feed about 2 cows per hectare during the pasture season.

But because the import of minerals to the farm area as a whole was very limited (possibly some with straw), and even on these low lying peat-soil some drainage of minerals occurred, the average herbage production was low. So a taxation is that only about 1 cow per hectare could be foddered the whole year round.

The hayfields comprising about two thirds of the total area of a farm were the source for fodder during wintertime, when the cattle was housed in the stable.

The composition of vegetation on those hayfields was quite different from those on the pastures. The fields situated at the greatest distance from the farm-house, with the lowest mineral status had a very rich flora, sometimes with about a hundred or more different plant species. It was called "blue" grassland (*Cirsio-Molinietum*), as the colour of the herbage was blue green and gray green during the growing season. This in contrast with the pasture land, which had a more dark green colour. On the hayfields *Molinia coerulea* was the dominant grass species. Another important species was the *Carex panicea*, called the "blue sedge" with its blue green leaves. Other frequently occurring species were a thistle *Cirsium dissectum*, various sedge species, *Gentiana pneumonanthe* with nice blue violet flowers and various orchid species.

The richness of this vegetation was possible as the low mineral supply caused a low growth rate. Because of this always enough light was left near the bottom, even at the time of cutting (about half August), so that different species had live possibilities. The mineral situation was not so extremely low that only specialists under the plant species could live there. The mineralization from the peat was regular, when after the extremely wet situation in wintertime, the peat became drier in the growing season. As no other factors were extreme either, various species find there life conditions in this environment.

The hay production was very low compared with the manured fields. From former cutting experiments was found that the yield would be about two tons per hectare of dry matter. Compared with the average production of about 12 tons dry matter as an average per ha nowadays, it is only a fraction.

The quality of the hay in respect to the mineral composition and proportions was good. Only the phosphate percentage was too low and the digestibility of carbohydrates and protein was low.

On the grassland farms the zonation of the green pastures behind the farm-houses and the yellow brown zone in wintertime, altering in the blue green-grey green zone during the growing period, remained until the fertilizers appeared. This rather stable period, only sometimes disturbed by troubles with the water regulation gave a contribution to the prosperity of the towns in the sixteenth and seventeenth century.

Also in later centuries the by-products of the beer and other alcoholic production and cheap fodder grains, were used for pig feeding, and so some import of minerals to the grassland farms was possible.

13.3 Change in vegetation and production of the grassland after better drainage control of the polders and the application of fertilizers

With the introduction of motor pumps, the control of the groundwater-level became better. This created a better possibility to get with farm wagons to the fields at a greater distance from the farm-house. So together with the introduction of fertilizers, it meant a possibility to introduce minerals to those distant hayfields.

At the beginning phosphate and potash was used. Together with the nitrogen mineralized from the peat by the lowered groundwater table, an evolution of the "blue" grassland started. Species like *Molinia coerulea* and *Carex panicea* dominating the "blue" grassland quickly disappeared, and species like *Holcus lanatus*, *Anthoxanthum odoratum* already present in low percentages increased and *Poa trivialis* present in the "pasture" behind the farm-houses migrated to the hayfields. Many species like orchids and more rare sedge species disappeared. The number of species decreased from 80-100 to 40-50.

The new hayfield plant-community replaced in the years 1920-1930 almost all of the old "blue" grassland. The production increased to about 6-7 ton dry matter per ha. This meant that after a hay-cut in July, the aftermath could still be grazed.

This grassland type called haypasture was colourful during the hay cut as standing crop. The *Holcus lanatus*, a grass species with reddish glumes and the reddish brown colour of the sorrel (*Rumex acetosa*) and the yellow of the group of *Caltha palustris*, *Ranunculus acris* and *-repens*, *Rhinanthus glaber*. On the more humid places the reddish colour of the *Lychnis flos-cuculi* was striking.

Depending on the type of use and the groundwater supply we found various types of this *Calthion* vegetation.

At the end of 1930 and from 1945 again also the amount of fertilizer nitrogen increased to an average of about 70 kg pure N per hectare per year.

From 1960 until nowadays the amount of nitrogen increased highly. On the moment the average is about 250 kg N/ha/year.

Together with the increase in N the grass silage replaced more and more the role of hay as a fodder.

Also the mixed use-system per field increased, with the purpose of obtaining a better and more homogeneous floristic composition of all the grassland on the farm.

Therefore the differences in the vegetation of the grassland in the peat-district grow smaller and smaller.

Still we find the difference between the predominantly grazed fields near the farm-house, because the same species from former days are still there, but more dominant now with less accompanying species. The dominant pasture species like *Lolium perenne* and *Poa trivialis* have migrated to the grassland further away from the farm-house although they occur here in lower percentages.

A species like *Holcus lanatus* coming from the former "blue" grassland, became dominant in the successor, the colourful haypasture of 1920-1950 and migrated in low percentages to the above-mentioned pastures. This species is benefitted by fertilizing as found in experiments, but not tolerant to regular grazing. Therefore its optimum is situated in the fertilized hay pastures.

Also a "mow" species *Alopecurus pratensis* is important in the haypas-

tures, sometimes with rather high percentages.
Some other plant species like *Rumex acetosa, Anthoxanthum odoratum* and *Cardamine pratensis* remained as relicts in the grassland fields to the centre of the polders.
The production of the grassland has increased again and is now on an average 12 tons of dry matter per ha per year. This means a doubling of the production of the period 1930-1950.
If the drainage situation of the peat is good, and with the additional feeding of concentrates at present usual, a cattle density of 2-2.5 units per ha is an average. The average fertilizer nitrogen dressing is 250 kg pure N per ha per year. In some places the intensity of the grassland exploitation is so high, that we can speak of over-exploitation. This is indicated by plant species like *Poa annua, Stellaria media, Rumex obtusifolius* and *-crispus* and *Agropyron repens.*
In cutting experiments with grassland types on peat with optimal phosphate and potash situation, as an average of 10 years research, without N-fertilizer we found an average uptake of 300 kg pure N in the total annual herbage yield per hectare on the well drained peat soil. This uptake is 215 kg N on the more poorly drained peat, in the plots which were not fertilized with N in those 10 years.
So this means fertilizer application on peat soil had to be adapted to this knowledge to prevent over-dosing and over-exploitation.

13.4 An additional function of the peat district

Nowadays with landreconstruction development the results of vegetation surveys are used to get information about possibilities for nature and landscape management.
In the peat-district plans are developed to restore the former above-mentioned haypasture vegetation. So on the vegetation maps special attention is given to the vegetation types with as many as possible relict plant species of former vegetation types. To this purpose the vegetations along the ditch sides are also surveyed. Often those linear-elements have more relicts as the grassland fields. It could be possible that these linear-elements serve as dissimination centres to the hayfield. On the latter fields an adapted management had to be devel-

oped, to decrease the level of minerals in the soil and adjusting the time of cutting, to give some plant species the possibility of seed production.

Because in the peat-district still many grassland birds are nesting and finding feed, this function is of interest as well.

By more intensive grassland exploitation possible by higher fertilizer input and drainage improvement, the cattle number and grazing frequency increased. This cattle is moved already early in the growing season together with the traffic of agricultural machinery and wagons to the more distant fields in the polders. So the quietness of those parts of the polder of earlier days disappears. It also means that more and more nests of the grassland birds are disturbed.

To preserve and develop the possibilities for brooding of the grassland bird, in some regions restrictions to grassland use and drainage are planned.

With the knowledge about decreased grassland production with those restrictions, the cost price to maintain grassland bird brood regions are calculated.

So the knowledge about the relation between the floristic composition and the growth factors, giving the indication of the production level are used for some aspects of nature management in the peat-district.

In this respect experiments are also done about recovering the former vegetation types, not only of the grassland, but also of the banks of the ditches and in the water of the ditches.

This means that the peat-district will be given a new function, not only for a number of biologists, but also for the recreation of many people in this densely populated coastal district.

	I	II	III
Lolium perenne	63	9	
Poa trivialis	13	31	
Poa pratensis	+	2	
Poa annua	3	+	
Agrostis stolenifera	7	24	
Phleum pratense	2	1	
Cynosuris cristatus	1	–	
Trifolium repens	2	+	
Cirsium arvense	+	–	
Ranunculus acris	+	+	
Ranunculus repens	3	+	
Taraxacum officinalis	1	+	
Cardamine pratensis	1	+	
Plantago major	+	–	
Carex hirta	+	–	
Potentilla anserina	+	–	
Agrostis tennis	3	4	
Stellaria media	+	+	
Polygonum hydropiper	+	+	
Bellis perennis	+	+	
Festuca pratensis	–	7	
Glechoma hederacea	–	+	
Bromis mollis	–	3	
Dactylis glomerata	–	1	
Cerastrium fontanum	–	+	
Alopecuris geniculatus	+	+	
Festuca rubra	–	+	1
Holcus lanatus	1	29	1
Plantago lanceolata		+	1
Rumex acetosa		1	+
Luzula campestris		+	+
Anthoxanthum odoratum		+	5
Juncus effusis		+	5
Carex nigra		+	+
Lychnis flos-cuculi		+	–
Trifolium pratense		+	
Molinia caerulea			62
Carex panicea			7
Eriophorum angustifolium			1
Potentilla erecta			2
Valeriana dioica			+
Viola canina			+
Hypochaeris radicata			10
Cirsium palustre			1
Centaurea pratensis			+
Sieglingia decumbens			3
Agrostis canina			1
Cirsium dissectum			1
Galium palustre			+
Festuca ovina			+
Succisa pratensis			2
Achillea ptarmica			+
Gentiana pneumonanthe			1
Orchis maculata			+

Records made 25 years and more ago of 3 grassland plots in the peat district of the province South-Holland. Record I is an example of the *Poa-Lolietum* and III of the *Cirsio-Molinietum*, both grassland communities mentioned on p. 215 and 216. Record II is an example of the community mentioned on p. 218 as the new hay field type.

14 REVIEW OF CHAPTER 13

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This paper has given us a good insight into the historical use of peat soils for grassland in The Netherlands. We particularly noted certain similarities and sometimes marked differences with our own agricultural developments.

When European settlers reached our shores they too penetrated by boat deeply into our country but choose to farm on mineral rather than on peat soil. The failure to develop Irish peat for agriculture is in our opinion not related so much to the absence of land scarcity as to the fact that Irish peats were less productive than what the initial settlers in The Netherlands and elsewhere found. The peatlands we had 1000 years ago were mostly of the blanket and raised types with relatively little fen available. It would be interesting to know the extent of fen peat in The Netherlands before burning and peat cutting started or was the fen only exposed in the burning and cutting operations?[1] Windmills were not a feature of even the most organized attempts to reclaim our peat areas for agriculture. Presently the need for pumping is being largely avoided by cutting through moraine gravel ridges and arterial drainage. Burning is no longer carried out as a mineral enriching technique. Open drainage ditches and shelter plantings are kept to an absolute minimum. Trees should be used more as a landscape feature rather than as a form of shelter until their positive contribution to grass or animal production is established. We find that no mention is made of surface claying or marling[2] or the use of farm yard manure (FYM) in the earlier reclamation periods. The establishment of grassland on Irish peats in times past necessitated such treatment. The use of a

cutting as distinct from a grazing regime on the Dutch peats must have quickly exhausted soil reserves of nutrients. Did these nutrients mainly come from coastal alluvial materials rather than the peat itself?[3]
Our peats contain very poor reserves of P and K. However, the efficiency of utilization of fertilizer derived P and K at the optimum rate of application is approximately 80 per cent for each nutrient. The high diversity in plant communities attributed to differences in mineral supply and use have not been exactly pinpointed in the paper. We are especially interested in species establishment and survival under varying moisture, nutrient and management levels. It would be useful to know if the effects of FYM as a supplier of major and trace mineral nutrients and as a seed carrying agent on the botanical composition have been separated. Would slurry produced under intensive systems of grassland management have similar effects?[4] We associate the use of slurry with weed spread. The dominance of *Lolium perenne* in grazed swards treated with FYM was probably mainly associated with higher levels of P and K. The disappearance of *Lolium* from Irish peat pastures is usually associated with acidity. In Ireland under cutting conditions a sward of rosette weeds and poorer grasses receiving yearly increments of N and P grown on peatland can be quickly converted to almost a pure culture of *Festuca rubra*) in the absence of K whereas in the absence of P rosette weeds predominate (Murphy 1966). The yield response to nitrogen and phosphorus on such pasture varied from 7.9 kg DM per kg N to 93 kg DM per kg P applied. *Phleum pratense* is not very competitive under Irish conditions and is more susceptable to iron chlorosis when grown on peatland. We find *Agrostis spp* plentiful where fertility is low but rarely does one find *Cynosurus cristatus* dominant. *Lolium perenne* is usually the most favoured spp. from a production point of view. However, equally good production of mutton has been obtained from *Poa trivialis/Trifolium repens* swards or swards of *Cynosurus cristatus* and *Agrostis tenuis* plus nitrogen when grown on mineral soil (Murphy 1965). The effect of prostrate type grasses on the utilization efficiency of the sward especially under moist conditions should receive more attention. In our opinion the use of *Stenotaphrum secundatum* (Roselawn St. Augustinegrass) in Florida helps, by means of its very thick stolons, to prevent poaching or damage caused by treading. We have no temperate climate equivalent to this grass. It might get over some of the disadvantages we associate with

reducing oxidation losses by keeping the watertable high. In present circumstances we recommend late varieties of *Lolium perenne* as well as *Poa trivialis* and *Trifolium repens* on poorly drained sites because of utilization problems. Generally the survival rate of the sown species will depend on acidity, nutrient and moisture levels and on whether the sward is used for cutting or grazing.

The mowing experiments described in the paper on old cow pastures showed an average response of 6 tonne of DM or a stocking rate of 2 cows per hectare during the grazing season without added nitrogen. Is it known what proportion of this nitrogen comes from peat mineralisation as distinct from clover or elsewhere?[5] In our experience very little nitrogen is released for plant growth on our newer peats because of an unfavourable C/N ratio. Under cutting conditions the dry matter production from a *Lolium perenne* sward per kg of applied nitrogen is 35 kg using up to 336 kg N/ha annum. The apparent recovery of fertilizer nitrogen from a sward so treated is 80%. The dry matter response to nitrogen on an established *Lolium perenne/Trifolium repens* sward similarly treated is only 12 kg. This raises under our conditions the importance of clover and the botanical and management conditions necessary for its survival. In this respect the compatibility of clover as a source of nitrogen and prostrate type grasses to improve bearing capacity needs to be further elucidated. The bearing capacity of the sward may also be improved by the addition of sub peat mineral materials to peat but is unfortunately in some circumstances associated with poor conversion of grass to animal product because of molybdenum induced copper deficiency. We need to know more about the ideal proportion of peat to mineral soil and the effect it has on grass utilization.

The paper states that better drainage and the use of fertilizer increased the *Holcus lanatus* and *Rumex acetosa* content of the sward. Under Irish conditions these species also become dominant where the soil is acid or where ground limestone is insufficiently incorporated irrespective of drainage conditions.

Today's stocking rate of 2.5 livestock units per hectare in Holland compares very favourably with our results where equivalent fertilizer N inputs are made. Grazing trials over a 184 day period on shallow cutover raised bog have shown that the optimum stocking rate is 4.3 bullocks per hectare having a starting liveweight of 280 kg where clover supplied

most of the nitrogen requiremtns of the sward. This can be increased to 5.6 bullocks per hectare of similar liveweight where artificial nitrogen is applied. One third increase in the carcass gain of heifers having a staring liveweight of 275 kg has been recorded from nitrogen applications to pasture stocked at approximately 8 heifers per hectare until mid-season and reduced to 4 per hectare thereafter. In our calf to beef systems work 2.5 calves can be carried to slaughter weight at 24 months of age or 1.6 cows and progeny to slaughter weight at 18 months of age on each hectare. In farm situations where peat and mineral land are farmed together we recommend that wherever possible the peats be used only for summer grazing leaving the mineral soil for conservation and slurry disposal. Some of our farmers are, under these conditions, realizing on a hectare basis a stocking rate of 2.5 cows and a milk production level of 11,400 litres. We have not measured the rate of release of N from our 'old' peat soils but we obtain as stated earlier a negligible N release from our 'new' peats. It is surprising therefore that similar stocking rates are achieved with similar fertilizer nitrogen inputs on 'old' Dutch and 'new' Irish peats. In how far could this be affected by differences in watertable heights?[6]

The paper raised the question of the over exploitation of grassland. What are the exact conditions whereby over exploitation is a problem?[7] We assume the author is concerned about overstocking under poor drainage conditions. In our circumstances *Lolium perenne* and *Trifolium repens* withstands heavy stocking under rotational grazing systems. Species like *Poa annua* and *Stellaria media* only become a problem under open pasture conditions such as in new reseeds or where insect damage to pasture occurs. Nowhere in the paper did we find mention of the *Juncus* family. This is one of our worst weeds in poorly drained and managed peat pastures. Other weeds of widespread occurrence are: *Senecio jacobaea, Rumex obtusifolius* and *Cirsium arvense*.

Ireland is probably less conscious of maintaining old hay pasture vegetation types as described in the paper. Perhaps it is due to our abundance of vegetation types and a greater predominance of hedgerows. No doubt in the future emphasis must be placed on this aspect also. We believe this must be done now in areas of countryside specially selected for their amenity/recreational potential. In the Irish context it is probably more difficult to prove on cost/benefit grounds the present

value of such a proposal. Having proved it in The Netherlands we are interested in the mechanisms you have to ensure that the area in question will be conserved for the purpose intende.
The agricultural development of Dutch peatland has been taking place over a long period of time whereas most of the Irish agricultural developments have yet to be accomplished. Perhaps the author would like to speculate on the likely impact of modern technology and energy availability on the future developments and use of these peatlands taking into account the differences in their present stage of development.

Notes
(1-3 from the editors, 4-7 from De Boer)

1 The excavated peat in the western part of The Netherlands consisted of raised bogs (moss peat) and partly clay-poor sedge peat, the still remaining peat (Figure 1, Table 2 and Figure 4a in Chapter 5) is a clayey wood peat, partly covered with shallow fluviatile sediment. It is unknown if there was any burning practice as an agricultural system on the reclaimed raised bogs before they were cut for fuel contrary to the agriculture on the raised bogs in the northeast of The Netherlands and in the northwest of Germany (cf. Figure 1 in Chapter 8).

2 There is nothing known about marling in the time of the Big Reclamation (Chapter 3); marl is available at a distance of over 200 km; of course, in recent times there is liming, if necessary.
Claying is also not known in these early times; but, in the reclaimed bog floors with their calcareous loamy soils locally there are many circular depressions (3-5 m wide and a depth of 2-3 m) filled in with peaty material. Mr. L.W. Dekker of the Soil Survey Institute of The Netherlands in an article (in preparation) thinks it highly improbable that these holes date back from the times the raised bogs were reclaimed but rather from the time of the peat cutting.

3 We do not know anything about manuring practices in the early stages of the Big Reclamation. Coastal alluvial materials have not been used, dune sand (cf. Chapter 5.2.2 and 5.3.2) has been used but we do not know when this practice started.

4 In some cases slurry can increase weeds in grassland. But if the slurry is well mixed and applied by not too dry weather conditions no weed spread will occur.

5 The percentage clover in the sward of the zero nitrogen plots in the described experiments was only 3-5%. So only a very low percentage of the nitrogen comes of this wild white clover.

6 The stocking rates of about 2 cows per hectare on the 'old' Dutch pastures is limited only to the first 1/3 front part of the farms. The mineral status (also phosphate and potash) was favourable and if the watertable was optimal for plant growth and in most circumstances not so high that grazing damaged the sward.

7 It is no possible to put the exact conditions whereby overexploitation is a problem. It is a combination of too high nitrogen application (higher than 300-400 kg pure nitrogen per year per hectare for peat soil with an optimal watertable) and damage of the sward by cattle grazing and machinery during rainy periods.

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