DE BRABANTSE BIESBOSCH

EEN STUDIE VAN BODEM EN VEGETATIE VAN
EEN ZOETWATERGETIJDENDELTA

A STUDY OF SOIL AND VEGETATION OF
A FRESHWATER TIDAL DELTA

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD
VAN DOCTOR IN DE LANDBOUWKUNDE
OP GEZAG VAN DE RECTOR MAGNIFICUS IR. W. DE JONG,
HOOGLERAAR IN DE VEETEELTWETENSCHAP,
TE VERDEDIGEN TEGEN DE BEDENKINGEN
VAN EEN COMMISSIE UIT DE SENAAT
VAN DE LANDBOUWHOGESCHOOL TE WAGENINGEN
OP VRIJDAG 12 FEBRUARI 1960 TE 16.00 UUR

DOOR

ISAAK SAMUEL ZONNEVELD

DE BRABANTSE BIESBOSCH

EEN STUDIE VAN BODEM EN VEGETATIE VAN EEN ZOETWATERGETIJDENDELTA

A STUDY OF SOIL AND VEGETATION OF A FRESHWATER TIDAL DELTA

BESTAANDE UIT DRIE BOEKDELEN
CONSISTING OF THREE VOLUMES

A. ENGELSE SAMENVATTING MET TEKSTFIGUREN EN TABELLEN
   SUMMARY WITH TEXT FIGURES AND TABLES

B. NEDERLANDSE TEKST
   DUTCH TEXT

C. BIJLAGEN
   APPENDICES

DE BRABANTSE BIESBOSCH

EEN STUDIE VAN BODEM EN VEGETATIE VAN
EEN ZOETWATERGETIJDENDELTA

A STUDY OF SOIL AND VEGETATION OF
A FRESHWATER TIDAL DELTA

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD
VAN DOCTOR IN DE LANDBOUWKUNDE
OP GEZAG VAN DE RECTOR MAGNIFICUS IR. W. DE JONG,
HOOGLERAAR IN DE VEETEELTWETENSCHAP,
TE VERDEDIGEN TEGEN DE BEDENKINGEN
VAN EEN COMMISSIE UIT DE SENAAT
VAN DE LANDBOUWHOGESCHOOL TE WAGENINGEN
OP VRIJDAG 12 FEBRUARI 1960 TE 16.00 UUR

DOOR

ISAAK SAMUEL ZONNEVELD

Aan mijn ouders

Aan mijn vrouw

Aan de Biesbosch en zijn bewoners

STELLINGEN

I

Naast en in combinatie met bodemstudie en bodemkartering is vegetatiekartering en vegetatiekundig onderzoek zowel algemeen wetenschappelijk als ook praktisch van betekenis voor weide-, bos-, akker- en tuinbouw, griend-, riet- en biezencultuur, voor landaanwinning en voor de voorbereiding en nastudie van cultuurtechnische werken.

II

Het continue karakter van overgangen tussen abstracte bodem- en vegetatie-eenheden en het arbitraire karakter van grenzen worden niet steeds voldoende onderkend.

III

De kalkarmoede van lage natte gronden in Nederland berust zowel op pedogene als op geogene processen.

IV

De door P. E. MÜLLER in de bodemkunde ingevoerde term „Mull" dient gereserveerd te blijven voor de aanduiding van een bepaalde macro-morfologisch gekenschetste bodemtoestand en niet gebruikt te worden voor een micro-morfologische humusvorm zoals door HARTMANN en KUBIENA is gedaan en door anderen (o.a. JONGERIUS) is nagevolgd.

MÜLLER, P. E.	1887	Studien über die natürlichen Humusformen. Berlin.
HARTMANN, F.	1951	Der Waldboden. Wien.
KUBIENA, W. L.	1953	Bestimmungsbuch und Systematik der Böden Europas. Stuttgart.
JONGERIUS, A.	1957	Morfologische onderzoekingen over de bodemstructuur. Diss. Wageningen. Serie: *Bodemkundige Studies* nr. 2. Reeks: *Versl. Landbouwk. Onderz.* nr. 63.12. 's-Gravenhage.

V

Het verband tussen het gehalte aan lutum en organische stof in sommige tropische, periodiek overstroomde gronden, zoals beschreven door JEWITT (1952), is hoofdzakelijk het gevolg van geogene factoren en minder van pedogene processen dan genoemde schrijver veronderstelt.

JEWITT, T. N.	1952	The distribution of organic matter in depth in some tropical seasonally flooded soils. *J. Soil Science* 3: 63-67.

Voor gebruik als kenmerk bij de bodemclassificatie verdient de waterfactor (n_1), gedefinieerd als: „het watergehalte van één eenheid lutum", de voorkeur boven die (n_2) waarvoor de definitie geldt: „de toename van het watergehalte per eenheid lutum bij toenemend lutumgehalte".

$$n_1 = \frac{A - 0{,}2Z}{L + bH} \quad n_2 = \frac{A - 20}{L + bH}$$

n = waterfactor.
A = watergehalte per 100 g grond, droog berekend.
L = lutumgehalte.
H = gehalte aan organische stof.
b = verhouding tussen waterbindend vermogen van organische stof en lutum.
Z = gehalte aan zand en eventuele overige weinig of geen waterbindende stoffen.

De door BENNEMA (1954) en anderen veronderstelde periodiciteit bij de relatieve zeespiegelstijging langs onze kust wordt voor de laatste vijf eeuwen door de resultaten van de bodemkartering in de Biesbosch bevestigd.

De fysisch-chemische verklaring voor het ontstaan van een lage lutum/slib-verhouding in Nederlandse sedimenten verdient de voorkeur boven de uitsluitend fysische.

Het berekenen van levensvormenspectra volgens de methode van SCHWICKERATH voor de bepaling van groepswaarden, zoals door SISSINGH (1952) en WESTHOFF (1947) is gedaan, verdient geen navolging.

SCHWICKERATH, M.	1931	Die Gruppenabundanz, ein Beitrag zur Begriffs-bildung der Pflanzensoziologie. *Englers Botan. Jahrb.* 64, 1.
SCHWICKERATH, M.	1940	Die Artmächtigkeit. Feddes Reprt., Beiheft 121.
SISSINGH, G.	1952	Ethologische synoecologie van enkele onkruidasso-ciaties in Nederland. *Meded. Landbouwhogeschool Wageningen.* Dl. 52., verh. 6.
WESTHOFF, V.	1947	The vegetation of dunes and salt marshes on the Dutch islands of Terschelling, Vlieland, and Texel. Diss. Utrecht. 's-Gravenhage (Stelling IV).

Het behoren tot de „climax"-vegetatie van een bepaalde boomsoort zegt algemeen gezien niets over de invloed van deze op de bodem.

Indien de waterstand na uitvoering van de deltawerken in het gebied van de benedenrivieren gedurende het vegetatieseizoen langdurig het peil van ca. 80 cm +N.A.P. nadert of overtreft, zal het areaal waarin buitendijkse griendcultuur en houtteelt mogelijk is, zeer sterk worden verkleind.

XII

Door afsluiting van Haringvliet en Volkerak zal de wetenschappelijke betekenis van in open contact met het riviermilieu gelegen, voldoend grote natuurreservaten niet verminderen.

XIII

Bij de voorbereiding en uitvoering van de deltaplannen dienen ruimschoots middelen beschikbaar te worden gesteld voor de uitvoerige bestudering, o.a. via vegetatie-kartering, van die landschapsvormen en levensgemeenschappen, die ten gevolge van de afsluiting van de zeegaten verloren zullen gaan.

XIV

Het vervangen van oude toponymen is, ook na ingrijpende technische veranderingen in het landschap, in het algemeen ongewenst.

XV

Het is wenselijk dat aan de Landbouwhogeschool een vaste cursus wordt gegeven in de eerste beginselen van de kennistheorie.

I. S. ZONNEVELD, 1960.

ERRATA

Boekdeel A
Volume A

Aan de literatuurlijst toevoegen:
To add to literature:

ANTIPA, D.,	1912	Das Ueberschwimmungsgebiet der unteren Donau. Anuarul Institutui Geologie al Romaniei. Bucharest.
JENNINGS, J. H. and J. M. LAMBERT,	1951	Alluvial stratigraphy and vegetational succession in the region of the Bare valley broads. *Journal of Ecology, 39,* 1 : 106 - 170.
KERN. J. en TH. REICHGELT	1952	Onze rivieroevers, schatkamers voor de floristiek. *De Levende Natuur, 55* : 106 - 115 en 126 - 134.

Boekdeel C
· *Volume C*

Bijlage 1:   bodemtype G3b, 5e en 6e kolom lees:
Appendix 1, soiltype G3b, 5th and 6th column $< 50 \ < 28,$ *read:* $< 35 \ < 19$

Bijlage 2:   lees:
Appendix 2: Rp *Glycerieto-Sparganietum vaucherietosum,* *read:* *Glycerieto-Sparganion*

V4 en V5: Kleine Watereppe   lees: Moerasscherm ...
Sium erectum, read: *Apium eu-nodiflorum* THLNG.

toevoegen: Volle grijze kleur zonder symbool: voornamelijk bouw- en grasland.
to add: *Full gray colour without symbol: predominantly arable and pasture land.*

Bijlage 13,   eerste kolom; lees: ,,in de bosformatie" tussen haakjes.
Appendix 13, first column: read: "in the forest formation" between brackets.

Circea: lees *(read) Circaea.*

„De aanhouder wint"
"Perseverance kills te game"

„Heen" *(Scirpus maritimus)*
op een lage zandplaat

Scirpus maritimus on a low sand-flat

INHOUD
CONTENTS

ABOUT THIS BOOK

The publication of this thesis: the results of the study of the soil and vegetation of De Brabantse Biesbosch has been seriously retarded in consequence of administrative and financial difficulties caused by the extensiveness of the manuscript.

The manuscript was prepared during 1954 and has definitely been closed in 1955. Thus literature published afterwards and subsequent own objections against some opinions in the book could not be discussed.

Now the manuscript is published as follows:

Volume A.   A summary in the English language, with text figures and small tables with English subscriptions. Because of the above mentioned reasons some photographs had to be dropped, owing to which hiats in the consecutive numbering of the text figures occur.

Volume B.   The complete Dutch text (in offset). No text figures and tables could be shown in this volume. In the Dutch text references are made to the figures of volume A. It will be rather difficult to read volume B without the illustrations and documentation of volumes A and C.

For all these imperfections we offer our apologies.

Volume C.   A portfolio with appendices (the larger maps, transects and vegetation tables).

ACKNOWLEDGEMENTS

DE BRABANTSE BIESBOSCH,
EEN STUDIE VAN BODEM EN VEGETATIE VAN EEN
ZOETWATERGETIJDENDELTA

KORTE SAMENVATTING

In deze studie wordt de geologische, bodemkundige en vegetatiekundige opbouw van een karakteristiek Hollands landschap, een zoetwatergetijdendelta, onderzocht.

Tevens wordt het gebruik, dat de mens van het landschap maakt of zou kunnen maken en de invloed, die dit op verschillende onderdelen van het landschap heeft, bij het onderzoek betrokken.

De Biesbosch kan worden beschouwd als een van de inbraken die de zee, gedurende de subatlantische transgressie, in het Noordwesteuropese veenlandschap van de kustvlakte heeft geslagen en wel in een deel, dat nog geen twee eeuwen bedijkt was. De geologische ondergrond, die deels uit slappe kleien bestaat die rijk zijn aan organische stof, blijkt reeds sinds het Subboreaal gedurende de ontwikkeling van een dik veenpakket vele meters te zijn geklonken.

Onder invloed van in de zeearm uitmondende rivieren begon onmiddellijk een sterke opslibbing. Het sedimentatiepatroon, en daarmee de bodemkundige gesteldheid, staat geheel onder invloed van enkele fluctuaties in de zeespiegelstijging. Tussen 1600 en ca. 1850 werden tijdens minder snelle zeespiegelstijgingen (eventueel stilstandsfase of kleine daling) grote massa's zand aangevoerd, die anders hogerop in het rivierbed zouden zijn blijven liggen. Deze zandmassa's gaven aanleiding tot de vorming van hoge zandplaten, die slechts konden worden bedekt met een dunne zware kleilaag (zandplaatgronden). Ook werden hoge zandige oeverwallen afgezet in het noordoosten van het gebied. Tevens werden in die tijd zeer zware, deels kalkarme kleiafzettingen gevormd. De contrastrijkdom, die het riviermilieu onderscheidt van dat van de zee, wordt hierdoor duidelijk aangetoond.

Vóór en nà genoemde periode werden sedimenten afgezet met veel gelijkmatiger overgangen in zowel horizontale als verticale richting. Veranderingen in de verhouding tussen oppervlak (inhoud) en toegangsweg naar de vloedkom, die de zeearm is, spelen ook een rol bij de sedimentatie. De invloed van de vegetatie op de sedimentatieprocessen is aanzienlijk. Deze is versnellend of vertragend, al naar gelang de vegetatie een stroomsnelheid ten gevolge heeft, die gunstig of ongunstig voor sedimentatie is. Het eerste is meestal het geval. Het laatste mag echter niet worden verwaarloosd.

De „relatieve korrelgrootteverdeling" (zie fig. 31 en 32), zich uitend o.a. in de lutumslibverhouding, die tussen de 50 en 60 % ligt, is kenmerkend voor het gebied en staat tussen die van zee- en riviersedimenten in. De aard van de klei is meer verwant aan die van rivierklei (o.a. kali- en fosfaatarm en tevens fixerend voor deze beide elementen). De geomorfologie is meer verwant aan die van de mariene sedimenten.

Het watergehalte van de jonge sedimenten is hoog, in het bijzonder vanwege het hoge gehalte aan organische stof. Hierin bestaat een karakteristiek verschil met jonge mariene afzettingen, die armer zijn aan humus. Het volume van de sedimenten is daarom bij gelijk gewicht in het zoete gebied veel hoger dan in mariene gronden. Gedurende de rijping, die voortgaat tijdens de opslibbing, neemt het watergehalte af, mede via vermindering van het gehalte aan organische stof. Voor de verklaring van de gang van het afzettingsproces, alsook voor de voorspelling van dikte van het kleidek en hoogte van het maaiveld na eventuele inpoldering, is de kennis van genoemde rijpingsprocessen van belang.

De afbraak van grote hoeveelheden met mineralen verzadigde organische stof doet zeer veel voedingsstoffen vrijkomen. De extreme vruchtbaarheid en de daarmee verband houdende enorme afmetingen van vele buitendijkse planten worden hierdoor verklaard.

De sterk anaërobe toestand in de onrijpe gronden heeft invloed op verschillende voor de vruchtbaarheid belangrijke elementen.

Organische zuren, die tijdens gereduceerde omstandigheden in het bodemwater oplossen (voornamelijk koolzuur), doen de kalk oplossen en daardoor uitspoelen. Deze anaërobe oplossing van kalk is de oorzaak van de primaire ontkalking. Doorluchting werkt de oplossing van koolzuur en daarmee de uitspoeling van Ca tegen[1]. Fosfor wordt gefixeerd door in oplossing zijnde ijzerverbindingen en ook door kalk. Mangaan wordt vermoedelijk gefixeerd door organische tussenprodukten, die tijdens het afbraakproces worden gevormd. In de kristalroosters wordt in het moerassige milieu vermoedelijk NH_4 geadsorbeerd, dat in de rijpste stadia geleidelijk weer wordt vervangen door K, hetgeen kalifixatie veroorzaakt. Het zwavelgehalte neemt af gedurende de rijping. Het is in dit zoete gebied niet hoog genoeg om vorming van katteklei te veroorzaken.

Van het gehele gebied werd een bodemkaart vervaardigd, waarop het onbedijkte land, wat dikte der lagen betreft, is weergegeven alsof het geheel fysisch gerijpt was, alsof dus reeds volledige klink had plaatsgevonden. De dikte van het kleiige dek op zandige ondergrond is een van de belangrijkste karteringskenmerken. Er werd niet op actuele, maar op potentiële ecologische eigenschappen gekarteerd. Het kaartbeeld geeft zowel landbouwkundige (ecologische, cultuurtechnische) gegevens als gegevens welke voor de geologie (sedimentologie e.d.) van belang zijn.

In de vegetatie werden gemeenschappen onderscheiden die gekenmerkt zijn door synmorfologische, dat zijn voornamelijk floristische, kenmerken, die ieder aan een eigen specifiek milieu bleken te zijn gebonden. Deze vegetatie-eenheden werden, voornamelijk via de literatuur, vergeleken met meer of minder verwante vegetaties elders. Ze werden ook ingedeeld in het systeem van de Frans-Zwitserse school.

Er bleek een duidelijke correlatie met het milieu te bestaan, waarvan de voornaamste factoren zijn de edafische (vooral de doorluchtingstoestand en rijkdom aan mineralen van de bodem) en de hydrologische (duur, frequentie en hoogte van overspoeling en de chemische samenstelling van het water).

Op te geringe doorluchting van de bodem blijkt de vegetatie te reageren met een hoog percentage aan planten met luchtkanalen in wortels, bladen en stengels (Telmatofyten). Op de mechanische invloed van de waterbeweging reageert de vegetatie door een hoog percentage aan planten met sterke ontwikkeling van steunweefsel (Sklerofyten). Aan slechts tijdelijk constante milieus zijn vegetaties gebonden met een hoog percentage eenjarige planten (Therofyten). Plaatsen, die ook bij laag water niet droogvallen, hebben een vegetatie die uitsluitend is opgebouwd uit soorten en standplaatsvormen van soorten, die gebonden zijn aan constante onderdompeling. Boven dit niveau ontbreken dergelijke vormen.

De vegetatiekaart, die van het buitendijkse gebied in het zuiden en zuidwesten werd vervaardigd, geeft een beeld van de milieuverschillen, die van belang zijn voor een begrip van de genese van het landschap onder invloed van geologische, biologische, hydrologische en antropogene factoren. Als indicator voor groeiomstandigheden van gewassen *(Phragmites, Salix* div. sp., *Populus* e.a.) kan de vegetatiekaart goede diensten bewijzen.

Polders met goede ontwatering behoren tot de betere kleigronden in Nederland. De

---

[1] Het primaire kalkgehalte van slib is vermoedelijk mede afhankelijk van de CO_2-spanning in het water tijdens de sedimentatie.

gronden met dunne kleidekken (zandplaatgronden) geven onder de huidige omstandigheden slechts plaatselijk verdrogingsgevaar. Wegvallen van de schommelende grondwaterstand tot lage niveaus, na een eventuele aaneenvoeging van alle polders tot één of enkele grote waterbeheersingseenheden, maakt voor deze gronden bijzondere cultuurtechnische voorzieningen noodzakelijk. De zandhoogte- en bodemkaart geven naast algemeen potentieel ecologische gegevens voor de landbouwcultuur een basis voor dergelijke en andere cultuurtechnische werken.

De vegetatiekaart geeft gedetailleerde informatie wat betreft de actuele bodemgesteldheid in het buitendijkse gebied.

Het buitendijkse landschap heeft, naast economische en recreatieve waarde, grote betekenis voor de reconstructie van het natuurlijke landschap van de kustvlakte van vóór de menselijke bewoning. Deze betekenis zal blijven bestaan en na uitvoering van het deltaplan zelfs iets worden vergroot, mits levend contact met het riviermilieu aanwezig blijft.

Biologische, geologische en verwante wetenschappen zullen bij het instellen van buitendijkse natuurreservaten gebaat zijn.

INTRODUCTION

In this work, an attempt is made to give a description of the physical character and genesis of a typically – as well unique in the Netherlands as in Europe – Dutch landscape, and at the same time, to give a description of the past, present and future use made of the landscape by man.

This task is approached from the geological, the pedological and the ecological view-points. The major factors which influence landscape are therefore all dealt with in this study. So man's influence – one of these factors – comes very much into the picture. Old and new topographical maps, air photographs, a soil map, soil analyses, a number of deeper soil borings, cross-sections, a vegetation map, vegetation records, analyses and transects comprise the most important data used in this study.

On some points, somewhat more detail is given, particularly where phenomena of more general pedological or ecological importance are involved.

Only the most important considerations, conclusions and results (from the view-point of the author) can, of course, be given in this summary. The tables, diagrams, and photographs – those not referred to in this summary as well as those which are – can throw light on a whole variety of the details and points of view.

The mapping was carried out, in the main, during the years 1951–1953, in charge of the Cultuurtechnische Dienst in order to obtain a scientific base for the planning of the agricultural improvements of the area. In addition, we utilised and expanded a certain amount of vegetation survey which we had already carried out privately and as a part of our studies at the University of Agriculture prior to 1951 (see ZONNEVELD, 1951).

GENERAL PART

I. PEDOLOGY AND VEGETATION AND THEIR PRACTICAL APPLICATION

Pedology and ecology are related sciences, in that they both study an extremely complicated set of factors and characteristics. Furthermore, a great many of the factors concerned are common to both studies.

The most important difference in the practical application is that the vegetation mirrors, in the main, the total present-day milieu.

In the case of the soil, one has the choice of a great number of characteristics which only partly correlate with the present-day milieu or which are only partly characteristic of it. More permanent factors which are not easily influenced, are often used as a basis for classification. This difference gives both advantages and disadvantages when comparing the two types of mapping. The soil map (appendix 1) published in this study, is an example of a document which portrays predominantly the more permanent elements of the soil milieu. The vegetation map (appendix 2) gives an indication of the contemporary milieu in which are specially noted the hydrology, the fertility, the soil-water characteristics, the soil constitution (which is in part connected with the soil-water characteristics) and also the micro-climate.

A combination of soil and vegetation mapping gives a deeper insight into the characteristics of a particular growing site than either one separately.

II. LANDSCAPE AND THE UTILIZATION OF NATURAL RESOURCES

The landscape can be divided into that part lying outside the dikes and the diked polders themselves. The land outside the dikes is entirely controlled by the free contact with a tidal river. It comprises open water, sand banks, silt banks, rush marshes, rough herbages, reed marshes, and willow coppice (Dutch "hakgriend"; mostly cut down after four years) as well as some naturally-colonising woody vegetation, principally willow (fig. 1, 5 and 13). This landscape beyond the dikes is characterised by a marked variation in aspect; from hour to hour as a result of the flow and ebb of the tide, and in the course of the year as a result of the changing seasons and the consequent vegetation development and the harvesting of the "crops". The landscape in the polders, which lie as rush and reed-fringed islands in the area, and some of which have developed into very large complexes, is for the most part an arable farming landscape with a rational system of field units (fig. 9). The houses stand sometimes on mounds (fig. 10), sometimes on the level ground.

The natural economic resources of the land outside the dikes are exploited by means of fisheries (fig. 11), duck decoys (fig. 13, 46 and 47), the gathering of rushes, and reed and willow cultivation. Inside the dikes, in the flood-free polders, arable farming is the activity carried on. There are also a few pastureland polders, with low embankments, which are used for grazing cattle (fig. 48), and for the production of hay.

In addition to its economic utilisation, the area, as a result of the wealth of the generally little known, but originally Dutch scenery, is developing into a recreation area of first importance (fig. 5, 8, 15 and 42).

Scientific research into the natural history of this extremely interesting area has only in recent years been more on the increase. The difficulty of access has no doubt been a retarding factor.

FIG. 1. Buitendijks landschap, gezien vanuit hoogspanningsmast nr. 30 naar het zuidwesten (voor oriëntatie zie bijlage 4). (Hoog water).

View to South-West on a landscape outside the dikes from electricity pylon nr. 30 (for orientation see appendix 4). (High tide).

FIG. 5.
Fijnste vertakking van het geulensysteem in het vloedbos van de verwaarloosde grienden van De Dood.
Op het water drijft vruchtpluis van wilgen.

The smallest creeks of the channel pattern in the tidal forest of the neglected willow beds of „De Dood".
On water level floating willow pappus.
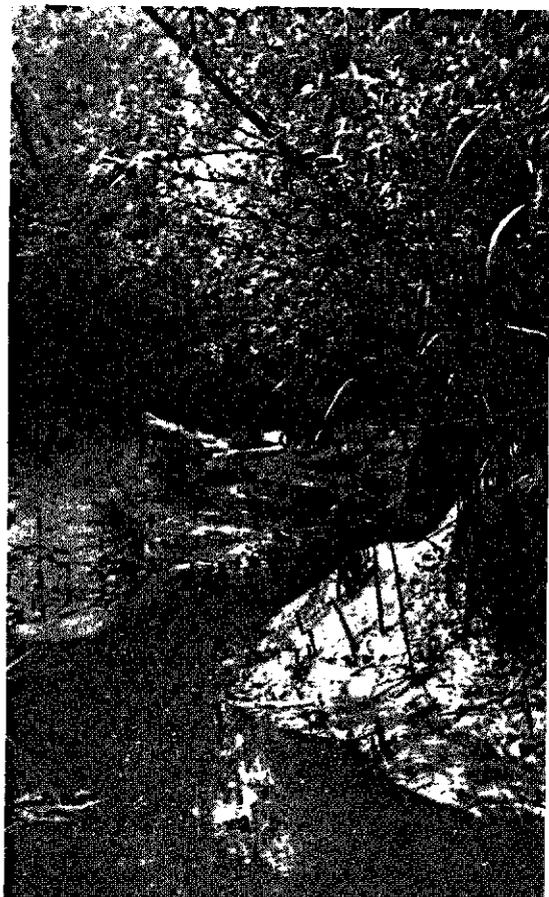
FIG. 8.
Het ijs vernietigt op de platen alles wat bovengronds zou kunnen overwinteren (winter 1955–1956; Gat van de Honderd en Dertig).
On the low flats destroying ice prevents hibernating (winter 1955–1956; Gat van de Honderd en Dertig).

FIG. 9.
Polderlandschap, gezien vanuit hoogspanningsmast nr. 30 naar het noordoosten (voor oriëntatie zie bijlage 4).
View to North-East on a polder landscape from electricity pylon nr. 30 (for orientation see appendix 4).

Fig. 10.
Polderlandschap (Maltha).
De boerderij is op een heuvel gebouwd.
Links het buitendijkse land; in dit geval gevormd door een smalle houtsingel *(Salix purpurea)* en een smalle zoom rietgors langs een groot water (Gat van de Noorderklip).
Landscape of the polder Maltha.
The farmhouse is built on a mound. To the left the land outside the dikes; in this case a narrow strip of willows (Salix purpurea) and reed marsh along a wide creek (Gat van de Noorderklip).

Fig. 11.
Herfst; beroepsvisser zeilend op de Reugt.
Autumn; a fisherman sailing on the Reugt.

FIG. 13.
Eendenkooi van de Visplaat met omgeving. Laagwater (zie ook bijlage 4).
Rechts in het midden een eendenkooi met vier vangpijpen. Links van de eendenkooi, langs het water, een strook spontaan opgaand wilgenbos. Rechts van de kooi twee duikerputten. Vergelijk ook de vegetatiekaart. Vele vegetatietypen kunnen daarop worden teruggevonden. Daarbij moet rekening gehouden worden met het schaalverschil. Niet alle kleine plekjes konden afzonderlijk worden gekarteerd.

Foto Kon. Ned. Luchtmacht 25-4-'52

FIG. 13.
Duc decoy of the Visplaat with surroundings. Low tide (see also appendix 4).
In the centre to the right a duck decoy with four "trap-ditches". Left of the duck decoy, alongside the
water a strip of spontaneous growing high willows. Right of the duck decoy two "culvert holes".
Compare also the vegetation map on which many types of vegetation can be found back. In conse-
quence of the difference in scale not every small plot could be mapped.

A. Open water.
   Open water.

B. Zandbank.
   Sand bar.

C. Slik met het eerste begin van vegetatie en cirkelvormige begroeiingen van mattenbies *(Scirpus lacustris)* (Rdq).
   Mud flat with the initial staged vegetation and circular stands of Scirpus lacustris (Rdq).

D. Ruigtevegetaties (Rdh, Rc, Rdf, Rf, Rce en Re).
   Rechts onder wordt deze vegetatie sterk door kreken doorsneden.
   Rough herbage vegetations (Rdh, Rc, Rdf, Rf, Rce *and* Re), *to the right below strongly intersected by creeks.*

E. Rietgorzen (let op de greppels).
   Tidal reed-marshes (notice the ditches).

F. Grienden, gekapt en niet gekapt.
   Willow coppice, cut and uncut.

G. Polder.
   Polder.

FIG. 15.
De Biesbosch is een geliefd recreatiegebied.
Landschap in de Grienden van De Dood (Schippersgat, bij hoogwater).
The Biesbosch is a favourite aquatic recreation area.
Landscape in the willow coppice area „Grienden van De Dood" (Schippersgat, at high tide).

III. FACTORS OF THE MILIEU

The Biesbosch can be considered as a freshwater tidal delta (fig. 1) lying in the Northwest European temperate maritime climate. The development of the soil and of the vegetation are to a large extent controlled by hydrologic factors, namely the dynamic contact with a tidal river carrying silt and highly eutrophic water (fig. 16 and 17).

The tidal movement has a horizontal and a vertical component. The tide wave flowing up river, becomes "piled up" against the grade (fig. 18). If the river broadens out inland, then a relative lowering of the water level can occur there (flood depression effect; VAN VEEN, 1950). The narrower the bottleneck of the flood basin and the broader the basin itself, the stronger is this flood depression effect, and vice versa (these effects can be studied in the figures 20 and 28).

Polder works and other hydrologic works influence the water level. The laying of the Nieuwe Merwede and of the Bergse Maas river courses, have considerably altered the river flow and tide regime by altering the grade of the river (fig. 19 and 20).

The important phenomenon of the wantide (Dutch "wantij"; see also VAN VEEN, 1950) occurs in the connecting channel of two different gully systems. In this zone flood currents arrive from two different sides and ebb currents flow off to seperate directions. Near this "watershed" the currents never reach high speeds.

The tidal fluctuation acts mainly, both on sediments and on vegetation, through the factor of flooding. This factor can be divided into a horizontal and a vertical movement. The vertical movement is composed of three elements, namely: the frequency of the flood (overtopping), the duration of the flood, and flood height. The frequency is in this work expressed as the number of flooding high tides as a percentage of the total numbers of high tides in the year (fig. 21). The duration can be expressed as the absolute total average duration, calculated on the basis of the average tidal curve (see fig. 22). The occasions when no flooding took place, however, are in that case reckoned as 0 or negative. The value calculated in this way for the duration of the flood is thus not accurate, and is partly affected by the frequency. The average duration of flooding calculated in hours per occurrence is more accurate (see fig. 23.a). This last value is only possible where very many separate measurements of tidal curves are available, and is rather time-consuming. In fig. 23.b the actual average flood duration of all high tides is given in percentage of tide duration. Here too, the frequency affects the results, since all occasions on which the water did not reach the recording stations were included in the calculations as zero. The height of the flooding above soil surface determines to what extent plants are completely or partly submerged (fig. 24).

The horizontal component of the flood operates in the main as current strenght. As the tidal curve becomes steeper, greater current strengths occur. The current is strongest half way between the two points at which the curve changes direction – high and low water. On the other hand, the greater the distance to the bottom and to the sides of the stream channel, the stronger is the current. On the accretions, the current strength decreases rapidly from the edge towards the centre, because of the braking effect of the vegetation and of the soil (see fig. 25). Wave action increases the effect of the current.

The result of all these factors which to some extent counteract one another, is that with increasing elevation of the soil surface, the influence of flooding decreases, as does the strength of the current. Only the phenomenon of the storm flood brings about relatively large water movements on the higher levels, where low flood frequencies obtain. This fact is significant for a true understanding of the sedimentation process. The fact that all the

flood elements are a function of the height and form of the tide curve, makes it possible to determine these elements when the tide curve is known. This curve was determined by means of measurements which are taken in various places in the Biesbosch and near Werkendam, partly by ourselves and partly from data produced by the Rijkswaterstaat (State Waterworks Administration), and which were found to be approximately the same for the entire research area where measurements were carried out.

The height of the floods at the places being investigated was measured by a simple automatic floodtop meter which we ourselves developed – the "bakjeslat". This "bakjeslat" is a stick with little trays or cups which record the highest flood prior to the taking of the reading. The height of this flood is obviously equal to the height of the highest cup which is found filled with water (fig. 26 and 27). By means of a fixed control point, the absolute height can then be measured.

From measurements carried out in the willow coppices of De Dood the order of magnitude of the local flood depression effects – effects which interfere with this method of measuring – was arrived at, and it appeared that these effects on the measured spots could be avoided measuring flood heights (see Dutch text III. 2.5.2., HEYLIGERS, 1955; fig. 28).

In the willow coppice the hydrological conditions often are influenced by means of low embankments (fig. 6 and 7). So the influence of flooding does not always correspond with the absolute height.

Measurements of the ground water table, in the willow coppice showed that a fluctuation occurs which lags a little behind the neap tide – spring tide rhythm. The daily tide fluctuation has little effect (see fig. 29 and 30).

During flooding about as much air remains present in that part of the soil lying above the water table as during low water. This fact is naturally of critical importance for living things in the soil. In the polders too, a somewhat similar state of affairs occurs under the influence of "kwel" – i.e. percolation of water through the soil below the dikes under the influence of the hydraulic pressure – and under the influence of retarded drainage.

FIG. 6.

Het water stroomt bij springvloed over de griendkade heen de griend binnen.

At spring-tide the water flows over the low embankments into the willow coppice.
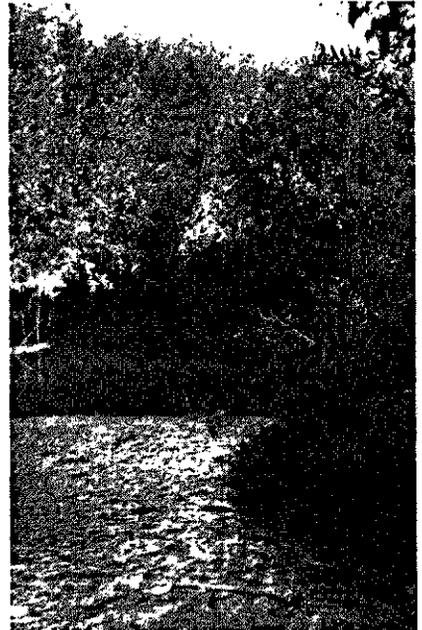
FIG. 7.

Een ,,duikerput" is een belangrijk element in het landschap. In de schaduw, op de achtergrond, de duikerklep.

A "culvert hole" is an important element in the landscape. In the shadow in the background the valve of the culvert.
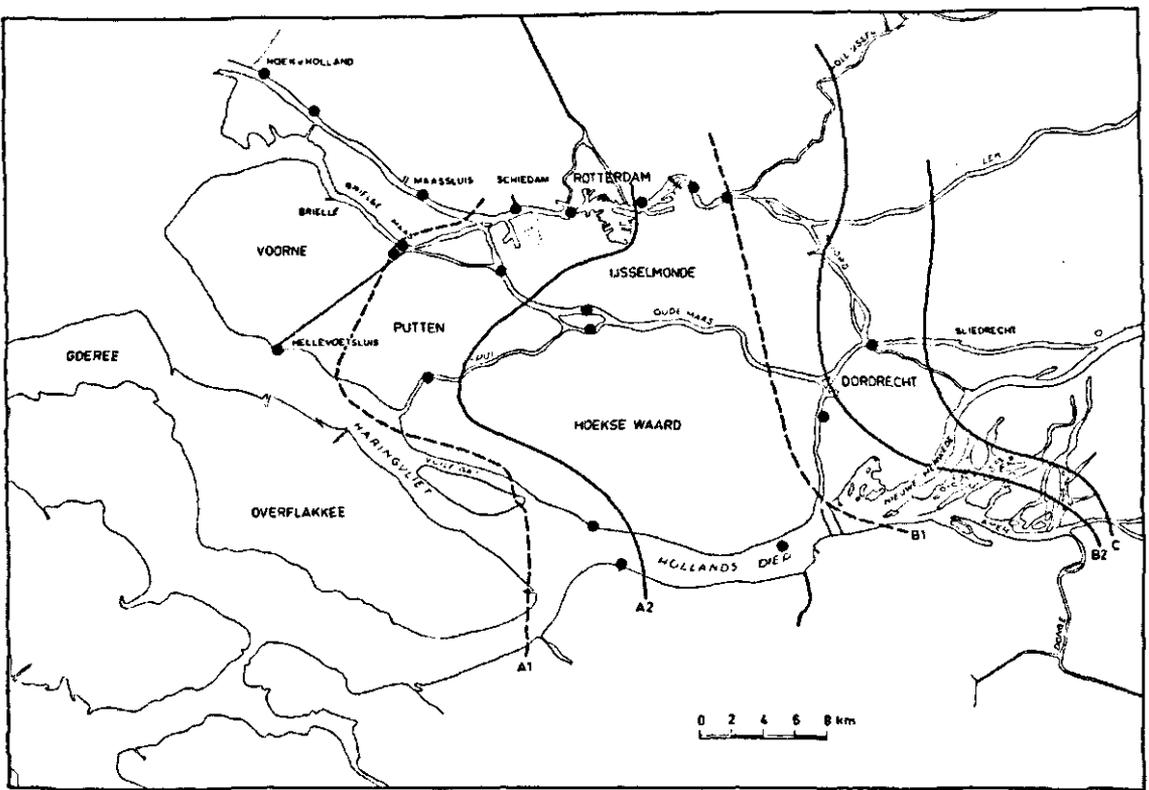
FIG. 16.

Overzicht van de brakwatergrenzen (300 mg Cl/liter) in het gebied van de benedenrivieren (naar gegevens van de Rijkswaterstaat). De punten geven de plaatsen aan, waar de chloorgehalten werden bepaald.

Survey of the brackish water boundaries (300 mg Cl/liter) in the area of the lower rivers (according to data of the State Water Works Administration). The dots mark the places, where chlorine-contents have been determined.

A1 Middelbare afvoer te Lobith: 2200 m³/sec. bij laag water.
    Mean outlet at Lobith: 2200 m³/sec. at low tide.

A2 Idem bij hoog water.
    Ditto at high tide.

B1 Middelbare afvoer te Lobith: 592 m³/sec. bij laag water.
    Mean outlet at Lobith: 592 m³/sec. at low tide.

B2 Idem bij hoog water.
    Ditto at high tide.

C Meest landinwaarts waargenomen grens in 1949 tijdens hoog water en krachtige westenwind.
    Most land-inwards registrated boundary in 1949, at high tide and heavy western winds.

FIG. 17. De huidige uitbreiding van het zoet- en brakwatergetijdengebied in Nederland, zoals deze uit de vegetatie kan worden afgeleid.

■	zoetwatergetijdengebied *freshwater tidal area*	▨	Pleistoceen *Pleistocene*
▨	brakwatergetijdengebied *brackish water tidal area*	▨	duinen en strandwallen *dunes and coastal ridges*
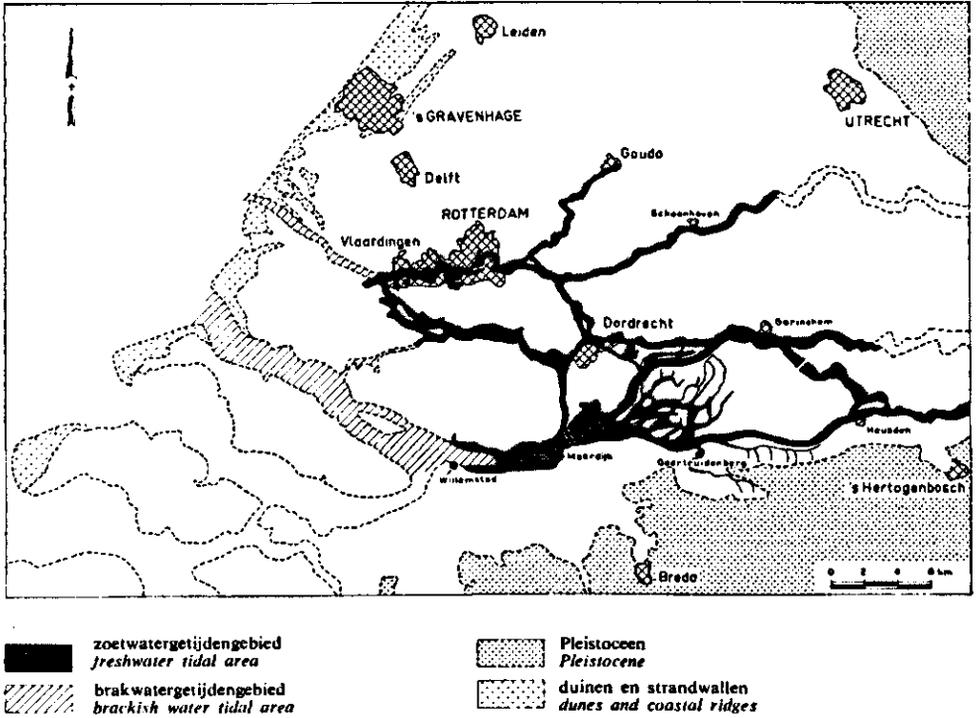
FIG. 17. *The present-day extension of the fresh and brackish water tidal area in the Netherlands as concluded from the vegetation.*
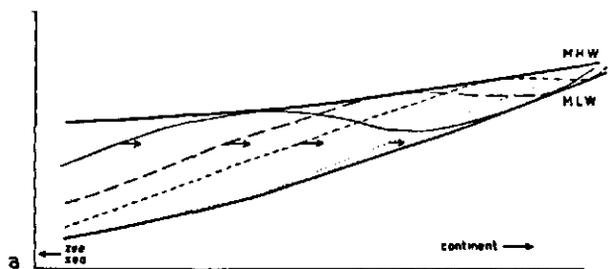
FIG. 18.
Schematische voorstelling van het verloop van de vloedgolf in een estuarium

a. zonder kom-effect,

b. met kom-effect (zijdelingse af-vloeiing).

M.H.W. = gemiddeld hoog water
mean high tide

M.L.W. = gemiddeld laag water
mean low tide
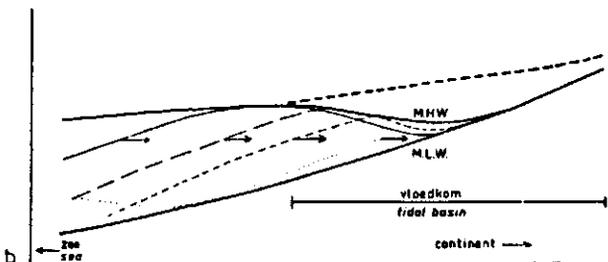
FIG. 18.
Sketch of the advance of the tidal wave in an estuary

a. *without flood-depression,*

b. *with flood-depression (collateral flowing off to a tidal basin).*

voortschrijdende vloedgolf
advancing tidal wave

FIG. 19.
De verandering in de loop van het water in het Biesboschgebied ten gevolge van het graven van de Nieuwe Merwede en de verlegging van de Maasmond.

A. Toestand vóór het graven van Nieuwe Merwede en Bergse Maas.

B. Huidige toestand.

door eb en vloed gevoede geulen / *creeks fed by ebb and flood*
geulen, alleen gevoed door de vloed / *creeks, only fed by flood*
dijken / *dikes*
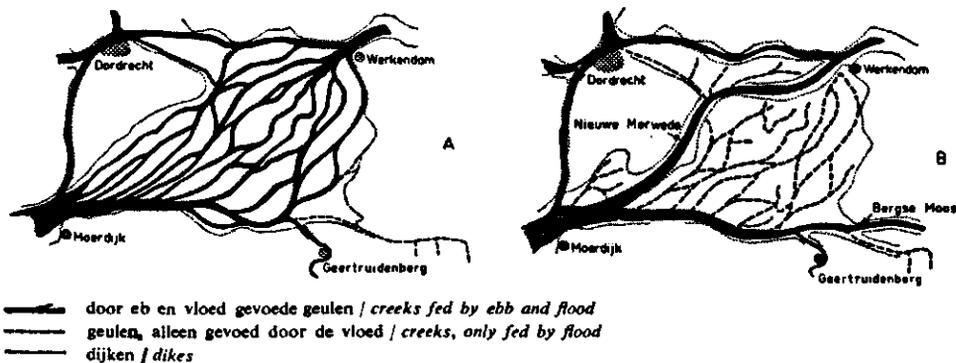
FIG. 19.
Change of river flow and tide regime in the Biesbosch area as a result of the digging of the Nieuwe Merwede and the diversion of the mouth of the Meuse.

A. *Situation before digging of the Nieuwe Merwede and Bergse Maas.*

B. *Present-day situation.*

FIG. 20. Gemiddelde hoogwaterstanden (M.H.W.) tussen Hellevoetsluis en Zaltbommel in de jaren 1931–1939; ontleend aan Rijkswaterstaat, „Tienjarig overzicht der Waterhoogten 1930–1939".

	Haringvliet
▬	Hollands Diep
▬·▬·▬	Nieuwe Merwede (en Waal)
••••••••••	Biesbosch (Gat van de Noorderklip en Gat van den kleinen Hil)
················	Kanaaltje en Gat van het Hoofd (Biesbosch)
+ + + + +	Amer
▬ ▬ ▬ ▬▪	Bergse Maas

Hs	= Hellevoetsluis	L.Z.	= Lage Zwaluwe
Z	= Zuidland	Dr	= Drimmelen
W	= Willemstad	G.H.	= Gat van den kleinen Hil
M	= Moerdijk	R	= Reugt
D	= Deeneplaat	Dm	= Dongemond
KvtL	= Kop van 't Land	Wbi	= Werkendam (binnen)
Wbu	= Werkendam (buiten)	H	= Hedel
Z	= Zaltbommel		

FIG. 20. *Mean high tide levels (M.H.W.) between Hellevoetsluis and Zaltbommel 1931–1939; taken from Rijkswaterstaat, „Tienjarig overzicht der Waterhoogten 1930–1939".*

Verband tussen hoogteligging en overspoelings-
frequentie in 1949 nabij Moerdijk.

De frequentie geeft het percentage van het totaal
aantal vloeden dat een bepaalde hoogte bereikte.

FIG. 21.
*Relation between altitude and frequency of
flooding in 1949 near Moerdijk.*

*The frequency indicates the percentage of the total
number of flooding high tides, reaching a certain
level.*

——— zomerhalfjaar / *summer half year*
············ winterhalfjaar / *winter half year*
M HW = gemiddeld hoogwater / *mean high tide*

FIG. 22. Links: Gemiddelde getijcurve in de Brabantse Biesbosch.
Rechts: Verband tussen hoogteligging en gemiddelde overspoelingsduur in tijdspercenten.
(H is de hoogte van overspoeling van niveau N; D is de duur van overspoeling van
niveau N; M.H.W. is gemiddeld hoogwater; M.L.W. is gemiddeld laagwater).
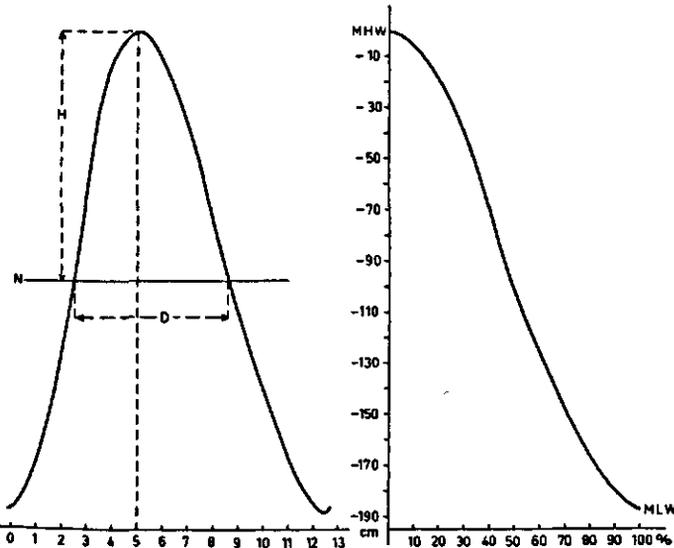
FIG. 22. *Left: Averaged tidal curve in the Brabantse Biesbosch.*
Right: Relation between altitude and averaged duration of flooding in percentage of time.
*(H is the height; D is the duration of flooding (overtopping) of level N; M.H.W. is mean
high tide; M.L.W. is mean low tide).*
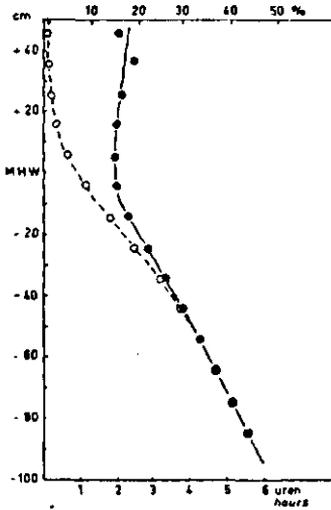
FIG. 23.
Overspoelingsduur te Werkendam (binnen).

FIG. 23.
Duration of flooding at Werkendam (Biesbosch side).

a. Gemiddelde overspoelingsduur per overspoelend tij
   Averaged duration of flooding per tide
b. Totale overspoelingsduur in procenten van de tijd
   Total duration of flooding in percentage of time
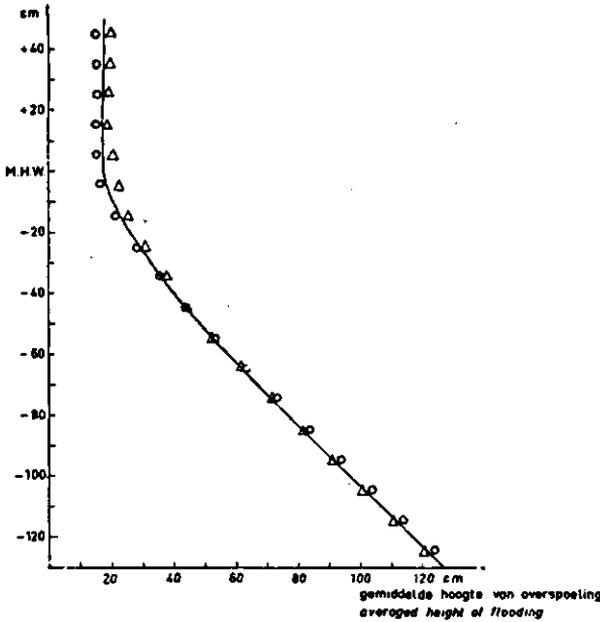
FIG. 24.
Gemiddelde hoogte van overspoe-
ling voor de overspoelende tijen in
de Biesbosch (als gemiddelde tus-
sen Werkendam (binnen) en Moer-
dijk).

FIG. 24.
*Averaged height of flooding for the
flooding tides in the Biesbosch (as
an average between Werkendam
(Biesbosch side) and Moerdijk).*

o   Werkendam (binnen)   *(Biesbosch side)*

Δ   Moerdijk

M.H.W. — gemiddeld hoogwater / *mean high tide*

FIG. 25. Schema van de stroomsterkte bij verschillende waterdiepten en bij het passeren van een opwas.
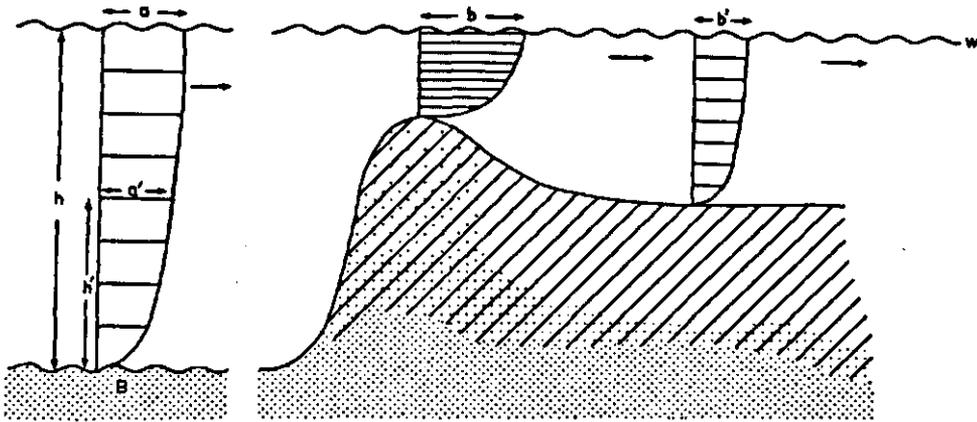
	kleiig sediment
	clayey sediment
	zand
	sand

w   wateroppervlak
     water surface

h   hoogte waterkolom
     height of the water column

a, b   stroomsnelheid
     velocity of the current

B   bodem van de geul
     bottom of the creek

Tussen b en b′ werd de verhouding getekend alsof er geen vertraging ten gevolge van wrijving met vegetatie optrad.

The ratio between b and b′ has been drawn to the neglect of retardation caused by the braking effect of vegetation.

FIG. 25. *Influence of an accretion and dissimilar waterdepths on current strenght.*

Cliché: Natuur en Landschap

FIG. 27. Schema van een vloedhoogtemeting volgens de „bakjeslatten"-methode.
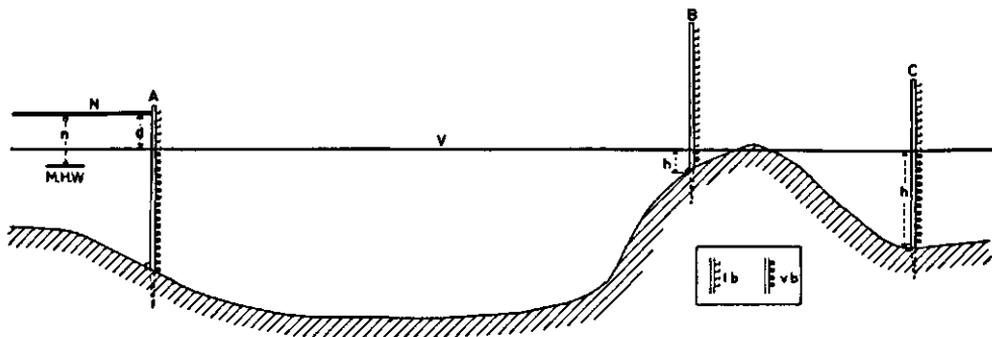
l.b.	lege bakjes / *empty cups*
v.b.	volle bakjes / *filled cups*
A	vloedtopmeter (bakjeslat) *floodtop meter (stick with cups)*
B en C	vloedtopmeter op meetplaatsen in het terrein *floodtop meters at points in the field to be measured*
N	vast niveau / *reference level (fixed control point)*
M.H.W.	gemiddeld hoogwater / *mean high tide*
n	niveauverschil tussen het vaste niveau N en M.H.W. *level difference between reference level N and mean high tide*
V	hoogte van een willekeurige vloedtop *height of any floodtop (at random)*
d	aflezing bij het vaste niveau *reading at the reference level*
b	aflezing op de plaatsen in het terrein *reading at the points in the field*

hoogte van het te meten punt ten opzichte van M.H.W. $= -(h + d - n)$
height of the point to be measured with respect to M.H.W. $= -(h + d - n)$

FIG. 27. *Outline of the measuring of the floodtop with use of "sticks with cups".*
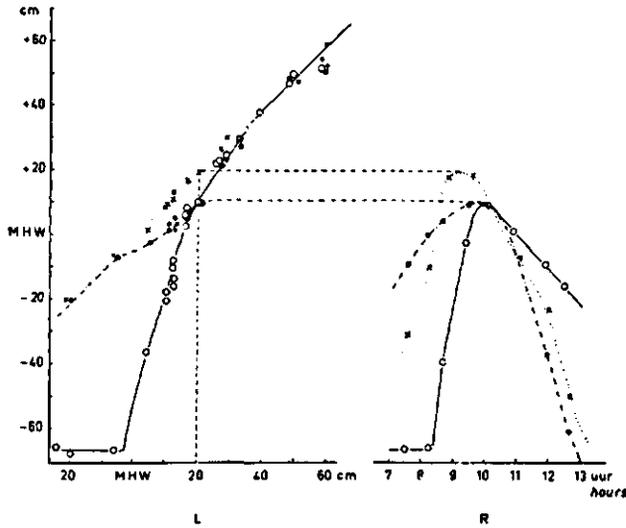
FIG. 28.
Invloed van de bekading op de overspoeling (opname P. C. HEYLIGERS).

FIG. 28.
Influence of small embankments on flooding (recorded by P. C. HEYLIGERS).

x ·········· x	kromme 1 Zijgat van het Binnenkooigat, zonder komeffect.
	curve 1 Branch of the „Binnenkooigat", without flood depression.
•—·—·—•	kromme 2 Zijgat van het Gat van de Turfzak, met kom-effect.
	curve 2 Branch of the Gat van de Turfzak with flood-depression.
o———o	kromme 3 Bekade griend (Tweede Weer).
	curve 3 Embanked willow bed (small dikes) (Tweede Weer).
↑ o	waarden hoger dan de top van de vloedtopmeter.
	values higher than the top of the floodtop meter.

L = Links   Verband tussen de vloedtophoogte op de beschouwde plaatsen en gemiddeld hoogwater, gemeten bij Maltha in het Gat van de Noorderklip.

L = *Left*   *Relation between the height of floodtop at the places concerned and mean high tide, measured near Maltha in the "Gat van de Noorderklip".*

R = Rechts   Getijkrommen op 28 augustus 1953 bij een vloedtophoogte (zonder komeffect) van 20 cm boven gemiddeld hoogwater.

R = *Right*   *Tide curves on 28th of August 1953 at a flood culmination point (without flood-depression) of 20 cm above mean high tide.*

FIG. 29. Schommelingen in de grondwaterstand, onder invloed van het tij (opgenomen door P. C. HEYLIGERS).

waterstand van het buitenwater / *water level of the open water in the creeks*

waterstand in boorgat A / *water level in bore hole A*

idem B / *ditto B*

idem C / *ditto C*

idem D / *ditto D*

idem E / *ditto E*

roestige zone
zone with iron oxide concretions
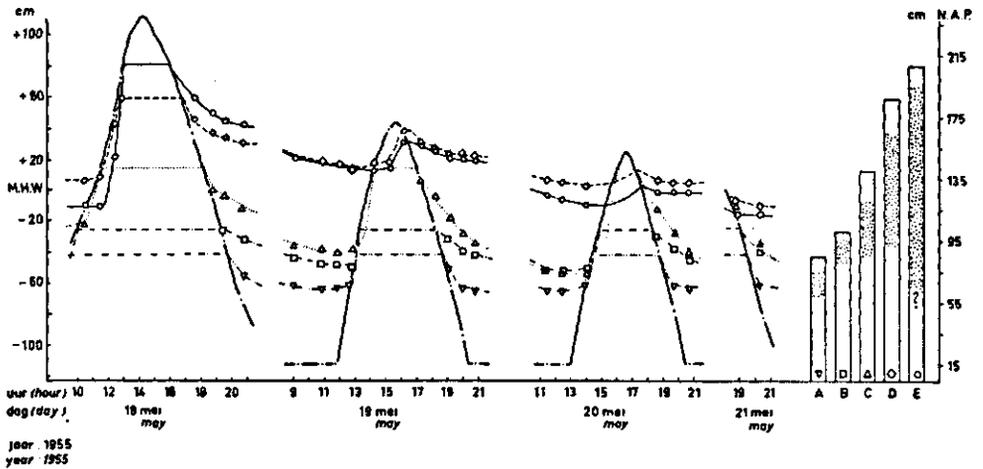
Rechts in de grafiek: Diepte en voorkomen van de roestige zone in het bodemprofiel op de plaatsen waar de metingen werden verricht.

Sketch right: *Depth and occurrence of the zone marked by iron oxide concretions in the profile at the places where measurings have been carried out.*

Plaats van meting: Heuvel van de Benedenkeet van de Noorderplaat in de Houtganzewei.

Place of measuring: *Mound of the Benedenkeet of the Noorderplaat in the Houtganzewei.*

FIG. 29. *Fluctuations of the groundwater table, influenced by tide action (recorded by* P. C. HEY-LIGERS).

FIG. 30. Verband tussen de hoogwaterstanden, de grondwaterstand, de bodemgesteldheid en de verticale verspreiding van enkele bodemorganismen in het vegetatietype V0-V1 op de Driessen Hennip (opgenomen door P. C. HEYLIGERS).
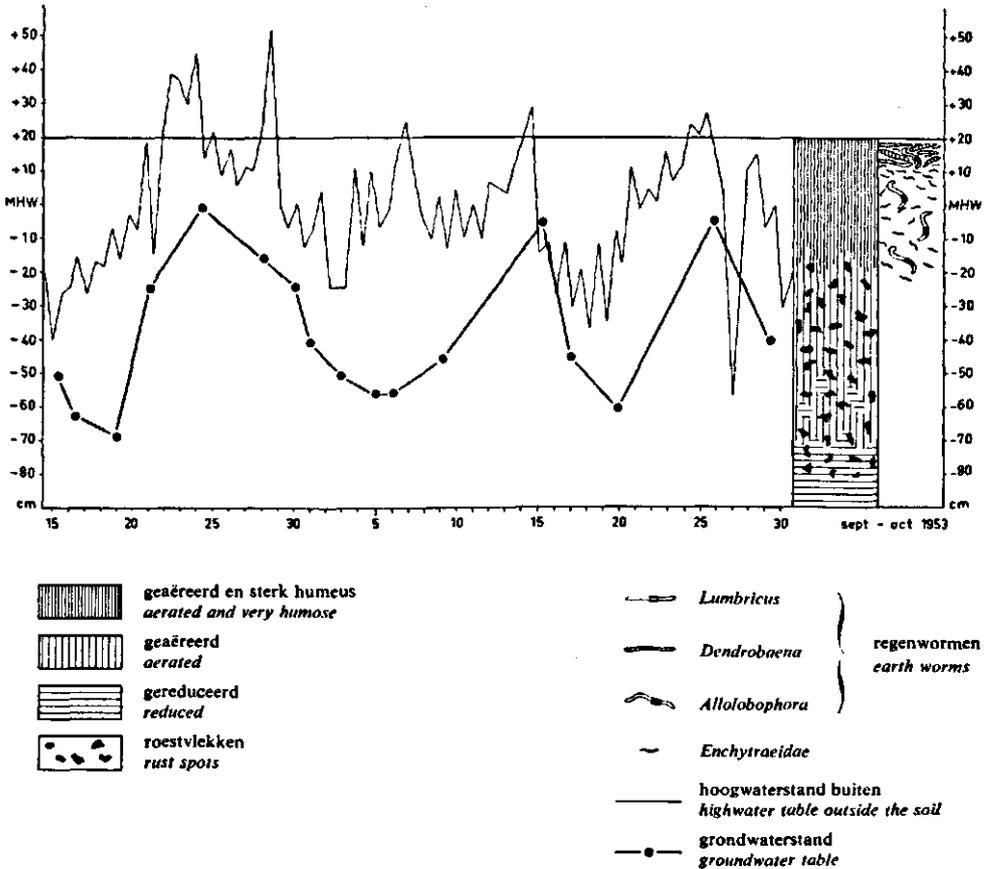
FIG. 30. *Relation between high tide levels, groundwater table, soil condition and vertical walk of living of some soil organisms in the vegetation type V0-V1 on the Driessen Hennip (recorded by P. C. HEYLIGERS).*

SOIL AND GEOLOGY

IV. SEDIMENTATION AND TEXTURE OF THE SEDIMENTS

In texture we differentiate the "degree of heaviness" and "relative particle size distribution". The first value depends on the absolute content of the fine fraction (principally smaller than 2 mu) and varies from place to place. The relative particle size distribution is constant for a whole area and expresses the ratio between the composite soil fractions in relation to the "degree of heaviness"; it can be represented in the form of a triangular graph or a "sizing graph according to DOEGLAS" (see fig. 31 and 32).

Freshwater tidal sediments differ from marine clay and river clay sediments, as far as their relative particle size distribution is concerned, in having a lower clay/silt ratio than is found in these latter areas. The sediments laid down before about 1600 and after about 1850 have the lowest percentage of clay and have, moreover, the lowest percentage of the coarser sand fractions. Those laid down between 1600 and 1850 have a higher clay/silt ratio, though this ratio is still lower than that normally encountered in the river clay area. The content of coarser sand fractions is considerably higher than with the earlier and later sediments (fig. 31 and 32 and table A).

The origin of the low clay/silt ratio can be explained in terms of coagulation and peptisation processes (ZUUR, 1951; VAN ANDEL and POSTMA, 1955) or in terms of mechanical processes (DOEGLAS, oral information). It is also suggested that a renewed carrying away of the lastdeposited silt layer could be a contributary factor in the low clay/silt ratio (fig. 33). The variations within the freshwater tidal area can be explained through fluctuations in the sea level as a result of which between 1600 and about 1850 the influence of the river was dominant (see Chapter IX).

Heaviness is determined by the velocity of the current during the transportation and settling out of the sediments.

Variations in current strength, together with the cohesion of the sedimented material, fashion the stratification which is characteristic of sedimentation in fluctuating water (fig. 34a and b).

Organisms, particularly animal organisms, can disturb the stratification by homogenising the sediment. Examples of this process are given from research work carried out in willow coppice by HEYLIGERS (1955; see also fig. 30). Sediments usually become heavier in texture towards the surface as a result of the decreasing current speed (fig. 35). A sandier layer can again be formed in the highest levels under the influence of the relative high number of gale flood overtoppings (see Chapter III). Vegetation encourages or hinders sedimentation according to whether slowing down of the stream results in a speed favourable or unfavourable for sedimentation. In fig. 37 this can be read by the differences between high and low situated places in summer and winter (see also fig. 36). Along the edges of clumps of vegetation acceleration of the stream and consequent erosion can occur. Vegetation thus introduces relief into the landscape (fig. 38, 42 and 43).

On the floor of stream channels both ebb and flood currents occur simultaneously at the turn of the tide; giving rise to sand ridges where the two currents scour parallel to one another (ebb and flood scour systems, see VAN VEEN, 1950 and fig. 13, 44, 39 and the appendices 1 and 2). This process is often the first stage in the formation of sand-banks. After the appearance of vegetation, fairly heavy material is often laid down on the highest parts. A similar abrupt capping of heavy clay can be formed on top of a sandy substratum containing, little silt, through a relative fall in sea level. In the remaining cases, a substratum of thin layers of sandy clay is first formed which becomes progressively heavier in texture

towards the surface until it finally consists of practically homogeneous clay or silty clay (fig. 34, 35, 131 and 48 and the appendices 1 and 3).

Accretions can grow outwards by coalescence with secondary accretions. The intervening area, which can have the form of a long gully, is then filled up in the "vlaai"-stage. A "vlaai" is an elongated basin or channel which occurs mainly in "wan"-tides (fig. 41, 48 and 133).

Erosion is persistent along the banks which are most exposed to the current. Under the influence of vegetation and also of the sandy substratum, which is more liable to erosion than the upper layers, which are heavier and more securely anchored by roots, steep and sometimes overhanging banks are formed (fig. 43). Where wave action operates against a sandy bank during a long period, a beach can be formed (fig. 42).

The digging of "greppels" or small open drainage ditches often encourages sedimentation by speeding up the shrinkage as a result of the acceleration of the physical ripening or initial alluvial soil formation (see Chapter V) and in that a more rapid sedimentation takes place in the ditches because of their relatively lower position.

Embanking hinders the sedimentation and influences the current regime outside the embankments. The sluices associated with the embankments give rise to the sluice culvert holes ("duikerputten"), which are so characteristic of the landscape (fig. 7, 13 and 44). On both sides of the embankment, differences in soil constitution can occur. In many cases, the embankments have been laid along natural boundaries, so that the soil differences are primary ones, and have not been caused by the embankment itself (fig. 45). The embanking has nearly always adapted itself to the "gemeenten" or parish boundaries (fig. 46 and 47). Thus, the old bed of the Meuse, to which later estate boundaries, and later still, parish boundaries were adapted (HINGMAN, 1885; VLAM, 1947), as a result of embanking along its length, has again locally become a soil boundary. In fig. 48, the accumulation of land is schematically shown.
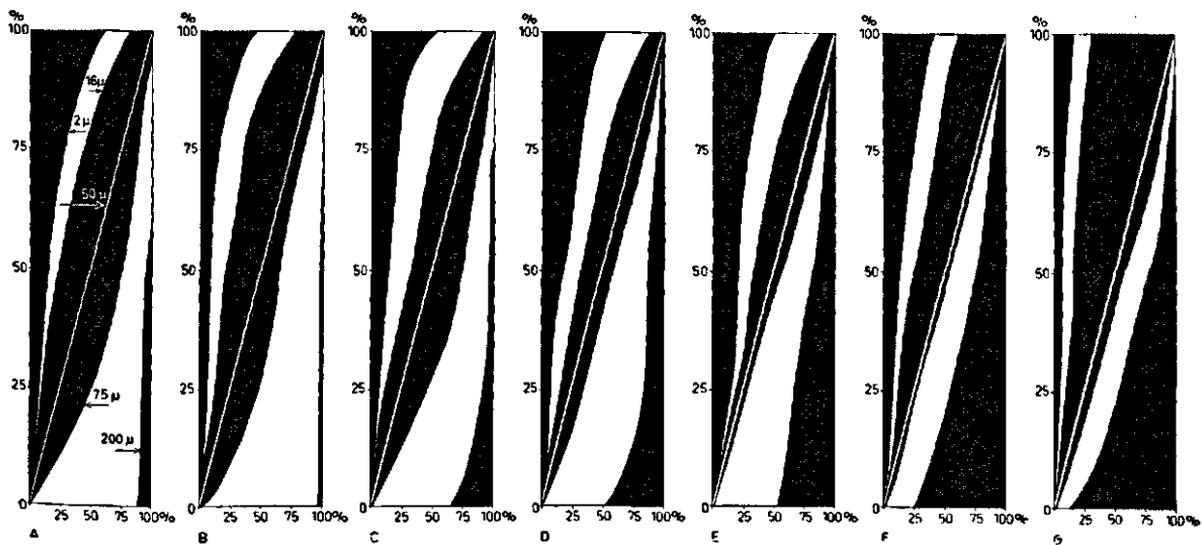
FIG. 31. Overzicht van de granulaire samenstelling van enkele gronden vergeleken met gronden uit de Biesbosch.

Survey of the texture of some soils as compared with Biesbosch soils.

A. Jonge zeeklei van Zuid-Beveland volgens HAANS en DE BAKKER naar 15 analyses.
Young marine soil of Zuid-Beveland according to 15 analyses of HAANS and DE BAKKER.

B. Estuariumklei uit het Land van Heusden en Altena volgens SONNEVELD, naar 30 analyses (schrift. meded.).
Estuary soil of the Land van Heusden en Altena according to 30 analyses of SONNEVELD (written information).

C. Biesboschklei, afgezet na 1800, naar ± 30 analyses.
Biesbosch soil, deposited after 1800, according to ± 30 analyses.

D. Biesboschklei, afgezet tussen 1600 en 1800, naar 58 analyses.
Biesbosch soil, deposited between 1600 and 1800 according to 58 analyses.

E. Rivierklei van de Maaskant volgens VAN DIEPEN, naar 36 analyses (schrift. meded.).
Fluvial soil of the Maaskant, according to 36 analyses of VAN DIEPEN (written information).

F. Uiterwaardklei uit Noord-Limburg, volgens SCHELLING, naar 27 analyses (schrift. meded.).
River meadow soil of Noord-Limburg, according tot 27 analyses of SCHELLING (written information).

G. Loess uit Zuid-Limburg, volgens VAN NISPEN TOT PANNERDEN en SCHELLING, naar 100 analyses (schrift. meded.).
Loess of Zuid-Limburg, according to 100 analyses of VAN NISPEN TOT PANNERDEN and SCHELLING (written information).

De grafieken zijn voorgesteld volgens DOEGLAS en werden daarna geschematiseerd. De grenzen 2, 16, 50, 75 en 200 mu zijn in de figuren aangegeven (zie A).

The graphs according to DOEGLAS have been adjusted afterwards. The limits 2, 16, 50, 75 and 200 mu are drawn in the diagram.
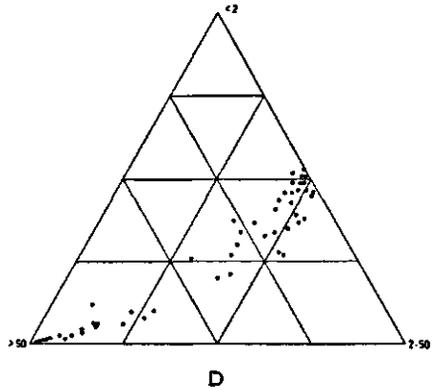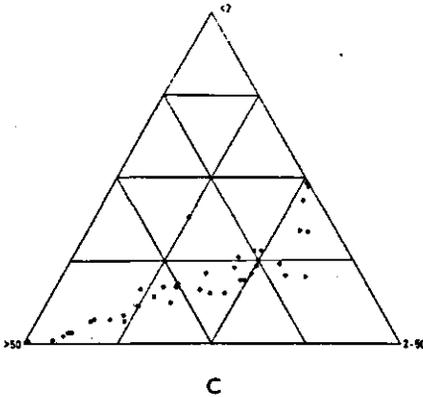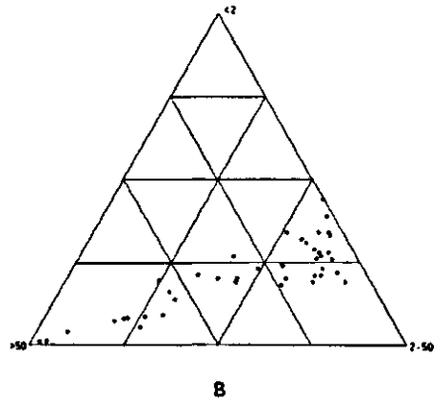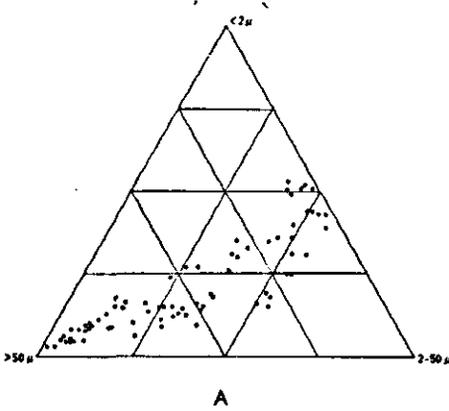
A. Zuid-Beveland. Jonge zeesedimenten, naar ± 94 gegevens van DE BAKKER.
   Zuid-Beveland. Young marine sediments, according to ± 94 data of DE BAKKER.

B. Land van Heusden en Altena. Estuariumsedimenten tussen ca. 1421 en 1600 afgezet, naar gegevens van SONNEVELD.
   Land van Heusden en Altena. Estuary sediments deposited between about 1421 and 1600, according to data of SONNEVELD.

C. Biesbosch. Estuariumsedimenten (tussen ca. 1800 en heden afgezet).
   Biesbosch. Estuary sediments (deposited after about 1800).

D. Biesbosch. Estuariumsedimenten, tussen ca. 1600 en 1800 afgezet.
   Biesbosch. Estuary sediments deposited between about 1600 and 1800.
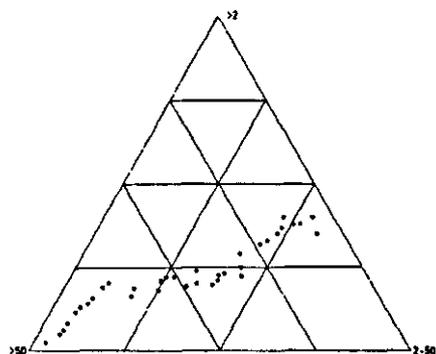
E
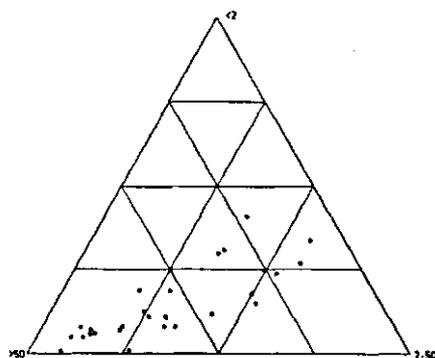
F
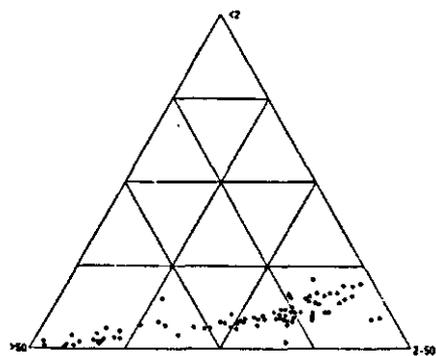
G

FIG. 32.
Vergelijking tussen de relatieve korrelgrootte-
verdeling van verschillende Nederlandse klei-
en loessgronden door middel van driehoeks-
grafieken.

*Comparison between the relative grain size
distributions of various clay and loess soils in
the Netherlands, by means of triangular graphs.*

E. Maaskant. Riviersediment (stroomruggrond), naar gegevens van VAN DIEPEN.
   Maaskant. Fluvial sediments (levee soils), according to data of VAN DIEPEN.

F. Noord-Limburg. Uiterwaardsedimenten, naar gegevens van SCHELLING.
   Noord-Limburg. River meadow sediments, according to data of SCHELLING.

G. Loess, naar gegevens van VAN NISPEN TOT PANNERDEN en SCHELLING.
   Loess, according to data of VAN NISPEN TOT PANNERDEN *and* SCHELLING.
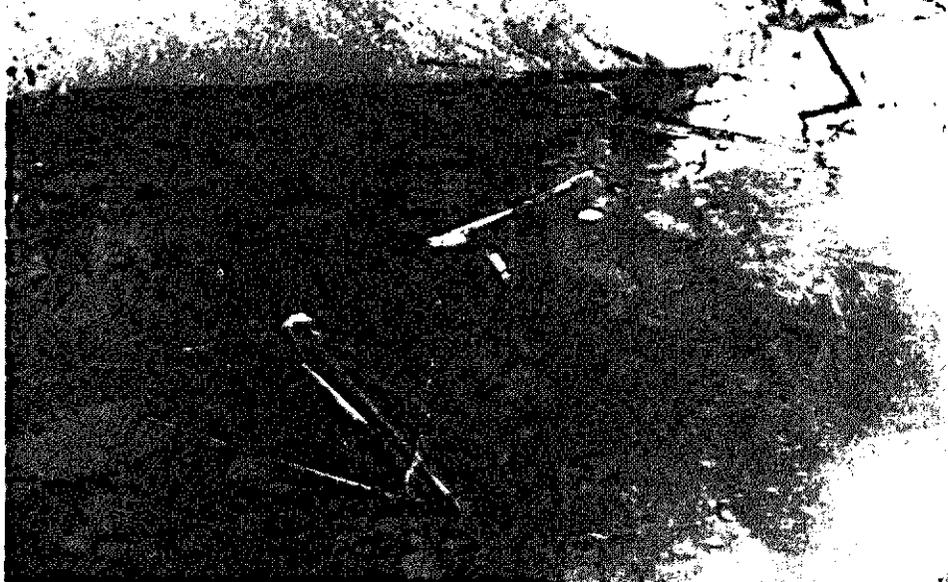
FIG. 33.

Bij opkomend water wordt het laatst afgezette sliblaagje weer opgenomen.
During rising tide the last deposited silt layer is taken up again.

FIG. 34a.

Doorsnede door een rietgorsoeverwal.
De gelaagde opbouw der sedimenten valt op.
De lagen hebben een gebogen vorm.
Exposure of a reed-marsh levee.
Notice the stratification of the sediments.
All layers show a curved shape.

FIG. 35.
Erosie van een oude griend-
opwas (Bol).
Het is duidelijk te zien, dat
het sediment onderaan ge-
laagd is en naar boven meer
homogeen kleiig wordt.

Erosion of an old willow cop-
pice accretion (Bol).
The sediments towards the
surface are distinctly less
stratified and more homoge-
neously clayey than below.

Cliché: Natuur en Landschap
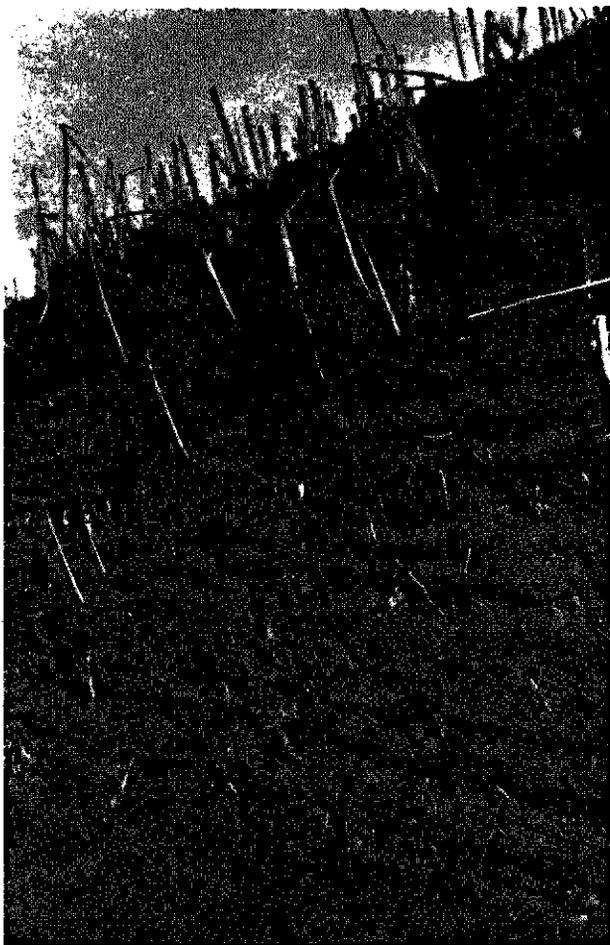
FIG. 34b.
Detail van fig. 34a bij het hoog-
ste punt van de oeverwal. De
zandige laagjes worden gemak-
kelijker uitgespoeld.

A detail of fig. 34a near the
top of the levee. The sandy
layers are easier washed.

A   aantal mg droge stof per dm² per dag
    quantity of dry matter in mg pro dm² pro day
B   percentage van de totale droge stof
    percentage of the total dry matter
▨   kalk / *lime*
▢   afslibbaar / *particles < 16 mu*
▥   organische stof / *organic matter*
▦   zand / *sand*
×   lutum / *particles < 2 mu*
■   organische stof / *organic matter*
⊘   kalk / *lime*
H   herfst / *autumn*
W   winter / *winter*
L   lente / *spring*
Z   zomer / *summer*
1/10 – 1/12   1 oktober 1952–1 december 1953

Fig. 37.

Invloed van de vegetatie op de sedimentatie.

Onder elke figuur is het nummer van het permanente kwadraat en de hoogte ten opzichte van gemiddeld hoogwater (M.H.W.) aangegeven.

PK2 lage oeverwal *(Scirpus maritimus* domineert).

PK3 laag betrekkelijk beschut liggend kaal slik.

PK5 lage kom *(Scirpus lacustris* domineert).

PK8 middelhoge oeverwal *(Phalaris arundinacea* domineert).

PK7 middelhoge kom *(Typha latifolia* domineert).

Influence of vegetation on sedimentation.

The number of the permanent sample plot and the height with regard to mean high tide (M.H.W.) is given underneath each graph.

PK2 low natural levee (Scirpus maritimus dominates).

PK3 low fairly sheltered bar flat.

PK5 low back swamp (Scirpus lacustris dominates).

PK8 medium-high natural levee (Phalaris arundinacea dominates).

PK7 medium-high back swamp (Typha latifolia dominates).

Fig. 36.

Slibafzetting aan de lijzijde (ten opzichte van de ebstroom) van biezenpollen op de Boerenplaat, nadat door baggerwerken het stroomregiem zo gewijzigd is, dat het milieu rustiger geworden is (najaar 1954).

Sedimentation of silt on the lee-side (of the ebb-stream) of the stands of rushes on the "Boerenplaat" after alteration of the current regime by dredging-operations. The operations effected a more quiet milieu (autumn 1954).

Fig. 38.
Negatieve invloed van de vegetatie op de aanslibbing: bevordering van het reliëf.
Langs de rand van de Heenbegroeiing treedt stroomversnelling op. Hierdoor ontstaat een diepte vlak voor de begroeiing.
(Zandvlakte van de Boerenplaat, najaar 1954).

Negative influence of vegetation on sedimentation: introducing of relief.
The current accelerates just before the vegetation edge of the stand of Scirpus maritimus. At the place of the rapids dephts come to being.

Fig. 39.
Een kleine schaarrug in een kreek op de Boerenplaat. Op de voorgrond de vloedschaar, dood-lopend tegen de rug. Midden links de ebschaar.
A low scour ridge in a creek on the Boerenplaat. In the fore-ground the flood-current ends against the ridge. Medium at the left back the ebb-current.

Fig. 41.
„Vlaai". Wantijgebied van het Buitenkooigat.
„Vlaai". Wantide area of the Buitenkooigat.

Fig. 42.
Afslag aan de oever van het vloedbos, o.a. door golfslag. Vorming van een zandig strand.
(Visplaat; langs de eendenkooi; zie ook fig. 13).

Erosion on the bank of a tidal forest, o.a. caused by the wash of the waves.
Formation of a sandy beach.
(Visplaat; along the duck decoy; see fig. 13.)

Cliché: Modder is gevaarlijk

FIG. 43.
Erosie ten gevolge van ondermijning van de oever. Het doorwortelde gedeelte biedt het langste weerstand (Bol).
Erosion caused by undermining of the banks. The parts anchored by roots resist longer (Bol).

FIG. 44.
Noorderplaat en omgeving (zie ook bijlage 4).
Weipolder met zeer recente en oude overslagen.
Voorts allerlei stadia van buitendijks gebied.

A. open water	D. rietgorzen
B. zandplaten en -banken	E. grienden
C. ruigten	F. weipolder, gedeeltelijk iets geïnundeerd

In het midden links recente dijkbreuk met overslag.
Bij × duikerputten.
Bij 30: mast nr. 30 van hoogspanningsleiding (vergelijk fig. 13i).
De kartering vond plaats voor de dijkdoorbraak; de jongste overslag werd derhalve niet gekarteerd.
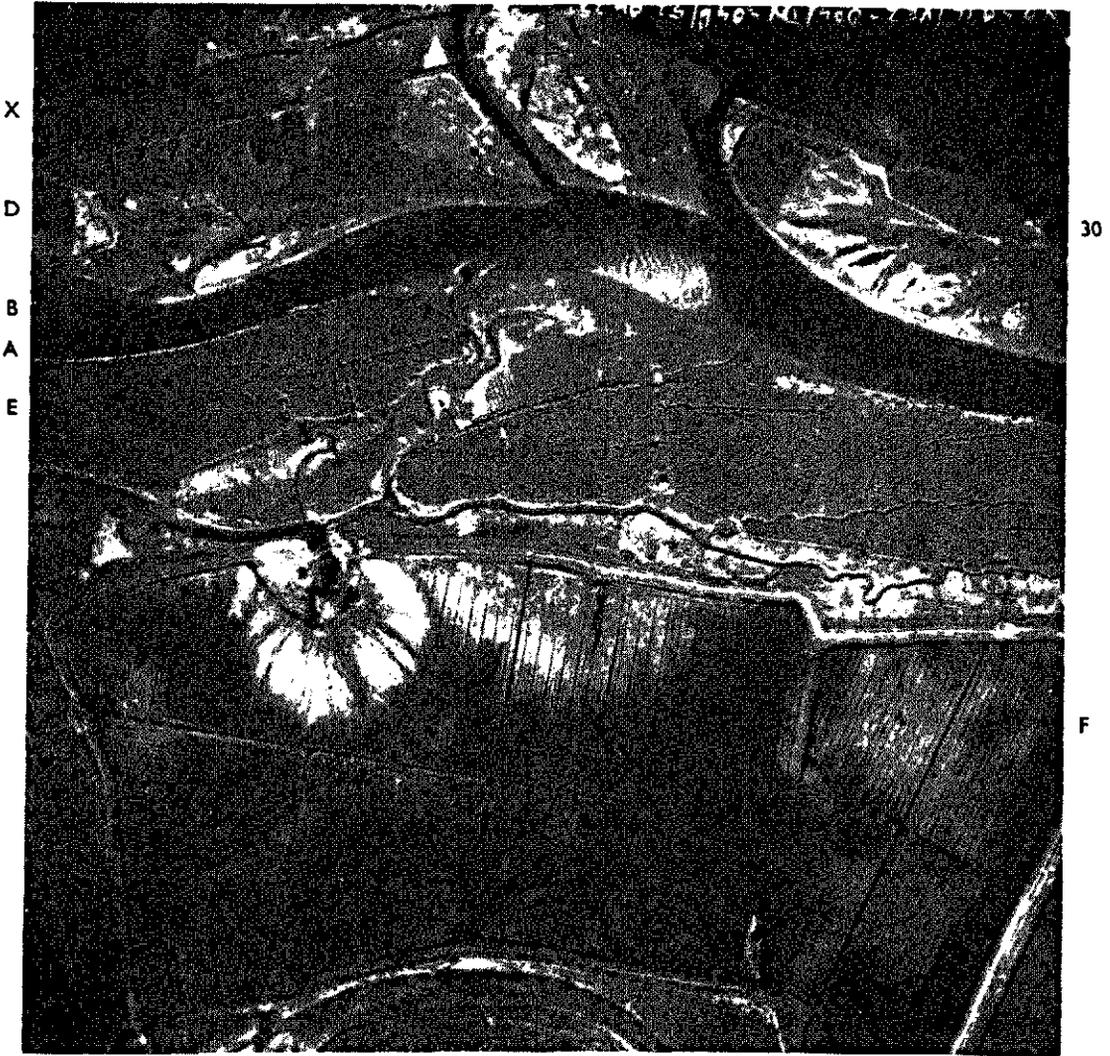
Noorderplaat and environment *(see appendix 4)*.
Pasture polder with very recent and old dike breach spill soils.
Besides several stages of the non-embanked area.

A. *open water*

B. *sand-flats and sand-bars*

C. *rough herbages*

D. *reed marshes*

E. *willow beds (coppice)*

F. *pasture polder, partly slightly inundated*

In centre left recent dike-breach with spill sediments.
Near × culvert holes.
Near 30: electricity pylon nr. 30 (see also fig. 131).
Mapping was executed before the breach of the dike. So the younger spill soils could not be mapped.
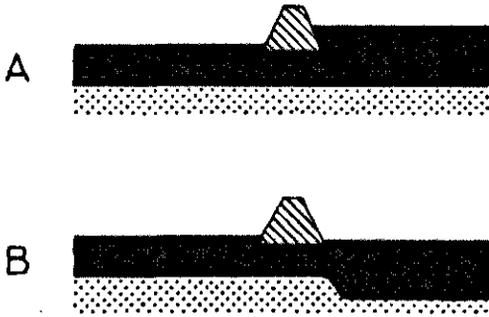
FIG. 45.
Bodemverschil aan weerszijden van een dijk.
Links ouder, rechts jonger land.

A = De dijk is primair, het bodemverschil secundair.
B = Het bodemverschil (bijv. de hoogte van de zandondergrond) is primair, de dijk is aan het oorspronkelijk bodemverschil aangepast.

B is, in allerlei variaties, algemener dan A.
Combinaties van A en B komen veel voor.

Dissimilarity in soil on both sides of a dike.
To the left older, to the right younger land.

A = Dike is primary, dissimilarity in soil secondary.
B = Dissimilarity in soil (e.g. the original height of the sandy subsoil) is primary, the dike has been adapted to the original dissimilarity.

B is, in several variations, more common than A.
Combinations of A and B often occur.

TABEL A / TABLE A.

Lutum/slib-verhouding *Clay/part. < 16 mu ratio*	50	55	60	65	70%	
De grens van 50% 2 mu komt overeen met *The boundary of 50% 2 mu corresponds with*	100	90	83	77	73%	afslibbaar *part. < 16 mu*
De grens van 35% 2 mu komt overeen met *The boundary of 35% 2 mu corresponds with*	70	64	58	54	50%	afslibbaar *part. < 16 mu*
De grens van 25% 2 mu komt overeen met *The boundary of 25% 2 mu corresponds with*	50	45	42	38	36%	afslibbaar *part. < 16 mu*

Middelwaard

Bruine kil, omzoomd met
ietgorzen
*Bruine kil, bordered by
reed-marshes*

FIG. 46.

Sporen van oude eendenkooien op de Bruinhoeksewaard (Hogepolder)
en Joachimsveld (vergelijk bijlage 4 en fig. 47).

*Traces of former duck decoys in the Bruinhoeksewaard (Hogepolder) and
Joachimsveld (compare appendix 4 and fig. 47).*

FIG. 47.

Het gebied van fig. 46 en omgeving omstreeks 1640 [1]. De kooien zijn hier kennelijk nog in bedrijf. In „den Prickwaert" bevinden zich „vangpijpen", die niet op een „wet", maar op een open kreek uitkwamen. De huidige gemeentegrens (zie bijlage 4) is reeds aanwezig. De bedijking werd later aan deze grens aangepast.

The area of fig. 46 and surroundings around 1640 [1]. The duck decoys were obviously still in operation at this time. In "den Prick-waert" occur "trap-ditches". These "trap-ditches" were not connected with a "wet" but ran out into a normal open creek. The present-day community boundary (see appendix 4) existed already. The embanking has adopted itself to this community or parish boundaries later on.

[1] Het hier afgebeelde kaartgedeelte is aanzienlijk groter dan de op bijlage 4 weergegeven omvang, vooral in westelijke richting. Merk op dat de inschriften op de kop staan. Blijkbaar was voor de toenmalige gebruiker van deze kaart een blik in zuidelijke richting van veel belang.

The part of the map given above is larger than the size at appendix 4, particularly in western direction. Notice that the inscriptions have been placed upside down. Obviously a vieuw in southern direction was of great importance for the use in those days. Just as in fig. 46 the north is placed at the top.

VIII   M.H.W.   M.L.W.

VII   M.H.W.   M.L.W.

VI   M.H.W.   M.L.W.

V   M.H.W.   M.L.W.

IV   M.H.W.   M.L.W.

III   M.H.W.   M.L.W.

II   M.H.W.   M.L.W.

I   M.H.W.   M.L.W.

a   b   c   d   e   f   g   h   i   j   k   l

matig fijn zand / *medium fine sand*	Heen / *Scirpus maritimus*	V₁–V₃ natuurlijke vegetatie / *original vegetation*

matig fijn zand
medium fine sand

grof zand
coarse sand

slibhoudend zand
clay containing sand

klei
clay

afwisselend kleiige en zandige lagen
alternating clayey and sandy layers

venige klei
peaty clay

rietveen
reed peat

mosveen
sphagnum peat

zeggeveen
sedge peat

dijk
dike

bemaling
mill drainage

duiker
culvert

kade
small dike

Heen
Scirpus maritimus

Driekantige Bies
Scirpus triqueter

Mattenbies
Scirpus lacustris s.l.

Rietgras
Phalaris arundinacea

Moeraskruiskruid
Senecio paludosus

Kattestaart
Lythrum salicaria

Harig wilgenroosje
Epilobium hirsutum

Riet
Phragmites communis

verschillende zegge-soorten
Carex div. sp.

Wolfspoot
Lycopus europaeus

Grote Lisdodde
Typha latifolia

Kleine Lisdodde
Typha augustifolia

Dotterbloem
Caltha palustris

Liesgras
Glyceria maxima

Egelskop
Sparganium erectum

Pijlkruid
Sagittaria sagittifolia f. sagittifolia

V₁–V₃ natuurlijke vegetatie
original vegetation

V₁–V₃ griend
willow bed

V₄ en V₅ natuurlijke vegetatie
original vegetation

V₄ en V₅ griend
willow bed

Alnetum glutinosae

V₆ natuurlijke vegetatie
original vegetation

grasland
pastures

bouwland
arable land

Sphagnetum

Rdq

Rd

Rc

Rdf

Rf

Re

R

Rb

Rp

FIG. 48.
Schematische voorstelling van de landgroei.
The accumulation of land (schematically shown).

Voor de lettersymbolen zie de legenda van de vegetatiekaart of het vegetatieoverzicht (bijlage 2 en 7).

For letter-symbols see legend of vegetation map or vegetation survey (appendix 2 and 7).

V. INITIAL ALLUVIAL SOIL FORMATION
(PHYSICAL RIPENING AND SHRINKAGE)

Initial alluvial soil formation can be distinguished in physical and chemical "ripening". Physical ripening is the process by which young newly deposited sediments are transformed into firm ground. The basis of this process is the loss of water of hydration from the clay and organic matter colloids (table B and C and fig. 50A, B, C and D and 51). There is in addition, a distinct fall in organic matter content, since decomposition tends to outstrip more and more the formation of new organic material (fig. 50E, F, G and H and table E). The loss of water and of organic matter is accompanied by a considerable decrease in volume (fig. 50I, J, K and L). Shrinkage of layers rich in colloidal material is one of the most spectacular features of the initial alluvial soil formation as a result of the physical ripening (fig. 53). The ripening is studied according to Hissink's method (1935) by means of measurements of clay content, silt content, volume of the mineral fraction, organic matter content and total water content, in soils of varying texture and in varying stages of land formation (fig. 52). These stages are rush-marsh, rough herbage ("ruigte"), reed marsh, willow coppice and polder, and they seem also to represent stages in initial alluvial soil formation. In the willow coppice a distinction was drawn between the *Fraxinetum* and the *Salicetum* coppice (see Chapter X). The stage of physical ripening can be expressed as the water content of one gram clay (part. < 2 mu). This is by approximation n in the formula:

$A = 20 + nL + nbH$ .... (1) (see also Smits, 1953; Zuur, manuscript 1958)[1].

A = water content of 100 gram dry soil.
20 = the points where the curves of fig. 50 and 51 intercept the ordinate.
L = % clay.
H = % organic matter.
b = ratio between water-absorbing capacity of organic matter and clay (part. > 2 mu).

In the tables C, D, E and F the estimated value of b was 3 and 4. For freshwater soils b was estimated with help of a graphical method (see fig. 51a). The found value (b = 4) differs from that (b = 3) used for marine soils at the Soil Laboratory of the Authority of the Wieringermeer at Kampen (Zuur, manuscript 1958, see Zuur, 1954), but is not very reliable.

It seems that about half the loss in water is caused by dehydration and half by decomposition of water-holding organic matter (table F). In marine sediments, conditions are different, as can be calculated from the data of Hissink (1935). The stage comparable with the willow coppice in sedimentation, relative elevation and consequent hydrological position is the marine tidal marsh ("kwelder"). The volume of water of hydration per unit of colloidal material does seem to be identical with the corresponding volume in willow coppice, but the total volume of water is much greater in the willow coppice, due to the much higher content of organic matter (fig. 51). Thus, in the transition from kwelder to polder, the percentage of the total water loss which is due to the breakdown of organic matter is about 1/6, whereas that in the transition from willow coppice to polder is about 1/2 (table F). In reed marshes even the in wet condition measured volume of organic matter can be over 50 %, thus forming a transition to peat soils ("modderklei"; fig. 52 and table G).

Since the ripening, and thus also the shrinkage, is a function of the content of colloidal material, the shrinkage can be calculated when the stage of ripening and colloidal content are known. Since the organic matter content within the ripening stages shows a certain

---

[1] A more correct formula should be: $A = 0.2 Z + n (L + bH)$; (Z = sand etc.), see volume B.

correlation with the clay and silt content (fig. 50 and 51), to know the clay content is therefore sufficient.

It is now possible to set up graphs on the basis of the volume weight measurements on which the approximate value of the shrinkage can be read off for every given value of the clay-(silt) content (fig. 56). Using these graphs, it is possible to make up, for every stage in the ripening process, tables for the different soil types, which are delimited on the basis of the thickness and heaviness of the various profile layers (table H). A table was also composed predicting, for each of the most important soil types, the lowering of the land surface (table I). In this way the future characteristics of the soil profile after shrinkage can be shown on a soil map and at the same time, the level of the land surface can be predicted. Levelling out of the ditches has, in the willow coppice, a further slight influence on the sinking of the land surface (fig. 55). Given conditions of reasonable aeration in the soil, the ripening process, and the consequent shrinkage, takes from 50 to 100 years before it is more or less complete (fig. 54). The nature and height of the future soil profile are naturally of great importance in connection with the carrying out of land improvement works. The influence of the water table on the proceeding of ripening and shrinkage is apparent (fig. 57).

It appears that the sediments of a freshwater tidal area shrink much more markedly than marine sediments in the same stage. The shrinkage of a kwelder with for example 50 % of its particles smaller than 16 mu, may be at the most 10 to 20 %, while with an willow coppice of the same texture and in the same ripening stage, the shrinkage is about 50 %. Shrinkage is also important for a full understanding of sedimentation. Ripening and sedimentation can take place simultaneously because the former process is more or less irreversible and in this way a relatively high bank can undergo considerable further sedimentation without any real increase in height (see appendix 5 fig. K).

In the substrata of the Biesbosch, which are made up for a good part of peat and plastic clay layers, a certain degree of shrinkage can also be expected, in places where the water level will be lowered. An exact investigation of this shrinkage was not carried out. On the basis of the principles worked out by HUIZINGA (1940) it can be expected that this shrinkage will not be large, for the following reasons:

a. Most of the area which already consists of diked polders will be subjected to no great lowering of the water table.

b. The most plastic layers are those which were laid down deepest, where the effect of the forces (intergranular pressure) which determine the shrinkage is least strong.

c. The peat layers have already been fairly strongly compressed during formation and later as a result of the great mass of sediment laid down since the St. Elizabeth flood (table J).

d. A certain amount of water is forced out of the under-lying pleistocene layers beneath the layers of holocene sediment and this process tends to counteract the shrinkage in preventing the squeezing out of the absorbed water.

FIG. 49.
Scheurvorming in een dun sliblaagje, afgezet op een vrij hoge zandplaat. (Boerenplaat, zomer 1955).
Cracks in a thin clay layer deposited on a fairly high sand flat. (Boerenplaat, summer 1955).

RUIGTE EN BIEZENGORS
Rough herbage and marsh of rushes
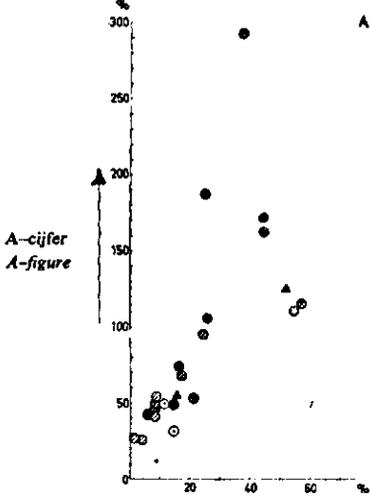
RIETGORS
Reed-marsh
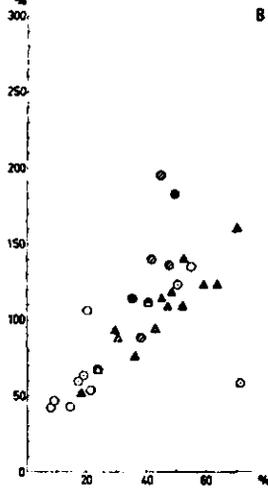
VLOEDBOS EN GRIEND
Willow coppice and tidal forest
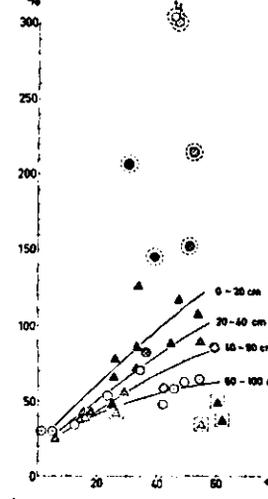
A
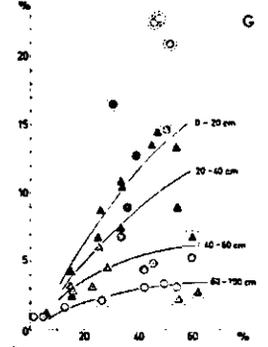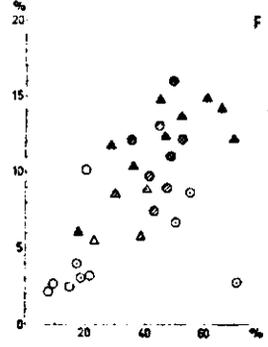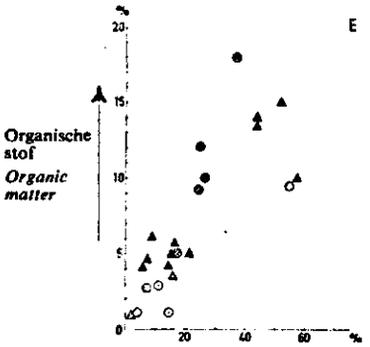
B

A-cijfer
A-figure

0 – 20 cm
20 – 40 cm
40 – 60 cm
60 – 100 cm

Afslibbaar
Particles < 16 micron

E

F

G

Organische
stof
*Organic
matter*

0 – 20 cm
20 – 40 cm
40 – 60 cm
60 – 100 cm

Afslibbaar
Particles < 16 micron

I

J

Volume
percentage
droge stof
*Volume
percentage
dry matter*

80 – 100 cm
40 – 60 cm
0 – 100 cm
20 – 40 cm
0 – 20 cm
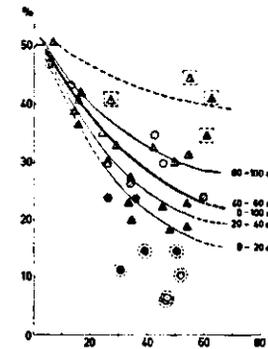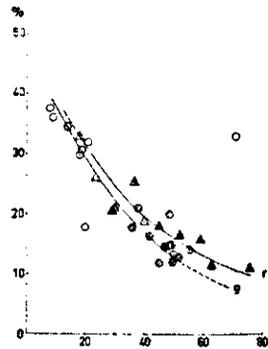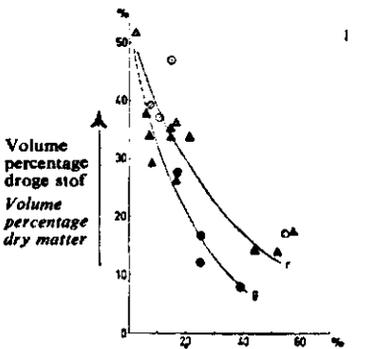
Afslibbaar
Particles < 16 micron

Fig. 50A t/m K.

Het verband tussen het A-cijfer (bovenste rij), percentage organische stof (middelste rij), volumepercentage droge stof (onderste rij) (alle op de ordinaat) en het percentage afslibbaar (abscis).

The relation between the A-figure (upper row), the percentage of organic matter (middle row), volume percentage of dry matter (lower row) (all three at the ordinate), and the content of particles < 16 mu (abscissus).
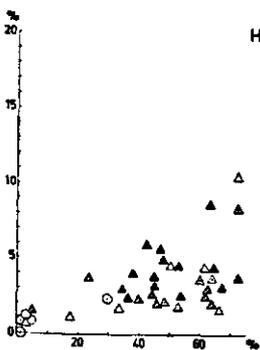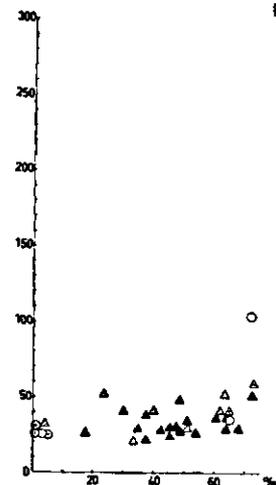
○ (g)   volkomen gereduceerde grond
totally reduced soil

△ (r)   meer of minder geaëreerde grond
more or less aerated soil

● ▲   0— ca. 20 cm beneden maaiveld
0— about 20 cm below surface

⊗ △   20—40 cm beneden maaiveld
20—40 cm below surface

◐ △   40—60 cm beneden maaiveld
40—60 cm below surface

⊙ △   60—80 cm beneden maaiveld
60—80 cm below surface

○ △   <80 cm beneden maaiveld
<80 cm below surface

— n—m cm   gemiddelde kromme voor de laag van n—m cm beneden maaiveld, geldend voor *Salicetum*-grienden, uitgezonderd griendtype V5 en kombos
n—m cm   averaged curve for the layer n—m cm below surface, holding for Salicetum-beds, except for the beds of type V5 and the tidal back swamp forests

▢   bodem onder de griend- en vloedbosgemeenschap met *Carex remota* en *Circaea lutetiana* (V0) (*Fraxinetum*-griend)
soil under the willow coppice and tidal forest community with Carex remota and Circaea lutetiana (V0) (Fraxinetum willow coppice)

◯   bodem van het kombos en de extreem weke ondergrond van de gemeenschap van *Salix purpurea* en *Alisma plantago-aquatica* (V5); kuil 23
soil of a back swamp forest and the extremely soft subsoil under the community of Salix purpurea and Alisma plantago-aquatica (V5); pit 23

r =   gemiddelde kromme voor de roestige (min of meer geaëreerde) lagen
averaged curve for the rusty (more or less aerated) layers

g =   gemiddelde kromme voor de geheel gereduceerde (anaerobe) lagen
averaged curve for the totally reduced (anaerobic) layers
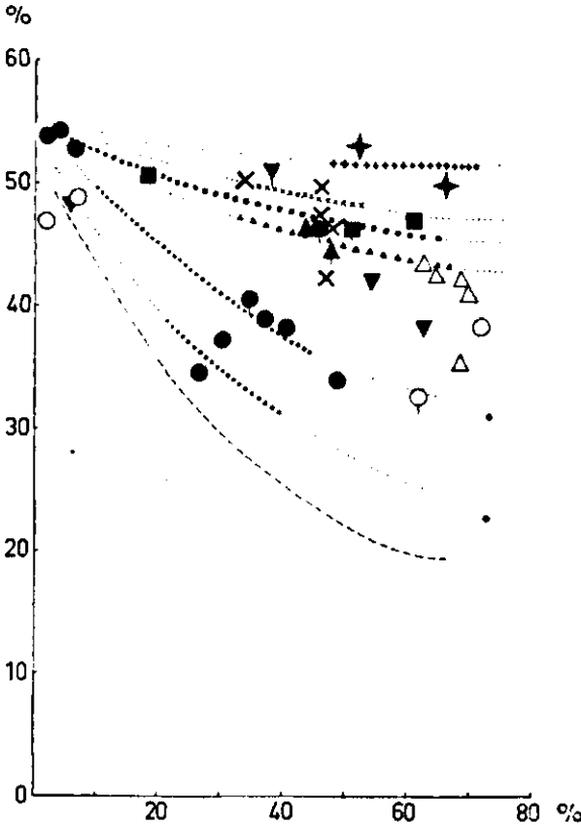
FIG. 50L.

Het verband tussen het volume-percentage droge stof (zonder humus en CaCO₃) (ordinaat) en het percentage afslibbaar (abscis).

FIG. 50L.

The relation between the volume percentage of dry matter (without humus and CaCO₃) (ordinate) and the content of particles < 16 mu (abscis).

·······✚	oude stroomruggrond, die vele eeuwen geaëreerd is geweest (thans overdekt) *old levee soil, aerated during many centuries, presently capped* Bouwpolder *Polder with arable land*
·······✕	ca. 310 jaar bedijkt *embanked for about 310 years*
·····■	ca. 225 jaar bedijkt *embanked for about 225 years*
·······▲	ca. 110 jaar bedijkt *embanked for about 110 years*
▼	ca. 70 jaar bedijkt *embanked for about 70 years*
·······●	ca. 35 jaar bedijkt *embanked for about 35 years*
⠿	ca. 100 jaar of langer geleden bedijkt, daarna in griend gelegd en 10 jaar geleden opnieuw bedijkt *embanked for about 100 years or more, later on transformed into willow coppice and embanked anew ten years ago*

○	weipolder ca. 150 jaar bedijkt *grassland polder embanked for about 150 years*
·	kalkarme laag in het waardengebied *layer poor in lime in the "waarden"-area*
○▲▼■●	bovenste laag ca. 5—10 cm beneden maaiveld *topsoil about 5—10 cm below surface*
- - - - - - -	gemiddelde kromme voor de griend (*Salicetum*) *averaged curve for the Salicetum willow coppice*

FIG. 51.

Het verband tussen het A-cijfer resp. het gehalte aan organische stof met het afslibbaar in de bovenste 80 à 120 cm van profielen in verschillende rijpingsstadia.

The relation between the A-figure resp. the organic matter content with the content of part. < 16 μ in the upper 80 to 120 cm of profiles in different stages of initial soil formation in alluvial soils.
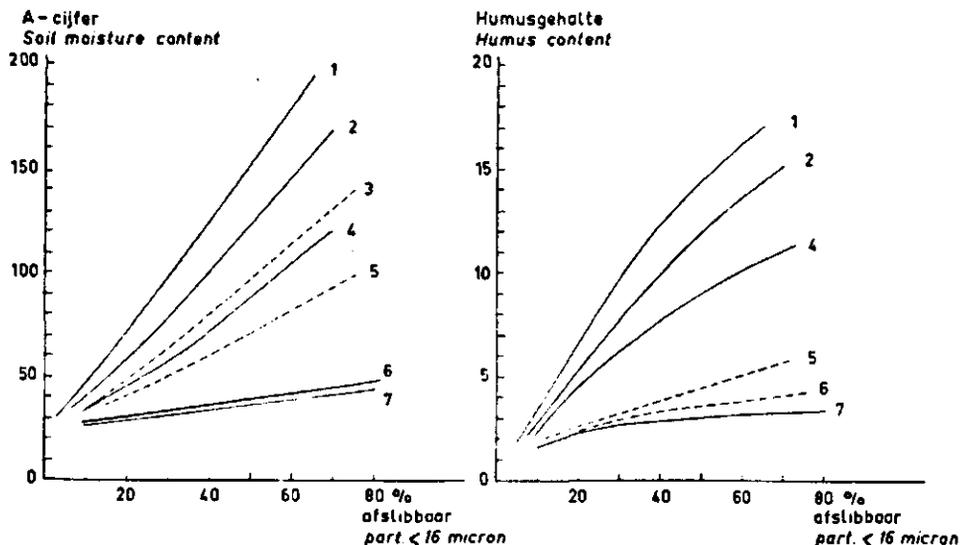
1. **Ruigte en biezengors**
   Rough herbage and marsh of rushes

2. **Rietgors**
   Tidal reed-marsh

3. **Zuiderzee-slib**
   Zuydersea-silt

4. *Salicetum*-griend en vloedbos
   Salicetum willow coppice and tidal forest

5. **Kwelder**
   Marine foreland

6. *Fraxinetum*-griend
   Fraxinetum willow coppice

7. **Polder**
   Polder

Het A-cijfer betreft het watergehalte in g/100 g droge grond.
The A-figure refers to the water content in g/100 g oven-dry soil.

Het humusgehalte is uitgedrukt in g/100 g droge grond.
The humus content is determined in g/100 g oven-dry soil.

FIG. 51A. Grafische bepaling van de verhouding (*b*) tussen het waterbindend vermogen van lutum en van organische stof bij *Salicetum*-griendgronden.
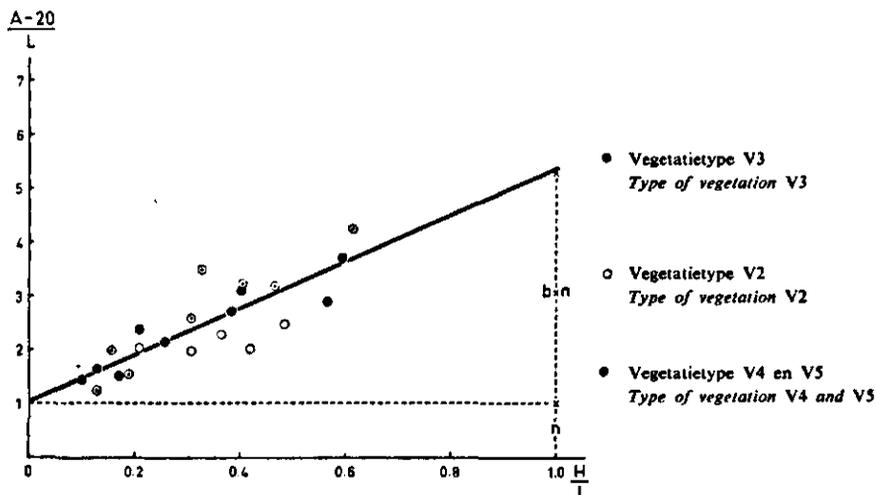
FIG. 51A. *Graphic determination of the ratio (b) between the ability of waterbinding of clay and organic matter in soils below Salicetum willow coppice.*

LEGENDA FIG. 52.

1. Minerale delen (nat berekend)
   Mineral constituents (computed as in wet conditions)

2. Organische stof (nat berekend)
   Organic matter (computed as in wet conditions)

3. Minerale delen, behalve $CaCO_3$
   Mineral constituents, except $CaCO_3$

4. $CaCO_3$

5. Organische stof
   Organic matter

6. Water
   Water

7. Lucht
   Air

   3, 4 en 5 zijn droog berekend
   3, 4 and 5 are computed as in dry conditions

Linkerzijde
Het luchtvolume is buiten beschouwing gelaten
Left side
The air-volume is left out of consideration

Rechterzijde
Right side

Fig. 52.

Volumeverdeling van de bodemcomponenten in profielen met verschillende rijpingsstadia.

Horizontaal: percentage van het volume van de ongeroerde grond.
Verticaal: diepte in cm beneden maaiveld.

Volume-distribution of the soil constituents in different stages of initial soil formation (physical ripening).

Horizontal: Percentage of the volume of the unstirred soil.
Vertical: depth in cm below surface.
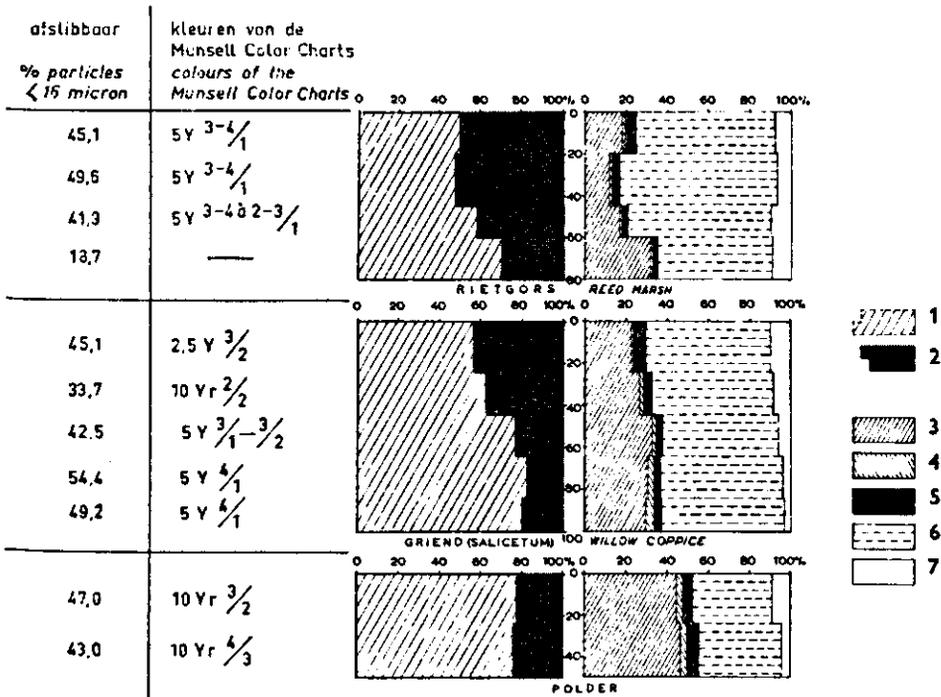
FIG. 53. De volumepercentages van minerale delen, water en lucht bij het optreden van klink.
(Uit h.v. = h'v' volgt het klinkpercentage = $\frac{h'}{h}$ .100 = $\frac{v}{v'}$ .100).
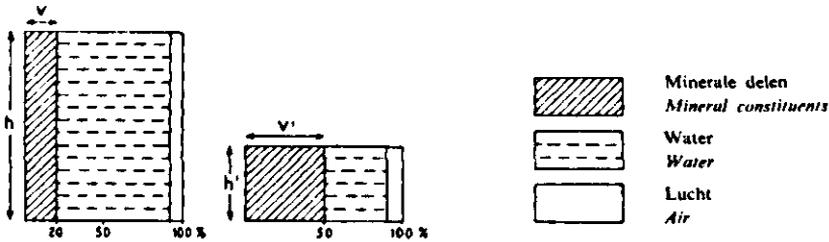
FIG. 53. *Volume percentages of mineral constituents, water and air before and after shrinkage.*
(*Out of* h.v. = h'v' *follows the shrinkage percentage* = $\frac{h'}{h}$ .100 = $\frac{v}{v'}$ .100).

FIG. 54. Vermindering van de dikte van de bovenste 100 cm als gevolg van inklinking (uitgaande van een *Salicetum*-griend).
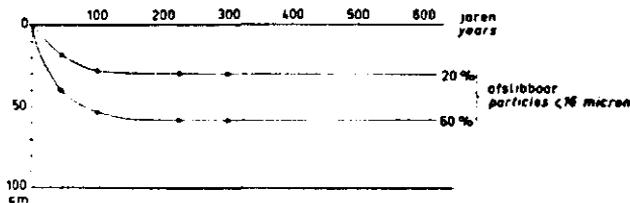
FIG. 54. *Decrease in thickness of the upper 100 cm caused by shrinkage (Salicetum willow coppice).*
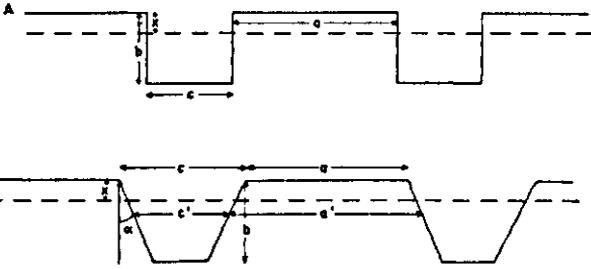
FIG. 55.

Hoogteverlies ten gevolge van egalisatie.

Lowering of the surface as a result of levelling.

A. Het verlies ($\times$) door egalisatie is $\dfrac{b.c}{a+c}$

B. Het verlies ($\times$) door egalisatie $\dfrac{b.c - b^2 \text{ tg}x}{a+c}$ of $\dfrac{b.c'}{a'+c'}$, (niveau van a' en c' is $\frac{1}{2}$ b — maaiveld)

A. *Lowering* ($\times$) *by levelling is* $\dfrac{b.c}{a+c}$

B. *Lowering* ($\times$) *by levelling is* $\dfrac{b.c - b^2 \text{ tg}x}{a+c}$ *of* $\dfrac{b.c'}{a'+c'}$ *(level of a' and c' is $\frac{1}{2}$ b — soil surface)*

FIG. 56. Klink van de bovenste meter na 80 à 100 jaar in procenten.

Percentage of shrinkage of the upper meter after 80 to 100 years.
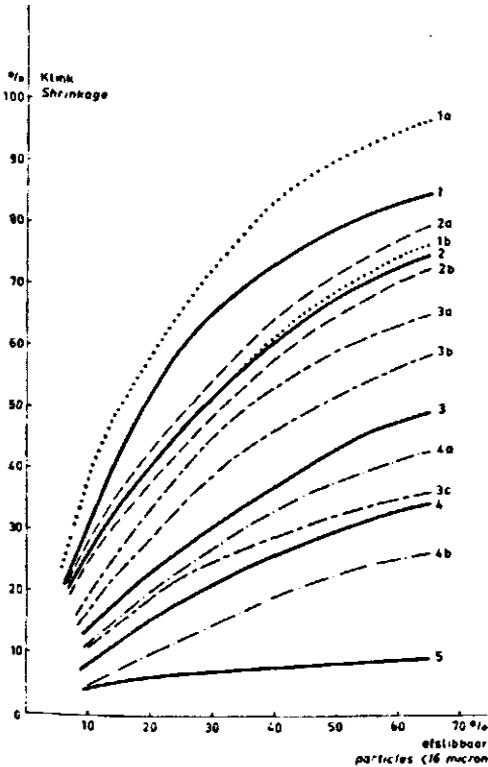
1. Ruigte- en biezengorsbodem (gemiddeld)
   Rough herbage and marsh of rushes soils (averaged)

1a. Gereduceerd
    Reduced

1b. Ruigtebodem met roest
    Rough herbage soil with iron oxide concretions

2. Rietgorsgronden (gemiddeld)
   Reed-marsh soils (averaged)

2a. Gereduceerd
    Reduced

2b. Rietgorsbodem met roest
    Reed-marsh soil with iron oxide concretions

3. *Salicetum*-griend (gemiddeld, tevens 40—60 cm)
   Soil under a Salicetum willow coppice (averaged, also 40—60 cm)

3a. 0—20 cm

3b. 20—40 cm

3c. 60—100 cm

4. Polder 40 jaar (gemiddeld)
   Polder 40 years (averaged)

4a. Polder 40 jaar, 50—80 cm
    Polder 40 years, 50—80 cm

4b. Polder 40 jaar, 0—50 cm
    Polder 40 years, 0—50 cm

5. *Fraxinetum*-griendbodem (gemiddeld)
   Soil under a Fraxinetum willow coppice (averaged)

FIG. 57. Schema van de verlaging van het maaiveld en de diktevermindering van het kleidek ten gevolge van klink, bij verschillende standen van het grondwater.
Aangenomen klinkfactor is 0,5.

Niet geklonken klei
Non-shrinked clay

Fysisch gerijpte (geklonken) klei
"Physically ripened" (shrinked) clay

Zand
Sand

——— Grondwaterniveau
Groundwater table
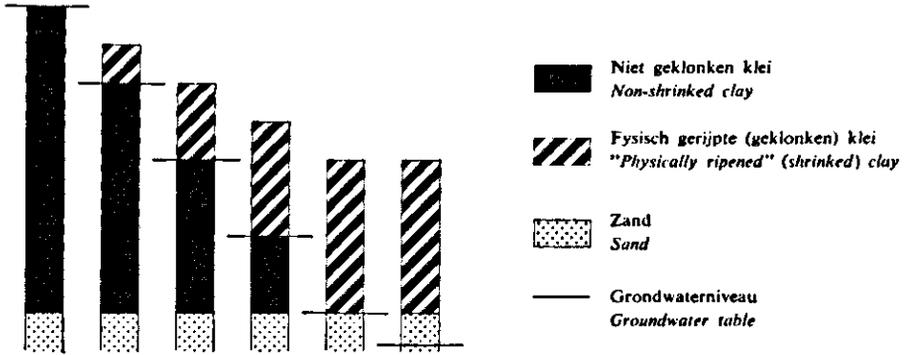
FIG. 57. *Scheme of the lowering of the soil surface and the decrease in thickness of the surface clay layer as a result of shrinkage, at various groundwater tables.*
Supposed shrinkage factor is 0.5.

TABEL B. Watergehaltecijfers (A-cijfers) uitgedrukt per gram afslibbaar.

	Ruigte *Rough herbage*	Rietgors *Reed-marsh*	Salicetum stage Griend *Willow coppice*	Fraxinetum stage Griend *Willow coppice*	Polder *Polder*	Kwelder *Marine tidal marsh*
1 g slib (resp. lutum) komt overeen met x g humus / *1 g particles <16 mu (resp. particles <2 mu) corresponds with x g organic matter* — x is voor: / *x is in the case of:*	0.30 (0.57)	0.24 (0.46)	0.18 (0.35)	0.07 (0.13)	0.06 (0.11)	0.08 (0.14)
1 g slib (resp. lutum) komt overeen met x g water (gebonden aan zand, humus en slib) / *1 g particles <16 mu (resp. particles <2 mu) corresponds with x g water (bound to mineral and organic matter)* — x is voor: / *x is in the case of:*	3.1 (6.0)	2.5 (4.8)	1.8 (3.5)	0.7 (1.3)	0.7 (1.3)	1.4 (2.7)
1 g slib (resp. lutum) komt overeen met x g water (gebonden aan humus en slib) / *1 g particles <16 mu (resp. particles <2 mu) corresponds with x g water (bound to particles <16 mu and organic matter)* — x is voor: / *x is in the case of:*	2.7 (5.1)	2.1 (3.9)	1.4 (2.6)	0.4 (1.8)	0.3 (0.6)	1.0 (1.5)

TABLE B. *Water content figures (A-figures) per gramme particles < 16 mu.*

TABEL C. Gemiddelde waarde van het watergehalte (in g) per gram slib en per gram organische stof, aannemende dat de verhouding van de watergehalten van slib en organische stof in alle stadia gelijk is.

	Lutum Particles <2 mu (= n)		Organische stof Organic matter (= bn)	
	b = 3	b = 4	b = 3	b = 4
Ruigte / *rough herbage*	1.9	1.6	5.8	6.4
Rietgors / *reed-marsh*	1.7	1.4	5.0	5.5
Griend, *Salicetum*-stadium / *willow coppice, Salicetum stage*.	1.3	1.1	3.8	4.4
Griend, *Fraxinetum*-stadium / *willow coppice, Fraxinetum stage*.	0.5	0.5	1.6	2.0
Polder / *polder*	0.4	—	1.3	—
Kwelder / *marine tidal marsh*	1.1	—	3.3	—

TABLE C. *Average value of the water content (in g) per gramme particles < 2 mu and per gramme organic matter, assuming that the ratio of the water contents of particles < 16 mu and organic matter is the same in all stages.*

TABEL D. Watergehalte (A-cijfer) van organische stof en lutum in lagen van het profiel onder griend (Salicetum).

Diepte van de laag beneden maaiveld *Depth of layers below surface* cm	Organische stof per g lutum *Organic matter per g particles <2 mu*	Totaal water per g lutum gebonden aan organische stof en minerale delen *Total water per g particles <2 mu bound to organic and mineral matter*	Water in 1 g lutum (= n-cijfer in formule 1) *Water in 1 g particles <2 mu* (= n-figure in formula 1)		Water in 1 g organische stof *Water in 1 g organic matter* (= n × b)	
			b = 3	b = 4	b = 3	b = 4
0– 20	0.54	3.8	1.5	1.2	4.4	4.9
20– 40	0.40	2.9	1.3	1.1	3.9	4.4
40– 60	0.21	2.2	1.3	1.2	4.0	4.8
60– 80	0.13	1.7	1.2	1.1	3.5	4.3
80–100	0.13	1.35	1.0	1.0	2.9	3.5

TABLE D. *Water content (A-figures) of organic matter and particles < 2 mu of layers of the profile under willow coppice (Salicetum).*

TABEL E. Watergehalte van de afgebroken organische stof.

Diepte van de laag beneden maaiveld *Depth of layer below surface*	Afgebroken organische stof per g lutum *Decomposed organic matter per g <2 mu* (α)	Waterverlies per g lutum *Loss of water per g particles <2 mu*			Gemiddeld watergehalte van de afgebroken organische stof per g *Average water content of decomposed organic matter per g* $x = \dfrac{\gamma-\beta}{\alpha}$
		Totaal *Total* (γ)	Door dehydratatie *By dehydration* (β)	Door humus-afbraak *By decomposition of organic matter* ($\gamma-\beta$)	
	1	2	3	4	5
0– 20	0.41	3.2	1.2	2.0	4.9
20– 40	0.27	2.3	1.1	1.2	4.5
40– 60	0.06	1.6	1.2	0.4	6.6
60– 80	(0.02)	1.1	1.1	ca 0.0	
80–100	(0.02)	0.8	0.8	ca 0.0	

TABLE E. *Water content of the decomposed organic matter.*

TABEL F. Waterverlies door dehydratatie en afbraak van organische stof bij overgang van het ene rijpingsstadium naar het andere, berekend per gram lutum.

Overgang van → naar *Transition from → to*	Verlies aan organische stof (α) gedurende de overgang *Loss of organic matter during the transition (α)*	Watergehalte van de afgebroken organische stof (β) *Water content of the decomposed organic matter (β)*	Waterverlies / *Loss of water*		
			Totaal (γ) *Total* (γ)	Door afbraak van organische stof (α x β) *By decomposition of organic matter (α x β)*	Door dehydratatie van minerale delen en organische stof (γ — α x β) *By dehydration of mineral parts and organic matter (γ—α x β)*
Ruigte➤rietgors . . . . . *Rough herbage➤reed*	0.11	6.0	1.2	2.7	0.4
Rietgors➤griend . . . . . *Reed➤willow coppice*	0.11	5.0	1.3	0.6	0.7
Griend➤polder . . . . . . *Willow coppice➤polder*	0.24	4.4	2.0	1.1	0.9
Ruigte➤polder. . . . . . *Rough herbage➤polder*	0.46	5.2	4.5	2.4	2.1
Kwelder➤polder . . . . . *Marine tidal marsh➤ polder*	0.03	3.3	0.9	0.1	0.8

TABLE F. *Loss of water by dehydration and decomposition of organic matter during transition of one stage of ripening into the other, computed per gramme particles <2 mu.*

TABEL G. Volume natte organische stof in % van het totaal volume ongeroerde grond.

Profielkuil nr. *Profile pit nr.*	5 Rietgors *Reed-marsh*	28 Griend *Willow coppice*	7 Polder *Polder*
Diepte van de laag onder maaiveld *Depth of layers below surface*			
0– 20	50	43	22
20– 40	52	37	23
40– 60	42	23	
60– 80	30	17	
80–100		20	

TABLE G. *Volume wet organic matter in % of the total volume unstirred soil.*

TABEL H. Tabellen voor de berekening van de inklinking van bodemprofielen.

RIETGORS incl. RUIGTE en BIEZENGORS *Reed-marsh, rough herbage and marsh of rushes*		
Klinkfactoren voor: Gelaagde laag: *Shrinkage factor of: Stratified layer:*		0.6
Homogene kleilaag *Homogeneous loamy to clayey layer,*	zwaarte C: *texture class C:*	0.55
Idem *Ditto*	zwaarte D: *texture class D:*	0.33
Idem *Ditto:*	zwaarte E: *texture class E:*	0.27

GRIEND en VLOEDBOS (alleen Salicetum) *Willow coppice and tidal forest (Salicetum only)*		
Klinkfactoren voor: Gelaagde laag: *Shrinkage factor of: Stratified layer:*		0.8
Homogene kleilaag *Homogeneous loamy to clayey layer, texture class C:*	zwaarte C:	0.67
Idem *Ditto*	zwaarte D: *texture class D:*	0.55
Idem *Ditto*	zwaarte E: *texture class E:*	0.45

Griend en Vloedbos — zwaarte C (texture class C)

Diepte slibarm zand in dm *Depth of sand poor in clay in dm*	Dikte homogen kleidek in dm *Thickness homogeneous clayey and loamy cover in dm*									
	0	2	4	6	8	10	12	14	16	18
4	3	3	2¾	—	—	—	—	—	—	—
6	5	4¾	4¾	4¾	—	—	—	—	—	—
8	6¾	6¾	5¾	5¾	5¾	—	—	—	—	—
10	8	7¾	7	7	7	6¾	—	—	—	—
12	9¾	9¾	8¾	8¾	8	8	8	—	—	—
14	11	11	10¾	10¾	10	10	9¾	9¾	—	—
16	13	12¾	12½	12	11¾	11¾	11	11	11	—
18	14½	14	14	13¾	13¾	13	13	12¾	12¾	12¼ (12½)

Griend en Vloedbos — zwaarte D (texture class D)

Diepte slibarm zand in dm *Depth of sand poor in clay in dm*	Dikte homogen kleidek in dm *Thickness homogeneous clayey and loamy cover in dm*									
	0	2	4	6	8	10	12	14	16	18
4	3	2¾	2¾	—	—	—	—	—	—	—
6	5	4¾	4¾	3¾	—	—	—	—	—	—
8	6¾	6¾	5¾	5¾	4¾	—	—	—	—	—
10	8	7¾	7¾	6¾	6¾	5¾	—	—	—	—
12	9¾	9	8¾	8	7¾	7	7 (6½)	—	—	—
14	11	10½	10	9¾	9	8¾	8 (8½)	8 (7½)	—	—
16	13	12½	12	11½	11	10½	10 (10½)	10 (9½)	9¾ (9½)	—
18	14½	14	13½	13	12½	12	12 (12)	11½ (11½)	11 (10½)	11 (10½)

Zwaarte C (Texture class C)

Diepte slibarm zand in dm *Depth of sand poor in clay in dm*	Dikte homogen kleidek in dm *Thickness homogeneous clayey and loamy cover in dm*									
	0	2	4	6	8	10	12	14	16	18
4	2¾	2¾	2	—	—	—	—	—	—	—
6	3¾	3¾	3¾	3¾	—	—	—	—	—	—
8	5	4¾	4¾	4¾	4¾	—	—	—	—	—
10	6	6	6	5¾	5¾	5¾	—	—	—	—
12	7	7	8	7	7	6¾	6¾	—	—	—
14	8¾	8¾	8	8	8	8	8	7¾	—	—
16	9¾	9¾	9¾	9	9	9	9	9	9	—
18	11	10¾	10¾	10¼	10	10	10	10	10	10

Zwaarte D (Texture class D)

Diepte slibarm zand in dm *Depth of sand poor in clay in dm*	Dikte homogen kleidek in dm *Thickness homogeneous clayey and loamy cover in dm*									
	0	2	4	6	8	10	12	14	16	18
4	2¾	2¾	1½	—	—	—	—	—	—	—
6	3¾	3	2¾	2	—	—	—	—	—	—
8	5	4¾	3¾	3	2¾	—	—	—	—	—
10	6	5¾	5	4¾	4½	3¾	—	—	—	—
12	7	6¾	6	5¾	5	4¾	4	—	—	—
14	8¾	8	7¾	7	6¾	5¾	5	4	—	—
16	9¾	9	8¾	8	7¾	7	6¾	6	5¾	—
18	11	10¾	9¾	9	8¾	8	7¾	7¾	6¾	6

Zwaarte E (Texture class E)

Griendtabel (willow coppice table)

Diepte slibarm zand in dm / Depth of sand poor in clay in dm	Dikte homogeen kleidek in dm / Thickness homogeneous clayey and loamy cover in dm									
	0	2	4	6	8	10	12	14	16	18
4	3	2¾	2	1½	—	—	—	—	—	—
6	5	4	3½	2½	2	—	—	—	—	—
8	6½	5¾	5	4	3¾	2¼	—	—	—	—
10	8	7½	6¼	6	5	4	3	—	—	—
12	9½	9	8	7½	7	6	(5½)	—	—	—
14	11	10½	10	9½	8½	7¼	7 (7)	7 (6¼)	—	—
16	13	12	11½	10½	10	9¼	9	8¼ (8)	8¼ (7)	—
18	14½	13½	13	12½	11½	11	12¼ (10)	(9½)	(9)	9½ (8)

TABLE H. *Tables for the calculation of the shrinkage of soil profiles.*

Zwaarte E (Texture class E)

Diepte slibarm zand in dm / Depth of sand poor in clay in dm	Dikte homogeen kleidek in dm / Thickness homogeneous clayey and loamy cover in dm									
	0	2	4	6	8	10	12	14	16	18
4	2¼	1¾	1¼	1¼	—	—	—	—	—	—
6	3¼	3	2¼	1¾	1¼	—	—	—	—	—
8	5	4	3¾	3	2	1¼	—	—	—	—
10	6	5¼	4½	4	3¾	2¼	1	—	—	—
12	7	6¼	6	5	4¼	4	3	—	—	—
14	8½	7¾	7	6½	6	5	4½	4	—	—
16	9½	9	8½	7½	7	6½	5½	5	4½	—
18	11	10	9½	9	8	7½	7	6	5½	5

De cijfers in de tabellen geven voor elke oorspronkelijke dikte van het homogene kleidek en diepte van het zand, de diepte van het zand onder maaiveld na de totale fysische rijping (inklinking).

De dikte van het homogene kleidek in rijpe toestand wordt weergegeven door het bovenste cijfer in elke verticale kolom (het cijfer, dat voor de zanddiepte geldt, wanneer de dikte van het homogene kleidek gelijk is aan de zanddiepte).

De tabellen hebben betrekking op normale uit een homogeen kleidek en/of gelaagde laag op zand opgebouwde profielen. Afwijkende profielen worden berekend met de klinkfactoren. Deze geven het deel van de oorspronkelijke laagdikte, dat overblijft na inklinking.

De tussen haakjes geplaatste waarden in de griendtabel gelden, wanneer het profiel beneden 1 meter even humeus is als het gemiddelde van de lagen in de bovenste meter.

The figures in the tables indicate the depths of sand below soil surface, for every original thickness of the homogeneous loamy and clayey layer and the original depth of the sand. The thickness of the homogeneous loamy layer in mature condition is given by the uppermost figure in every vertical column (that is the figure that holds, if the thickness of the homogeneous layer equals the depth of the sand).

The tables refer to normal profiles consisting of a homogeneous clayey or loamy layer and/or a stratified layer on sand. Deviating profiles can be calculated with the help of the shrinkage factors. These give the part of the original thickness of layers after shrinkage.

The figures between parentheses in the willow coppice table refer to profiles, which are, below 1 metre, as humous as the average of the layers in the uppermost metre.

TABEL I. Daling in dm van het maaiveld ten gevolge van inklinking en egalisatie van de voor-
naamste bodemtypen, voor een ontwateringsdiepte van 80 cm onder het toekomstige
maaiveld, na afloop van de klink.

Diepere ontwatering zal bij de P- en PL-typen geen, bij de overige typen geen noemenswaard
grotere daling ten gevolge hebben. Geringere ontwatering zal minder daling veroorzaken en
leiden tot dikkere kleidekken dan op de bodemkaart zijn aangegeven.

De cijfers tussen haakjes geven de spreiding binnen het bodemtype weer.

	Gors (reed and rush marsh)	Salicetum-griend (Salicetum willow coppice)	
G1c	5½	3½ (±½)	Ter oriëntatie:
G1d	8¼ (±1½)	4 (±½)	Gemiddelde hoogte:
G2c	6	4	gors G- en P-type ca. 4–10 dm+NAP;
G2d	11½ (±1½)	5 (±½)	gors PL-type ca. 0–6 dm+NAP;
G3c	6½	4½	PL1 meestal beneden NAP.
G3d	14½ (±1½)	6 (±½)	De gorzen met dikkere kleidekken liggen meestal
G3e	—	8½ (±1)	relatief hoog.
G4c	6½	4½	griend bekaad:
G4d	16	6½	ca. 8–11 dm+NAP;
G4e	—	9	griend onbekaad:
			ca. 11–15 dm+NAP.
P1c	1½ (±1½)	1½ (±1)	
P1d	5 (±2)	2½ (±½)	
P2c	2½ (±1)	3 (±½)	
P2d	9 (±2)	4 (±1)	*For orientation:*
P3c	5½ (±1)	4 (±½)	*averaged height:*
P3d	13½ (±2½)	5½ (±½)	*marsh G– and P–type about 4–10 dm+NAP;*
P3e	—	8 (±1)	*marsh PL–type about 0–6 dm+NAP;*
			PL1 mostly below NAP.
PL1c	1 (±1)	1 (±½)	*Marshes with thicker clay covers are mostly*
PL2c	3 (±1)	2	*fairly high situated.*
PL2d	5½ (±2)	2½ (±1)	*embanked willow coppice:*
PL3c	5 (±1)	3 (±1)	*about 8–11 dm+NAP;*
PL3d1	7½ (±2½)	3½ (±1)	*embanked willow coppice:*
PL3d2	11 (±2)	5 (±1)	*about 11–15 dm+NAP.*

*For the types P and PL a deeper depth of drainage will not result in a lowering. Other types will
practically not lower. A less depth of drainage will cause a less lowering and will result in thicker
clayey surface layers than is indicated on the soil map.*

Numbers between brackets indicate the deviation in the soil type.

TABLE I. *Lowering in dm of the surface caused by shrinkage and levelling of the principal soil types,
for a depth of drainage of 80 cm below the future surface after shrinkage.*

Tabel J / Table J.

Materiaal en diepte (cm) Material and depth	Organische stof Organic matter	Minerale delen Mineral components	A-cijfer A-figure	Vol.-gew. Vol. weight
Veen / Peat 510 –NAP	76.4	23.6	424.4	0.198
Veen / Peat 590 –NAP	70.3	29.7	372.0	0.225
Klei / Clay 610 –NAP	18.4	81.6	155.9	0.501

NAP = Amsterdam Ordnance Datum.

VI. BEHAVIOUR OF CERTAIN IMPORTANT ELEMENTS DURING THE INITIAL ALLUVIAL SOIL FORMATION (CHEMICAL RIPENING)

During the process of initial alluvial soil formation, changes also occur in the nature of the elements which are present in the soil, and in their compounds. Of these Fe, Mn, K, P, S, and N will be considered.

The behaviour of iron is striking in that this element has strongly coloured compounds. Ripe soils display brown colours because of the presence of tro-valent iron compounds. Reduced soils have grey and black colours, the black FeS playing an important part in determining the colour. (The other processes of reduction are discussed below). The brown Fe-compounds are present partly as concretions, and they may also partly occur in the soil as finely divided particles, since the matrix colour in ripe soils which have not undergone the process of homogenisation is definitely browner than in unripe soils.

One frequently sees coming out of the banks, little streams of water which are recognizable from the thin film of iron oxide forming on the surface of the water. Sand layers can become cemented by iron rust (fig. 58). These iron compounds indicate the presence of a flow of water underneath the banks between the back swamp and the creeks (fig. 59). This water flow is of importance in the discussion of the behaviour of calcium.

The older ripe soils are not so very much poorer in iron than those in the youngest stage of ripening (fig. 61 and appendix 17). The movement of iron, therefore, though spectacular, is not quantitively very great.

In the ecological investigations, the thickness of the aerated layer was delimited by the depth of the "rust" in the profile (Chapter XI).

Manganese was investigated by drs. DE GROOT (see DE GROOT, 1956). There exists an equilibrium between:

$$MnO_2 \quad \rightleftarrows \quad Mn^{++} \quad \rightleftarrows \quad MnO_2$$

MnO_2	Mn^{++}	MnO_2
almost inert	exchangeable	easily reduceable.
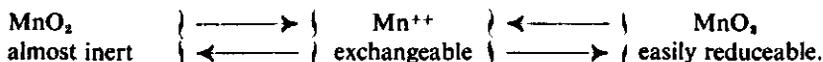
In freshly laid down silt, manganese seems to exist largely in the inert form. By reduction Mn^{++} ions are formed from the inert MnO_2. These ions can again be oxidised to reduceable MnO_2. During the maturation, the reduceable MnO_2 increases in the more aerated stages, while the exchangeable Mn^{++} simultaneously decreases. In the final stage of ripening, the polder, the reduceable manganese decreases again, presumably as a result of a transformation into inert MnO_2. The exchangeable Mn^{++} is then zero (see table L).

In the freshwater area, the content of reduceable MnO_2 is much higher than in the marine area. The much stronger reducing action of the organic matter-rich freshwater milieu contributes undoubtedly to this difference, since for the formation of reduceable MnO_2, Mn^{++} must first be formed through reduction.

It appears that in the freshwater area Mn-deficiency occurs even with a relatively high Mn-content, while in the marine area with the same Mn-content, this is not the case.

It should appear that this Mn-deficiency occurs only where the C/N ratio is greater than 11. This is obviously related to the stage of ripening. Soils with a C/N ratio greater than 11 still contain a great deal of organic matter in the process of decomposition, during which process Mn-fixing organic compounds are presumably formed. During the ripening moreover, part of the total manganese seems to be lost.

Freshly deposited silt in the Biesbosch is rich in calcium but there is however a considerable difference between summer and winter in silt of identical heaviness (fig. 63). A similar difference can be seen in the silt collected from water from the river Lek at Vreeswijk for the "Gemeentewaterleidingen van Amsterdam". The silt which is collected and allowed to

sediment in the summer appears to have a much higher content of calcium than the silt sampled in the winter (see fig. 62). As an explanation we suggest that in summer there is much more plant life present in the water and a great deal of CO_2 is therefore used up by assimilation. The CO_2-pressure in the water is thus slight and more Ca as $CaCO_3$ can be precipitated. The opposite behaviour of the Ca dissolved in the water (fig. 62) may support this hypothesis.

The difference in $CaCO_3$-content in the sediments along the N.W. European coast – as found by VERHOEVEN (oral information) – could also to a considerable extent depend on differences in the quantity and activity of the phytoplankton differences controlled by climate. The bending down of the curves of fig. 63 might be a result of the less aerobic water conditions of the more quiet back swamp milieu, where heavier sediments have been deposited.

On the boundary of the diluvium at Raamsdonksveer is found a deposit which is poor in calcium and which has probably been partly formed by calcium-poor sedimentation of silt in a milieu affected by acid diluvial water. Silt sedimented by Meuse-water has about half the lime content of that one sedimented in Rhine-water. Probably differences in pH are here the cause. This means that the cause of the differences in lime-content of older Rhine and Meuse sediments – as mentioned by PONS (1957) – is still working.

The process of decalcification is encouraged by wet, reducing, anaerobic conditions. This can be explained by the fact that the CO_2 which has been formed through the decomposition of organic matter must dissolve, since it cannot escape into the air. The high CO_2 pressure thus obtained allows $Ca(HCO_3)_2$ to form, and Ca can thus be carried away in solution. Also several organic and similar products (probably also by chelating processes) can bring in solution Ca. The ironstained streams which have already been discussed (fig. 58 and 59) indicate the existence of a method by which the calcium can escape. The forming of gas-bubbles as shows fig. 60 points to the reducing processes. The same holds for the redox-potential data of table K.

The fact that heavy, wet back swamp sediments are almost invariably poorer in calcium than soils of the same age under oxidising conditions, shows that this state of affairs is the norm. The same truth would also be indicated by the ancient farmers "saying that wet land goes acid" ("natte grond verzuurt") – a saying which some soil scientists (among others MASCHHAUPT, 1947) have denied.

In the figures 64, 65, 66 and 67 the calcium content of the Biesbosch soils in various stages of ripening is given.

Since decalcification is strongest where reduced soils have been laid down on top of coarse sandy sub-stratum (as it were on a sieve), the average lower calcium content of the heavier soils accompanies the greater change of having reducing conditions in colloid-rich sediments. Increasing the aeration (through embanking, digging ditches etc.) strongly retards the decalcification. This fact is in contradiction to the early ideas of, among others, MASCHHAUPT and HISSINK (1924).

The reduction of sulphates and the oxidation of sulphides can play a contributary part in the decalcification of marine areas. They are however, not essential. Conditions of reduction form the universal agent of decalcification of young and of heavy low lying soils (fig. 68). We want to put that decalcification is predominantly a "gley"-phenomenon [1].

---

[1] When this manuscript was finished PONS (1957) published the thesis: the low calcium-carbonate content of river basin soils should be the consequence of the sedimentation of silt poor in lime. The reason should be the CO_2-tension in the water, similar as we stated before to explain the difference between summer- and winter-sediments. Undoubtedly an important tendency acts in the mentioned way, we maintain however, that decalcification in anaerobic conditions ("gley"-phenomenon) is at least as important. Perviousness of heavy clay layers to water is not an impediment for this thesis.

The potassium content of ripe Biesbosch soils is relatively low, and amounts to about half of that of marine soils of the same heaviness. In fresh silt, the content is much higher, but it is again about half that of marine silt. The explanation is probably the higher potassium content of sea water (see table N and O).

The decrease during ripening is caused partly by uptake by vegetation and partly by breakdown of organic matter (see for the vegetation uptake, samples 2 and 3 in appendix 17; see also table P).

Fairly strong potassium fixation occurs with progressing ripening, presumably because of the escape of NH_4-ions present in the crystal lattice in the lower stages of ripening (see fig. 69).

This last explanation follows a hypothesis due to prof. SCHUFFELEN and prof. EDELMAN. This potassium fixation tends to emphasise any lack of potassium in the soil. Heavy removal of potassium in the ripest stage through excessive cultivation of sugar-beet could also partly account for potassium fixation and deficiency.

The content of phosphate also decreases during maturing of the soil, both the absolute content and the content per unit of humus (fig. 70 and table Q and O and appendix 17). The availability of the phosphate decreases as the ripening progresses as appears from the difference between the "total" P-content and the "citric acid soluble" P-content. There is less phosphate present per unit of humus than in marine soils at the same stage of ripening.

This, probably, is a result of the higher proportion of animal organic matter in marine sediments. In the ripe soils of the freshwater tidal area, phosphate fixation occurs. The causes of this fixation are probably the high calcium content and the mobility in the younger stages, of a great deal of the iron as a result of the reducing conditions.

Sulphur has a part to play in the reduction of iron, and the total content decreases as the ripening progresses (see table M and appendix 17). The sulphur values are lower than in the marine area. In one place, where the calcium had been completely removed by the processes described above, we observed in a fossil ditch the first beginnings of the formation of neutral "katteklei" (VAN DER SPEK, 1950). The sulphur content there was relatively high as a result of the presence of many willow leaves, which according to analyses, build up a high concentration of sulphur (see table P).

The content of nitrogen in the organic matter increases as ripening advances, and consequently the C/N ratio also decreases from 25 in freshly-deposited silt to below 10 (table A and K) in the most advanced stage of ripening. The type of N-compounds in the soil is probably important from the ecological point of view, but was not more closely studied. The strong breakdown of organic matter provides an enormous surplus of non-absorbed cations and anions. The abnormal size of much plant species can be explained by this phenomenon.

.
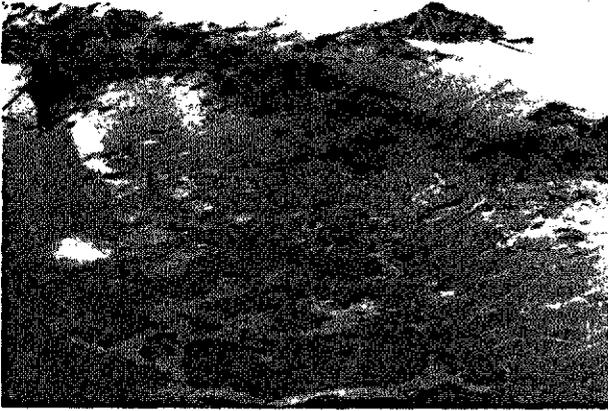
FIG. 58.

IJzerhoudend water sijpelt uit de oever.

Door de oxydatie van het ijzer wordt zo de stroom, die uit de kom onder de oeverval door naar de afwateringskreekjes vloeit, zichtbaar.

Iron-stained water seeping out of the bank.

The little streams of water from the back swamp to the creeks, flowing underneath the creek levee, become visible by the thin film of iron oxide on water surface.
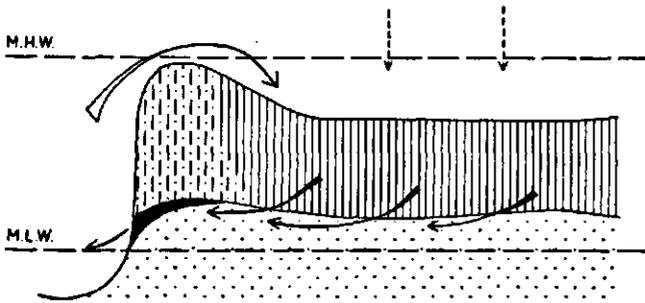
FIG. 59.

Waterbeweging in de bodem van een gors.

Water movement in the soil of a reed or rushes marsh.

d door roest verkit zand
sand cemented by iron oxide

e vloedwater
flood water

f regenwater
rain water

g tijdens laagwater optredende waterstroom
water flow at low tide

M.H.W. = gemiddeld hoogwater
mean high tide

M.L.W. = gemiddeld laagwater
mean low tide
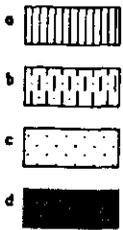
a klei (modder)
silty clay loam (muddy)

b zandige klei, gelaagd
stratified loam

c zand
sand
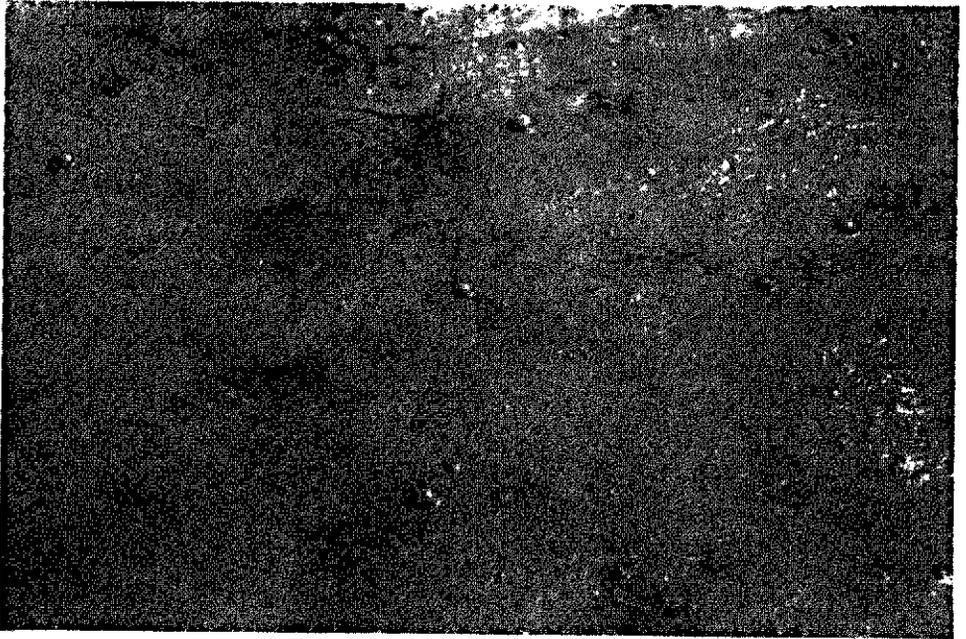
FIG. 60 *a* en *b*.
Gasblaasjes in week slik (boven).
In vaster slik ontstaan hierdoor putjes (beneden).

Gas bubbles in soft silt (top).
In firmer silt in this way small holes are formed (below).
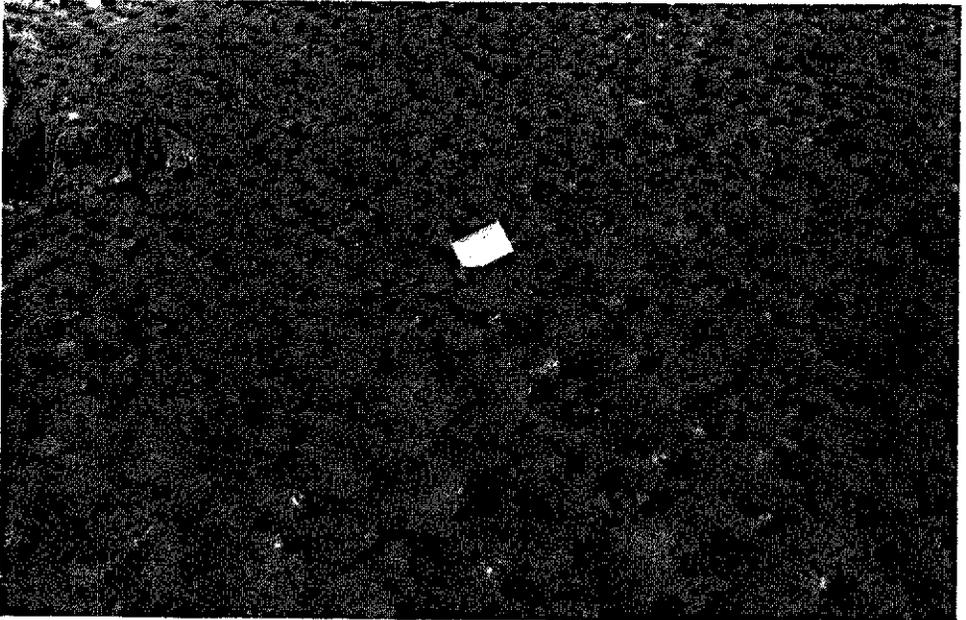
FIG. 61.

Het verband tussen de gehalten aan Fe_2O_3 en lutum in de verschillende rijpingsstadia.

The relation between the content of Fe_2O_3 and particles <2mu in various stages of initial soil fortion.
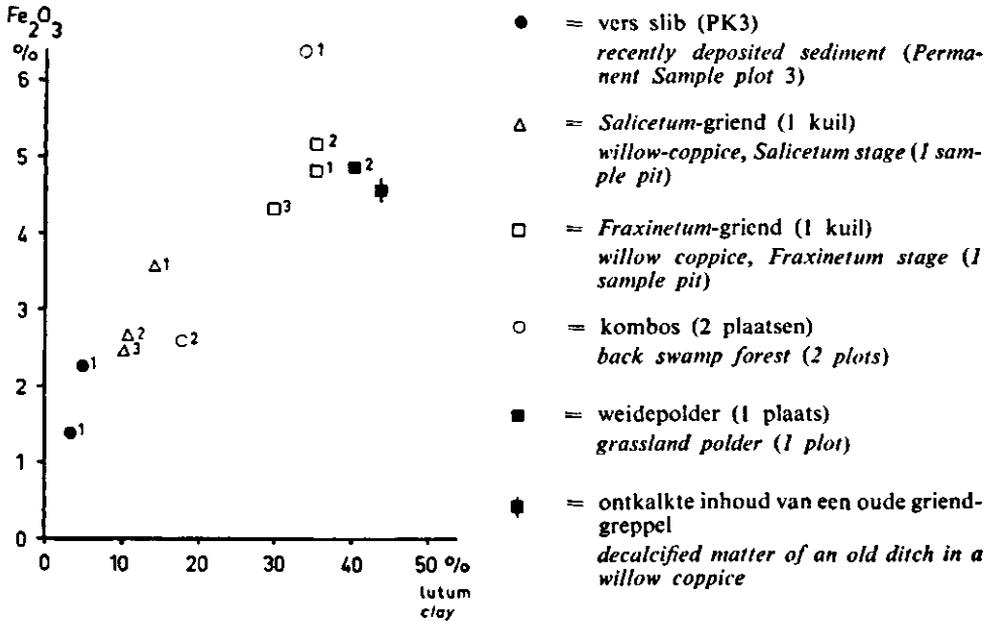
De cijfers bij de symbolen geven de positie aan van de lagen van het bodemprofiel, waarin de monsters zijn genomen.

The figures to the symbols indicate the position of the layers in the sampled soil profiles.

```
1 = ca.  0—20 cm      )
2 = ca. 20—40 à 60 cm } onder maaiveld
3 = ca. 40—80 cm      ) below surface
```

FIG. 62.

Het verband tussen het kalkgehalte van vers uit rivierwater gewonnen slib, de chemische samen-
stelling en het slibgehalte van het water gedurende het jaar 1954 in de Lek bij Vreeswijk (naar
gegevens van de Gemeentewaterleidingen van Amsterdam).

*Relation between the lime content of fresh silt won out of riverwater, the chemical composition, and
silt content of the water during 1954 in the river Lek near Vreeswijk (according to data of the Am-
sterdam Water Board).*

—— Ca aan slib gebonden   ⟨ in percentage van het slib
     Ca adsorbed to the sediment   ⟨ *in percentage of the sediment*

- - - - Ca opgelost in water
     Ca dissolved in water

—·— Slib
     Sediment

·········· HCO₃⁻

- - - Cl⁻

· · · PO₄≡   ⟩ in mg/liter

—— O₂

- - - - - SO₄⁻

-·-··-· pH
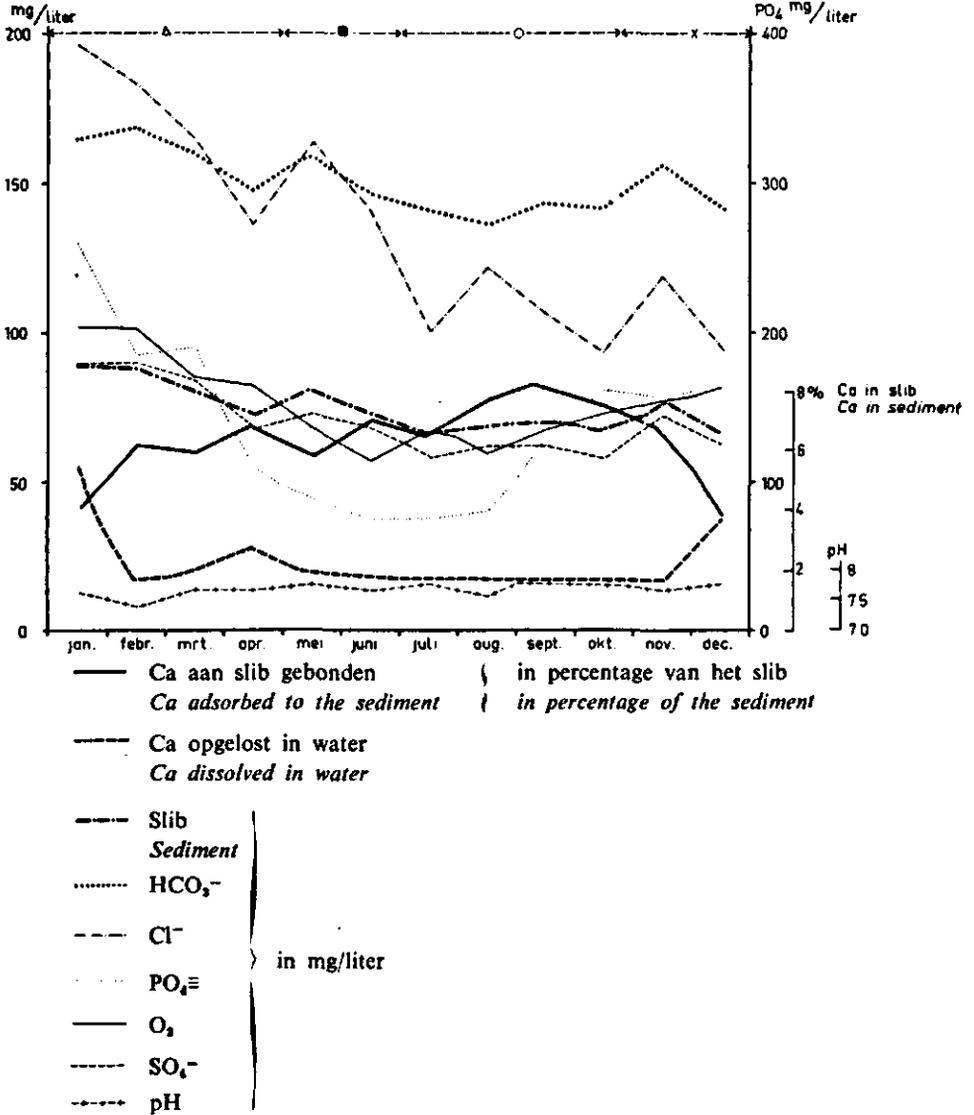
—△—■—○—×— Perioden, waarin vers slib verzameld werd in de Biesbosch. De resultaten hiervan
zijn in fig. 63 weergegeven.

*Periods in which freshly laid down sediment in the Biesbosch has been collected.
The results are give in fig. 63.*

Fig. 63.

Het verband tussen het kalkgehalte van vers, onder natuurlijke omstandigheden afgezet slib, het afslibbaar en de jaargetijden in de Brabantse Biesbosch (Boerenplaat en Jonge Deen).

Relation between the lime content of freshly under natural conditions laid down silt, the fine fraction (<16 mu) and the seasons (Boerenplaat and Jonge Deen).

x········· Herfst (24/10/'52 — 1—5/1/'53)
Autumn

Δ---- Winter (1—5/1/'53 — 1/5/'53
Winter

■—— Lente (1/5/'53 — 1/7/'53)
Spring

o—— Zomer (1/7/'53 — 3—5/11/'53)
Summer

←Δ→ Afslibbaar, geschat
Fine fraction < 16 mu, estimated

. Herfst (20/1/'52 — 5/1/'53)[1]
Autumn[1]

° Zomer (1/7/'53 — 5/11/'53)[1]
Summer[1]

▲ Herfst en winter (5/11/'53 — 24/5/'54)[1]
Autumn and winter[1]
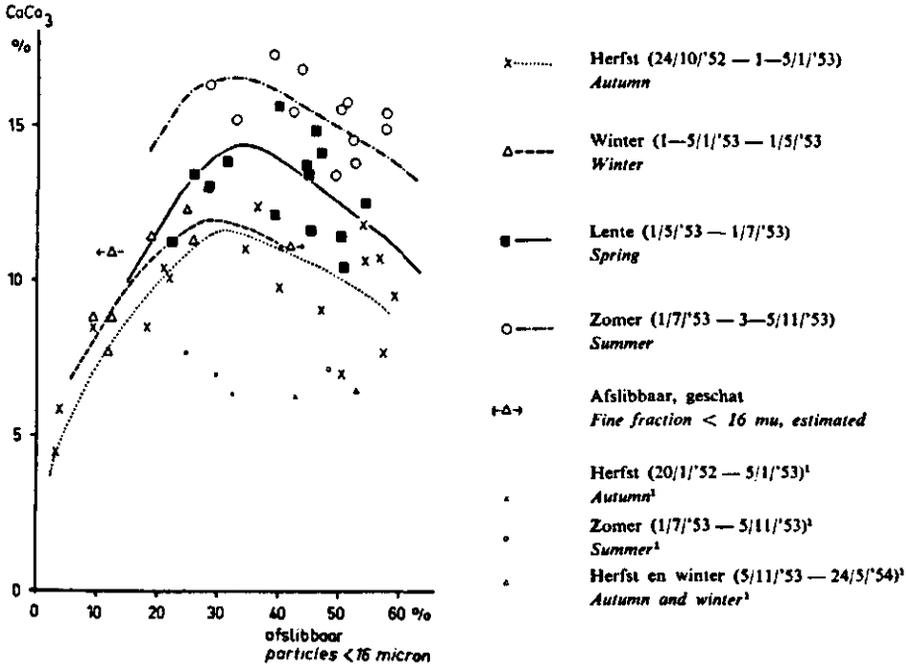
[1] Enkele monsters uit de Grienden van De Dood
Some samples from the willow coppice in the Grienden van De Dood

Fig. 64. Enige kalkgehalten van vers in O_2-rijk milieu afgezet slib.
Lime contents of silt freshly deposited in O_2-rich milieu.

● Vers slib uit de Biesbosch
Fresh silt from the Biesbosch

■ Humusarme monsters van diepten van meer dan één meter uit de Biesbosch
Samples of the Biesbosch poor in humus taken at depths of more than 1 meter

---- Vers slib uit de Dollard volgens ZUUR (1954)
Fresh Dollard-silt according to ZUUR (1954)

········ Linker gedeelte van de "polder"-curve (ter vergelijking)
Left part of the "polder" curve (for comparison)
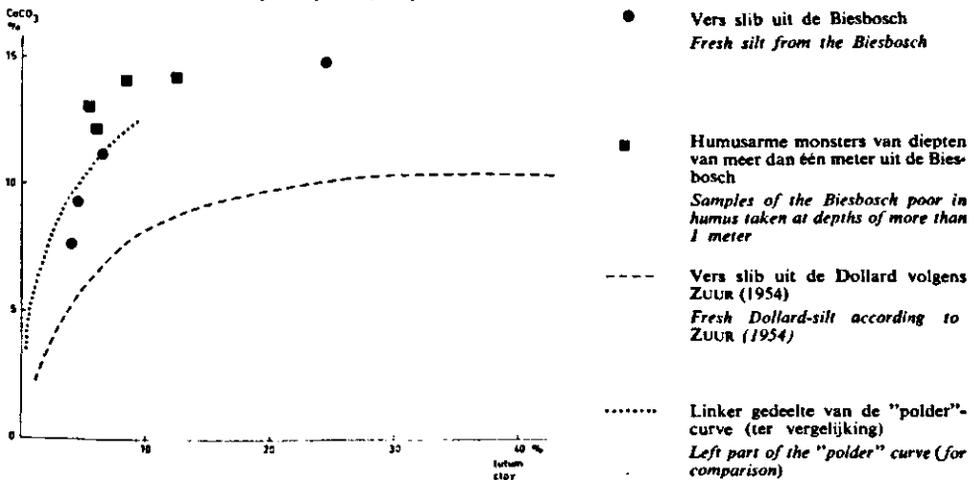
FIG. 65. Enige kalkgehalten uit rietgorsgronden.
Some lime contents of reed-marsh soils.
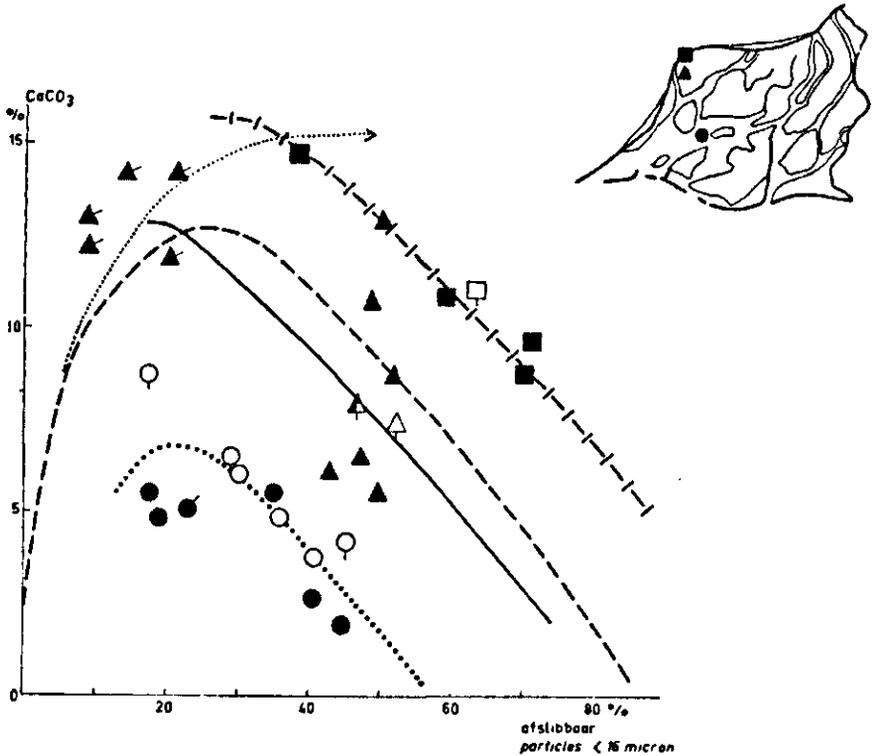
O   ●   Monsters van de Houtganzewei (3 kuilen) met curve
....   *Samples of the Houtganzewei (3 pits) with curve*

□   ■   Monsters van het gors van de Spiering (1 kuil) met curve
—⊢—⊢—⊢—   *Samples of the marsh of the Spiering (1 pit) with curve*

△   ▲   Monsters van het Gat van den Hardenhoek (2 kuilen) met curve
————————   *Samples of the Gat van den Hardenhoek (2 pits) with curve*

Q   ⬚   △   Monsters, dicht aan de oppervlakte genomen (5 à 10 cm)
     Samples, taken just below surface (5 to 10 cm)

⬤   ▲   Monsters op 100 cm of dieper genomen
     Samples taken at 100 cm below surface or deeper

....   Vermoedelijke curve voor vers in O₂-rijk milieu afgezet slib
     Supposed curve for silt freshly deposited in O₂-rich milieu

— — — — —   Kromme van de polders (zie fig. 67)
     Curve of polders (see fig. 67)

De open legendatekens hebben betrekking op monsters met roest, de gevulde op monsters zonder roest.
The open symbols refer to samples with iron oxide concretions, the filled ones to samples without iron oxide concretions.
Op het kaartje is de ligging van de drie groepen aangegeven.
The inset-map shows the location of the 3 groups.

Fig. 66. Enige kalkgehalten van griendgronden.

Some lime contents of willow coppice soils.
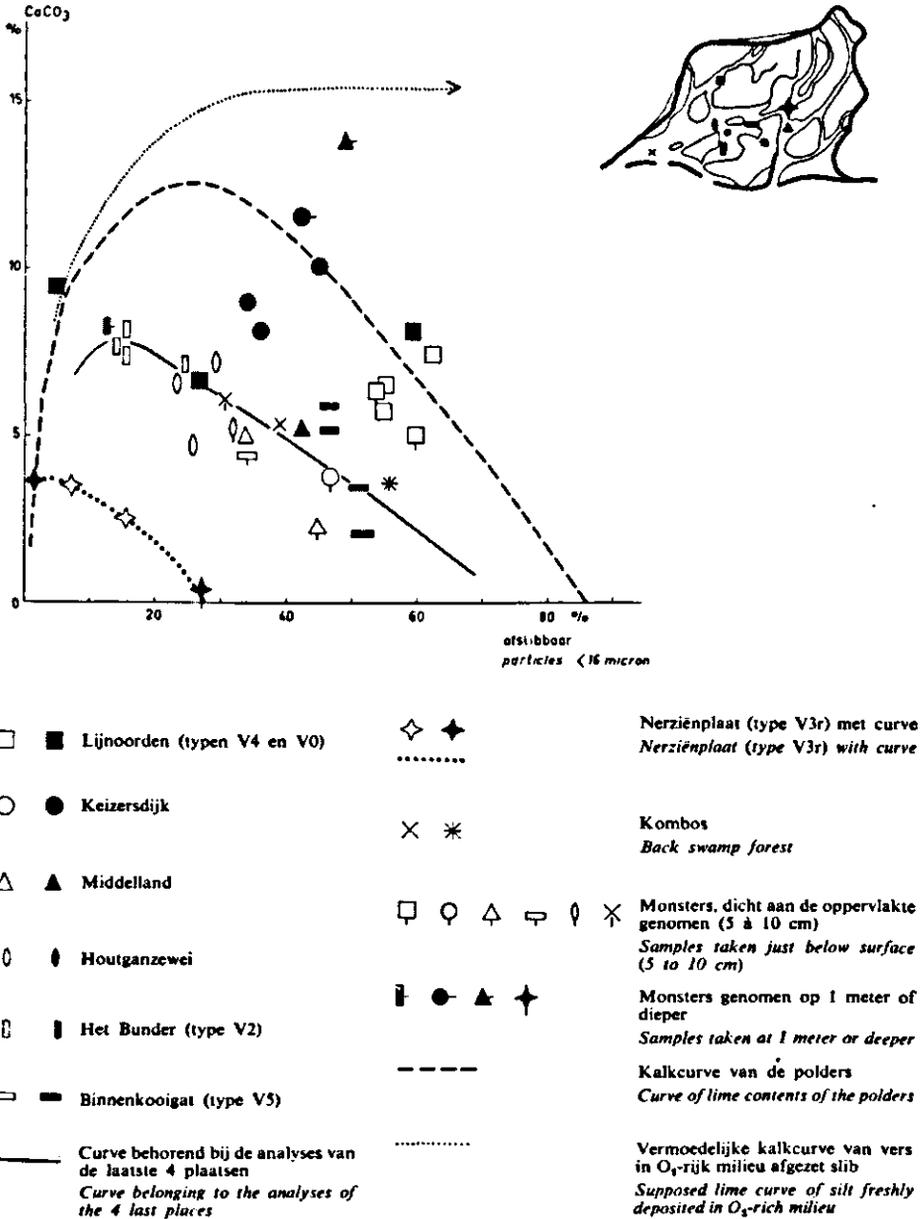
De open legendatekens hebben betrekking op monsters zonder roest, de gevulde op monsters met roest.

The open symbols refer to samples without iron oxide concretions, the filled ones to samples with iron oxide concretions.

Op het kaartje is de ligging van de groepen aangegeven.

The inset-map shows the location of the groups.

FIG. 67.

De verhouding tussen de ge-
halten aan CaCO₃ en de percen-
tages afslibbaar van monsters
uit polders.

*The relation between the con-
tents of CaCO₃ and the percen-
tages of particles <16 mu of
polder samples.*
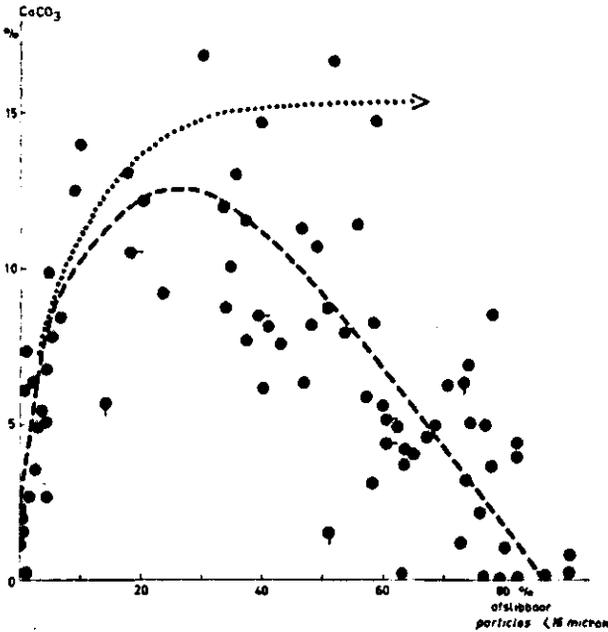
● Monsters uit de bouwvoor van de Karnemelkspolder (deze polder is 225 jaar oud en was lange tijd graslandpolder)
Samples of the till of the Karnemelkspolder (this polder has an age of 225 years and has been a grassland polder for a long time)

●- Monsters uit één der andere lagen van deze polder
(Samples of another soil layer in this polder)

••••••• Vermoedelijk CaCO₃-curve van vers in O₂-rijk milieu afgezet slib
Supposed CaCO₃-curve of silt freshly deposited in O₂-rich milieu

FIG. 68.
Schema van de ontkalking.
Scheme of the decalcification.

b. Idem, gereduceerd (primaire ontkalking, voor-
namelijk veroorzaakt door gisting)
Ditto, reduced (primary decalcification, principally caused by "fermentation")

c. Zoute aanslibbing min of meer geaëreerd (als a,
maar de sulfaatreductie werkt de primaire ont-
kalking tegen)
Salt water accretion, more or less aerated (like a, but primary decalcification checked by sulphate reduction)

d. Zoute aanslibbing, gereduceerd (als b, maar sul-
faatreductie werkt de primaire ontkalking tegen)
Salt water accretion, reduced (like b, but primary decalcification checked by sulphate reduction)

e. Brakke sterk humeuze en gereduceerde afzetting
(als d, maar sulfaatreductie werkt de primaire ont-
kalking tegen, bij oxydatie begint kattekleivorming)
Brackish, very humose and reduced deposit (like d, but primary decalcification checked by sulphate reduction; when oxidizing the formation of acid clay (pyrite-containing) sets in

f. Tijdstip van bedijking
Time of embankment

a. Zoete aanslibbing, min of meer geaëreerd (primaire ontkalking
voornamelijk veroorzaakt door uitspoeling en wortelactivi-
teit)
*Fresh water accretion, more or less aerated (primary decalcifi-
cation, principally caused by washing out and activity of
roots)*

FIG. 69.
Verband tussen kalifixatie (volgens de natte methode), het afslibbaar en de ouderdom van de grond.
Relation between the fixation of potassium (according to the wet method), the content of the fraction <16 mu, and the age of the soil.
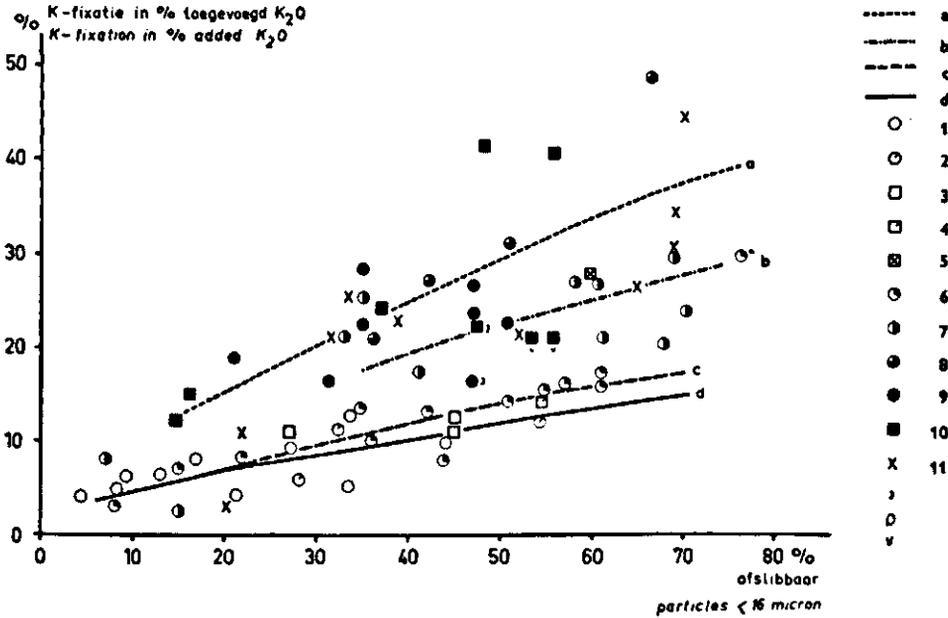
a. bedijkt voor 1800
   embanked before 1800
b. bedijkt tussen 1800—1900
   embanked between 1800—1900
c. bedijkt na 1900
   embanked after 1900
d. onbedijkt land: slikken, gorzen en grienden
   not embanked land: mud flats, reed-marshes and willow coppice
1 = vers slik en rietgors
   fresh sediment and reed-marsh
2 = sinds enkele jaren bedijkt gors
   reed-marsh, embanked some years ago
3 = griend (*Salicetum*-stadium)
   willow coppice (Salicetum stage)
4 = sinds enkele jaren bedijkt *Salicetum*-stadium
   willow coppice embanked some years ago in the Salicetum stage
5 = oude griend in het *Fraxinetum*-stadium
   old willow coppice in the Fraxinetum stage
6 = polder bedijkt na 1900
   polder embanked after 1900
7 = polder bedijkt tussen 1800 en 1900
   polder embanked between 1800 and 1900
8 = polder bedijkt tussen 1641 en 1800
   polder embanked between 1641 and 1800
9 = polder bedijkt tussen 1461 en voor of omstreeks 1641
   polder embanked between 1461 and before or about 1641
10 = polder bedijkt omstreeks 1461
   polder embanked about 1461
11 = oude rivierafzettingen, meer dan 1000 jaar geleden afgezet
   old fluvial sediments, deposited over 1000 years ago
J = betrekkelijk jong rijpingsstadium op het tijdstip van bedijking
   relatively unripe soil at the moment of embankment
O = betrekkelijk oud rijpingsstadium op het tijdstip van bedijking
   relatively ripe soil at the moment of embankment
V = na bedijking vermoedelijk sterk verjongd door overstromingen
   after embankment probably covered by younger sediments as a result of inundations

FIG. 70. Het verband tussen het gehalte aan fosfor en organische stof.
The relation between the content of phosphorus and organic matter.

1. Vers slib
   Recent silt

2. Gors en ruigte
   Marsh and rough herbage

3. Bouwland
   Arable land
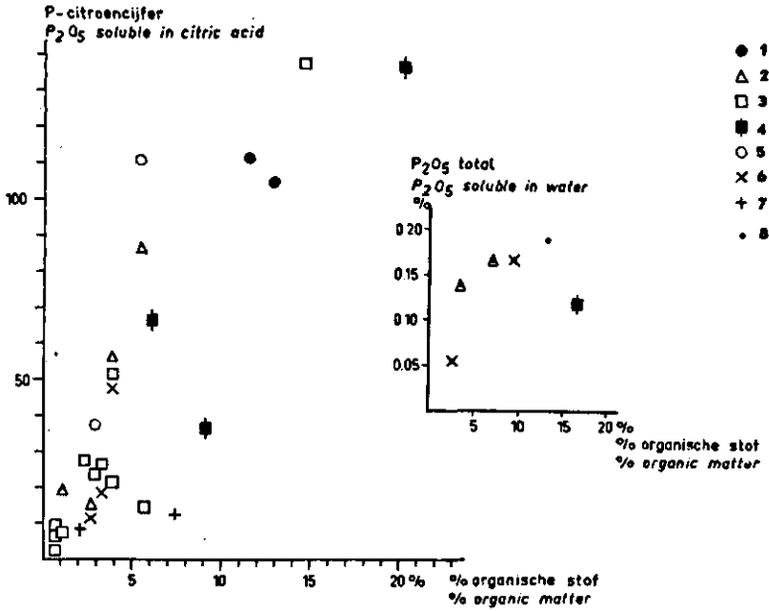
4. Kombos
   Back swamp forest

5. Vrijwel vers slib
   Almost recent silt

6. Griend (*Salicetum*)
   Willow coppice (Salicetum)

7. Griend (*Fraxinetum*)
   Willow coppice (Fraxinetum)

8. Komruigte
   Back swamp herbage

TABEL K. Redox-potentiaal in de bodem bij verschillende ontwikkelingsstadia. (Bepaald op het Instituut voor Bodemvruchtbaarheid te Groningen.)

Nummer Number	Ontwikkelingsstadium Stage of development		Redox-potentiaal in de bovenste 20 cm Redox-potential in the upper 20 cm	C/N (0–20 cm)
70–94	Slik Fresh silt		60	25
	Rietgors Reed-marsh		.	
282	G6		50	
260	G5		40	
132	G5		250	22
259	G3		155	
118	G3		125	19
283	G2		190	
	Griend Willow coppice	Salicetum albae alismetosum		
119	V5		160	19
274	V5		315	
117	V4		430	16
257	V4		190	
280	V4		410	
275	V4		395	
134	V4		530	20
	Griend Willow coppice	Salicetum albae cardaminetosum		
256	V3q		580	
255	V3		480	
281	V3		500	
271	V3		354	
270	V2		420	
272	V2		460	
263	V1		490	
	Griend Willow coppice	Cariceto remotae Fraxinetum		
116	V0		390	13
254	V0		395	
	Bouwland uit griend (1952) Arable land, former willow coppice (1952)			
127			455	17
	Bouwland uit rietgors (1952) Arable land, former reed-marsh (1952)			.
123			385	13

Voor de vegetatie-eenheden, zie hoofdstuk X.
For the units of vegetation, see chapter X.

TABLE K. Redox-potential in the soil at various stages of development. (Determined at the Institute for Soil Fertility at Groningen).

TABEL L. Verband tussen enige bodemeigenschappen (gemiddelde waarden) en rijpingsstadia in de Biesbosch (volgens DE GROOT, 1956).

Rijpingsstadia *Stages of initial alluvial soil formation*	Aantal monsters *Number of samples*	Uitwisselbaar Mn in dpm *Exchangeable Mn in ppm*	Reduceerbaar Mn (met uitw. Mn) *Reducible Mn in ppm (incl. exch. Mn)*	Redox potential	Verhouding van org. stof *C/N-ratio of organic matter*
Vers slik . . . . *Mud flats*	25	47	54	60	26
Rietgors . . . . *Reed-marshes*	7	87	485	140	26
Salicetum-griend . . . *Salicetum willow coppice*	17	6	904	410	20
Bouwland met Mn-gebrek . . . . *Arable land with Mn- deficiency*	38	(verwaarloosbaar) *negligible*	447	—	16–11
Gezond bouwland . . . *Healthy arable soils*	25	(verwaarloosbaar) *negligible*	357	—	11–7

TABLE L. *Relation between some soil factors (average values for the mentioned amounts) and stages of initial alluvial soil formation in the Biesbosch (according to DE GROOT, 1956).*

TABEL M. Het gehalte aan totaal zwavel, berekend als SO₄, totaal calcium, berekend als CaO en het calciumcarbonaatgehalte, in verschillende rijpingsstadia. Bedrijfslaboratorium voor Grond- en Gewasonderzoek te Oosterbeek.

Rijpingsstadium *Stage of initial soil formation*	Nummer permanent kwadraat (PK) en profielkuil (K) *Number permanent sample plot (PK) and sample pit (K)*	Eigen nummer *Private number*	Diepte in cm *Depth in cm*	SO_4 milli-eq.	CaO milli-eq.	$CaCO_3$	Org. stof % *Organic matter %*	Afslibb. % *Fraction < 16 mu*	pH (KCl)
Vrijwel vers slib . . . . *About recently silt 30–40 deposited*	PK3	91	0–5	10	218	11.1	5.2	9	7.7
		92	30–40	8.9	197	10.1	2.8	6	7.7
Rietgorsoeverwal . . . . *Natural levee of a reed-marsh*		105	5–30	2.9	128	6.4	3.7	23	7.3
		106	50–70	0.0	121	6.0	1.0	7	7.6
		107	90–100	15.–	183	9.0	2.4	10	7.5
Salicetum-griend . . . . *Willow coppice (Salicetum) stage*	PK11 (K16)	108	0–20	4.2	167	7.7	3.7	23	7.4
		109	20–50	2.5	174	8.5	2.7	18	7.5
		110	50–80	0.9	144	7.3	2.3	17	7.4
Fraxinetum-griend . . . . *Willow coppice (Fraxinetum) stage*	K15	111	0–20	2.4	131	5.7	7.1	62	7.3
		112	20–60	2.1	155	7.8	2.1	62	7.4
		114	60–80	0.2	149	7.7	1.3	50	7.4
Polder . . . . *Polder*	K13	95	20–60	0.2	130	6.2	2.0	65	7.4
Kombos (V6) . . . . *a* *Back swamp forest (V6) . . . . . a*		23	0–20	35.–	129				
Kombos (V6) . . . . *b* *Back swamp forest (V6) . . . . . b*	PK9	94	30–40	19.–	142	6.5	9	27	7.4
Fossiele griendgreppel (uit ± 1700) *Fossile willow coppice ditch (about 1700)*	K13	99	140–160	6.1	35	0.2	5.8	73	5.8

TABLE M. *The content of total sulphur, computed as SO₄, total calcium, computed as CaO and the content of calciumcarbonate, in different stages of initial soil formation. According to results of analyses, carried out by the Laboratory for Soil and Crop Analyses at Oosterbeek.*

TABEL N. Kali-gehalte in verschillende rijpingsstadia in 0,1 mg per g lutum.

Vers slib Wieringermeer / Fresh silt Wieringermeer	Wieringermeerslib, korte tijd na droogvallen, ook kwelder / Silt of the Wieringermeer shortly after reclamation also marine foreland		Onbegroeid vers slib Biesbosch / Bare silt flat Biesbosch	Begroeid slib en rietgors / Overgrown silt flat and reed marsh	Kombos / Back swamp tidal forest	Salicetum-griend / Salicetum willow coppice	Fraxinetum-griend / Fraxinetum willow coppice	Polder / Polder
		Gerijpte bodem in Wieringermeer. / Ripened soil in Wieringermeer	22	10	13	8	3	4
			22	7	11	9[1]	3[1]	2
			21	16[1]		7[2]	3[2]	2[2]
				13[2]				1[1]
				7[2]				5[1]
				7				4
								3
								5
								3[2]
Gegevens / Data	Bodemkundig Laboratorium Kampen		2 plaatsen / 2 plots	3 plaatsen / 3 plots	2 plaatsen / 2 plots	1 plaats / 1 plot	1 plaats / 1 plot	3 plaatsen / 3 plots
Gem. 40	25	8	22	10	12	8	3	3

[1] Laag op ca. 30–50 cm diepte / Layer about 30–50 cm deep.
[2] Laag op ca. 50–100 cm diepte / Layer about 50–100 cm deep.
[3] Kalkarme laag / Layer poor in lime.

Alle analyseresultaten met < 10 % afslibbaar zijn niet opgenomen.
All results of analyses with < 10 % particles < 16 mu are not entered.

TABLE N. *K-content in the various stages of initial alluvial soil formation in 0.1 mg per gramme particles < 2 mu.*

TABEL O. Granulaire en chemische samenstelling van Biesboschgronden in verschillende rijpingsstadia naar

No. Lab. te Kampen / Nr. Lab. at Kampen	Rijpingsstadium resp. vegetatie / Stage of initial soil form. resp. vegetation	No. naburige profielkuil / No. nearest profile pit	C/N	Organische stof / Organic matter	C	N	P-citr. / P-citric acid	P_2O_5 totaal / "P_2O_5 total"	P-citr./ P-tot. / P-citr. acid/ P-tot.	K_2O in %/∞	pH
1	2	3	4	5	6	7	8	9	10	11	12
26863	Rdg	PK3	24.2	10	5.80	0.24	198.6	308.7	64.5	21.2	7.4
26871	Rd	27	22.7	7.8	4.53	0.20	153.7	247.0	62.2	17.2	7.5
26868	Rdf	PKA	27.3	9.9	5.74	0.21	129.7	230.8	54.5	15.7	7.4
26869	Rce	PK6	22.6	14.4	8.35	0.37	137.1	269.4	50.9	23.9	7.2
26873	Rc	26	25.6	7.5	4.35	0.17	106.3	213.1	49.5	14.9	7.4
26877	G5–	5	20.2	14.6	8.47	0.42	161.9	298.3	54.3	29.1	7.2
26855	G5–(à 3)	6	23.8	11.9	6.90	0.29	148.4	256.5	57.9	17.8	7.3
26870	G2	4a	25.4	7.0	4.06	0.16	105.0	203.7	51.5	12.5	7.3
26860	G5r	12	18.5	16.9	9.80	0.53	168.9	309.0	54.7	27.4	7.2
26875	G5	11	19.3	15.6	9.05	0.47	187.7	350.1	53.2	19.9	7.5
26859	±G5	9	20.1	17.7	10.27	0.51	206.0	347.0	59.5	37.2	7.3
26854	Re	8	22.9	16.2	9.39	0.41	228.2	366.2	62.2	22.2	7.3
26858	V6	(L)	21.8	24.8	13.98	0.64	272.2	370.0	73.5	30.6	7.2
26864	V5	—	20.5	16.6	9.63	0.47	121.4	256.6	47.1	19.4	7.6
26861	V4	14	16.3	15.5	8.99	0.55	103.2	255.7	40.2	19.3	7.4
26865	V3	—	25.5	10.0	5.80	0.23	94.0	224.7	42.0	13.7	7.5
26872	V3	21	21.7	12.7	4.37	0.34	100.4	248.0	40.5	14.1	7.7
26862	V3	28	19.3	19.3	11.20	0.58	95.9	260.6	36.4	13.2	7.4
26866	V2	16	22.3	9.6	5.57	0.25	84.9	209.4	40.5	10.8	7.6
26856	V1	—	19.5	8.4	4.87	0.25	69.9	192.5	36.2	10.3	7.8
26857	V0	15	11.7	7.9	4.58	0.39	21.9	180.8	11.6	13.8	7.8
26867	Weipolder Grassland polder	29	10.8	9.5	5.51	0.51	23.2	187,6	12.3	11.1	7.3
26876	± 100 jaar oude bouwpolder ± 100 years old arable land polder	7	10.2	3.2	1.74	0.17	47.1	192.3	24.5	15.1	8.2
26874	± 250 jaar oude bouwpolder ± 250 years old arable land polder	10	9.7	4.5	2.61	0.27	28.5	171.9	16.5	11.5	7.8
26878	± 400 jaar oude bouwpolder ± 400 years old arable land polder	24	9.7	3.0	1.74	0.18	49.7	178.3	27.8	19.3	8.4

De cijfers hebben betrekking op mengmonsters (0–20 cm), gestoken in de omgeving van de genoemde profielkuilen. De zwaarte
Figures refer to mixed samples (0–20 cm) taken in the vicinity of the mentioned profile pit. Heaviness is determined at the layer of about

TABLE O. *Granular and chemical composition of Biesbosch soils in different stages of initial soil formation*

analysen verricht op het Bodemkundig Laboratorium van de Directie Wieringermeer te Kampen.

CaCO₃	Lutum % ca. 5–15 cm van de pro- fielkuilen *Clay % about 5–15 cm of the profile pits*	Slib ca. 5–15 cm van de pro- fielkuilen *Part. <16 mu about 5–15 cm of the profile pits*	Kali in 0.1 mg per gram lutum *Potassium in 0.1 mg per gram clay*	P-citr. in mg per gram humus *P-citric acid in mg per g humus*	„Totaal P₂O₆" in mg per gram humus *"Total P₂O₆" in mg per g humus*	
13	14	15	16	17	18	
13.6	5.4	8.5	39.3	20	30.9	
11.1	9	16.5	19.1	19.7	31.6	
10.5	—	—	—	13.1	23.3	
8.8	22.6	44.1	·10.6	9.5	18.6	
7,8	8,0	14.1	18.6	14.2	28.5	
5.2	23.6	45.1	12.3	11.1	21.0	
7.9	15.6	29.2	11.4	12.3	21.5	
8.9	10.1	17.8	12.4	15.0	29.0	
8.2	25.5	47.0	10.7	10.0	19.3	Pas tot grasland ont- gonnen rietgors en ruigte
8.8	27.1	52.0	7.0	12.1	22.5	*Recently reclaimed*
12.4	36.0	63.5	10.3	11.6	19.6	*reed-marshes and*
14.9	25.8	52.4	8.6	14.0	22.5	*rough herbages (grassland)*
6.2	—	—	—	11.3	15.3	
2.8	—	—	—	7.3	15.5	
6.1	28.4	54.3	6.8	6.7	16.5	
8.6	—	—	—	9.4	22.5	
6.4	17.9	23.7	7.9	8.2	19.6	
1.2	23.3	45.1	5.6	5.0	13.5	
7.2	14.1	25.2	7.7	8.8	21.7	
8.8	—	—	—	8.3	23.0	
6.2	33.1	60.2	4.1	2.8	22.8	
0.7	36.5	63.6	3.0	2.4	19.8	
6.7	26.0	47.0	5.8	15.7	64.2	
1.5	31.0	51.0	3.7	5.3	38.0	Polder. Vermoedelijk kort tevoren be- mest *Polder. Probably manured shortly before*
8.4	23.7	45.5	8.1	16.5	59.2	

is bepaald aan de laag ca. 5–15 cm in de profielkuilen uit 4 ringmonsters van 2 wanden.
5–15 cm from 4 soil core samples of two profile faces.

according to analyses of the Soil Laboratory of the Authority of the Wieringermeer at Kampen.

TABEL P. Kali- en zwavelgehalte van enkele vegetatievormende planten in de Biesbosch (oktober 1953; naar resultaten van analyses, verricht door het Bedrijfslaboratorium voor Grond- en Gewasonderzoek te Oosterbeek).

		K₂O In % van de droge stof In % of dry matter	Kg/ha grove benadering Kg/ha rough approx.	SO₄ In % van de droge stof SO₄ In % of dry matter	Kg/ha bij grove benadering Kg/ha rough approx.	Totale droge stof per/ha in kg bij grove benadering Total dry matter/ha in kg rough approx.
Scirpus lacustris (Mattenbies of Zoete Bies)	Spruit *Shoot*	0.81	60	0.39	30	7 000
	Wortel *Root*	1.17	120	0.31	30	10 000
Glyceria maxima (Liesgras)	Spruit	3.07	150	0.36	20	5 000
	Wortel	1.38	40	0.57	15	3 000
Typha latifolia (Grote Lisdodde)	Spruit	1.46	110	0.26	20	8 000
	Wortel	1.90	320	0.60	100	17 000
Typha angustifolia (Kleine Lisdodde)	Spruit	0.82	220	0.26	70	26 000
	Wortel	1.34	320	0.38	80	22 000
Scirpus triqueter (Driekantige Bies)	Spruit	1.47	50	0.36	10	3 000
	Wortel	0.78	25	0.29	10	3 000
Scirpus maritimus f. typ. (Heen of Zeebies), zoete vorm / *freshwater form*	Spruit	0.91	80	0.21	20	9 000
	Wortel	0.95	50	0.17	10	5 000
Phragmites communis (Riet)	Spruit	0.63	140	0.22	50	22 000
	Wortel	1.16	450	0.76	300	40 000
Phalaris arundinacea (Rietgras)	Spruit	1.43	70	0.33	20	5 000
	Wortel	0.57	30	0.72	35	5 000
Scirpus tabernaemontani (Zoute of Ruwe Bies), verm. kruising met *Scirpus triqueter* / *prob. cross with Sc. triqueter*	Spruit Wortel	1.12	—	0.50	—	—
Salix purpurea (Bittere Wilg) hoge standplaats / *high habitat*	vers blad *fresh leaf*	0.99	—	1.17	—	—
Salix purpurea (Bittere Wilg), lage gereduceerde standplaats / *low reduced habitat*	vers blad *fresh leaf*	0.52	—	0.68	—	—
Salix alba („Rood wilgenhout") hoge standplaats / *high habitat*		1.68	—	1.64	—	—

De cijfers per ha zijn berekend aan de hand van weging over één oppervlak van 50 × 50 cm = ¼ m². (Dode wortels voor zover aanwezig zijn meegerekend). De cijfers zijn dus globaal.
Zo was het rietgors (*Phragmites*) zeer regelmatig. Vermoedelijk geeft het cijfer wel een juist beeld (droge-stofproduktie bovengronds komt overeen met top-cijfers uit de literatuur) (POHJALA, in BITTMANN, 1953).
Typha angustifolia was zeer onregelmatig, het cijfer is zeker te hoog.

The numbers are computed per ha by means of weighing over one surface of 50 × 50 cm = ¼ m² (dead roots were counted in).
So the numbers are rough. The reed-marsh (Phragmites communis) was very regular. Probably the number gives a clear picture (dry matter production at the surface corresponds with the top-numbers of the literature) (POHJALA, in BITTMANN, 1953).
Typha angustifolia was very irregular, the number of it is certainly too high.

TABLE P. *Potassium and sulphur content of some vegetation forming plants in the Biesbosch, according to analyses, carried out by the Laboratory for Soil and Crop Analyses at Oosterbeek.*

TABEL Q. Het gehalte aan „P₂O₅ totaal" en het P-citroengetal berekend per gram organische stof in milligrammen van Biesboschgronden naar analyseresultaten van het Bedrijfslaboratorium voor Grond en Gewasonderzoek te Oosterbeek, vergeleken met mariene gronden.

	Vers, weinig of niet begroeid slib — Recently deposited silt. Bare to faintly overgrown (2 pl.)	Rietgors en ruigte — Reed-marsh and rough herbage		Salicetum-griend — Salicetum willow coppice (2 pl.)	Fraxinetum griend — Fraxinetum willow coppice (2 pl.)	Kombos — Back swamp tidal forest (2 pl.)	Polder — Polder (6 pl.)	Mariene gronden / Marine soils — Vers onbegroeid slib — Recently deposited bare silt	Kwelder voor Reiderwolderpolder (Dollard) — Marine tidal marsh of Reiderwolderpolder (Dollard) (1 pl.[5])	Polders — Polders
		oeverwal — natural levee (1 pl.)	kom — back swamp (1 pl.)							
P-citroen / P-citric acid	9.9 8.8 21.- 13.4	15.4 7.1[1]	9.9 17.0[1]	13.4 7.4[1] 5.5[2]	2 4.8[1] 7.7[2] 2.4	6.8 4.2[1] 12.-	13.6 7.2c 5.7c 3.0c 8.8[1] 8.5 1.4 7.8 4.-	Wieringermeer[1] gemiddeld / averaged 20.0 Dollard[4] (10 pl.) 29.5, 31.-, 27.-, 11.5[1] 36.-, 29.5, 31.-, 54.5, 20.5, 8.6	11.0[1] 12.0[1] 16.0[1]	Wieringermeer[4] >10.0 Vijf jonge Dollardpolders (5 pl.) 14.0, 12.5, 16.5, 23.0 Oudere Dollardpolders (3 pl.) 7.5, 6.0, 10.5, 3.1
Gem. / Averaged	13.2	11.3	13.5	8.8	4.2	7.7	6.6	20.0 en 27.6	13	16 / 6.5
P₂O₅		36.0 24.0	15.0	18.0[1] 20.0	—	7.0	—	Dollard[4] (10 pl.) 62.0, 86.0, 50.0, 38.0[1], 59.0, 52.0 59.5, 80.0, 46.0, 31.3	38.5 41.0[1] 60.5	41.0, 57.5, 61.0, 67.0, 48.0 41.5, 39.0, 40.0
Gem. / Averaged		30	15	19		7		56	47	55 / 40

Met uitzondering van de cijfers voor de slikken hebben de ongemerkte cijfers betrekking op monsters van 6-10 à 20 cm diepte, genomen in profielkuilen.
Het Dollardslib werd bemonsterd in de laag 0-3 cm onder maaiveld.

[1] Monsters genomen tussen 20-40 cm onder maaiveld.   [2] Monsters genomen tussen 40-60 cm onder maaiveld.   [3] Monsters genomen tussen 60-80 cm onder maaiveld.
c = kalkloze laag in het „Waardengebied".   Pl. = het aantal plaatsen waarop monsters zijn genomen.   [4] Naar ZUUR, 1954.   [5] Naar HISSINK, 1935.

Excerpt of the figures for the muddy flats the unmarked refer to samples of 6-10 to 20 cm depth taken in profile pits.
The Dollard silt is sampled in the layer 0-3 cm below surface.

[1] Samples taken between 20-40 cm below surface.   [2] Samples taken between 40-60 cm below surface.   [3] Samples taken between 60-80 cm below surface.
c = non calcareous layer in the "Waarden" area.   Pl. = the number of plots in which samples have been taken.   [4] According to ZUUR, 1954.   [5] According to HISSINK, 1935.

TABLE Q. *The content of "P₂O₅ total" and the P-citric acid number computed per gramme organic matter in milligrammes of Biesbosch soils, according to analyses of the Laboratory for Soil and Crop Analyses at Oosterbeek, compared with marine soils.*

VII. THE SOIL MAPPING

The soil mapping carried out in the Biesbosch is intermediate between the "single value" and the "soil type" mapping. It follows closely the method which has been developed since 1940 by EDELMAN and his collaborators. The main object of the soil mapping was to give a basis for land improvement works which are for a great part concerned with altering the water regime in the soil. The soil-water characteristics are therefore among the most important guiding principles considered in deciding on the mapping criteria. The water relationships themselves and the directly dependent characteristics of the soil (gley phenomena, structure etc.) were not used as mapping factors, however, since the map picture in that case would be too quickly liable to change. Only a rough division is made in four stages of initial alluvial soil formation. On a few places (as an example) a mapping is carried out on gley-criteria of a ripened polder soil (fig. 71).

Since these water relationships mentioned above are of the utmost importance for the actual growth of the "crop", leaving them out of consideration in the mapping means that, generally, no close correlation can be expected between the present growth of the vegetation and the soil units. Only in extreme cases is this correlation the case (old creek beds, thin high sand flat soils etc.).

General agricultural experience shows that soils with a silty upper layer which is thinner than 80 cms depend on the groundwater table for obtaining the optimum water supply for crops. If the contact with the groundwater is interrupted, then drought conditions can occur. In the Biesbosch, no drought conditions seem to occur, in most cases, when the clay layer is less than 80 cms and even less than 50 cms. This can be explained by the instability of the water table which, in rising and falling, reaches up to the level of the clay layer, due to the effect of "kwel" and the periodic reduction in drainage discharge with the tide regime. In a few very elevated places, where the contact with the groundwater was interrupted, it could be established that with wheat, peas, flax and oats, the abovementioned relationship between growth and the thickness of the clay did hold (at least as far as the length of the stalk was concerned) (see fig. 72 and 73).

The thickness of the clayey and silty topsoil on sand is taken therefore as one of the most important mapping criteria.

With the still unripe soils, the soil profile is considered as it would appear after complete shrinkage. It was thus possible to obtain a map which allows an easy comparison of land lying both inside and outside the dikes.

The soil profiles are usually constituted as follows, going from below upwards: medium fine (sometimes medium) porous sand with low silt content, then a layer of small alternating clayey and sandy bands and then a layer of more or less homogeneous clay.

In sedimented profiles, whenever the full silty upper layer is less than 80 cms thick, then the banded layer is absent or at least is not thicker than 25 cms and contains clearly differentiated bands of sand with a low silt content (the sand flat soils "P"). Along the banks of creeks the homogeneous clay topsoil is sometimes absent or variable in thickness, while a banded layer is always present and the sand invariably begins below 80 cms. Outside the centre of the area, similar soils are found over great areas farther away from the creeks.

In the first place, a division is made between soils of different stages of soil formation. The divisions made are:

a. rough herbage, rush-marsh and reed-marsh,

b. "*Salicetum*" (willow coppice),

c. "*Fraxinetum*" (willow coppice), polder in permanent pasture and not yet fully ripe arable polders,

d. ripe polders.

Whenever soils are encountered with a fairly thick stratified layer, and whose silty top-soil (after allowance for shrinkage) is thinner than 80 cms (soil type PL on appendix 1), we are dealing almost invariably with unripe sediments (reed- and rush-marsh), which have not nearly reached the final stage in sedimentation.

Particularly in the north-east, soils are found with a homogeneous layer of more than 80 cms (non-stratified clay-containing soils G4). In the north-east, the lower part of the homogeneous clay layer is, in many places, poor in calcium. Running from N.W. to S.E. through the Biesbosch is a zone where the sand is fairly coarse. Both these last phenomena are mapped as special distinctions. Within all the groups mentioned, subdivisions are made according to the heaviness and the thickness of the layers. Locally, soils with lighter top-soils on heavier subsoils occur. We are dealing here either with flood deposits caused by the breaking of a dike, or with places where, as a result of changes in the regime of sedi-mentation, lighter sediments were laid down on top of heavier ones. The in chapter III mentioned increasing frequence of gale floods influences also this phenomenon. Where the latter was very clear it has been mapped. It is normal that the very toplayer has everywhere a somewhat lower clay content.

A number of areas can be delimited in the region under investigation according to the nature of the soil; areas which are characterised by the predominance of certain soil types. These areas are given in fig. 78N.

a. Region with a layer poor in calcium (or "Waarden" region, after the most important local toponym "Waard", fig. 74). The soils there are heavy and generally homogeneous for more than 80 cms. Elevated natural sandy levees also occur along the north-east side of this area of sedimentation.

b. Region with non-stratified soils (G4).

c. Eastern sand bank soil region (lying partly in western Heusden and Altena).

d. Western sand bank soil region with medium to coarse sands (on the north-east side of the centre of the Brabant Biesbosch).

f. Region with stratified soils.

g. Region with fine sandy stratified soils (in the extreme east and the extreme south-west and the adjoining areas.)

From the centre of the sand bank region, one can see the transition from clay to sand towards the edges of the banks becoming less abrupt on the west, south-west, south, and south-east. The profiles in the region of stratified soils also become more uniform, less banded, and getting a lower clay/silt ratio in the same direction, till on the "Dordrecht island" (Eiland van Dordrecht) and in the western part of the Land van Heusden en Altena very fine sandy silts and clayey soils with a relative low clay/silt ratio are found.

In cross-sections, appendix 5 and fig. 85, a supplement to the soil map is given, so that an impression of the relief can be gained. The legend is further more as concisely as possible provided with profile sketches and information about the main relief characteristics of the various soil types.
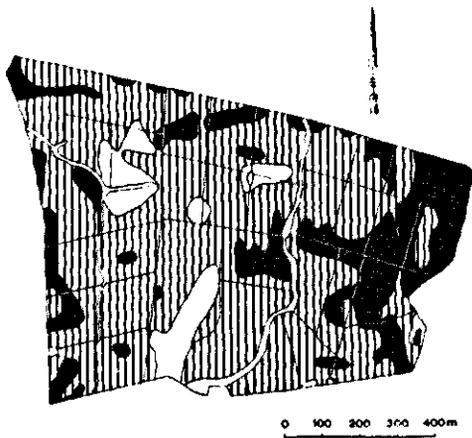
FIG. 71.
Kaart van de polder Maltha, aangevende de diepte van de permanent gereduceerde ondergrond (1952).
Map of the polder Maltha indicating the depth of the permanently reduced subsoil (1952).

Permanente reductie: 7 dm (plaatselijk 6 dm) beneden maaiveld
Permanent reduction: 7 dm *(locally 6 dm) below surface*

Permanente reductie: 8 en 9 dm beneden maaiveld
Permanent reduction: 8 and 9 dm *below surface*

Permanente reductie: 10 en 11 dm beneden maaiveld
Permanent reduction: 10 and 11 dm *below surface*

FIG. 72.
Lengte van haver- en tarwehalmen in verband met de dikte van het slibhoudende dek op matig fijnzandige droge ondergrond.
Lenght of oats and wheat related to the thickness of the clay-containing surface layer on a moderately fine-sandy dry subsoil.

hoogte van het gewas
(height of the crop)
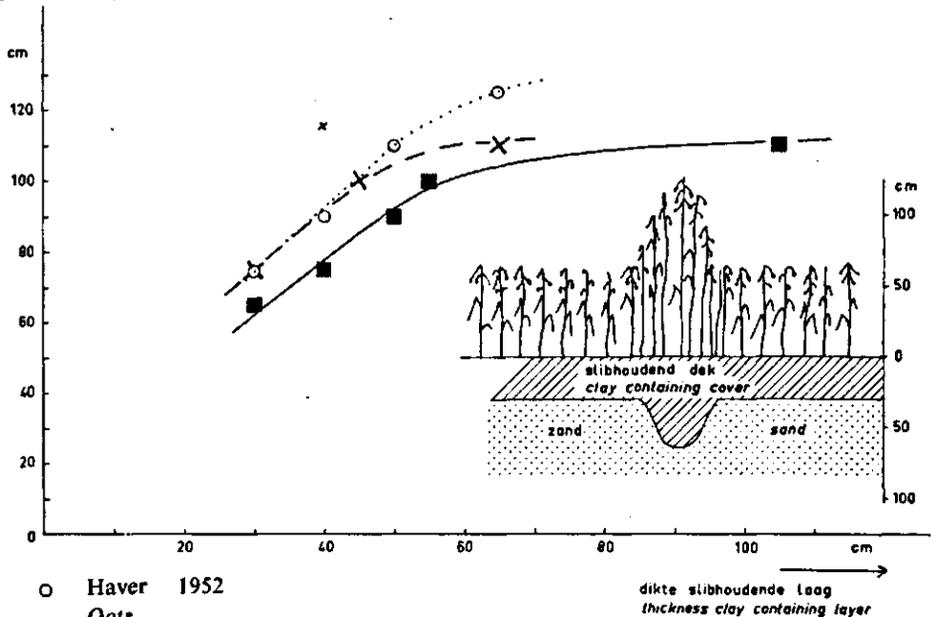
o	Haver *Oats*	1952
×	Tarwe *Wheat*	1952

Het afwijkende symbool betreft een lagere plaats
The deviating symbol refers to an observation of a lower situated spot

■	Tarwe *Wheat*	1954

dikte slibhoudende laag
thickness clay containing layer

FIG. 73.
Groeiverschillen in haver op hetzelfde perceel
veroorzaakt door de verschillen in dikte van
de slibhoudende laag.

120

90

60

30
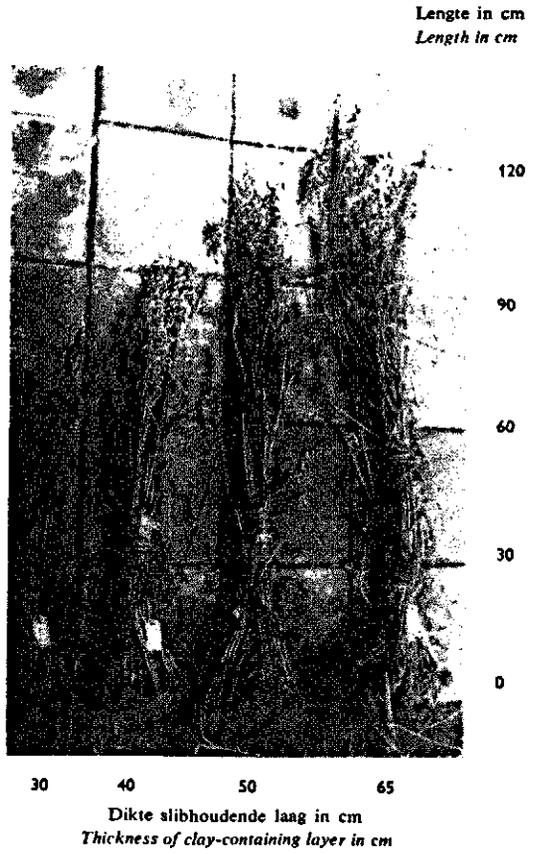
FIG. 73.
Differences in growth of oats on the same lot.
These differences are caused by the varying
thickness of the clay-containing surface layer.

0

| 30 | 40 | 50 | 65 |

Dikte slibhoudende laag in cm
Thickness of clay-containing layer in cm

FIG. 74.
Kalkloze laag (direct boven gelaagde hori-
zont) in type op overgang tussen Pe3 en Ge3
(Kievitswaard, kuil 3).
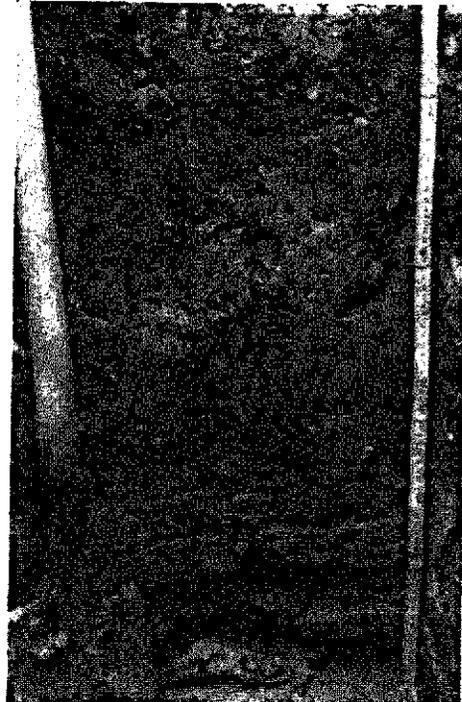
FIG. 74.
Layer poor in lime (immediately above strati-
fied horizon) in soil type transitionally between
Pe3 and Ge3 (Kievitswaard, pit 3).

VIII. COMPARISON OF THE SOIL CONDITIONS WITH THOSE OF OTHER AREAS, BY MEANS OF A CONSIDERATION OF THE SYSTEMATIC CLASSIFICATION

In foreign literature little sub-division of recent soils is made. In the descriptions of soil formation, the process of initial alluvial soil formation (physical and chemical ripening) is not considered, though it undoubtedly is a typical process of soil formation.

The distinction of the units in the Biesbosch is principally a morphometric one i.e. according to measurable characters of the profile layers (thickness, heaviness, etc.). In earlier investigations in the Netherlands the classifications were principally on the basis of landscape. In this system, the Biesbosch would fall into the Estuary landscape, which includes the fresh and the brackish parts of the Dutch river estuaries, and which can be considered as a transition between the river clay and the marine clay. The usual composition of the Estuary landscape has much in common with the south-western marine clay area. There the sand flat soils are also found. (See KUIPERS, 1948; PONS and OVAA, 1950). It can be said that the Biesbosch, from the point of view of geomorphology, is most closely related to the marine clay region. The chemical composition of the clay, the colour etc. is closely similar to the river clay region. The texture of the sediments takes up an intermediate position. Within the region itself, the northern part is most closely related to the river clay, and the south, south-east and south-west most closely related to the marine clay region. Contrasts with the marine clay region are, for example, the chemical characteristics of the clay, often the higher coarse sand content and the relative low clay/silt ratio of the clay. The transition from clay to sand is generally more abrupt, and the soil heavier – particularly down in the profile – than in the "new-land" soils in the salt water region. In most of this, the influence of vegetation during sedimentation is noticeable.

The sand bank complex in the Kraayertpolder on Zuid-Beveland could have been formed under conditions similar to those of the Biesbosch, during a period of stability or of lowering in the subatlantic rise in sea level. These conditions could have occurred about 1100 to 1350. These sand bank soils too, then, have been formed as a result of the elevation of the sand and not because they have been "cut off too soon from the mother" i.e. too soon enclosed by dikes.

In this chapter various descriptions of classifications according to soil and landscape criteria in the south-western marine clay and estuary regions are compared with the Biesbosch.

The name "gorsgrond" which is used for soils in the estuary region is liable to be confused with the land lying outside the dikes, and is therefore not used.

IX. GEOLOGY AND GENESIS

On the basis of existing deep borings, together with some we personally carried out, details of the geology of the deeper substrata were gathered (fig. 75, 76 and 77). The soil mapping and information on a great number of old map-fragments (fig. 78C t/i I), put us in a position to reconstruct the geological history after the St. Elizabeth flood – the great flood which occasioned the creation of the Biesbosch.

The pleistocene substratum of the Biesbosch was formed by the flank of the North Brabant plateau, which slopes down from south-east to north-west, and in which local steep-sided valleys can occur, which just to the south of the Biesbosch lie at sea level (N.A.P.) and in the north sink to about 12 metres below sea level (fig. 77 and 78S). It consists in the lower part of alternating layers of loamy and sandy deposits (Günz and Günz-Mindel interglacial, Kedichem-series, DOPPERT and J. I. S. ZONNEVELD, 1955), while the upper part consists of gravel-containing sands of the probably High Terrace (II 1), covered with fine sands which can probably be considered as wind-blown cover sand. In the extreme north, the impression is gained that there the Holocene rests on the bed of the „Würm river" (BENNEMA and PONS, 1952; J. I. S. ZONNEVELD, 1947; fig. 75, 76, 77 and 78S).

In the neighbourhood of those places where the great inroads into the former Zuid-Holland Waard took place, the holocene deposits are locally completely eroded away; elsewhere too the Holocene is locally much disturbed (fig. 78R, 75 and 81).

In the south, the Holocene, right up to the youngest sediments after the St. Elizabeth flood, seem to consist of peat. In the north, the lowest part of the Holocene is more clayey, obviously as a result of the rivers found in that region, and must partly be considered as a fairly strongly compressed "mud clay" ("modder-klei") of atlantic age, with included clay and peat lenses (see fig. 75C and 76).

In those borings which were subjected to pollen analyses, layers older than atlantic were not present (fig. 79). The pure peat layer which lies above the clayey layers, appeared to be subboreal. Locally, there appeared to be another thin clay layer formed on top – presumable subatlantic. In the north, this peat is mainly wood peat, with oak, ash and alder remains. In the south, there was also a more oligotrophic vegetation, as is indicated by *Calluna* remains. Comparison with data from Hekelingen (fig. 80; FLORSCHÜTZ, 1953) shows that the layers which lay on the surface during the Subboreal, have been lowered at least five metres by shrinkage. This shrinkage had already begun in the Subboreal, as can be seen from the thick subboreal peat layers, which were formed above (fig. 75C, 76 and 79).

During the Holocene, the rivers probably migrated in a southward direction.

After the river clay region which has just been described and which showed many similarities in soil conditions to the present-day Alblasserwaard, had been diked for from one and a half to two centuries and had been brought to a prosperous and well-controlled area, the dikes broke down during a period of lay supervision (Hoekse and Kabeljauwse quarrels) (FOCKEMA ANDREAE, 1950). The first dike burst came in the south-west, about where the Moerdijk-bridge is now situated (fig. 78B). It was thus that the Hollandse Diep was created in its present-day form. The flood waters were at first salt, as can be seen from the finding of small double *Cardium* shells in various places on the former surface and in gullies in that surface (fig. 76). Within one to two years after the flooding from the south-west, the dike between Woudrichem and Werkendam broke down, among other places near Werkendam and Sleeuwijk. The entire central and western parts of the old "Waard" now stood under water, as a result of the fact that during the period of cultivation, the land had sunk to a

considerable extent (fig. 78B). The region has been divided into various accretion areas, according to the pattern of ancient and recent creeks (fig. 78A and B).

A great deal of sand was brought into the area by the rivers. The greater part of the sediment laid down before the St. Elizabeth flood, according to sediment-petrologic analyses carried out by J. I. S. ZONNEVELD, consisted of Rhine sand (table R). Above the mean low water level, clayey sediments were also laid down, partly under the influence of vegetation. The building up of land was strongest in the east, where on the slowly silting-up flooded land of the western part of the present-day Land van Heusden en Altena, a sheltered milieu existed, unaffected by rivers. The quickly built Musterd dike prevented the submergence of the old Land van Heusden during floods (see also SONNEVELD, 1954).

Strong silting-up also took place in the west, where the flood regime had predominantly a wan-tide character (Chapter III). The central area, the "central gullies or "opwas area" [1], in fact the area of the present Biesbosch, remained open longest. Land accumulation took place here from the north-west corner and from the north-east, using respectively as sedimentation "cores" the stream-ridges along the line of the Dubbel near Dordrecht and the former ridges of the Werken-stream which had been formed through inversion of the landscape, and which were therefore only slightly submerged. Up until 1600 this silting-up occurred mainly under the influence of a slowly rising sea level. After 1600, a period of equilibrium, perhaps even of fall in sea level took place (BENNEMA, 1954). On the one hand, this led to the abrupt deposition on the already existing areas of sedimentation, of much heavier sediment (compare fig. 78C and D with 78N, see also fig. 82). Where no factors such as the digging of ditches etc. counteracted decalcification, strong decalcification tended to take place ("waard"-region and region with layers poor in calcium). The dating was possible by comparing the land and water surface on old maps with the soil map (compare fig. 78C t/i I with 78N, 82 and appendix 1).

A second result of the period of equilibrium was that the river beds were not filled in with sand, and – in consequence of the relative lowering of the base level of erosion – even began to cut into their beds. There was consequently a greater transport of sand to the Biesbosch. In front of the deltaic area which was forming at the mouth of the Merwede near Werkendam, great quantities of sand were deposited after 1600, forming the basis of the present sand flat soils (types P).

Immediately in front of the mouth of the delta channels, fairly coarse to even gravelly sands in places, were laid down. Farther from the crest of the deltaic fan, the sand banks did not accumulate to such a height. Furthermore, about the time when the delta had expanded itself to that point, a further rising in sea level began, and on top of that, all sorts of hydrologic works were carried out which, through decreasing the size of the flood basin, tended to raise the mean water level. The digging of sand, from the rivers was also carried on. In sediments, therefore, which were formed after about 1800, the sand is found considerably deeper beneath the surface (on appendix 1 and 3 and the figures 78 and 82 this all can be read).

During the regression period, as has been said, heavy clays were laid down on the crest area of the delta which already existed before 1600, and these clays were initially liable to decalcification (Chapter VI). When these clays were taken into cultivation, as willow coppice and permanent pasture polders, the process of decalcification ceased, as can be seen from the evidence of old ditches which cut through the layer poor in lime and which have been later filled in with material rich in calcium-carbonate. The tremendous transporting of sand

---

[1] The term "opwas" indicates an isolated silting-up isle. The term "aanwas" means an accretion silting up just before and in connection with the older land (see also page 98).

– along the delta channels, which led to the formation of high sand banks in front of the delta – led also to the formation, on the stream-ward side of the silting area, of high sandy natural levees which partly lay across heavier, earlier deposited sediments (fig. 78Q (north-east), 82, 84, 85, 86 and appendix 1). The dating of the natural levees could be arrived at through close scrutiny of the patterns shown on old and new maps (see fig. 87).

Thus the area which has been most strongly influenced by the river is rich in contrasts: considerable differences in relief; abrupt transitions within the profile from heavy clay to fairly fine to fairly coarse sand with a low silt content; changes over short horizontal distances from heavy clay with a low calcium content to lighter, calcium-rich natural levees. The sediments which have been formed more under the influence of the sea are much more uniform, both horizontally and vertically. The contrast, therefore, between the rich variety of a land mass and the uniformity of the sea, can be discerned in the patterns of sediment-ation. This contrast appears even in the relative particle size distributions (see fig. 31 and 32). The sediments laid down during the period of equilibrium or of regression have a much higher content of the coarsest fractions (over 200 mu) and of the finest fractions (below 2 mu). They have thus a somewhat higher clay/silt ratio than the soils formed in the period of full transgression (Chapter IV).

On the boundary between the region of stratified soils, which was formed after 1800, and the sand bank soil region, there is a zone with soils which have an upper clay layer which becomes clearly lighter towards the surface (fig. 78Q, south-west). A higher water level (transgression) has been the cause of this phenomenon. A similar cause has given rise to the lighter upper layer which is found over most of the Vervoorne Polder, diked some-where about 1500. Here, however, the raising of the water level which led to the deposition of a lighter sediment, was not caused by an acceleration of the rise in sea level, but by the narrowing of the flood basin as a result of the building of the Kornse-Dussense dike about 1461.

Other somewhat lighter topsoils were formed as a result of dike breaches and of sub-mergence during storm floods (Chapter IV).

After the building of the Bandijk and the cutting of the Nieuwe Merwede and the Bergse Maas, sediment was no longer brought into the Biesbosch from the north-east, but from the south and the south-west. The sedimentation pattern of the sand banks formed thereafter, is therefore totally different from the others.

On the basis of the pattern of stream- and tide-scoured channels ("eb- en vloedscharen") in the old and the new areas of sedimentation, an impression of the most important current directions can be arrived at. With the exception of the youngest banks, the ebb-current has always been dominant. It is not unlikely that during the initial period of formation north-western winds predominated.

The place names of the area show a certain correlation with the genesis, partly in that certain names were in fashion in certain periods and tended thereafter to fall out of use, and partly in that specific land and water forms were usually given a particular name (fig. 78L and M).

Thus, nearly all the silted-up areas which were in existence before about 1600 to 1650, are named "waard". A few which were reclaimed very early, are called "polder". Thus the region with the layer poor in calcium has many "waard"-names. The sand flat soil region has many imaginative names such as Maltha, Hardenhoek, Kijfhoek, and locally also, the name "sand". Outside the sand flat soil region this name, linked directly with the physical origin of the region, is not found. The "waard"-name was later replaced by "plaat", so that many of the younger polders, particularly in the region of stratified soils, bear the name "plaat" (flat).

The name "Gat" meaning gully, is restricted to the youngest gullies. The area where these names occur lies totally within the central area or "opwas"-area the true Biesbosch. The name "Kil" is met with mainly in the area of sedimentation against already existing land ("aanwas"-area[1]) and is used to denote long, narrow gullies. "Diep" is found only in the west, and is used for all sorts of water channel. "Vaarten" and "vlieten" occur principally south of the Amer and denote typical gullies in the "aanwas" area. The dammed-up ends of the "kils" in the Land van Heusden en Altena, seem to be called "gantel". "Vlaai" has already been mentioned in the fourth chapter, and is a creek with steep shelving banks on both sides. "Hennip" is a small oval accretion.

The names of many plants, animals and people are perpetuated in the place names (see Dutch text).

The division of the land into units is almost everywhere a rational rectangular one, adapted to efficient agriculture and more or less also to natural conditions. Only in the north-east an old principle of division is followed ("opstrekkende verkaveling"), which bears no relation to the existing "kils" and to modern farming. Largely as a result, the hydrological and agricultural conditions in that region are unsatisfactory (fig. 78K).

[1] See foot-note page 96.

FIG. 75A t/m I.

Geologische doorsneden door de Biesbosch naar gegevens van boringen, verricht door de Rijks-
waterstaat, aangevuld met gegevens van de auteur.
De ligging van de raaien is aangegeven op bijlage 4.

*Geological sections through the Biesbosch according to data of borings, carried out by the State
Waterworks Administration, completed by data of the author.
The location of the traces is given in appendix 4.*

LEGENDA
Legend

Fijn tot matig fijn zand
Fine to medium fine sand

Grof zand
Medium to coarse sand

Grind
Gravel

Klei
Silty clay and silty clay-loam

Klei met zand
Sandy loam and sandy clay-loam

Slibhoudend zand
Clay-containing sand

Veen
Peat

Klei met veen en venige klei
Clay or silty clay with peat

Zandige klei met veen en venige zandige klei
Sandy clay with peat and peaty sandy clay

Kleiig veen
Peat with clay

Zoetwaterschelpen
Freshwater shells

Het microreliëf is niet nauwkeurig weergegeven.
Micro-relief, not exactly indicated.

FIG. 75A.
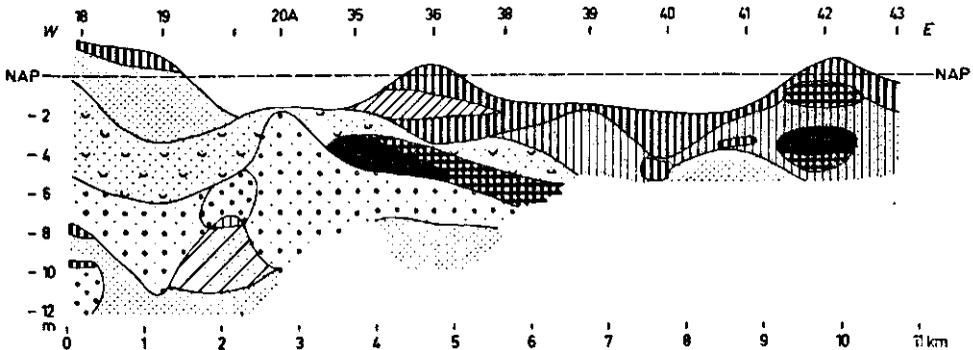
FIG. 75B.
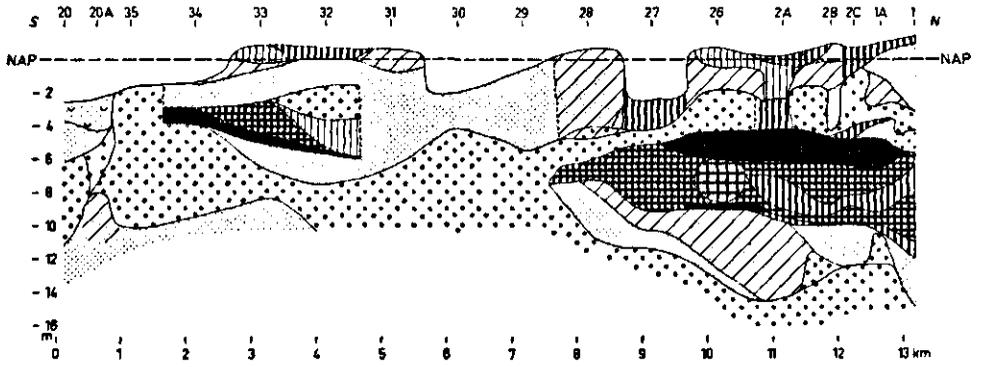
FIG. 75C.
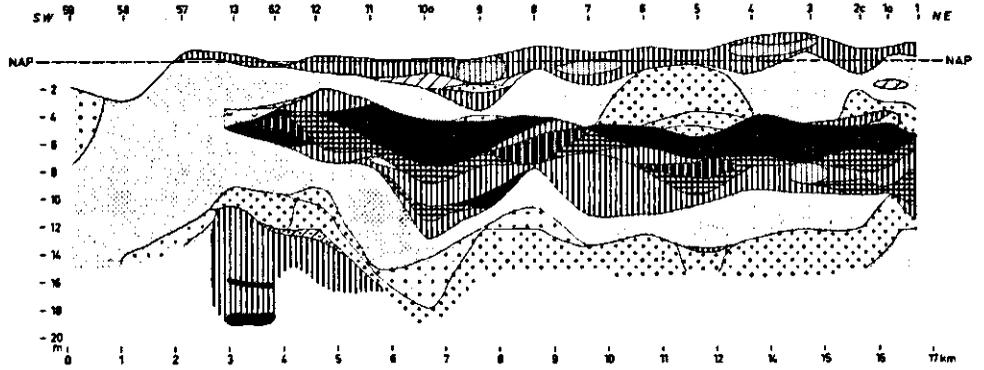
FIG. 75D.
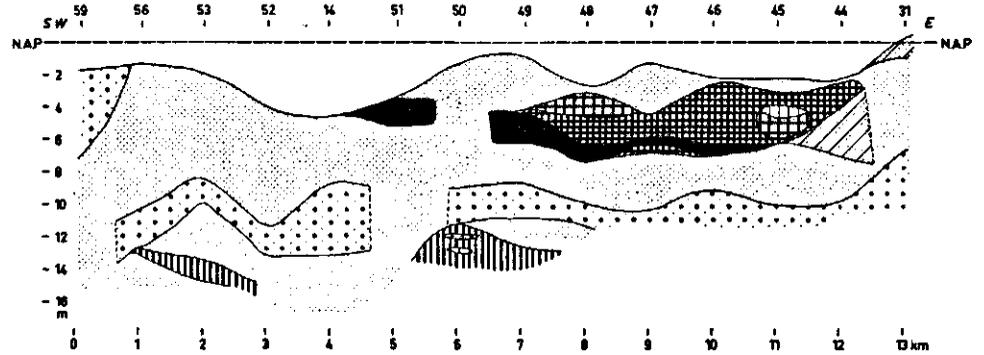
FIG. 75E.
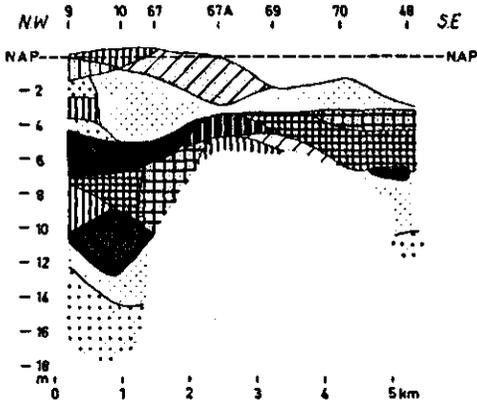
FIG. 75F.
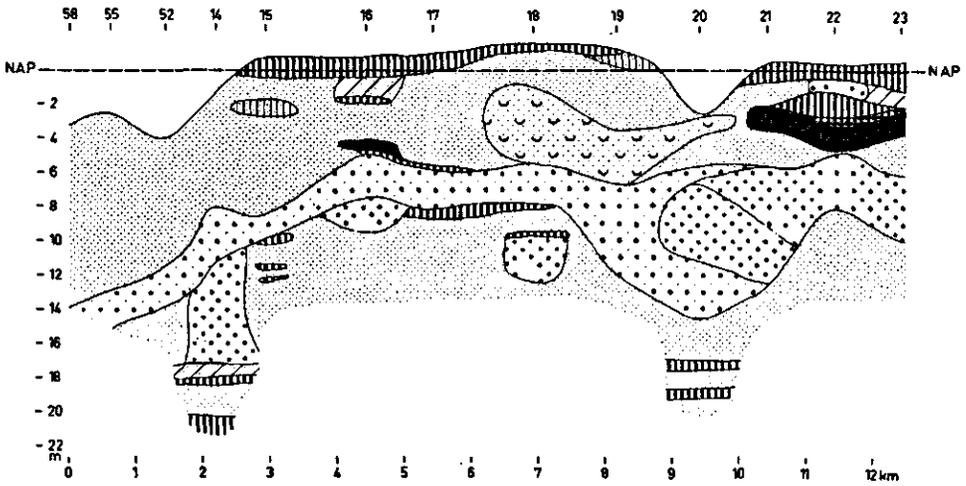
FIG. 75G.
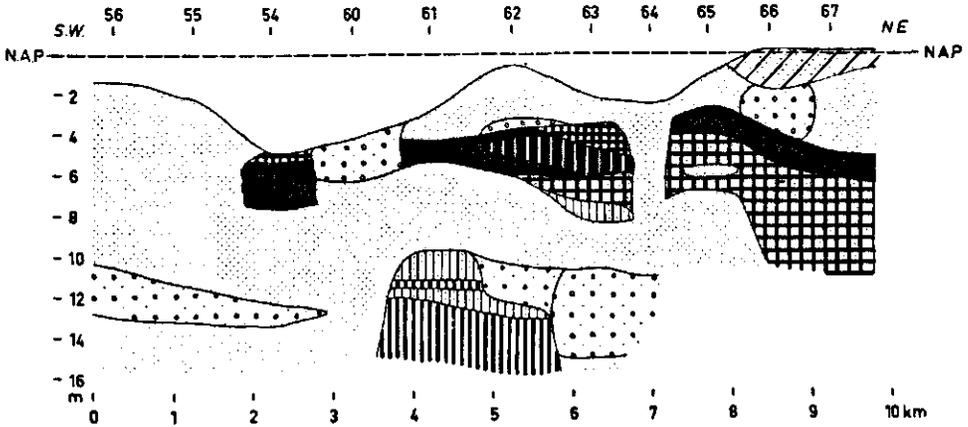
FIG. 75H.
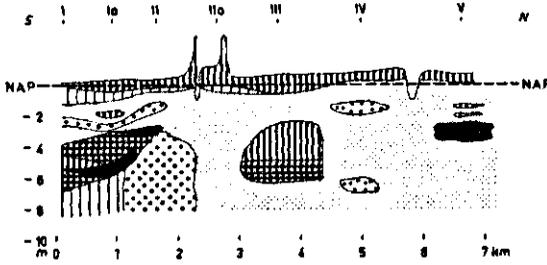
FIG. 75I.
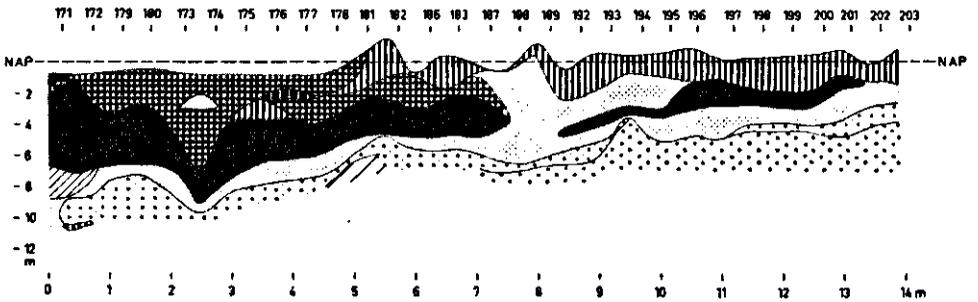
FIG. 76.

Erosiegeul in het klei-veenlandschap in de werkput van de Spieringsluis (tot 5 m diepte gebaseerd op directe waarneming, verder naar beneden afgeleid uit de pulsboringen Spieringsluis nummer 7 t/m 12 van de Rijkswaterstaat).

Erosion gully in the clay-peat landscape in the construction pit of the Spieringsluice (down to a depth of 5 m based on direct observation, further downward concluded from the borings Spieringsluice nr. 7 to 12 (inclusive) of the State Waterworks Administration).

FIG. 77.

Schematische doorsnede door de rijpe opwassen langs de as van de Biesboschdelta.
Schematic section of the ripe accretions along the axis of the Biesbosch delta.

a. Bovenste meters op grote verticale schaal.
   Upper meters on large vertical scale.

b. Het gehele Holoceen en bovenste Pleistoceen op kleinere verticale schaal.
   All of the Holocene and Upper Pleistocene on a smaller vertical scale.
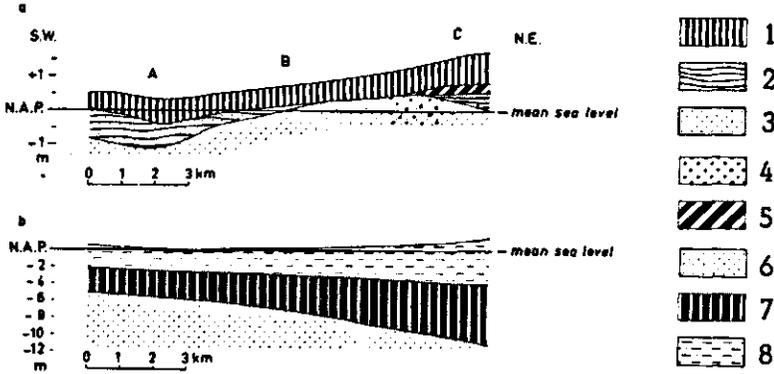
1. klei
   loam, clay-loam, silty clay-loam, silty clay

2. gelaagde afzettingen
   stratified deposits

3. fijn zand
   fine sand

4. grof zand
   coarse sand

5. kalkarme klei
   clay poor in lime

6. Pleistoceen
   Pleistocene

7. Holoceen (voor 1421 afgezet)
   Holocene (deposited before 1421)

8. Holoceen (na 1421 afgezet)
   Holoceen (deposited after 1421)

A. gebied met gelaagde klei- en zavelgronden
   area with stratified clay soils and sandy clay soils

B. zandplatengebied
   area of sand flat soils (sand undeep in the profile)

C. Waardengebied (met kalkarme laag)
   "Waarden"-area (with a layer poor in lime)
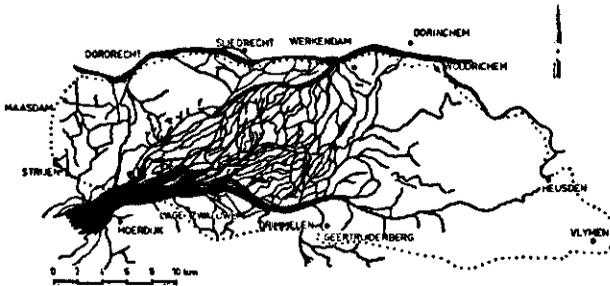
FIG 78.

FIG. 78A.

Kaart van bestaande en aan verkavelingsbeelden nog te herkennen natuurlijke geulen in het gebied van de voormalige Zuidhollandse Waard.

Map of the former "Zuid-hollandse Waard" showing natural gullies, still recognizable by the land division.
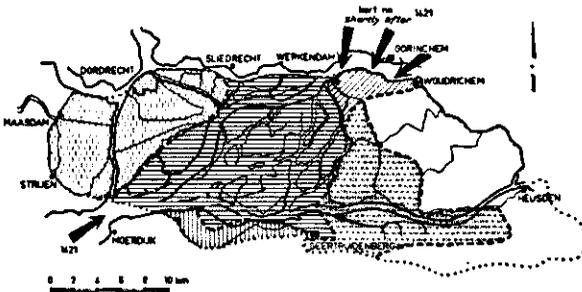
FIG. 78B.

Het gebied van de voormalige Zuidhollandse Waard ingedeeld naar morfogenetisch belangrijke gebieden.

Area of the former "Zuid-hollandse Waard" grouped according to morphogenetic important areas.

1. Wantij of westelijk aanwasgebied
   Wantide or western accretion area

2. Centraal geulenopwas- of deltagebied
   Central gully accretion area or delta area

3. Oostelijk geulengebied
   Eastern gully area

4. Oostelijk aanwasgebied
   Eastern accretion area

5. Zuidelijk aanwasgebied
   Southern accretion area

6. Niet door transgressie aangetast gebied
   Area not affected by transgression

7. Inbraken
   Inroads

1550

1620

1790

1839
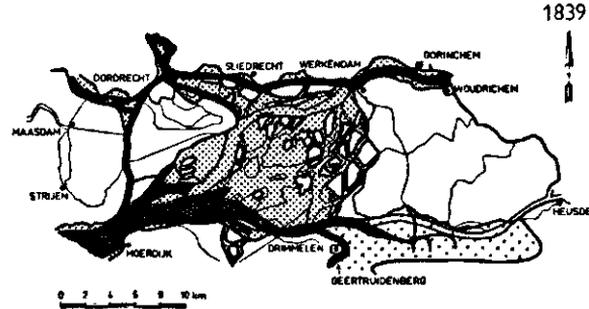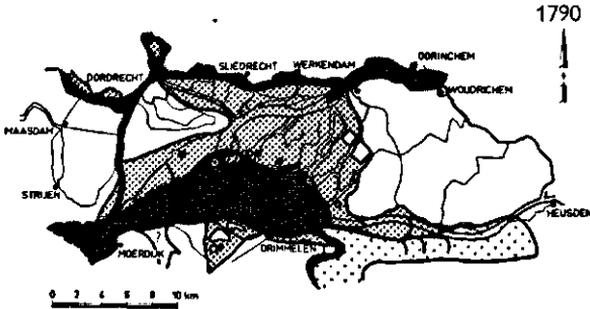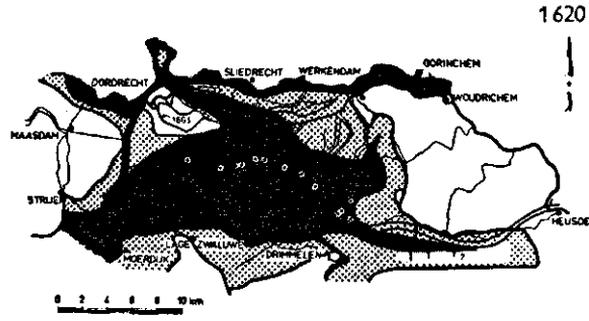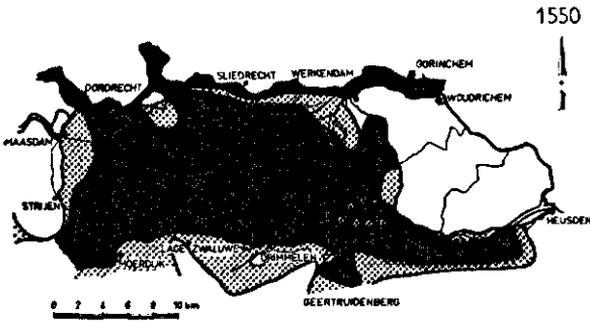
Legenda Figuren 78C t/m J.
Legend figures 78C t/i J.

1. Open water
   Open water
2. Onbedijkte op- en aanwassen
   Not embanked accretions

3. Bekaad land dat bij normale hoge stormvloed onder water kan lopen (onbewoond boezemgebied)
   Embanked areas open for normal high gale floods
4. Bij normale stormvloed watervrij land
   Embanked areas without inundations during gale floods
5. Bolbakens geplaatst in 1560
   Beacons erected in 1560
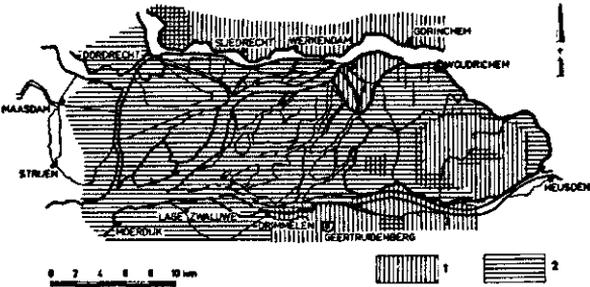
1. „Opstrekkende heerden"
   Strip-land division
2. Rationele verkaveling (op het niet-verjongde land plaatselijk onregelmatige blok- en slagenverkaveling)
   Rational land division (on the not rejuvenated land locally irregular block- and strip division)
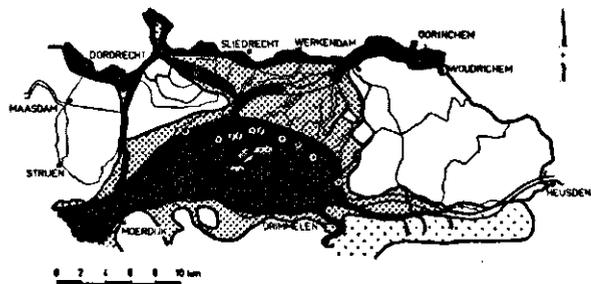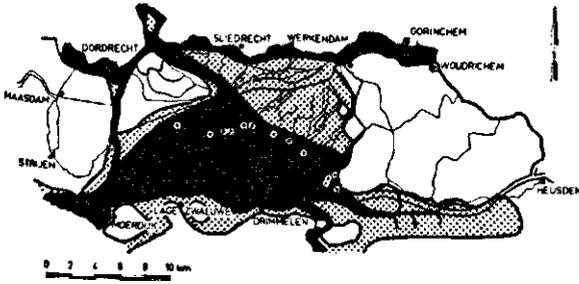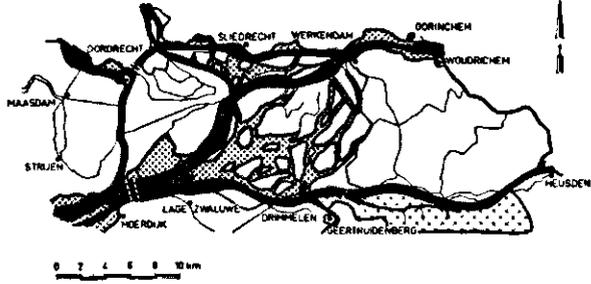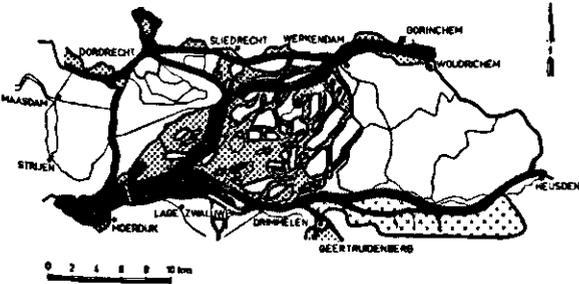
FIG. 78C t/m J (bovenste twee rijen, van links naar rechts).

Overzicht van de landgroei na de St. Elizabethsvloed tot heden, volgens oude kaarten (fragmenten).

View of the accretion after the flood of St. Elizabeth up to the present (upper two rows, from left to right), according to old maps (fragments).

FIG. 78K (blz. 106, links beneden).

Verkavelingstypen volgens HOFSTEE en VLAM (1952) in de Brabantse Biesbosch.
Types of land division according to HOFSTEE and VLAM (1952) in the Brabantse Biesbosch. (Page 106, bottom left).
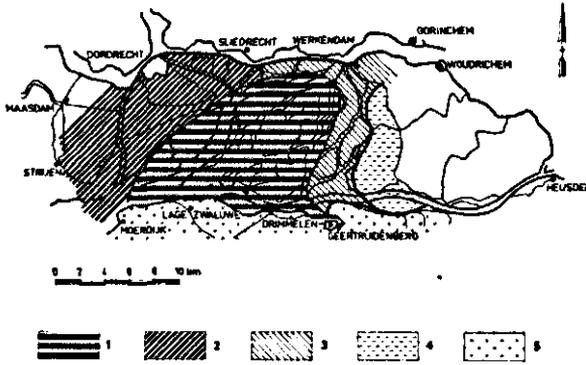
FIG. 78L.
Voorkomen van verschillende waternamen in de Brabantse Biesbosch.

Occurrence of various "water"-names in the Brabantse Biesbosch.

1. gebied met „gat"-namen
   area with "gat"-names

2. westelijk „kil" en „diep"-namengebied
   western area with "kil" and "diep"-names

3. oostelijk "kil"-namengebied
   eastern area with "kil"-names

4. gebied met "gantel"-namen
   area with "gantel"-names

5. gebied met "vliet" en „vaart"-namen
   area with "vliet" and "vaart"-names
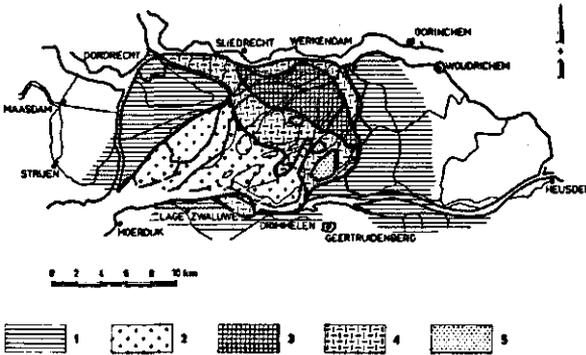
FIG. 78M.
Kaart van het Biesboschgebied met toponymische gebieden ge-baseerd op landnamen.

Map of the Biesbosch area divided in toponymical areas according to landnames.

1. Voornamelijk „Polder"-namen
   Principally "Polder"-names

2. Voornamelijk namen eindigende op „Plaat"
   Names principally ending in "Plaat"

3. Voornamelijk namen eindigend op „Waard"
   Principally names ending in "Waard"

4. Voornamelijk fantasienamen en namen eindigende op „Hoek"
   Principally phantasy names and names ending in "Hoek"

5. Namen eindigend op „Zand"
   Names ending in "Zand"
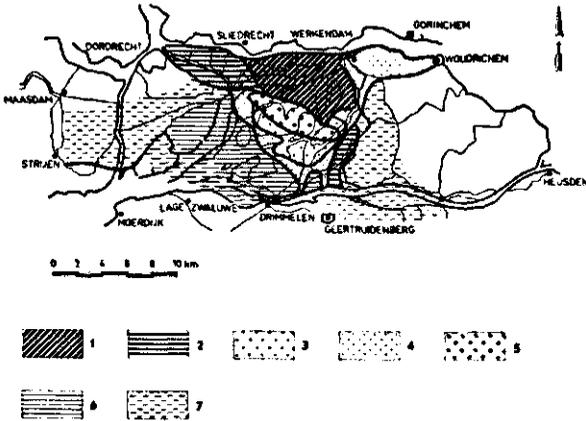
FIG. 78N.
Indeling in gebieden naar de meest
voorkomende bodemgesteldheid.

Division in areas according to the
dominant soil condition.

1. Zware kleigronden met kalkloze laag
   Heavy clay soils with non-calcareous layer
2. Weinig aflopende zware kleigronden
   Heavy silty clay soils with little downward decrease in clay content
3. Hoog liggende zandplaatgronden
   Relatively high situated soils with sand within 80 cm below surface
4. Laag liggende zandplaatgronden
   Relatively low-lying soils with sand within 80 cm below surface
5. Zandplaatgronden met matig grof zand
   High-lying soils with medium coarse sand within 80 cm below surface
6. Zavel- en kleigronden met gelaagde, aflopende ondergrond
   Clay-loam and silty clay-loam soils with stratified subsoil
7. Weinig gelaagde, aflopende zavelige gronden
   Faintly stratified loamy soils merging into fine sand
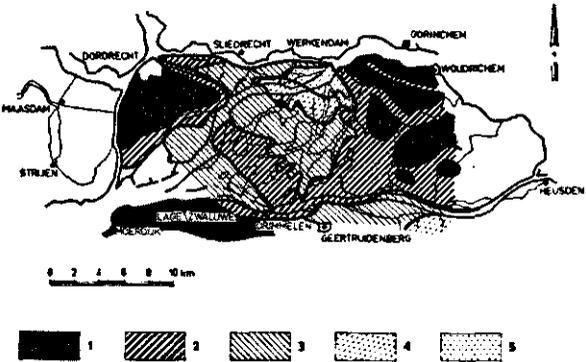
FIG. 78O.
Zeer globale hoogtekaart van het
bedijkte land.

Rough contour map of the em-
banked land.

1. beneden N.A.P.
   below N.A.P.
2. overwegend 0-5 dm + N.A.P.
   predominantly 0-5 dm + N.A.P.
3. overwegend 5-9 dm + N.A.P.
   predominantly 5-9 dm + N.A.P.
4. overwegend 9-12 dm + N.A.P.
   predominantly 9-12 dm + N.A.P.
5. overwegend hoger dan 12 dm + N.A.P.
   predominantly higher than 12 dm + N.A.P.

(N.A.P. = *Amsterdam Ordnance Datum*)
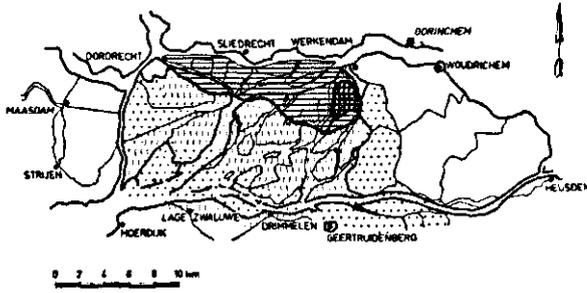
FIG. 78P.
Zwaarte van de bouwvoor.

Heaviness of the till.
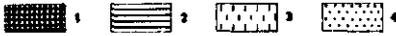
1. overheersend > 80% afslibbaar
   predominantly > 80% particles < 16 mu

2. overheersend tussen 65-80% afslibbaar
   predominantly between 65-80% particles < 16 mu

3. 35-65% afslibbaar (part. < 16 mu)

4. 20-50% afslibbaar (part. < 16 mu)
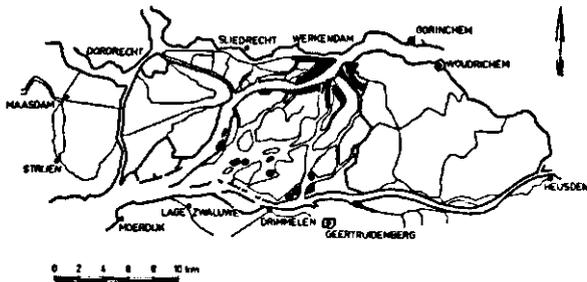
FIG. 78Q.
Plaatsen waar een lichter dek op
een zwaardere ondergrond rust.

*Places where a lighter cover overlies
a heavier subsoil.*

In het noorden zandige oeverwallen.
In the North sandy natural levees.

In het zuiden klei- en zaveldekken op zwaardere ondergrond.
In the South covers of loam and sandy clay overlying a heavier subsoil.
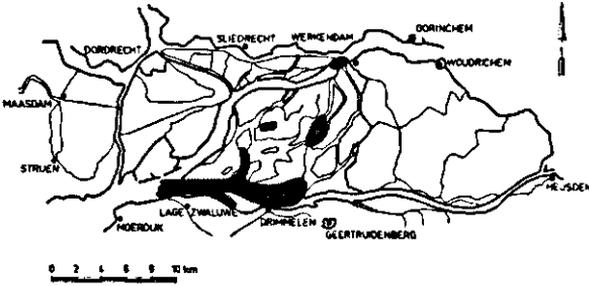
FIG. 78R.
Gebied waar het Holoceen geheel is opgeruimd, voorzover dit uit boringen blijkt.

The Holocene in this area has completely disappeared as far as borings could show.
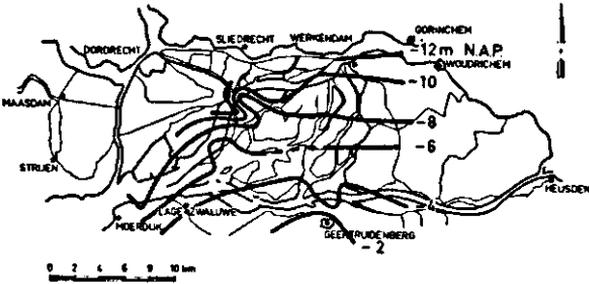
FIG. 78S.
Hoogteligging van het Pleistoceen ten opzichte van N.A.P.

Altitude of the Pleistocene compared to N.A.P.
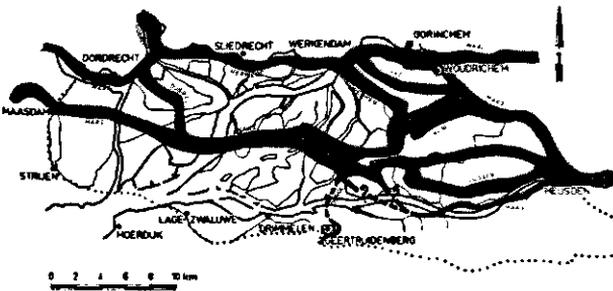
FIG. 78T.
Schets van de vermoedelijke loop der stroombeddingen in het Biesboschgebied en het Land van Heusden en Altena (het laatste volgens SONNEVELD, 1954).

Sketch of the supposed location of the riverbeds in the Biesbosch area and the Land van Heusden en Altena (the latter according to SONNEVELD, 1954).

m – N.A.P.

10 % 20 30 40 50 60 70 80 90 100 %

0 5 10 %

4,06

geen monster
no samples

5

6

7

8

9

10

Salvinia natans

H
H

H
Lij
Car
H
Car

Ur.

H

Car

H
H

H

H

Ly

H
Sol

H

Chenop.

Fagus 0,7%

Picea 0,7%

Picea 0,7%

Plantago mar.

Chenop.

Plantago lanc.
cf. Viburnum

cf. Viburnum

pollenarm (poor in pollen)

cf. Viburnum

Chenop.

pollenarm („   )

pollenarm („   )

pollenarm („   )

pollenarm („   )

Chenop.
cf. Viburnum

Chenop.

Nuphar
Chenop.

Picea 0,7%

Fagus ⎫
Abies ⎬ elk
Picea ⎭ 0,7%

Nuphar
Chenop.

Picea 0,7%

Nuphar

Nuphar

Nuphar
Chenop. Plantago

Fagus 0,7%

Nuphar Chenop.
Chenop.

pollenarm („   )

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37

FIG. 79.

Pollendiagram Spieringsluis.
Pollendiagram Spieringsluice.

	Veen
	Peat
	Klei
	Silty clay
	Kleiig veen
	Clayey peat
	Humeuze klei
	Humose clay

● *Pinus*

○ *Betula*

⊕ *Salix*

□ *Alnus* { in het profiel: *Alnus*-vruchtje / in the profile: *Alnus fruit*

■ *Quercetum mixtum*

◻◆ *Corylus*

▲ *Fagus*

···· *Ulmus*

Legenda van de symbolen in het profiel
Legend of the symbols in the profile

H Hout
  Wood

Ly *Lycopus*-vruchtje
   Lycopus fruit

Sol *Solanum*-zaadje
    Solanum seed

Ur *Urtica*-zaadje
   Urtica seed

Car *Carex*-nootje
    Carex nut

D *Diatomeae*

T *Typha*

FIG. 80.

Pollendiagram Hekelingen
(naar FLORSCHÜTZ (1953) diagram II, monsterserie U).

Pollendiagram Hekelingen
(according to FLORSCHÜTZ *(1953) diagram II, sample series U).*
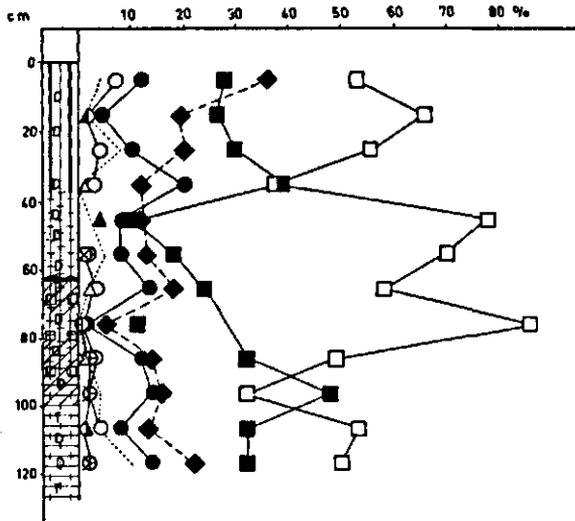
Voor legenda zie fig. 79.
For legend see fig. 79.

FIG. 81.
Kluit veen, geërodeerd uit de diepe geulen en aangespoeld op een slikplaat.
Vegetatie: *Scirpus lacustris* L. *ssp. glaucus* (Mattenbies) (SMITH) HARTMAN (Rdq).
(Sasseplaat).

Lump of peat, eroded out of the deep gullies and drifted ashore on a muddy silt flat.
Vegetation: Scirpus lacustris L. ssp. glaucus (SMITH) HARTMAN (Rdq).
(Sasseplaat).

FIG. 82.

De tegenwoordige bodemgesteldheid van het gebied van de voormalige Zuidhollandse Waard.

Present day soil condition in the area of the former Zuidhollandse Waard.
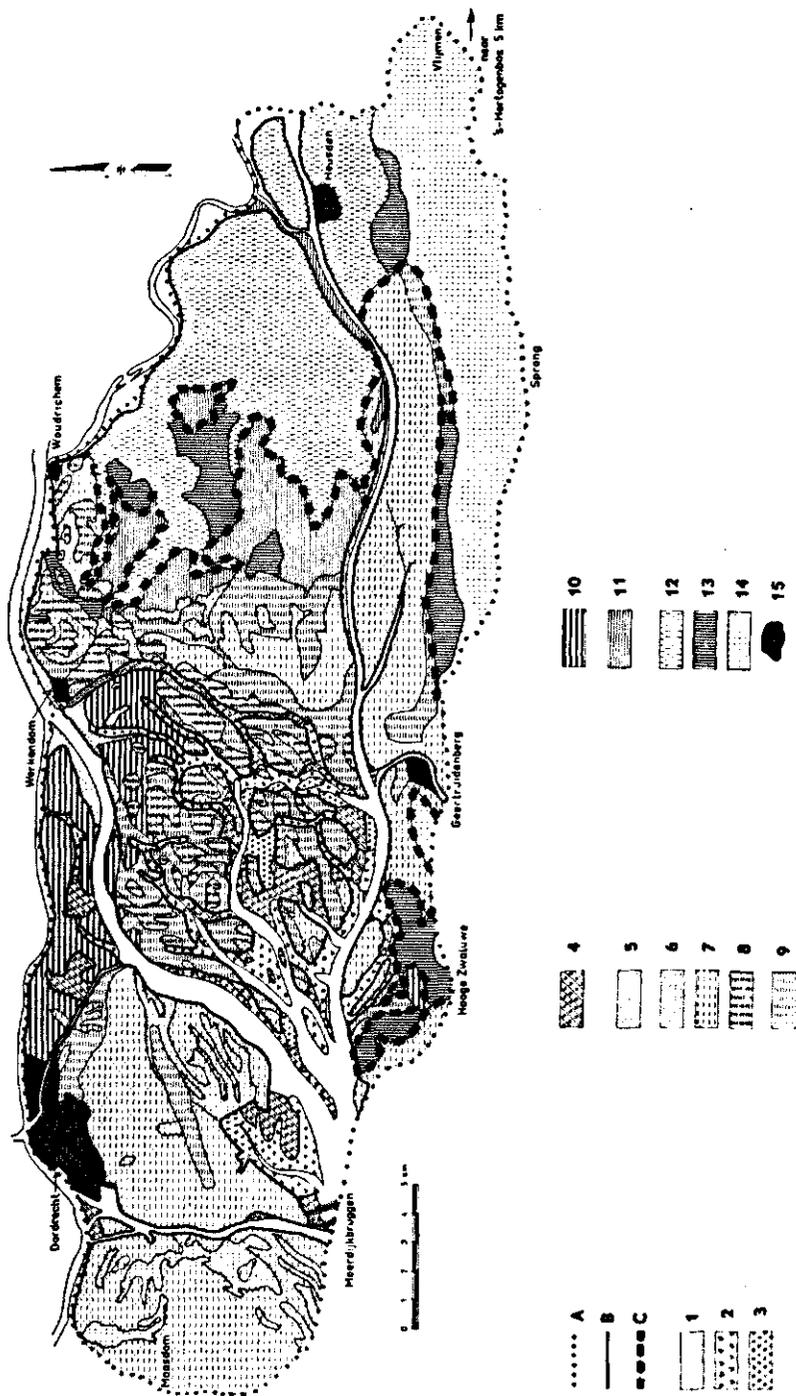
A. Omgrenzing van het gebied van de voormalige Zuid-hollandse Waard

Boundaries of the area of the former Zuidhollandse Waard

B. Kaden en dijken die normale stormvloeden keren

Dikes higher than normal gale floods

C. Begrenzing van de afzettingen tegen het onbeïnvloede oude land (type 12–14) daterend na de St. Elisabethsvloed

Boundaries of the deposits after the "St. Elisabethsvloed" (high gale flood of 1421)

1. Open water met plaatselijk zandbanken

Open water, locally with sand-bars

2. Slikken, riet- en biezengorzen

Mud flats, marshes with reed and rushes

3. Grienden met een dun kleidek op een hoogliggende zand-ondergrond

Willow coppice on a thin cover of clay-loam on highly situated subsoil of fairly coarse sand

4. Grienden met relatief dik kleidek

Willow beds on a relatively thick silty clay-loam surface layer, without a highly situated sandy subsoil

5. Zeer hoog gelegen zandige oeverwallen overwegend met rivierduinkarakter

Very highly situated sandy natural levees predominantly riverdune-like

6. Lichte zavel, geleidelijk overgaand in een zandige onder-grond; slibhoudend dek dikker dan 80 cm

Sandy loam gradually merging into a sandy subsoil; silt-containing surface layer over 80 cm

7. Vrij sterk sloefige zavel geleidelijk overgaand in een zandige ondergrond; slibhoudend dek dikker dan 80 cm

Silt-loam and loam merging into a sandy subsoil; silt-containing surface layer over 80 cm

8. Iets sloefige kleigronden met slibhoudend dek dunner dan 80 cm, dat abrupt overgaat in matig fijn tot matig grof slibarm zand (zandplaatgronden)

Clay-loam and silty loam abruptly changing within 80 cm into relatively coarse sand

9. Iets sloefige kleigronden met slibhoudend dek dikker dan 80 cm meest via een gelaagde overgaand in zandige ondergrond

Clay-loam and silty clay-loam gradually merging into sandy subsoil

10. Iets sloefige zware tot zeer zware kleigronden, met binnen 80 cm meest een nog iets zwaardere compacte kalkarme laag in het profiel

Silty clay often with a non-calcareous layer in the profile

11. Over oude rivierklei uitwiggende dunnere zavelige en kleiige, min of meer sloefige afzettingen van ná de St. Elisabethsvloed

Thin cover of younger sediments lying over older river deposits dating from before the "St. Elisabethsvloed" (1421)

12. Rivierklei-afzettingen van vóór de St. Elisabethsvloed

River deposits dating from before the "St. Elisabethsvloed" (1421)

13. Veengronden ten dele met dikker of dunner dek van zware klei

Peat soils partly covered with silty clay layers

14. Pleistoceen zand, inclusief enige kleine complexen ge-broken gronden

Pleistocene sand, including some transitional soils

15. Steden en dorpen

Towns and villages

2 t/m 4. Onbedijkte gronden, fysisch onrijp

Not embanked areas with physically unripe soils

6 t/m 14. Voornamelijk bedijkte fysisch rijpe gronden

Mainly embanked areas with physically ripe soils

FIG. 83.

De posities van het front van de Biesboschdelta met tussenpozen van 50 jaar (waar nodig geïnter-poleerd tussen de bekende posities van dit front, zoals die blijken uit fig. 78C t/m J).

Outlined positions of the front of the Biesbosch delta with intervals of 50 years (if necessary the frontlines have been interpolated between the known positions as shown in fig. 78C t/i J).
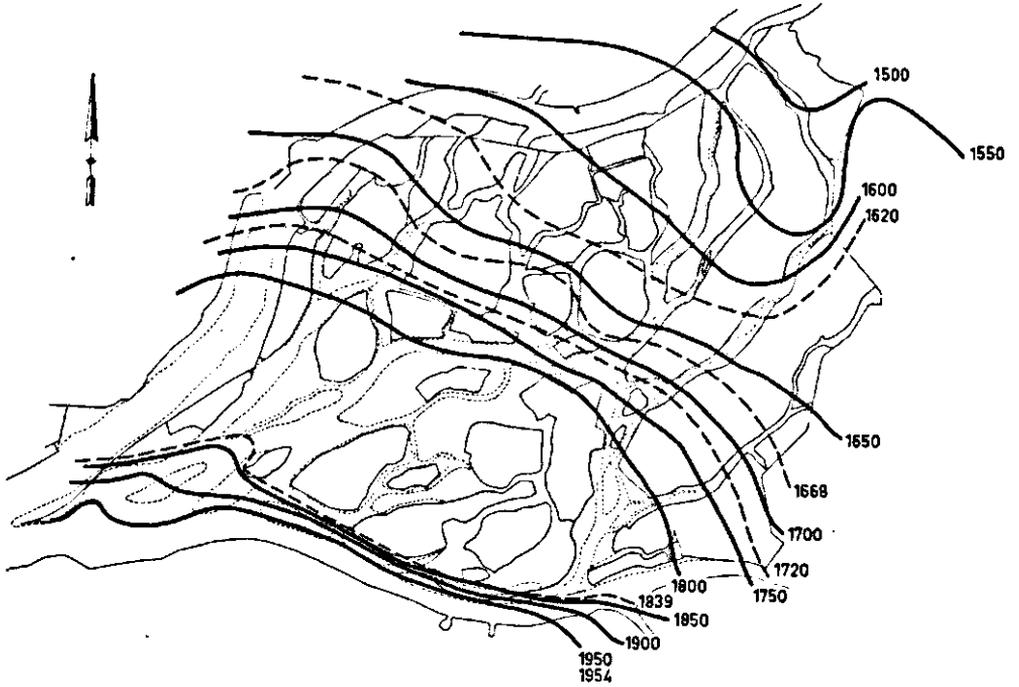
FIG. 84.

De zandige oeverwal breidt zich in een weiland langs de Merwede uit. (Kwellingen; ten oosten van Werkendam).

Sandy natural levee expanding into a pasture along the Merwede. (Kwellingen; east of Werkendam).

FIG. 85.

Schematisch beeld van de zandige hoge oeverstroken in het „waarden"gebied.
Sketch of the sandy high creek banks in the "waarden"-area.
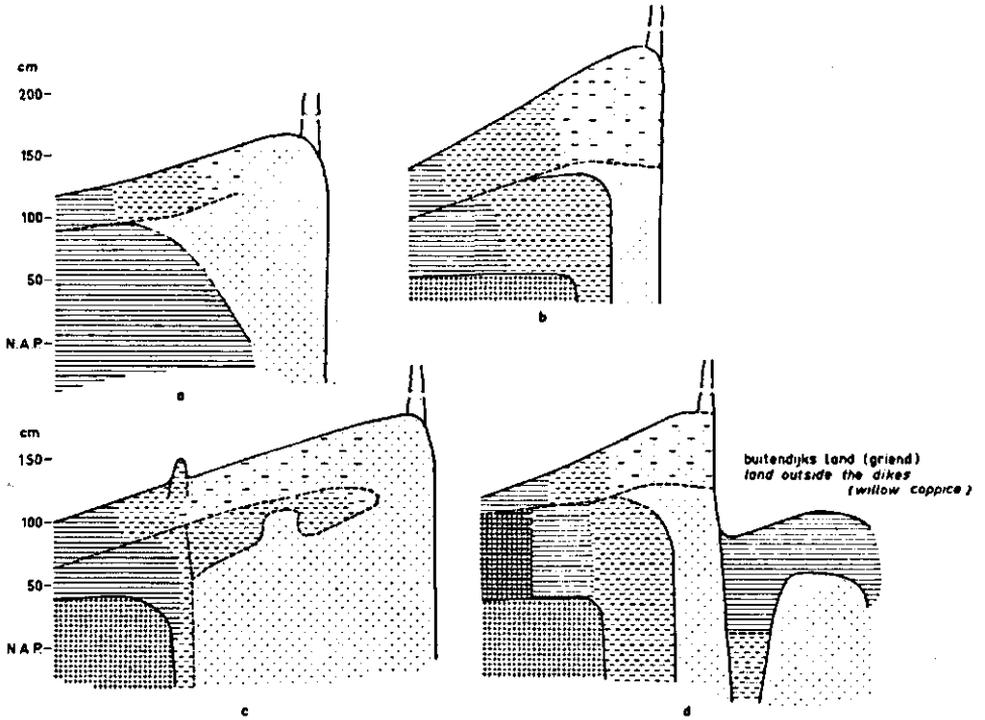
a. Groeningswaard
b. Noord

c. Middelveld
d. Weren onder de Bakkerskil

	kalkarme zware klei *clay poor in lime*
	zware klei (e en f) *silty clay (e and f)* ·
	matig zware klei (d) *silty clay-loam to silty (d)*
	lichte klei *light clay-loam*
	zavel tot sterk slibhoudende zand *loam to clay-containing sand*
	slibarm zand *sand poor in clay*
	dijken en oude kaden *dikes and old embankments*

Luchtfotoarchief Stichting voor Bodemkartering; opname Geallieerde Luchtmacht 3-2-1945

Fig. 86.
Hoge zandige oeverwal langs de noordzijde van de Nieuwe Merwede (M). Het benoorden de Bandijk (B) liggende deel van het poldertje ,,Noord" was kort geleden geïnundeerd. De oeverwal ligt inmiddels weer droog (licht), het meer naar achter gelegen deel is nog nat (donker). Langs het haventje ligt opgebrachte grond.
Vergelijk de bodemkaart (bijlage 1).
A = Polder Aart Floyenbosch, Jonge Janswaard.
S = Sneepkil, in het oosten afgesneden door een zandige oeverwal, die nagenoeg het gehele gebied buiten de dijk beslaat.
(Positie zie bijlage 4).

High sandy natural levee along the north side of the Nieuwe Merwede (M). The part of the polder Noord situated north of the embankment ("Bandijk") (B) was inundated short before. The high natural levee is already dry (light), the lower parts behind are still wet (dark). Along the little harbour the soil is artificially raised.
Compare the soil map (appendix 1).
A = Polder Aart Floyenbosch, Jonge Janswaard.
S = Sneepkil, in the eastern part cut off by a sandy natural levee, that covers nearly the whole area outside the dikes.
(Position see appendix 4).

B   A

Fɪɢ. 87.

De Middelwaard met omgeving, zoals deze op oude kaarten voorkomt (zie ook bijlage 4).
A. geeft de toestand weer omstreeks anno 1800.
B. anno 1684.

Aan het beeld van de verkaveling en de begrenzing van de oevers is te zien, dat er langs de Bruine Kil aan de noordnoordoostzijde van de Middel- of Dwarswaard (op de kaart van ca. 1800 staat Nelismannen Middel Dwarswaard) tussen 1684 en ca. 1800 een strook land is aangegroeid. Blijkens de bodemkaart is dit juist de hoge zandige oeverwal. Deze vindt dus haar oorsprong in genoemde periode.
(Merk op, dat de noord—zuidas „ondersteboven" ligt).

.

.

.

.

FIG. 87.

The Middelwaard with surroundings as shown on old maps (see appendix 4).
A. *represents the situation around anno 1800.*
B. *anno 1684.*

As shown by land division and limitation of the banks, alongside de Bruine Kil, north-north-east of the Middel- or Dwarswaard (Nelismannen Middel Dwarswaard on map of around 1800) a strip of land could grow. According to the soil map this accretion is just the high sandy creek ridge. Consequently the origin of the ridge turns back to the period between 1684 and 1800. (Notice the "upside down" north–south axis).

TABEL R. Zware-mineralenanalyse van enkele zanden in de Biesbosch (J. I. S. ZONNEVELD).

Monsternummer *Nr of sample*	Plaats *Location*	Diepte onder N.A.P. in cm *Depth below N.A.P. in cm*	Prep. no. juni 1956	toermalijn *tourmaline*	zirkoon *zircoon*	granaat (kleurloos + rose) *garnet (colourless and pink)*	rutiel *rutile*	stauroliet *staurolide*	distheen *disthene*	andalusiet *andalusite*	sillimaniet korrel + fibroliet *sillimanite grain + fibrolite*	topaas *topaz*	epidoot *epidote*	saussuriet s.s. *saussurite s.s.*	alteriet s.l. *alterite*	hoornblende s.l. *horn-blende*	baz. hoornblende *bas. horn-blende*	augiet *augite*	hypersteen *hypersthene*	olivijn e.d. *olivine a.c.*	titaniet Eifel *titanite Eifel*	titaniet s.l. *titanite s.l.*
17	Kroon	ca. 0—40	11313	9	—	13	—	2	2	—	—	—	6	8	26	10	7	11	—	■	3	—
53	Vogelenzang	ca. –30 → 20	11314	1	1	13	2	—	2	—	×	—	13	5	43	12	3	6	—	—	××	—
130	Sluisput Spieringsluis	–130	11320	1	—	15	—	1	1	—	—	—	18	5	27	24	3	5	—	—	—	—
129	Sluisput Spieringsluis	180	11319	3	—	9	—	2	—	—	—	—	12	10	34	19	2	3	—	—	—	—
128	Sluisput Spieringsluis	230	11318	—	—	8	—	2	1	1	1	—	26	7	27	24	1	3	—	×	—	—
127	Sluisput Spieringsluis	280	11317	—	—	3	—	2	—	1	1	—	17	10	36	28	—	3	—	—	—	—
126	onderste laag zand op veen rustend *lowest sandy layer lying on peat*	380	11315	3	—	9	—	4	3	—	1	—	8	8	31	23	2	6	—	—	—	—
126a	onderste laag zand op veen rustend *lowest sandy layer lying on peat*	380	11316	5	3	25	—	2	—	—	2	—	28	7	24	10	—	2	—	—	—	—
131	centrum van geel, kriskras gelaagd zand *core of yellow, cross bedded sand*	250	11321	3	—	17	—	—	—	1	1	1	3	14	17	20	6	15	—	—	2	—

TABLE R. Analyses of heavy minerals of some sands in the Biesbosch (J. I. S. ZONNEVELD).

PART III

VEGETATION

FIG. 88.
Langs de Merwede bij Sleeuwijk.
Begroeiing van *Scirpus cf.* × *scheuchzeri*, BRÜGGER.
Oktober 1955.
Along the Merwede near Sleeuwijk.
Vegetation of Scirpus cf. × *scheuchzeri*, BRÜGGER.
October 1955.
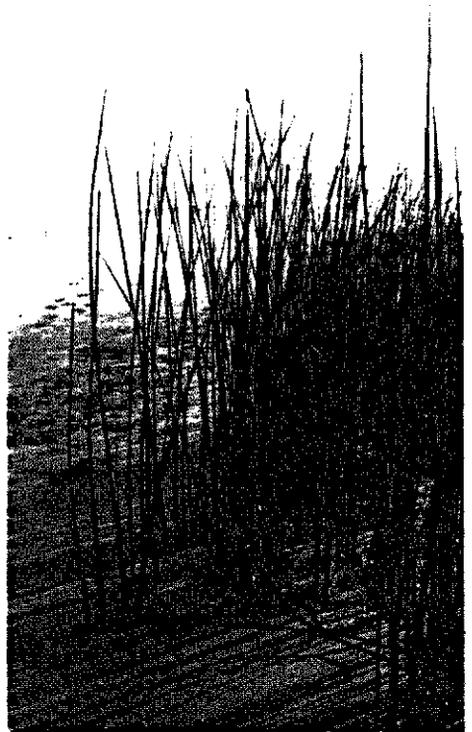
X. DESCRIPTION OF THE PLANT COMMUNITIES IN THE LAND OF THE BIESBOSCH LYING OUTSIDE THE DIKES

The investigation techniques follow the French-Swiss school (see BRAUN-BLANQUET, FULLER and CONARD, 1932). More consideration was given, however, to the milieu conditions than is often done, judging from many publications of this school.

Floristic botany is intentionally kept in the background, though many disciples of this school seem to do quite the reverse. The classification of the vegetation within the region is carried out according to the main principle of the French-Swiss school, namely the characteristic combination of species, arranged so that the units lend themselves most easily to ecological study. Thereafter, these units are transposed into units in the "hierarchical" system of the French-Swiss school (Chapter XIII). In this way, the creation of new associations is avoided as much as possible, and the units which were identified were included as far as possible as sub-associations, variants and subvariants. Only one new association, characterized by a good number of species was identified.

In naming some of the communities which are characterized by strongly dominant species, the nomenclature current in the Scandinavian school was used.

We considered, however, that the extremely detailed analytical method used by the Scandinavians, which in our opinion falls as short in synthesis as some of the workers of the BRAUN-BLANQUET school do in analysis, was not suitable for the rough area studied and for the main aim of our investigation.

The vegetation units were for the most part named by using the names of one or two of the most important species for that community, e.g. the community of *Phragmites communis* and *Caltha palustris*, together with a symbol: G5.

The scientific name, which is used on the map and in the graphs according to the system of the French-Swiss school being a name liable to alteration, was used as little as possible.

The Latin names of the species correspond to the flora of HEUKELS and WACHTER (1952): *Beknopte schoolflora voor Nederland*, 8th. edition. The name of the author is only added in cases of deviation from this authority. Where the systematic name according the BRAUN-BLANQUET system is used without giving the name of the author, then the nomenclature can be found in: *Overzicht der plantengemeenschappen in Nederland*, 2nd edition, by WESTHOFF, DIJK, PASSCHIER and SISSINGH (1946).

The major classification of the vegetation is as follows:

I. Vegetation of permanently submerged places (fig. 89), even at low water.

II. Vegetation of rough herbage ("ruigte") (fig. 96, 97, 100, 106, 107, 109, 110 and 112), and rush-marshes (fig. 91, 94, 104 and 105).

III. Vegetation of reed-marshes (fig. 111, 114 and 117).

IV. Vegetation of tidal forests and willow coppices (fig. 119, 125, 127, 129 and 130).

V. Vegetation of floating mats (fig. 113).

The division into the five major groups coincides with the difference in the characteristic species composition, in the dominant species, and in the visual appearance, as well as with the difference in environment and utilization of the vegetation. A further sub-division can be made within groups I, II, III and IV, according to differences in growth location due to geomorphology.

The divisions made are:

A. Vegetation of low banks (fig. 91) and low stream levees.

B. Natural levee vegetation (fig. 96).

C. Vegetation of small creek sides (fig. 100).

D. Vegetation of back swamp (fig. 104, 107 and 129).

These divisions are all characterized by a specific combination of species.

Within group D, a further sub-division is possible, between back swamps with the more or less firm soils and back swamps with weak soils.

A further sub-division exists in all the groups according to the elevation and the consequent influence of submergence. In appendix 7, the vegetation is shown schematically in relation to the milieu. The same figure is also included in the legend of the vegetation map, in order to give as easily as possible an impression of the ecological significance of the communities which have been distinguished. Such a representation is no more than an approximation, as is shown in chapter XI, since it is not possible to represent fully on a flat surface a system of more than two dimensions.

The reed-marshes have a separate section; they occur in similar conditions of soil and of hydrology as the rush-marshes and the rough herbage of medium and high locations. Man, through encouraging the reed by his activities of planting, cutting and ditching, is the major factor leading to the continued existence of large reed-marshes. The absolute dominant *Phragmites* (reed) determines to a great extent, the character of the milieu. The differences with the remaining rough herbage and rush-marshes are so great that separate reed-dominated communities must be made.

In the detailed Dutch text of this chapter, the communities are further described according to their appearance, characteristic species composition, and their milieu.

It is not possible to give a summary of these descriptions which gives more information than can be gained from the tables, photographs and diagrams, to which the readers attention is drawn (see the appendices 8, 9, 10, 11, 12, 13, 14, 15, 16 and the tables S, T and U).

The plant succession was studied in sample squares. The development of one of these squares was followed photographically, by taking a series of photographs from an electricity pylon (see fig. 131 with explanation).

In the initial phases, especially if the spot is not too lowlying, species appear, as a result of the lack of competition, which are obviously in a anomolous milieu, since when they are brought into contact with existing vegetation, competition leads to their rapid disappearance.

In the lower stages, the succession is mainly allogenic (TANSLEY, 1920). In the transition from the community V2 to V0, the autogenic (TANSLEY, 1920) element becomes important.

Back swamp vegetation is rarely found higher than 30 cms below mean high water level, because of man's interference. It would be expected that at that elevation, the vegetation would develop into the *Magnocaricion eletae* KOCH (1926) and thereafter to an *Alnion glutinosae* MALQUIT (1929), MEIJER DREES (1936).

The wood vegetation also has an influence on the undergrowth. This influence, however, is not so powerful as is the case in the reed-marsh. Furthermore, it is not a case of one dominant; various wood types occur in the tree and bush levels. All the vegetations which have a planted or natural "storey" of woody vegetation are grouped to the willow coppice and tidal forests, irrespective of their floristic composition. In this chapter, the conception exclusive and preferential species are used. These terms have the same significance as "regional

exclusive and preferential characteristic species" of the French-Swiss school (BRAUN-BLANQUET c.s., 1932). In this discussion, only the occurrence within the tidal area is considered. Although some rough herbage communities show more relative variations than some rough herbage with woodland undergrowth, the division wood — rough herbage — reed-marsh is considered more important than differences in floristic composition.

In general for the division wood — non-wood, we recommandate to apply this principle (characteristic species within and outside the wood formation). In chapter XIII this is discussed in detail.

Samples of *Chlorophyceae* and *Cyanophyceae* and *Diatomeae* were taken from a number of spots in the Biesbosch and from areas of transition to the brackish region and to the non-tidal region of the river, and from these samples the algae flora was determined by the specialists AM. TYGE CHRISTENSEN (Copenhagen), dr. J. TH. KOSTER (Leiden) and drs. A. VAN DER WERFF (Abcoude). These data are collected and arranged in the tables of appendix 14 and appendix 15. Little can be published on the soil moss flora which occurs only in the communities V1 and V0. Consideration is given to the epiphytic moss vegetation in BARKMAN (1953).

Community of Nuphar luteum, Potamogeton perfoliatus and Potamogeton pectinatus (V).
In foreground facies with predominantly Potamogeton pectinatus. The vertical sticks are floodtop meters ("sticks with cups").

FIG. 91.
September 1952:
Gemeenschap van *Scirpus triqueter* (Driekantige Bies) en *Scirpus maritimus* (Heen) (Rdq): facies op weke bodem.
Op de voorgrond: *Scirpus lacustris* ssp. *glaucus f. major.*
Daarachter: *Scirpus triqueter* (Driekantige Bies).
Op de achtergrond: *Scirpus lacustris* ssp. *lacustris* f. *pendula.*
(Boerenplaat, Permanent kwadraat 3).

September 1952:
Community of Scirpus tri-queter and Scirpus mariti-mus (Rdq). Facies on soft substratum.
In the foreground: Scirpus lacustris ssp. glaucus f. major.
Next behind: Scirpus tri-queter.
In the background: Scirpus lacustris ssp. lacustris f. pendula.
(Boerenplaat; Permanent sample plot 3.).

FIG. 92.
Vegetatie van *Scirpus maritimus* (Heen) (Rdq à Rdh). Hoewel de flora een maximale hoogte aan-
geeft van 120 cm, is de bies hier manshoog.
*Vegetation of Scirpus maritimus (Rdq à Rdh). The rushes here reach to man's height, though the
flora gives a maximal height of 4 feet.*

FIG. 93.
Scirpus triqueter (Driekantige Bies).

FIG. 94.
Oostelijke zijde van de Boerenplaat, naar het westen toe gezien. Op de voorgrond een oeverwal met de gemeenschap van *Scirpus maritimus* (Heen) en *Phalaris arundinacea* (Rietgras) (Rdh); op de achtergrond een slik-vlakte met de gemeenschap van *Scirpus triqueter* (Driekantige Bies) en *Scirpus maritimus* (Rdq) (voorjaar).

Eastern part of the Boerenplaat with view to the west. In the foreground a natural levee with the community of Scirpus maritimus and Phalaris arundinacea (Rdh); in the background a mud-flat with the community of Scirpus triqueter and Scirpus maritimus (Rdq) (spring).

FIG. 96.
Een kleine kreek. Op de oeverwallen de gemeen-schap van *Senecio paludosus* (Moeraskruiskruid), *Lythrum salicaria* (Kattestaart) en *Scirpus maritimus* (Heen) (Rc).
Op de voorgrond een zandrug van het schaar-systeem. Laag water (Boerenplaat). Zie ook fig. 97.

Small creek. On the levees the community of Senecio paludosus, Lythrum salicaria and Scirpus maritimus (Rc). In the foreground a sand ridge of the ebb and flood scour system.
Low tide (Boerenplaat). See also fig. 97.

FIG. 97.
De kreek van fig. 96 in het vroege voorjaar.
The creek of fig. 96 in the early spring.

FIG. 100. Gemeenschap van *Veronica anagallis-aquatica* (Water-ereprijs) en *Polygonum hydropiper* (Waterpeper) (Rp).
Toestand in het voorjaar:

o.a. *Myosotis scorpioides* (Moeras-vergeet-me-niet)
Polygonum hydropiper (Waterpeper)
Veronica anagallis-aquatica (Water-ereprijs).
(Boerenplaat; mei 1953).

Community of Veronica anagallis-aquatica and Polygonum hydropiper (Rp).
Situation in the early spring:

a.o. *Myosotis scorpioides*
Polygonum hydropiper
Veronica anagallis-aquatica.
(Boerenplaat; May 1953).
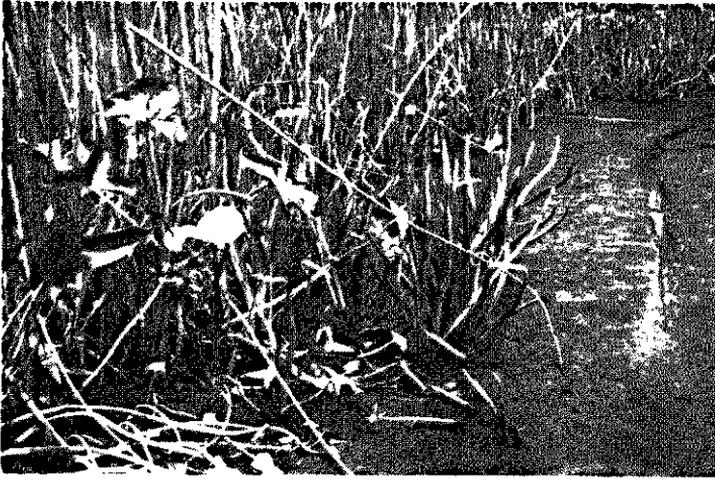
FIG. 104.

Gemeenschap van *Scirpus lacustris* (Mattenbies) en *Sagittaria sagittifolia* (Pijlkruid) (Rf).

Te zien zijn: *Scirpus lacustris* ssp. *lacustris* (Mattenbies), *Caltha palustris* (Dotterbloem), *Alisma plantago-aquatica* (Waterweegbree) en *Sagittaria sagittifolia* f. *sagittifolia* (Pijlkruid).

Community of Scirpus lacustris and Sagittaria sagittifolia (Rf).

Recognizable are: Scirpus lacustris ssp. lacustris, Caltha palustris, Alisma plantago-aquatica and Sagittaria sagittifolia f. sagittifolia.

FIG. 105.

Pionierbegroeiing op de Boerenplaat.

Gemeenschap van *Scirpus lacustris* (Mattenbies) en *Lythrum salicaria* (Kattestaart) (Rdf à Rdq).

Voorjaarsaspect. Te zien zijn: *Scirpus lacustris* ssp. *lacustris* (Mattenbies) en *Caltha palustris* (Dotterbloem). De hoogte is ca. 110 cm – M.H.W.

Let op de putjes in het slik rechts (VI.2.4.).

Initial vegetation on the Boerenplaat.

Community of Scirpus lacustris and Lythrum salicaria (Rdf à Rdq).

Situation in spring. Recognizable are: Scirpus lacustris ssp. lacustris and Caltha palustris. The elevation is about 110 cm – M.H.W.

Notice the holes in the silt right below (Chapter VI).

Fig. 106.

Gemeenschap van *Typha latifolia* (Grote Lisdodde) en *Sparganium erectum* ssp. *polyedrum* (Egelskop) (Re). Permanent kwadraat 7; Zuider Jonge Deen). Zie ook fig. 107.

Voorjaar, mei 1953. Aspectbepalend zijn: *Caltha palustris* (Dotterbloem) en *Typha latifolia* (Grote Lisdodde). Deze laatste zowel met de oude dode resten als met de jonge spruiten.

Community of Typha latifolia and Sparganium erectum ssp. polyedrum (Re).
(Permanent sample plot 7; Zuider Jonge Deen). See also fig. 107.
Spring, May 1953. Aspect determined by: Caltha palustris and Typha latifolia. The latter with dead old stems and young shoots.

Fig. 107.

Nazomer (vergelijk fig. 106). Permanent kwadraat no. 7.

Links: *Sparganium erectum* ssp. *polyedrum* (Egelskop), ook *Scirpus lacustris* ssp. *lacustris* (Mattenbies).

Rechts: o.a. *Phalaris arundinacea* (Rietgors).

Achter: *Typha latifolia* (Grote Lisdodde).

Late summer (see fig. 106). Permanent sample plot nr. 7.

To the left: Sparganium erectum ssp. polyedrum and Scirpus lacustris ssp. lacustris.

To the right: Phalaris arundinacea.
In the back-
ground: Typha latifolia.

FIG. 109.

Gemeenschap van *Typha latifolia* (Grote Lisdodde) en *Typha angustifolia* (Kleine Lisdodde) (Rce).

Zomeraspect met *Typha angustifolia* (Kleine Lisdodde) en *Caltha palustris* (Dotterbloem). P.K. 6.

Community of Typha latifolia and Typha angustifolia (Rce).
Aspect in summer with Typha angustifolia and Caltha
palustris. P.K. 6.

FIG. 110.

Voorjaarsaspect van de gemeenschap *Typha angustifolia* (Kleine Lisdodde) en *Caltha palustris* (Dotterbloem) (vergelijk fig. 109). P.K. 6.

Aspect in spring with Typha angustifolia and Caltha palustris (see fig. 109). P.K. 6.

FIG. 111.

Rietgors in de winter; aan de rand, waar het gewas erg ijl
stond. De grote lengte is duidelijk te zien.

The fringe of a reed-marsh in winter. The crop stood very thin.
The height of the reed is striking.

FIG. 112.

Gemeenschap van *Stachys palustris* (Moerasandoorn), *Typha latifolia* (Lisdodde) en *Sparganium
erectum* ssp. *polyedrum* (Egelskop) (Reh) op een natuurlijk, vrij hoog gors (30 à 40 cm – M.H.W.).
Typha latifolia (Lisdodde), *Phalaris arundinacea* (Rietgras), *Stachys palustris* (Moerasandoorn).
Op de achtergrond een rietzoom, die op de overgang van kom naar oeverwal groeit. (Roode Vaart;
zomer 1951).

*Community of Stachys palustris, Typha latifolia and Sparganium erectum ssp. polyedrum (Reh) on
a natural fairly high, accretion (30 a 40 cm – M.H.W.).*
Typha latifolia, Phalaris arundinacea, Stachys palustris o.a.
*In the background a reed belt, growing on the transition of back swamp to levee. (Roode Vaart;
summer 1951).*

Fig. 113.
Drijftilbegroeiing (IV).
Te zien zijn: *Myosotis scorpioides* (Moeras-vergeet-me-niet), *Impatiens noli-tangere* (Springzaad), *Bidens frondosus* (Tandzaad), *Symphytum officinale* (Smeerwortel) *Mentha aquatica* (Watermunt) *Stachys palustris* (Moerasandoorn) e.a.
Vegetation of floating mats (IV).
Recognizable are: Myosotis scorpioides, Impatiens noli-tangere, Bidens frondosus, Symphytum officinale, Mentha aquatica, Stachys palustris a.o.

Fig. 114.
Rietgors in het voorjaar bij hoog water.
Duidelijk zijn de oeverwallen langs de kreken te zien aan de hoger boven water uitstekende riet-stoppels. Op de voorgrond en links boven ziet men een geheel geïnundeerde kom. In het midden de kreek.

Reed-marsh in spring at high tide. The natural levees along the creeks are sharply marked by the higher emerging reed stubbles.

In the foreground and at the top left a totally inundated back swamp.

In centre the creek.

FIG. 117.

Caltha-rijke gemeenschap van *Phragmites communis* (Riet) en *Caltha palustris* (Dotterbloem) (G5r).
Op de achtergrond de typen G5 (plaatselijk G5r) (Boerenplaat; mei).

Community of Phragmites communis and Caltha palustris, rich in Caltha (G5r).
In the background the types G5 (locally G5r) (Boerenplaat; May).

FIG. 119.

Gemeenschap van *Salix* (Wilg), *Apium eu-nodiflorum* Thlng. (Knoopbloemige Moerasscherm) en *Rumex obtusifolius* ssp. *silvester* (Bosridderzuring) (V4) en de gemeenschap van *Salix, Cardamine amara* (Bittere Veldkers) en *Vaucheria* (Nopjeswier) (V3q).

Spontaan vloedbos bij hoog water. De wilgenboom in het midden is een *Salix fragilis*.

(Kooibos, Visplaat).

Community of Salix, Apium eu-nodiflorum Thlng. and Rumex obtusifolius ssp. silvester (V4) and the community of Salix, Cardamine amara and Vaucheria (V3q).

Spontaneously grown tidal forest at high tide. The willow tree in centre is a specimen of Salix fragilis.

(Duck decoy tree belt; Visplaat).

Fig. 125.

Gemeenschap van *Salix alba* (Wilg), *Cardamine amara* (Bittere Veldkers) en *Anthriscus silvestris* (Fluitekruid) (V3). Voorzomeraspect met *Valeriana officinalis* (Valeriaan).

Voorts zijn te zien:
Anthriscus silvestris (Fluitekruid), *Symphytum officinale* (Smeerwortel), *Phalaris arundinacea* (Rietgras), *Phragmites* (Riet).

Community of Salix alba, Cardamine amara and Anthriscus silvestris (V3). Situation in the early summer with Valeriana officinalis.

Further: Anthriscus silvestris, Symphytum officinale, Phalaris arundinacea, Phragmites communis.

Fig. 127.

Angelica archangelica (Aartsengelwortel) in griendtype V4. (Groene plaat; zomer 1953).

Angelica archangelica in community V4. (Groene plaat; summer 1953).

FIG. 129.
Gemeenschap van *Salix purpurea* (Bittere Wilg) en *Sparganium erectum* ssp. *polyedrum* (Egelskop) (V6) in een verwaarloosde griend.
Op de voorgrond *Caltha palustris* (Dotterbloem). (Oude Keizersdijk).
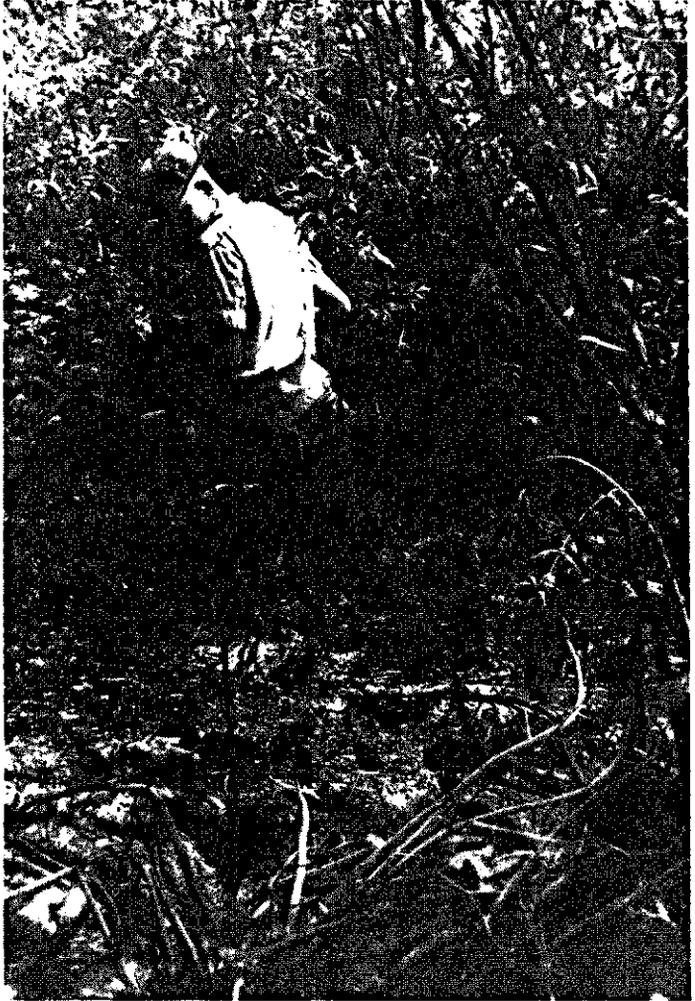
Community of Salix purpurea and Sparganium erectum ssp. polyedrum (V6) in a neglected willow coppice. In the foreground Caltha palustris. (Oude Keizersdijk).

FIG. 130.
Kruidenarme griend (V7) tot gemeenschap V4. Laag water (Grienden van De Dood); zomer).

Willow coppice, poor in herbs (V7) to community of type V4. Low tide („Grienden van De Dood"; summer).

FIG. 131.

Successie op een jonge plaat. (Permanente proefvlakte A, fotografisch gevolgd uit hoogspannings-mast nr. 30).

Blijkens de luchtfoto's van de Geallieerde Luchtmacht bestond de plaat in maart 1945 uit puur zand, zonder vegetatie. In 1948 waren verscheidene kleine haarden *Scirpus maritimus* (Heen) en *Scirpus triqueter* (Driekantige Bies) aanwezig. Ook kwam een pol *Butomus umbellatus* (Zwanenbloem) voor.

In 1950 was een min of meer slibhoudend dek aanwezig, variërend van 30–75 cm dikte. In het midden van het vlakke deel was het substraat vrij week. Transect B (zie bijlage 6) werd op deze plaat opgenomen.

Volgens een opname in december 1956 bleek de plaat aan de oevers, vooral aan de zuidzijde, ca. 20 cm te zijn opgeslibd. Het middelste gedeelte nam weinig in hoogte toe. Zo ontstond dus een differentiatie tussen kom en oeverwal.

De hoogte in 1950 was reeds geschikt voor de middelhoge ruigten (Rc, Rce en Re). Ten gevolge van de snelle groei van de plaat en de grote stroomsterkte was de plaat in die tijd nog niet met deze typen begroeid. De vegetatie kon echter worden gerekend tot de gemeenschap Rdq. Zij bestond voornamelijk uit pollen *Scirpus triqueter* (Driekantige Bies) (t) en *Scirpus maritimus* (Heen) (m). Er werd reeds een kleine pol *Typha angustifolia* (Kleine Lisdodde) (a) aangetroffen. De verschillende pollen breidden zich sterk uit en gingen elkaar overal raken. Daarbij werd *Scirpus triqueter*, die minder fors is dan *Scirpus maritimus*, door de laatste volkomen overgroeid. Na 1953 kon er van *Scirpus triqueter*, midden op de plaat, niets meer worden bespeurd.

Butomus, die in de lage kom Rf zijn actuele optimum heeft, kon op deze hoge plaat de concurrentie met *Scirpus maritimus* evenmin volhouden.

Naarmate de vegetaties zich meer sloten en de oeverwal-komvorming voortschreed, begonnen zich afwateringskreken te vormen. In 1951 was het eerste begin duidelijk te zien (bij K) terwijl in 1952 de kreek (k) reeds goed was ontwikkeld. In 1954 trad naast de beide *Typhae* een derde tot de middelhoge ruigten (Rce) behorende plant op, namelijk *Phragmites* (Riet). De *Typhae* hadden zich intussen sterk uitgebreid en de *Scirpus maritimus*-pollen hadden zich geheel aaneengesloten. Het is duidelijk te zien, dat de vitaliteit van deze pollen aan de randen het sterkst is. Op deze relatief hoge modderiger wordende plaat is het binnenste deel van de pollen spoedig minder vitaal.

Op de linkerfotohelften wordt getoond, dat tot 1956 de buitenste rand van de pol *Scirpus maritimus* zich naar de rand van de plaat uitbreidt. In 1956 is het polkarakter nauwelijks meer te herkennen. De opdringende rand *Scirpus maritimus* heeft meer het karakter van een opdringend recht front gekregen.

In 1956 komt links boven de letter k een pol van *Scirpus lacustris ssp. glaucus* (= *Scirpus tabernaemontani*) (Steenbies) voor. Voor 1952 kwamen enkele kleine pollen van deze pionier (of nauw-verwante overgangsvorm) ook midden op de plaat voor.

Op de foto's is voorts duidelijk het verschil in seizoenaspecten te zien. De *Typhae* zijn in het voorjaar donkerder, in het najaar lichter dan hun omgeving.

Langs de afwateringsgeul (k) valt in het voorjaar (april 1953) de begroeiing met *Vaucheria cf. compacta* (Nopjeswier) op; dit is de initiaalfase van de „kleine kreekoevergemeenschap" Rp. In de zomer en herfst is dit wier veel minder vitaal.

FIG. 131.

Succession on a young flat. Permanent sample plot A. Photographically recorded out of electricity pylon nr. 30.

According to the aerial photographs of the Allied Air Forces in March 1945 the flat was a bar accretion of pure sand, without any vegetation. In 1948 already various small centres of Scrirpus maritimus and Scirpus triqueter occurred. At that time also a stand of Butomus umbellatus was found. In 1950 the flat was covered by a more or less silty layer of 30-75 cm. In the centre of the flat part this deposits were rather soft. Transect B (see appendix 6) was recorded on this flat.

According to a record, taken in December 1956, it appeared that the flat along the borders, especially along the south-side, was silted up to about 20 cm. The inside part increased little in height. In this way back swamp and natural levee could come to difference. In 1950 the height of the flat was already suitable for the medium high rough herbages (Rc, Rce and Re).

In consequence of the rapid extension and the strenght of current in that period the flat was not yet overgrown by this types. The vegetation could be classed to the community Rdq, principally existing of stands Scirpus triqueter (t) and Scirpus maritimus (m). A small stand of Typha angustifolia already appeared.

Then the various stands extended strongly and reached each other everywhere. Attended with this extension the little robust Scirpus triqueter got overgrown by the much stronger Scirpus maritimus. According by Scirpus triqueter completely disappeared from the centre of the flat after 1953.

As little as Scirpus triqueter, Butomus, with actual top in the low back swamp Rf, could compete with Scirpus maritimus at the high flat.

As vegetation grew together and levee–back swamp formation proceeded, small drainage gullies came to development. In 1951 this creek formation could already be noticed (see k). The creek was well-developed in 1952.

In 1954 a third plant belonging to the community of medium-high rough herbages (Rce), Phragmites, appeared beside the two Typhae. In the meantime the extension of the two Typhae was increased strongly and the stands of Scirpus maritimus were grown together. It is evident, that the vitality is the highest at the outside edge of these stands. On these relative high, muddier growing flats, the inside parts of the centres become less vital soon. Until 1956 the outside edge of the stand Scirpus maritimus extended to the border of the flat. This is shown at the left sides of the photographs. In 1956 the stand-form is hardly recognizable. The outside extension edge of Scirpus maritimus has obtained the character of a forward pressing frontline.

In 1956 a stand of Scirpus lacustris ssp. glaucus (= Scirpus tabernaemontani) appeared (left-above letter k). Before 1952 some small stands of this pioneer (or closely related transition form) occurred too in centre of the flat.

At the photographs the difference in seasons is quite apparent.

In spring the Typhae are darker, in autumn lighter coloured than their surroundings.

Alongside the drainage creek (k) in April 1953, the overgrowth of Vaucheria cf. compacta the initial phase of the "small creek levee community" Rp can be noticed. In summer and autumn these algae are much less vital.

Ter oriëntatie zijn enkele individuele pollen omlijnd:
For orientation some individual stands are encircled:

m = *Scirpus maritimus* (Heen) (meestal inclusief *Phalaris*-pollen)
  (mostly stands of Phalaris included)
t = *Scirpus triqueter* (Driekantige Bies)
a = *Typha angustifolia* (Kleine Lisdodde)
l = *Typha latifolia* (Grote Lisdodde)
p = *Phragmites communis* (Riet)
r = *Phalaris arundinacea* (Rietgras)

Voorzomer 1950
Early summer 1950
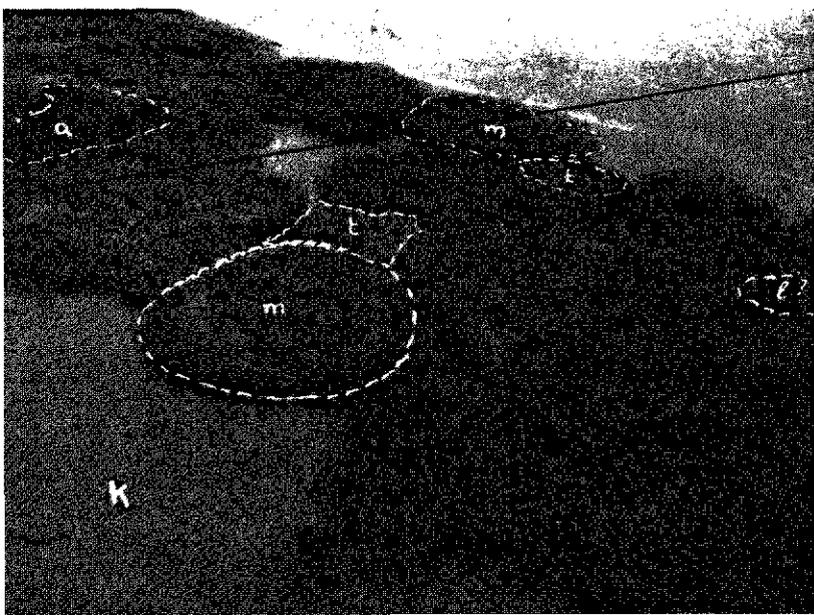
Zomer 1951
Summer 1951

Nazomer 1952
Late summer 1952

April 1953
April 1953
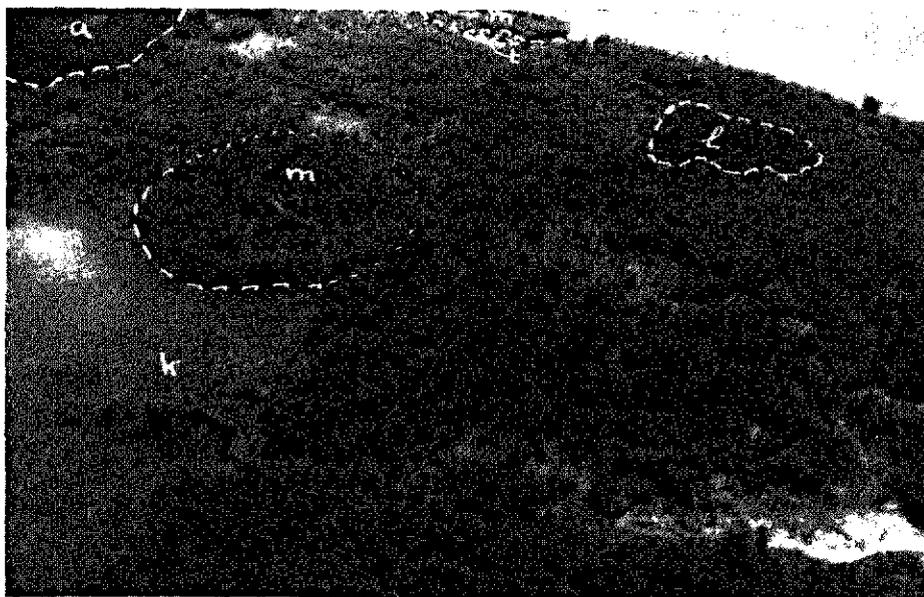
November 1954
November 1954
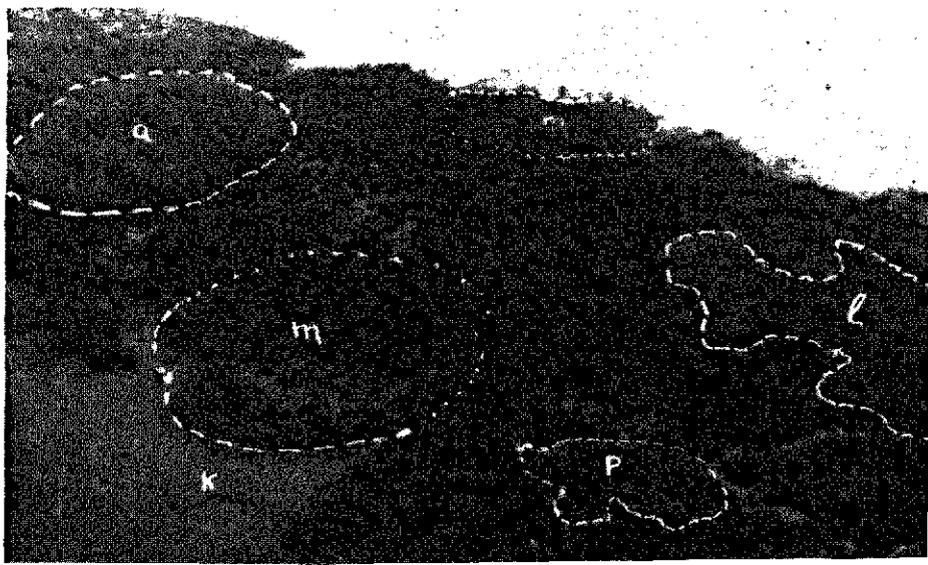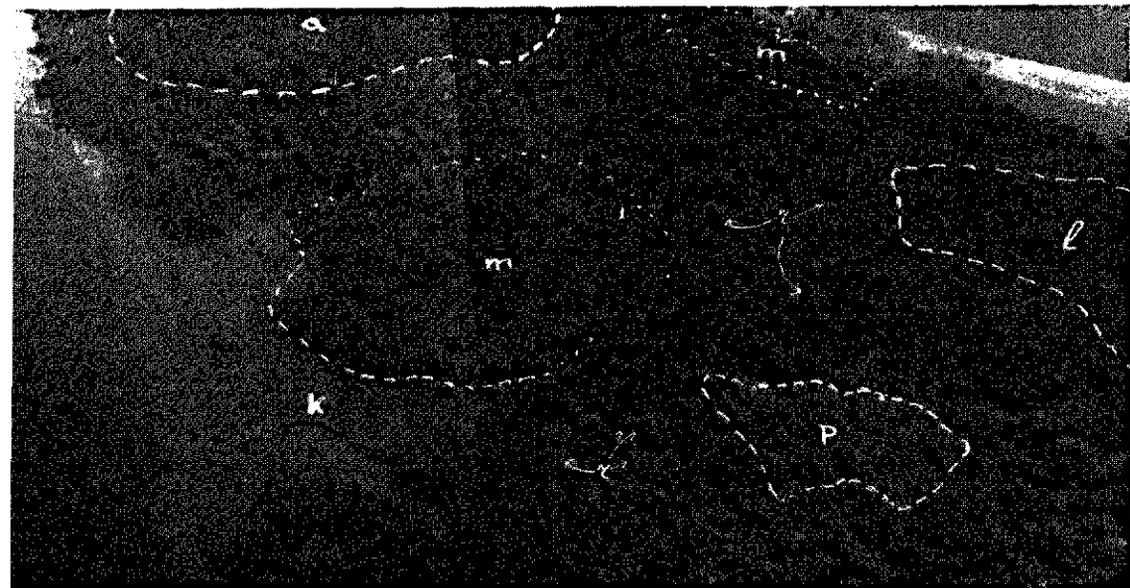
Juli 1955
July 1955
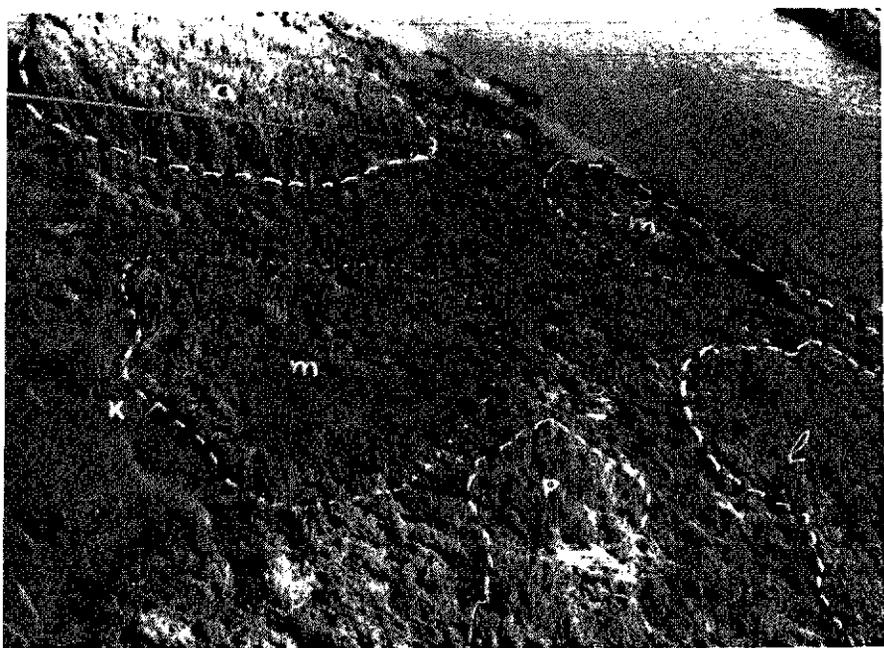
Oktober 1956
October 1956
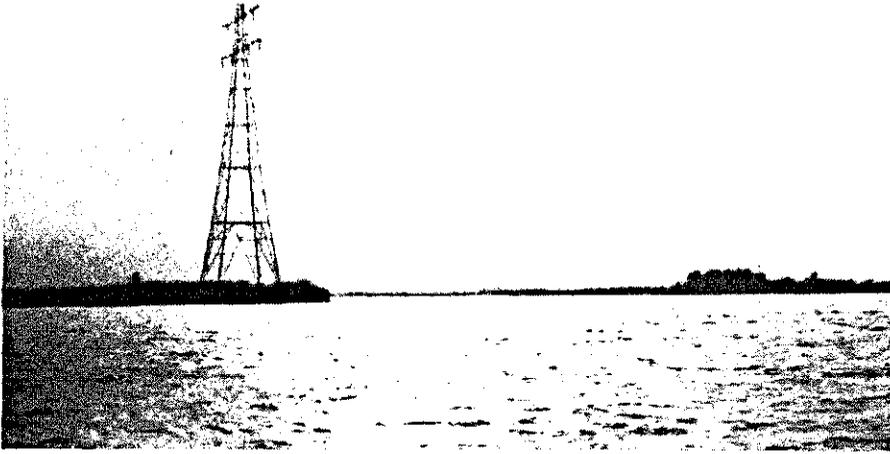
FIG. 131*h*.

Hoogspanningsmast nr. 30, van waaruit de serie opnamen van de zich ontwikkelende plaat werd gemaakt.
Een deel van de plaat is links zichtbaar. Gezicht naar het westen. Rechts de polder Maltha.

The photographs of the developing flat have been taken out of electricity pylon nr. 30.
A part of the flat is visible at the left side of this picture. View to west. At the right the polder Maltha.

TABEL S. De plantengemeenschappen van ruigten en biezengorzen.

		Gemeenschap / Community	Subvariant	Variant
Oeverwal / *Natural levee*	Ra	Gemeenschap / Community — *Heracleum sphondylium, & Valeriana officinalis*		
	Rb	Gemeenschap / Community — *Epilobium hirsutum, & Phalaris arundinacea*		
Kom / *Back swamp*	Reh	Gemeenschap / Community — *Stachys palustris, Typha latifolia, & Sparganium erectum ssp. polyedrum*		*Stachys*-rijke variant / *Variant rich in Stachys*
	Re	Gemeenschap / Community — *Typha latifolia, & Sparganium erectum ssp. polyedrum*	Typische subvariant van de / *Typical subvariant of the*	Typische variant / *Typical variant*
	Rce	Gemeenschap / Community — *Typha latifolia, & Typha angustifolia*	*Typha angustifolia*-rijke subvariant van de / *Typha angustifolia-rich subvariant of the*	
	Rf	Gemeenschap / Community — *Scirpus lacustris, & Sagittaria sagittifolia* f. *sagittifolia*	Typische subvariant van de / *Typical subvariant of the*	*Sagittaria*-rijke variant in / *Variant, rich in Sagittaria*
	Rdf	Gemeenschap / Community — *Scirpus lacustris, & Lythrum salicaria* →	*Lythrum*-rijke subvariant van de / *Lythrum-rich subvariant of the*	
Pioniervege-tatie, oever, oeverwal	Rc	Gemeenschap / Community — *Senecio paludosus, Lythrum salicaria, & Scirpus maritimus*		
	Rdh	Gemeenschap / Community — *Scirpus maritimus, & Phalaris arundinacea*		
Initial vegetation, bank, and natural levee	Rdq	Gemeenschap / Community — *Scirpus triqueter, & Scirpus maritimus*		
	Rp	Gemeenschap / Community — *Veronica anagallis-aquatica, & Polygonum hydropiper*		

De aan deze indeling ten grondslag liggende opnamen zijn. voor zover het de oeverwalvegetaties betreft, verenigd in bijlage 9 en
The underlying records of this division are collected for the natural levee vegetations in appendix 9, for the back swamp vegetations in

TABLE S. *Communities of rough herbages and marshes of rushes.*

Associatie-subassociatie	Verbond	Orde	Klasse
Association-subassociation	*Alliance*	*Order*	*Class*

Valerianeto-Filipenduletum, WESTHOFF (1949)	*Molinion coeraleae,* —➤KOCH (1926) *Calthion* *palustris* Tx. (1937)	*Molinietalia coeruleae,* KOCH (1926)	*Molinieto-Arrhenatheretea,* Tx. (1937)
Scirpeto-Phragmitetum calthetosum KOCH (1926) Tx. (1941)			
	Phragmition eurosibiricum, KOCH (1926) Tx. (1942), BR.-BL. et S. (1942)		
Scirpetum triquetri et maritimi *senecietosum paludosae*		*Phragmitalia eurosibirica,* KOCH (1926) Tx. (1942)	*Phragmitetea* Tx. (1942)
Scirpetum triquetri et maritimi *phalaridetosum*			
Scirpetum triquetri et maritimi *typicum*			
	Glycerieto-Sparganion, BR.-BL. et S. (1942)		

wat betreft de komvegetaties in bijlage 10.
appendix 10.

TABEL T. Synsystematisch overzicht van de rietgorsgemeenschappen.

	G1 Gemeenschap	)	*Phragmites communis* (Riet) &
	Community	)	*Heracleum sphondylium* (Bereklauw)
	G2h Gemeenschap	)	*Phragmites communis* (Riet) &
	Community	)	*Anthriscus silvestris* (Fluitekeruid)
Voornamelijk oeverwal	G2 Gemeenschap	)	*Phragmites communis* (Riet)
Predom. natural levee	*Community*	)	*Poa trivialis* (Ruw beemdgras) & *Ficaria ranunculoides* (Speenkruid)
	G3 Gemeenschap	)	*Phragmites communis* (Riet), *Caltha palustris*, (Dotterbloem)
		)	*Poa trivialis* (Ruw beemdgras) & *Ficaria*
	Community		*ranunculoides* (Speenkruid)
	Gemeenschap	)	*Phragmites communis* (Riet) &
	Community	)	*Phalaris arundinacea* (Rietgras)
	G5q *Caltha*-arme gemeenschap	)	*Phragmites communis* (Riet) &
	Community, poor in Caltha	)	*Caltha palustris* (Dotterbloem)
Voornamelijk kom	G5 Gemeenschap	)	*Phragmites communis* (Riet) &
Predom. back swamp	*Community*	)	*Caltha palustris* (Dotterbloem)
	G5r *Caltha*-rijke gemeenschap	)	*Phragmites communis* (Riet) &
	Community, rich in Caltha	)	*Caltha palustris* (Dotterbloem)
Voornamelijk kom;	G4 Gemeenschap	)	*Phragmites communis* (Riet) &
bij gereduceerde	*Community*	)	*Myosotis scorpioides* (Moeras-vergeet-me-niet)
vitaliteit van het riet			
Predom. back swamp	G4r *Caltha*-rijke gemeenschap	)	*Phragmites communis* (Riet) &
by reduced vitality of	*Community, rich in Caltha*	)	*Myosotis scorpioides* (Moeras-vergeet-me-niet)
the reed	(Gr)Vegetatie van *Phragmites communis* (Riet) en diverse ruigteplanten		
	Vegetation of Phragmites communis (reed) and various rough herbage plants		
Oever en kom	G6 Vegetatie van *Phragmites communis* (Riet) zonder andere kruiden		
Bank and back swamp	*Vegetation of Phragmites communis (reed) without other herbs*		

De aan de onderscheiding ten grondslag liggende opnamen zijn verenigd en gerangschikt in bijlage 12.
The underlying records of this division are collected and tabulated in appendix 12.

TABLE T. *Synsystematical survey of the communities of reed-marshes.*

Phragmites-Heracleum-Poa + Ficaria- { sociatie / sociation

Phragmites-Anthriscus-Poa + Ficaria- { sociatie / sociation

Phragmites-Poa + Ficaria- { sociatie / sociation

Phragmites-Caltha + Poa + Ficaria- { sociatie / sociation

*Phragmites-Poa + Ficaria-*sociatiegroep (*Phragmites-sociaties met een Poa + Ficaria-*societas)

Phragmites-Poa + Ficaria-sociation group (Phragmites-sociations with a Poa + Ficaria-societas)

Phragmites-Phalaris- { sociatie / sociation

Caltha-arme
Poor in *Caltha*

Phragmites-Caltha { sociatie / sociation

Caltha-rijke
Rich in *Caltha*

Rietgors, *Phragmites* consociatie
Reed-marsh, *Phragmites*
consociation
*Phragmitetalia
eurosibirica,* KOCH (1926),
TÜXEN (1942) à *Molinietalia
coeruleae.* KOCH (1926)

Phragmites-Myosotis { sociatie / sociation

Phragmites-Myosotis sociatiegroep
Phragmites-sociatie met een
*Myosotis-*societas

Phragmites-Caltha + Myosotis { sociatie / sociation

*Phragmites-Myosotis sociation
group Phragmites-sociation with
a Myosotis-societas*

Phragmites div. species { sociaties / sociations

TABEL U. Synsystematisch overzicht van de griend- en vloedbosgemeenschappen.

Subvariant

Op fysisch bijna rijpe bodem boven M.H.W.

On physically almost ripened soils above M.H.W.

Vo Griend- en vloedbosgemeenschap met *Circaea lutetiana en Carex remota*

Community of willow beds and tidal forest with Circaea lutetiana and Carex remota

V1 Gemeenschap | *Salix alba &*
Community | *Scrophularia nodosa*

Op fysisch matig rijpe bodem omstreeks tot boven M.H.W. gelegen

On physically moderately ripened soils about M.H.W. to above M.H.W.

V2 Gemeenschap | *Salix alba &*
Community | *Heracleum sphondylium*

V3 Gemeenschap | *Salix alba, Cardamine amara &*
Community | *Anthriscus silvestris*
typisch subvariant
typical subvariant

V3r Gemeenschap | *Salix alba, Anthriscus silvestris & Caltha palustris*
Community
Caltha-rijke subvariant
Caltha-rich subvariant

V3q Gemeenschap | *Salix alba, Cardamine amara & Vaucheria sp.*
Community
Subvariant *Vaucheria*
Subvariant with Vaucheria

Op fysisch matig tot weinig rijpe bodem, onder M.H.W. gelegen

On physically moderately ripened to faintly ripened soils below M.H.W.

V4 Gemeenschap *Salix div. spec., Apium eu-nodiflorum* THLNG. *& Rumex obtusifolius* ssp. *silvester*
Community

V5 Gemeenschap *Salix purpurea, Alisma plantago-aquatica & Apium eu-nodiflorum* THLNG.
Community

Op fysisch onrijpe (weke) bodem, beneden M.H.W. gelegen
On physically unripe (muddy) soils below M.H.W.

V6 Gemeenschap *Salix purpurea & Sparganium erectum* ssp. *polyedrum*
Community

Op fysisch onrijp tot matig gerijpte bodem, beneden M.H.W. gelegen.
On physically unripe to moderately ripened soils below M.H.W.

V7 Kruidenarme griend
Willow beds, poor in herbs

TABLE U. *Synsystematical survey of the communities of willow beds and tidal forests.*

Variant	Associatie-subassociatie *Association-subassociation*	Onderverbond *Sub-alliance*	Verbond *Alliance*	Orde *Order*	Klasse Class
	Cariceto remotae-Fraxinetum, KOCH (1926) *anthriscetosum*	*Alnion incanae* OBERDORFER (1953)	*Fraxino-Carpinion* Tx. (1956)	*Fagetalia silvaticae* PAWLOWKSI (1928), Tx. en D. (1936)	*Querceto-Fagetea* BR.-BL. et VL. (1939)
Variant met/*with* *Scrophularia nodosa*					
Variant met/*with* *Heracleum sphondylium*			*Alno-Ulmion* BR.-BL. et Tx. (1943), OBERDORFER (1953)	*Populetalia* BR.-BL. (1932), OBERDORFER (1953)	
	Salicetum albae, ISSLER (1926), MEIJER-DREES (1936) *cardaminetosum*				
Typische variant *Typical variant*		*Salicion* OBERDORFER (1953)	*Alnion glutinosae* MALQUIT (1929), MEIJER-DREES (1936)	*Alnetalia glutinosae* VLIEGER (1937)	*Alnetea glutinosae* BR.-BL. et Tx. (1943)
Variant met/*with* *Rumex obtusifolius* ssp. *silvester*					
Typische variant *Typical variant*					
Variant met/*with* *Sparganium erectum* ssp. *polyedrum*	*Salicetum albae* ISSLER (1926), MEIJER-DREES (1936) *alismetosum*				

XI. SYNECOLOGY

The synecological investigations were carried out by measuring the most important milieu factors in as many places as possible in the different communities (mesological synecology) and by studying how far the morphology of the vegetation, the species and the individual plants react to the various milieu factors (ethological synecology). The terms mesological and ethological synecology are proposed by PAVILLARD (1935).

The non-biotic, physical and chemical factors which in the freshwater region principally determine the ecological differences are:

The hydrological factor of submergence and the edaphic factor (mainly the aeration and the consistency in relation with the initial alluvial soil formation and the resultant general condition of the soil).

For the measurement of the influence of submergency, see chapter III. The edaphic factor was determined by means of a rough estimate of the soil consistency or more objectively by means of a little rod, which falling from a certain height, would sink to a specific depth into the soil. In addition, the distance of the soil surface to the level in the profile at which iron concretions were present was used as a measure of the aeration conditions. The measurement had to be done as simply as possible in the field, because of the difficult nature of the terrain. Any estimation of the intensity of iron staining in addition to the determination of its depth, was therefore dispensed with. The above mentioned soil factors correlate closely with the geomorphological location (natural levee – back swamp) and with the elevation. Water movement in the soil itself is considered in chapter III and controls the aeration and the circulation of the soil atmosphere. The influence of texture is felt through the other soil characteristics mentioned above, and it, too, is correlated with geomorphology and elevation.

In addition to these more physical and chemical factors, the biotic factors both, the vegetation itself and the factors external to the vegetation also have a part to play. E.g. the destructing activities of both high and low organisms influence the competitive powers of some species. The excrements of fish-eating birds (cormorants and herons) has a poisonous effect on many plants in the nesting colonies. The soil fauna is also important.

Man's influence is very great. Planting, harvesting and weeding all have a direct influence on the vegetation. Cutting keeps the rush-marsh free from "weeds". Planting and preparing the soil (by digging little drainage ditches) very much increases the area under *Phragmites*. The willow coppice is greatly affected by planting, weeding and harvesting.

The indirect influence of digging small drainage ditches is, as has already been pointed out, very great.

The universal controlling factor of vegetation – competition – prevails between the individual plants in the vegetation. As a result, differences between the actual amplitude (influenced by competition) and the potential amplitude (without competition e.g. laboratory conditions) arise. The former amplitude is always smaller than the latter.

One of the other factors which comes very much to the fore in the freshwater tidal area is one of protection: the "mass-effect". We understand by this term the fact that a large number of individuals are more capable of withstanding certain unfavourable conditions than one single plant (strength in numbers; see also WESTHOFF, 1954). Thus a good clump of vegetation offers better resistance to current erosion than a single plant. The same is true of willows in relation to, among other things, the passage of ice. The influence of this "mass-effect" through its effect on micro-climate is also of significance. Another factor of importance is the priority of colonization – "first come, first served" – which tends to lead to the occurrence of communities poor in species and dominated by one single species.

In the figures 137 (height-soil aeration diagrams) the relation between the hydrological and edaphic factors and the plant communities is given in general terms (see also fig. 132). In the figures 137A, C and E the boundaries of the points are accurately given, and in the figures 137B, D and F the "centre of gravity" of these clusters of points is shown, by means of which dates of places where only one of the factors was known, could be included in the calculation. The many over-laps are partly a result of the inaccuracy of the method; thus the strong oxidation conditions of the community V0 in comparison with V2 is not brought out, since the depth at which iron staining occurs is, at such depths of oxidation, no longer a true criterion, and the intensity of the staining and of the brown colour of the soil should also be taken into consideration in any assessment of the oxidation conditions. However, strong over-laps make it clear that the representation on a flat surface is not possible, since there are still more factors to be taken into account.

Thus the ecological extent of the communities G4 and G5 are practically identical (see fig. 137C and D). The floristic difference is that G5 and G5r contain only plants which complete their life cycle in the spring. G4 and G4r are characterized by the occurrence of other plants which flower in summer, among others, *Myosotis scorpioides*. Obviously in G4 and G4r the reeds allow more light to pass through than G5. The cause of this usually a disease of the reed, which is a result of the edaphic and hydrological conditions of the milieu (fig. 146). A comparison of the graphs gives, in addition, an insight into which reed-, rough herbage-, and willow bedscommunities grow in similar locations, and of how large therefore, are the differences in floristic composition which are caused by biotic factors under the domination of reed and willow. The sloping-off to the right of some of the boundaries indicates the increased resistence to the factor of submergence whenever better aeration is present (aeration effect). Plants of various types e.g. *Phragmites*, seem to be able to penetrate to lower levels or alternatively to be able to grow there more vigorously when they are connected by root stems to plants growing at a higher level (Rhizome-vicinism; fig. 133).

In the figures of appendix 6 a picture can be gained of the vegetation in relation to the plant height and the height of flooding.

In figure 135, the plant height of various dominants is given in relation to edaphic (expressed in consistency-units, determined by means of the falling rod method) and the hydrological factors (expressed in height relative to mean high water level).

Important vegetation boundaries seem to lie at mean high water level and at 40 cms below mean high water, where the flood frequency become respectively less than 50 % and less than 100 %. The most important vegetation boundaries lie at 100 cms below mean high water, where the duration of submergence is about 50% (or about six hours on each occasion), and at 15 cms below mean high water, where the flood duration curve changes direction and falls off very little further (see fig. 23.a. and 137) and at mean low water level, where the flood duration is 100 % i.e. continuous.

Three life form systems can be distinguished:

a. that of RAUNKIAER (1934) (fig. 139)

b. that of IVERSEN (1936) (Hydrotypes; fig. 139)

c. Sclerotypes (fig. 138).

This last group concerns a classification of all plants according to the development of the sclerenchyma using the steam method which IVERSEN (1936) adapted to his Hydrotypes, in which after treatment with steam, the "stiffness" of the dead plant material is estimated and assigned to one of three classes.

The results are given in fig. 138 and fig. 139. The life forms of RAUNKIAER are distinguished on the base of morphological adaptation to the climate. The spectra indicate (fig. 139) the location of the Biesbosch in the "hemicryptophyte climate" i.e. temperature zone. They give also information about vegetation characteristics which are not influenced by the climate. Thus, the increase in Geophytes (plants in this case with root stalk) can be explained by the increasing need at lower levels to have a good anchorage in the soil, and the need to protect the soil itself against erosion.

The decrease in Phanerophytes and Chamaephytes depends, among other things, on the factor of ice movement, which, at the lower levels, does great damage to all the vegetation which remains above the ground during the winter. The high number of Therophytes is characteristic of community Rp, which has a typical pioneer character. It grows only where other communities happen to be absent as a result of, for example, the destruction of other growth through choking under drifted plant remains (see fig. 139). Communities V4 and V5 are closely related to Rp. This is caused by the shadowing willow etage which on these low sites, hinders growth of other plants in summer time.

The difference between the Hydrotypes is determined to a great extent by the scleromorphism of the vegetation. IVERSEN (1936) considered scleromorphism as an adaptation to drought, for sclerenchyma protects the plant under wilting conditions. The mechanical influence of the current however, is in this tidal area much more important. It appears from fig. 141, that with increasing elevation (i.e. decreasing submergence-effect) scleromorphism decreases in the natural levee community. Because of its sheltered character the back swamp seems in this respect to be a much more uniform unit.

In the sedimentation, we see a parallel of this phenomenon (difference in more clayey and more sandy sediments in horizontal and vertical direction). At a similar elevation, the undergrowth of the woods seem to be less scleromorphic than the rough herbage, thanks to the sheltering effect of the wood storey. The same difference is found under the shelter of reeds. Above high water, the scleromorphism increases again. In this case, the scleromorphism can probably be considered as an adaption to drought, as IVERSEN contents.

The back swamp has a high content of Telmatophytes in IVERSEN's connotation (1936; plants with air-channels into the roots; fig. 142 and 141 – right side). This is a response to the reduced subsoil. Since Telmatophytes need a great deal of sclerenchyma, because of their open pores, which must remain open even at higher suction pressures, the scleromorphism of the back swamp is relatively high. The association Rp which has few Telmatophytes, and which grows in very sheltered places along the banks of little creeks moreover shows an ephemere character, and has then a much lower scleromorphism (see fig. 141).

The relation between the content of Telmatophytes and scleromorphism is given in fig. 140 and 141. It seems that, in addition to the clear correlation, there exists, as far as scleromorphism is concerned, a sharp distinction between back swamp and natural levee, determined by the intensity of the movement of the water. Sites more exposed to current action thus have, also if the content of Telmatophytes is equal, a higher scleromorphism as the more sheltered locations.

The characteristic that willows easily form roots on that part of their stem which is subjected to periodic submergence, is described in this chapter as a useful adaption to low lying, reduced, mostly weak subsoil. Silt is trapped in the root hairs on the stems and forms an absorption complex which receives a sufficient supply of air. For formation of stiltroots more episodic fluctuations of the water level are necessary. When the high water level holds for several days to months roots grow till they reach soil surface (fig. 136).

For some plants, the level about mean high water level seems to be analogous to the

permanent water level in areas of non-fluctuating water (e.g. *Scuttelaria, Rumex hydro-lapathum, Filipendula ulmaria*). For the first two, which are clearly ascleromorphic, the mechanical influence of the tide is obviously the limiting factor.

For many other plants, a level between high and low water, corresponds with the permanent water level referred to. (See vegetation tables, appendix 8–16).

For still others, low water level is the critical level e.g. for the drifting and floating water-plants. (In one single case, the level of the mud in the back swamp serves as the water level, – *Potamogeton natans*). These plants are always those which are held fast by the roots. Free floating water-plants do not occur permanently as a result of the strong tidal currents. Of the Amphiphytes in IVERSEN's connotation, *Sagittaria sagittifolia*, among others, does not occur as an Amphiphyte. The *f. vallisneriifolia* occurs only below mean low water, and the *f. sagittifolia* only above it. For this species, therefore mean low water is clearly analogous to the permanent water level in areas of non-fluctuating water. The Amphiphyte *Sium latifolium* is the only one which shows, in the same milieu, two types of leaf. And even here, the finely divided leaves appear above the ground first, and the less divided come after (see fig. 134). This happens also outside the tidal area (GLÜCK, 1936). It is obvious that in the case of *Sium latifolium* a more genetic factor is active, that is not influenced by ecological circumstances.

The tidal movement results in some species, which are nowhere else found together, achieve optimum growth side by side, e.g. *Caltha* and *Scirpus lacustris* and *Scirpus maritimus*. Other combinations point to the fact that the tidal influence has little or no effect, e.g. *Caltha* and *Filipendula*. The penetration to lower levels of, for example, *Caltha*, among species of rather deep submerged locations with which it does not grow together outside the tidal area, is described as the "duiker effect" (sinker-effect).

Root stalk plants reproduce themselves mostly by the multiplication of their underground parts *(Phragmites, Scirpus)*. Willows, too, can be multiplied spontaneously, as well as anthropogenic on a vegetative way, by means of broken twigs and shoots. Vegetative multiplication was also observed in *Caltha*, by means of small shoots which had taken root (fig. 143) and in *Sagittaria* by means of thickened root parts.

Generative propagation was observed in *Phragmites, Scirpus maritimus, Sparganium erectum ssp. polyedrum*, and many others.

Heracleum sphondylium, which was observed exclusively at or above mean high water as a fully developed plant, seemed nevertheless to be able to germinate below that level, according to test carried out by our collaborator HEYLIGERS (1955).

The floating mats seem to be able to make a contribution to the generative propagation of plants, in that they can act as a germinating bed which is unaffected by tidal influence. Various species even develop on these sites where they cannot, or scarcely can grow in a milieu which is affected by tidal influence.
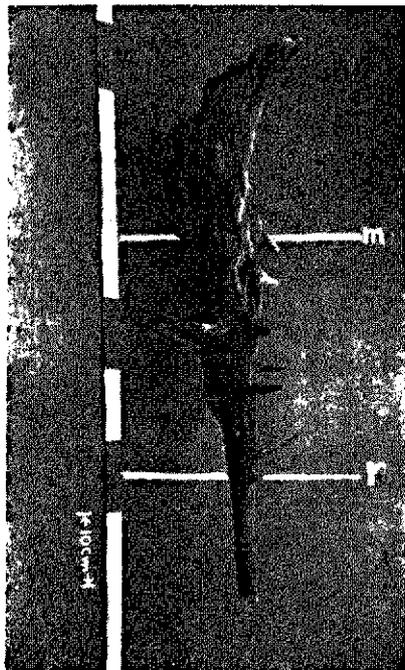
FIG. 132.

Wilgenstobbe.

De wortelontwikkeling is intensiever naarmate de doorluchting sterker is. Het onderste deel van de stek, waaruit de stobbe is gegroeid, verkeert nog in dezelfde staat als op de dag van poten. Door zuurstofgebrek kon hier geen groei optreden.

Willow trunk.

Root development is stronger in better aerated circumstances. The lower part of the cutting, of which the trunk is grown, did not change since day of planting, as a result of deficiency of oxygen at this depth.

M = maaiveld
   soil surface

R = ondergrens van de doorluchting van de grond
   underlimit of the soil aeration

FIG. 133.

Rietgors langs „vlaai" (hoofdstuk IV). Het riet daalt zeer diep af langs de glooiende oever tot dicht bij laagwater.
„Rizoom-vicinisme" (hoofdstuk XI).
juist opkomend water.

Reed-marsh along a "vlaai" (Chapter IV). The reed descends deep to short above low tide level.
"Rhizome-vicinism" (Chapter XI).
Just rising tide.

FIG. 134.

Heterofyllie bij *Sium latifolium* (Grote Watereppe).
De eerste, nog sterker verdeelde bladeren zijn reeds verdwenen.

Heterofylly at Sium latifolium.
The first more divided leaves have already disappeared.

FIG. 135.

Het verband tussen de hoogteligging van de bodem ten opzichte van gemiddeld hoogwater (M. H. W.) (horizontaal) en de lengte van enkele dikwijls dominerende kruiden (verticaal).

A. *Scirpus triqueter* (Driekantige Bies);
B. *Scirpus lacustris* (Mattenbies);
C. *Scirpus maritimus* (Heen);
D. *Typha latifolia* (Grote Lisdodde);
E. *Phragmites communis* (Riet).

De lengte van de planten werd gemeten aan de 10 langste volgroeide exemplaren van een bos, die rond de vloedtopmeter gesneden werd.

Relation between the elevation of the soil in regard to mean high tide (M. H. W.) (abscissus) and the length of some often dominating species (ordinate).

A. *Scirpus triqueter;*
B. *Scirpus lacustris;*
C. *Scirpus maritimus;*
D. *Typha latifolia;*
E. *Phragmites communis.*

The length of the plants has been measured to the 10 longest specimen of a bushel cut around the floodtop meter.

× = vaste bodem *firm soil*	r	= invloed van rizoom-vicinisme *influence of rhizome-proximity*
△ = vrij vaste bodem *fairly firm soil*	M.H.W.	= gemiddeld hoogwater *mean high tide*
□ = vrij weke bodem *fairly muddy soil*	+	= goede kwaliteit *good quality*
◯ = zeer weke bodem *very muddy soil*	—	= slechte kwaliteit *bad quality*
b = brak milieu *brackish milieu*		
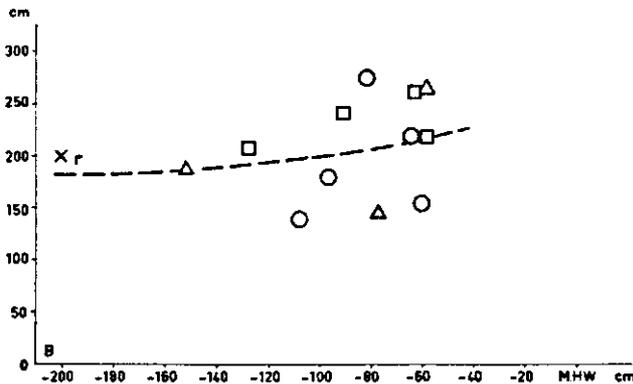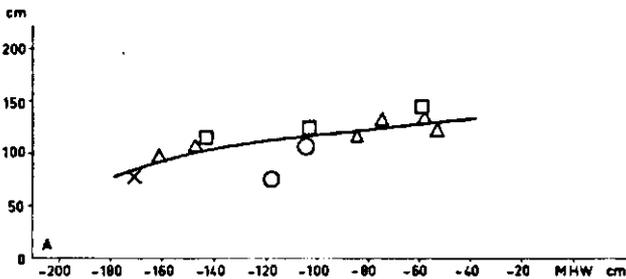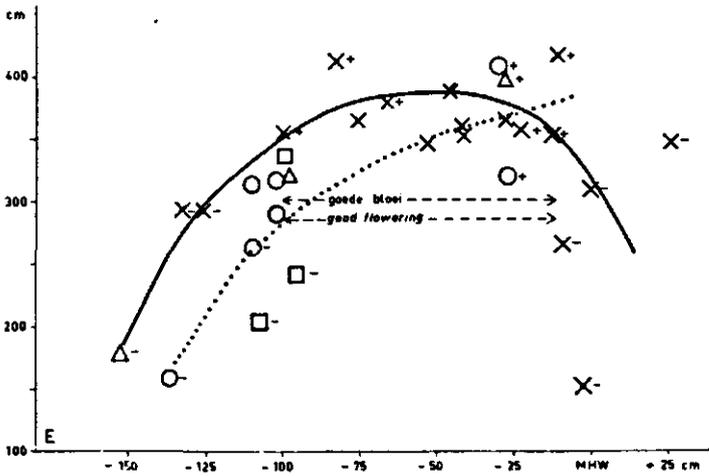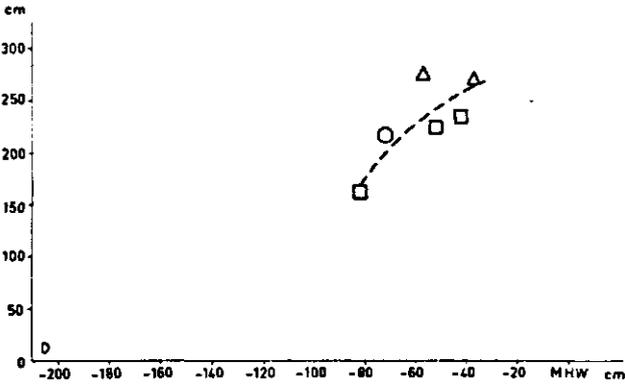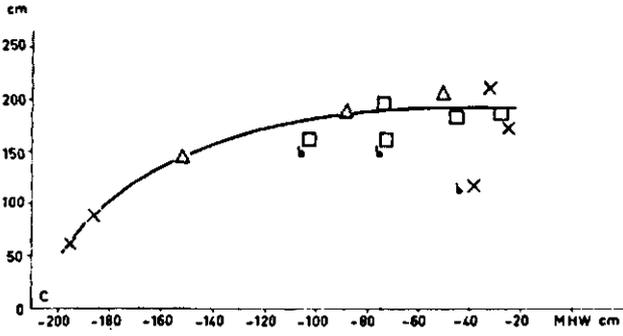
FIG. 136.

Salix alba met steltwortels, ontstaan in een milieu met episodische fluctuaties in de waterstand (augustus 1952; Loire, Montjean, Frankrijk).

Salix alba with stilt-roots, grown in a milieu with episodic fluctuations of the water-level (August 1952; Loire, Montjean, France).

FIG. 137.

Hoogte-bodemaëratiediagrammen.

Height-soil aeration diagrams.

De verschillende velden van de figuren 137A, C en E stellen de puntenzwermen per vegetatie-eenheid voor.

The various encircled areas of the figures 137A, C and E represent the cluster of points per plant community.

In de figuren 137B, D en F zijn de zwaartepunten van de puntenzwermen weergegeven.

The dots of the figures 137B, D and F respresent the centres of gravity of the clusters of points.

F = frequentie van overspoeling

F = *frequency of flooding*

D = duur van overspoeling per overspoelend tij

D = *duration of flooding per flooding tide*

De symbolen zijn dezelfde als in de legenda van de vegetatiekaart met weglating van de letter R.

The used symbols are the same as those of the vegetation map with omission of the letter R.

Punten gemerkt met een horizontale of verticale pijl geven aan dat de positie in horizontale of verticale richting onzeker is ten gevolge van een tekort aan punten.

Dots marked by a horizontal or vertical arrow-symbol indicate an unreliable position in horizontal or vertical direction, caused by a shortage of data.

FIG. 137A.
Vloedbos en griend.
Tidal forest and willow coppice.
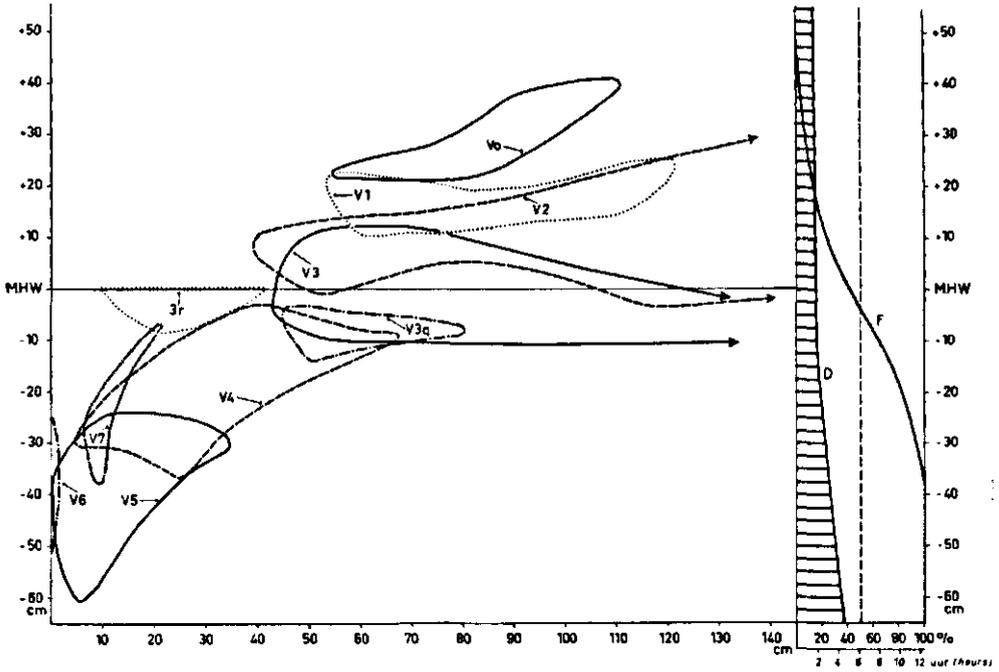
FIG. 137B.
Vloedbos en griend.
Tidal forest and willow coppice.
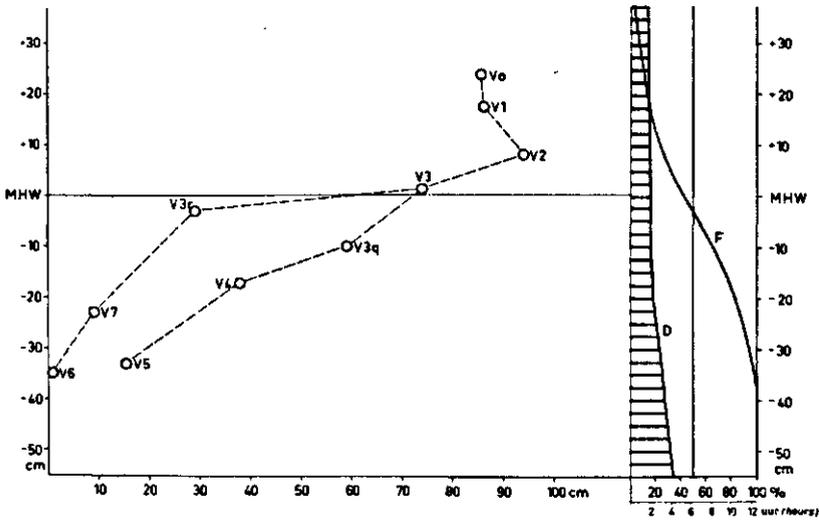
FIG. 137C.
Rietgors.
Reed-marsh.
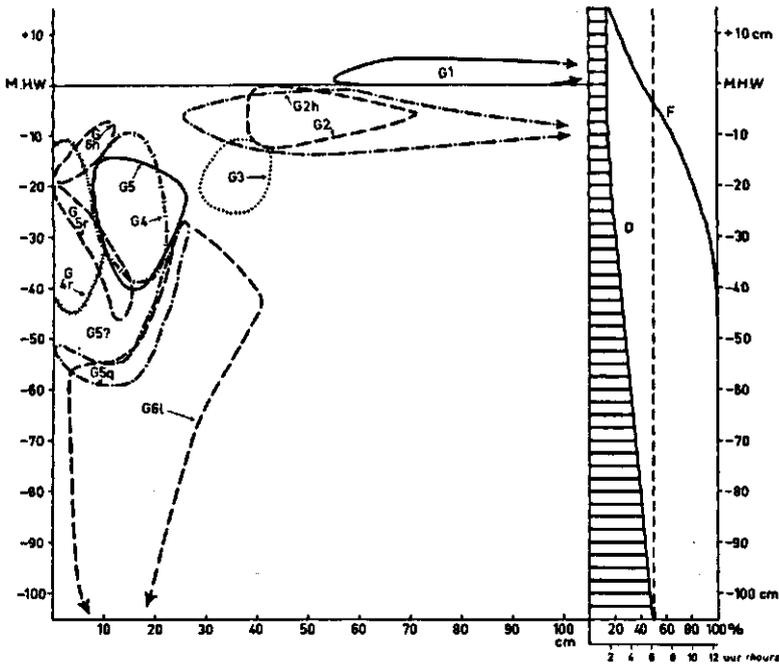
G6l laag gelegen deel van type G6
G6l *lower parts of type G6*

G6h hoog gelegen deel van type G6 (sporadisch voorkomend)
G6h *higher parts of type G6 (sporadically occuring)*

FIG. 137D.
Rietgors.
Reed-marsh.
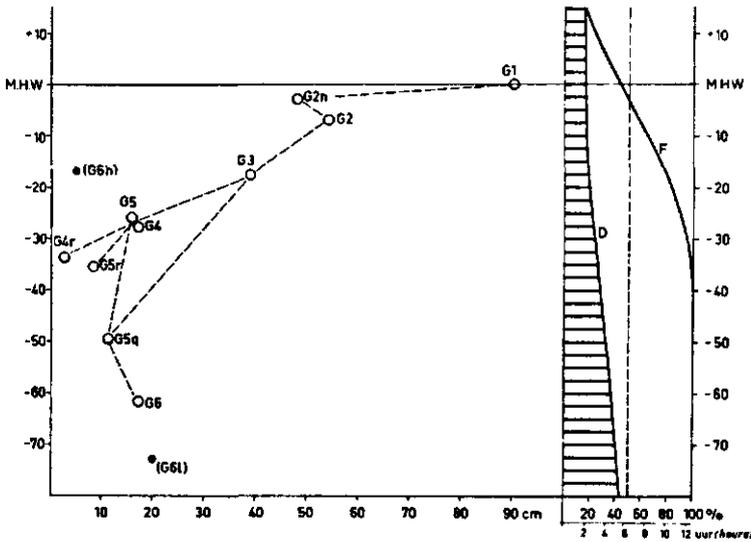
Fig. 137E.

Ruigten en biezengors.
Rough herbages and marsh of rushes.

diepte van de roest in cm
depth of iron oxide concretions in cm
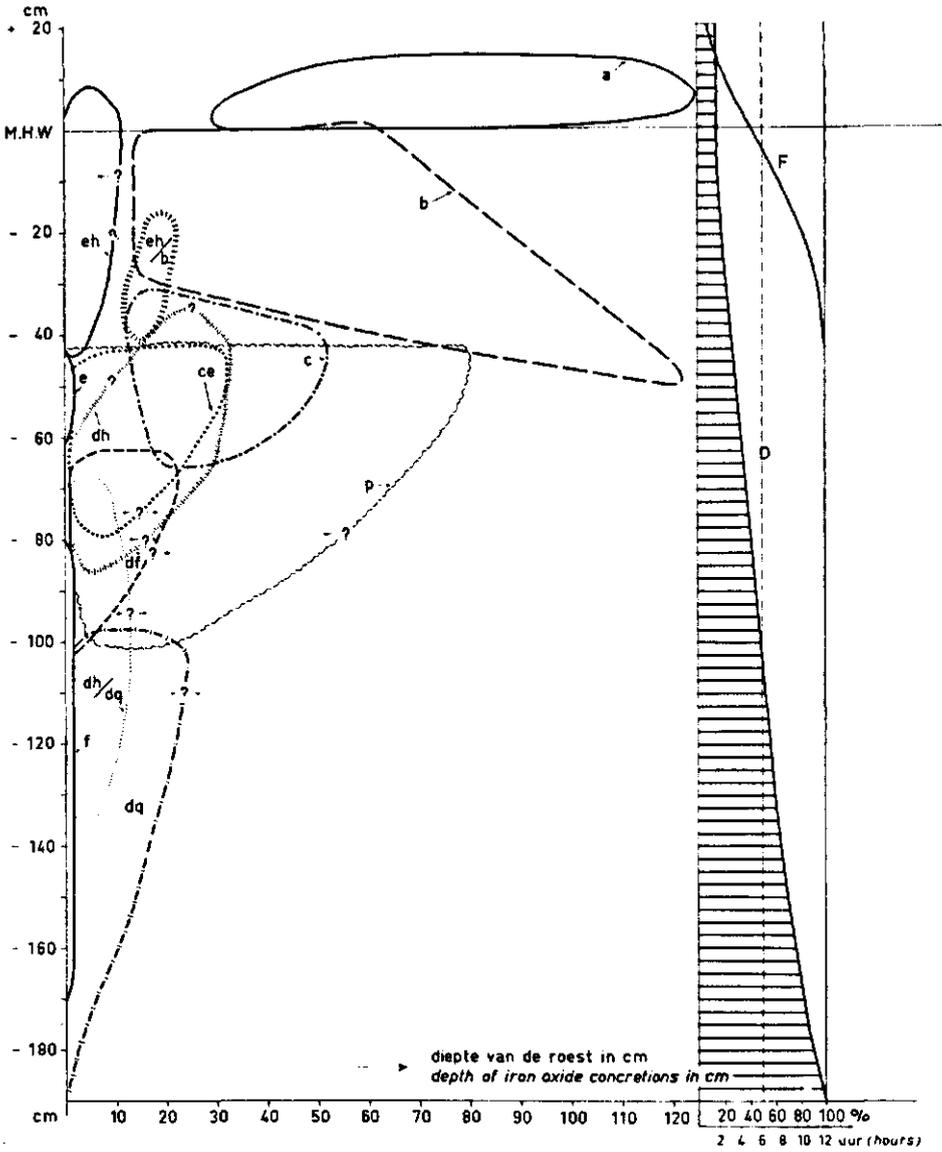
Fig. 137F.

Ruigten en biezengors.
Rough herbages and marsh of rushes.

diepte van de roest in cm
depth of iron oxide concretions in cm
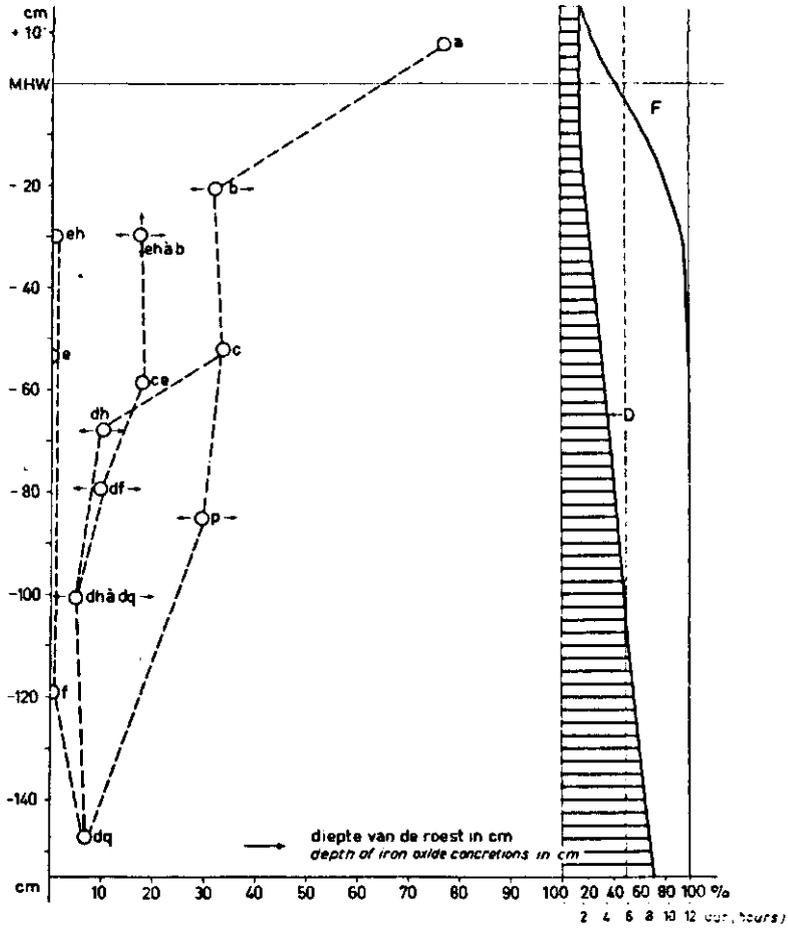
Fig. 138.

Sklerotypen-spectrum.
Spectre of sclerotypes.

Ruigte en biezengors.
Rough herbage and marsh of rushes.
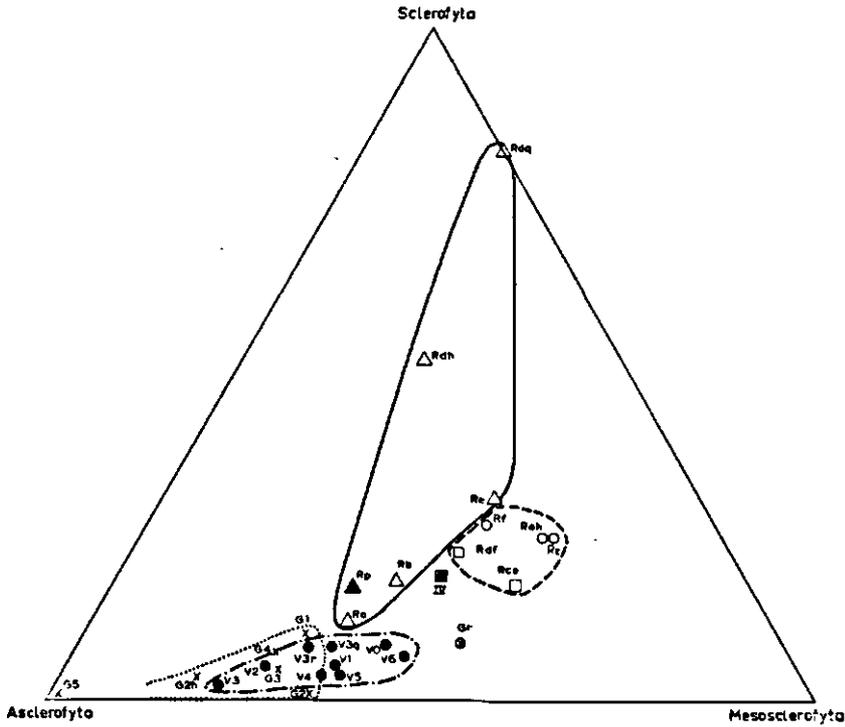
Δ   oeverwal
     natural levee   } ruigte en biezengors
○ □ kom   } *rough herbage and rush-marsh*
     back swamp

● griend en vloedbos (alleen kruiden-etage)
    willow coppice and tidal forest (layer of herbs only)

× rietgors (zonder *Phragmites* berekend)
    reed-marsh (calculated without Phragmites)

■ drijtil
    floating mat

⊗ rietgors – ruigtetype
    reed-marsh – rough herbage type

Voor de lettersymbolen zie de legenda van de vegetatiekaart.
For the letter-symbols see the legend of the vegetation map.

Fig. 139.

Levensvormenspectra volgens Raunkiaer en Iversen.
Life forms spectres according to Raunkiaer and Iversen.

V = griend en vloedbos (alleen kruidenlaag);
     willow coppice and tidal forest (layer of herbs only);

G = rietgors (berekend zonder *Phragmites*);
     reed-marsh (calculated without Phragmites);

Gr = rietgors-ruigtetype;
     reed-marsh – rough herbage type;

R = ruigte en biezengors;
     rough herbage and marsh of rushes;

(1) = oeverwal- en pioniervegetatie;
     natural levee and initial vegetation;

(2) = iets geaëreerde kom;
     somewhat aerated back swamp;

(3) = weke kom;
     muddy back swamp;

oh = vegetatie met *Hydrocharis morsus-ranae*;
     vegetation with Hydrocharis morsus-ranae;

V = vegetatie op permanent overspoelde plaatsen;
     vegetation on permanently flooded places;

IV = drijftilvegetatie.
     floating mats.

De gestippelde kolommen hebben betrekking op gegevens, die gebaseerd zijn op één enkele opname resp. op één enkele soort.
The dotted columns refer to data, based on one single observation resp. one single species.

Voor de lettersymbolen van de plantengemeenschappen zie de legenda van de vegetatiekaart.
For the letter-symbols of the communities see legend of vegetation map.

Levensvormen volgens Raunkiaer
Lifeforms according to Raunkiaer

Hydrotypen naar Iversen 1936
Hydrotypes according to Iversen

FIG. 140.

Het verband tussen de skleromorfie der vegetatie en de hoeveelheid daarin voorkomende Telmatofyten in procenten, uitgedrukt op basis van presentie.

The relation between the scleromorphy of the vegetation and the quantity occuring Telmatofytes in it, in percentage on base of presence.

1 = griendondergroei (beschut);

    willow coppice undergrowth (sheltered);

2 = idem, boven M. H. W. (kans op enige verdroging);

    ditto, above M. H. W. (chance of some desiccation);

3 = oeverwalruigte en biezengors (matig tot sterk geëxponeerd);

    natural levee rough herbage and rush-marsh (moderately to strongly exposed);

4 = komruigte en biezengors (beschut);

    back swamp rough herbage and rush-marsh (sheltered);

5 = kleine kreekoever (beschut);

    small creek bank (sheltered);

6 = rietgorsondergroei (overwegend voorkomend als kom);

    reed-marsh undergrowth (predominantly occuring as back swamp);

7 = rietgorsondergroei (overwegend voorkomend als oeverwal);

    reed-marsh undergrowth (predominantly occuring as natural levee);

8 = lijn I, waaronder uitsluitend beschutte vegetaties voorkomen.

    upper-limit of the sheltered vegetations.

FIG. 141.

Links: Het verband tussen de hoogte van het maaiveld en de skleromorfie van de vegetatie.

Rechts: Het verband tussen de hoogte van het maaiveld en de hoeveelheid voorkomende Telmatofyten, in procenten op basis van presentie.

Left: *The relation between the elevation of the soil surface and the scleromorphy of the vegetation.*

Right: *The relation between the elevation of the soil surface and the quantity of the occuring Telmatofytes in percentages on base of presence.*

1 = griend- en vloedbosondergroei
undergrowth of willow coppice and tidal fore

2 = komruigte en -biezengors
back swamp herbage and marsh of rushes

3 = oeverwalruigte en -biezengors
natural levee herbage and marsh of rushes

4 = rietgorsondergroei
reed-marsh undergrowth

5 = gemiddeld hoogwater
mean high tide

In plaats van Rk, lees Rp
Instead of Rk read Rp

FIG. 142.

Verband tussen de oxydatiediepte en het voorkomen van Telmatofyten.

Relation between the depth of oxidation and the occurrence of Telmatofytes.
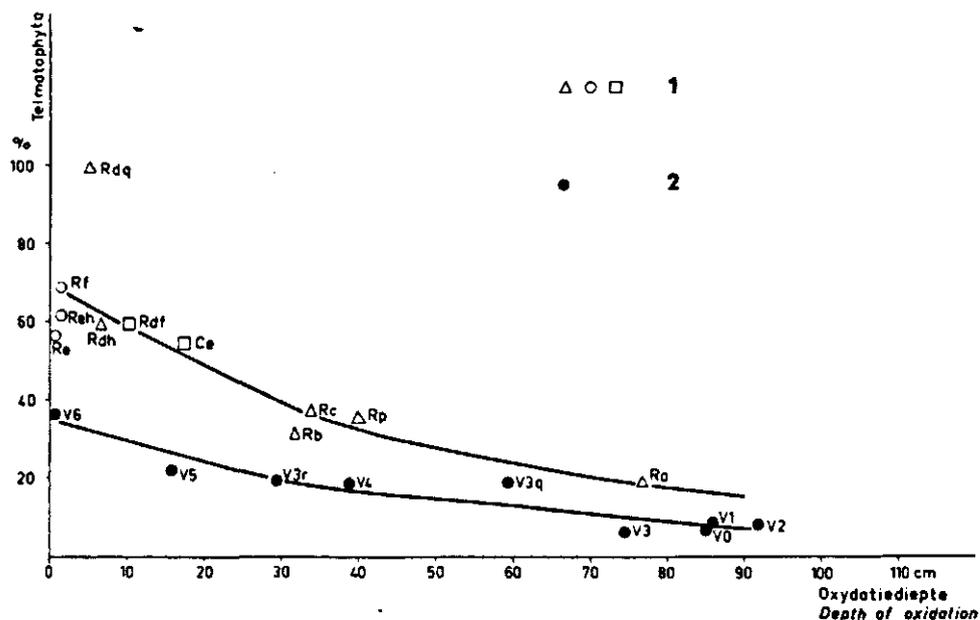
1 = Biezen en ruigtevegetatie (*Scirpetum triquetri et maritimi* en *Scirpeto-Phragmitetum calthetosum* met uitzondering van de *Phragmites*-facies).

Rushes and rough herbage vegetation (Scirpetum triquetri et maritimi and Scirpeto-Phragmitetum calthetosum, except the Phragmites-facies)

2 = Ondergroei van griend en vloedbos

Undergrowth of willow coppice and tidal forest

Het percentage Telmatofyten is berekend op basis van presentie.

The percentage Telmatofytes computed on base of presence.

Voor de lettersymbolen zie de legenda van de vegetatiekaart.

For the letter-symbols see legend of vegetation map.

FIG. 143.

Losdrijvende bewortelde spruiten van *Caltha palustris* (Dotterbloem):

A. in doorsnede,
B. van onderen.

Duidelijk is het litteken te zien, waar de spruit heeft vastgezeten aan een moederplant.

Loose floating rooted shoots of Caltha palustris:

A. transection,
B. from below.

The scar marks the former connection of shoot and mother plant.
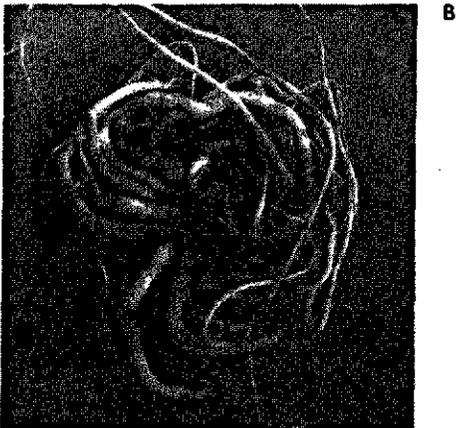
FIG. 146.

Waar het gors niet gesneden wordt, blijft het riet het volgende jaar in groei achter.
Duidelijk zijn de lange halmen met pluimen van het vorige jaar te zien. Op deze plaatsen is het gewas ruim een meter korter dan op plaatsen, waar het oude riet niet is blijven staan.

Where the plants not have been cut, the reed stays back next year.
The long reed stems survived from last year. At these places (in centre) the new shoots are about one meter shorter.

XII. VEGETATION MAPPING

Vegetation mapping enhance to a high extend the value of the results of investigation of vegetation, moreover, the geographical pattern of the vegetation is a help in adapting the results to practical ends. Only the area outside the dikes was mapped, since there was not sufficient time available for the study of the vegetation of the land inside the dikes (appendix 2).

The vegetation types were determined on the basis of vegetation records, which were arranged in table form. Only a few restricted areas were studied by means of Royal Netherlands Air Force air photos which were taken on a date and at an hour which we ourselves decided. These photos were ideally suited to the mapping of rough herbage and reed vegetations. In mapping where, above all, the combination of species and not the dominants used as a basis, a great deal of field work must, however, still be done. The base map (river map of the Rijkswaterstaat) which was excellent, even though in this quickly changing area, a little old, and which had been photopgrametrically compiled, made the use of air photos for the determination of exact location not strictly necessary.

The vegetation map is an instantaneous record: the succession carries on, and interference by man (diking, digging of ditches, etc.) can, in a short space of time, bring about alterations. The map pattern gives, in general terms, also geomorphological structure of the sedimentation features.

Along the creeks, one find vegetations which are more characteristic of more elevated and better aerated areas (natural levees), than of the central areas of the areas of sedimentation (back swamp).

The influence of the embankments is striking. A distinction is made between embankments which are intact and those which no longer, or only partly, function. The vegetation type on the crown of the embankment gives an idea of the elevation, but in particular, it points to the age. Thus, the embankments of the "Grienden van De Dood", which in part no longer function, carry the community V0, which indicates a ripe (i.e. old) soil. Younger embankments bear community V2 and V1. The type G5r is not homogeneous. It is more widespread one year than the other, as a result of the difference in speed of the growth of the reed, which in turn is dependent on the spring temperature.

One finds the community V0 principally on relatively high embanked willow coppices (formerly small pasture polders).

The types V7 are characterized by the absence of any undergrowth. In the first case, one is usually dealing with willow coppice, whose embankments have burst, and where the undergrowth, through the greater liability to submergence, has been destroyed. The still vigorous leaf-growth of the willows, which have not yet adapted themselves to the new conditions, hinders the growth of the light-loving vegetation which belongs to the lower types (V0 and V5; see also chapter XI).

With G6 one is usually dealing with a vigorous reed marsh, growing at a relative low elevation (occasionally at a higher elevation), in which the dense growth of the reed in combination with hydrological and edaphic influences hinders the growth of all other plants.

The soil and vegetation maps (appendices 1 and 2) in many cases give no visible correlation, since, as has already been pointed out (Chapter VII), the mapping criteria of the soil do not all reflect the present-day milieu. The best correlation is to be found on the youngest stage of ripening, where the texture is closely related to the aeration and the elevation of the soil. As can be seen from the rustelevation diagrams (fig. 137), a very strong correlation was to be found on maps (which have not been published) on which the reduction depth and the consistency were mapped.

XIII. COMPARISON OF THE VEGETATION OF THE BIESBOSCH WITH THAT OF OTHER AREAS, AND JUSTIFICATION OF THE SYNSYSTEMATIC CLASSIFICATION

In this chapter, remarks are made concerning the changes which the vegetations described here undergo in the transitions to the vegetations which are already known in the brackish and non-tidal river areas.

The first indicators of salt influence on the higher places towards the west are *Althaea officinalis*, *Oenanthe lachenallii*, and a little more to the seaside in the willow coppice, *Cochlearia officinalis* also appears.

At an early stage, *Scirpus tabernaemontani* GMEL. (equivalent to *Scirpus lacustris ssp. glaucus* (SM.) HARTM.) begins more and more to become dominant at lower levels. Among the species which penetrate farthest into the salt area, the following can be mentioned: *Phragmites communis*, *Typha angustifolia*, *Rumex crispus*, *Scirpus tabernaemontani*. *Scirpus maritimus* appears in the brackish area, principally in the *f. compactus* (fig. 144 and 145).

Comparison with the area of the upper river is less easy because of the scarcity of natural vegetation. Comparative studies of areas with different ratios between the duration, height and frequency of flooding, will give a better idea of the influence of the flooding factor. (In ZONNEVELD, 1955a and 1957a and b, the changes which probably will occur in the Biesbosch when the tidal influence is greatly reduced, are described).

In a half dammed-off tidal gully (Sneepkil) which experiences a tidal range of only about 1 metre, *Nymphaea alba*, *Salix cinerea* and spontaneously growing *Alnus glutinosa* which are absent in the Brabant Biesbosch, are found.

Exhaustive comparisons with the data from the inventories of old abandoned river channels (see BOTERENBROOD c.s., 1956 and VAN DONSELAAR and MÖRZER BRUYNS, 1956) cannot yet be carried out. From one or two excursions, it appears that higher up the rivers, the "sinker effect" becomes progressively less well developed as the tidal influence decreases. One characteristic difference is that in the Biesbosch, the *Agropyro-Rumicion* (NORDHAGEN, 1940) occurs seldom in natural locations, while along the rivers, this alliance is very common.

In the classification of the vegetation into units, the principle that a vegetation unit should be differentiated both on symmorphological (that is mainly floristic) and ecological grounds, is abandoned. The differentiation of the vegetation units is made rather on pure symmorphological characteristics, that is on characteristics which can be seen exclusively in the vegetation itself. The bringing in of other (ecological) characteristics endangers the use of vegetation as an independant indicator of the milieu. Mesological synecology data can be used as a guide for classification, but never as "characteristics" of the vegetation units.

In vegetation classification, one ought first to adapt the classification to the purpose which one has in mind. Later, one can fit into a wider system the units which have been described. The names, composed to the French-Swiss method, which are added to the names, which we gave to the associations differentiated, follow this principle. The making of such systems is not a purpose, but a means to an end. Better ones may therefore quite possibly exist. We felt no need to add new fundamental units (associations) to the existing system. This has been done in only one association, where it was necessary to avoid confusion *(Scirpetum triqueter et maritimi)*.

Scirpus tabernaemontani (GMEL.) *f. major* (CUSTOR) BAKKER and *Scirpus triqueter* can

be taken as selective characteristic species. *Scirpus maritimus f. typicus* can be considered as a preferential characteristic species with a definite optimum in this association.

The remaining communities are all arranged in the system as sub-associations, variants and sub-variants (see the schemes of the tables S, T and U).

It seems that various species which grow in close relation to communities belonging to the same associations outside the tidal area, do not occur in the land lying outside the dikes in the Biesbosch. This can either be a question of accessibility, or it can be caused by the fact that they are not proof against the specific tidal influence.

Below a list is given – presumably far from complete – of water- and marsh plants, which occur in the polders in the area, but which do not occur in the land outside the polders. These plants are:

Ranunculus lingua	*Comarum palustre*
Oenanthe aquatica	*Nymphoides orbiculata*
Equisetum fluviatile	*Hippurus vulgaris*
Stratiotes aloides	*Lysimachia thyrsiflora*
Cicuta virosa	*Stellaria palustris*
Hottonia palustris	*Valeriana dioica*
Ranunculus flammula	*Hydrocharis morsus-ranae*
Carex pseudocyperus	*Eriophorum angustifolium*
Utricularia vulgaris	*Lemna species*
Salix aurita	*Myriophyllum spicatum*
Lotus uliginosus	*Nymphaea alba*
Orchis majalis	*Salix cinerea*
Glyceria fluitans	

Accessibility is thus not the reason here for the absence. In the case of *Acorus calamus*, which does occur in tidal water (Rode Vaart near Moerdijk, and the Elbe delta) but which is absent in the Biesbosch, inside and outside the dikes, the opposite is true.

In this case, the species is in fact able to withstand the tidal milieu, but up till now, it has not reached the stage of spreading its diaspores into the Biesbosch. The "acclimatization" of *Angelica archangelica* is interesting; as in other west European rivers, it migrates to the lower parts of the rivers. During the investigation, we saw this plant establish itself, in the space of a few years, in the Biesbosch communities, and particularly in the communities Rb and Ra and V4, V3, V2 and V1.

In Dutch text 3.2.3. a suggestion is made for a division of the *Scirpeto-Phragmitetum* (table V). The floristic difference which depends on the difference in composition of the water and the character of its movement, is taken as the guiding principle for the distinction at sub-association level. The difference which depends on the height of the water or of the flooding, is taken as the criterion at variant level. In doing this, use is made of the tables of BOER (1942), and TÜXEN and PREISING (1942) and BOTERENBROOD c.s. (1956). One community described, in our view incorrectly, as an association by TÜXEN (1953), – ass. of *Sagittaria* and *Sparganium simplex*, is included in this provisional system as a variant. The species *Typha angustifolia* and *Ranunculus lingua*, which were named by TÜXEN and PREISING as typifying differential species for the "Teichröhricht" cannot be upheld as such, not even outside the tidal area, probably. We have, however, adopted the sub-associations made by the same authors, although under different names (table V).

The sub-association of the tidal area is named after *Caltha*, the plant which shows the "sinker effect" (see Chapter XI) so strongly, and which almost everywhere determines the aspect of this community in the spring.

It seems that the *Scirpetum triquetri et maritimi* forms the pioneer bank and levee vegetations (Rdq, Rd and Rc) and that the back swamp is the specific domain of the *Scirpeto-Phragmitetum* (Rdf, Rf, Rce and Re and Reh).

The community of *Veronica anagallis-aquatica* and *Polygonum hydropiper* (Rp) is related to various *Bidention tripartiti* associations (NORDHAGEN, 1940). The relationship with *Glycerieto-Sparganietum* (KOCH, 1926) is actually so great that we consider them to the same alliance *(Glycerieto-Sparganion:* BRAUN-BLANQUET and SISSINGH, 1942). The occurrence of these associations in the Biesbosch, indicate the relationship with the "rivulet or brook milieu" which is separated from the Biesbosch by many kilometers of river. The influence of *Glycerieto-Sparganion* (BRAUN-BLANQUET and SISSINGH, 1942) can also be seen in other communities in the tidal area, as can that of the *Bidention*-element.

The fairly important community of *Phalaris arundinacea* and *Epilobium hirsutum* (Rb) was not assigned to any particular association, but described as a typical transition community between the *Phragmitetalia* (KOCH, 1926) and the *Molinietalia* (KOCH, 1926), which still lies closest to the *Phragmitetalia.*

The community of *Heracleum sphondylium* and *Valeriana officinales* (Ra) is related to *Filipenduleto-Geranietum,* described by KOCH (1926), and to *Filipenduletc-Thalictretum,* of which a small table was published by PASSCHIER and WESTHOFF in 1942, and to *Valerianeto-Filipenduletum* (which is identical with the immediately previous association) about which WESTHOFF published a table in 1949. (See also SISSINGH in WESTHOFF c.s., 1946). The associations just named are so closely related that we would prefer to consider them as one association with different geographic forms. Preference is given to the name *Valerianeto-Filipenduletum,* since *Geranium pratense* has only a limited distribution area in central Europe.

The community of *Heracleum* and *Valeriana* (Ra) is moreover, related to the "Gezelschap van *Sonchus paluster*" – see VLIEGER and VAN ZINDEREN-BAKKER (1942) and also with the association *Stachys palustris* and *Angelica archangelica* (TÜXEN, 1949).

On fairly elevated, seldom submerged places, a community occurs which can be assigned to *Tanaceto-Artemisietum* (BRAUN-BLANQUET, 1931, 1949; see also SISSINGH, 1950) (Chapter X).

A few adventivious species, *Solidago lasiocarpa* and *Aster salicifolius* and *Aster salignis,* can occur in these communities alongside *Artemissia vulgaris, Tanacetum vulgaris* and many other tall species.

As a result of the absolute dominance of the *Phragmites* over large areas, and the consequent absence of the plants of the *Phragmition* associations which have been described as typical, the true reed-marsh communities could not be fitted into the French-Swiss system. For the description, the Scandinavian nomenclature, which is intended for dominant communities, is used (DU RIETZ, 1932). The ecological boundaries between the differentiated communities (sociations) sometimes coincide and sometimes fail to coincide with the boundaries of the rough herbage and rush communities. In appendix 7 and fig. 137C, D, E and F both cases can clearly be seen.

In general in woods associated with the rivers, a willow belt can be distinguished, which occupies the stretch immediately along the river, and which regularly is directly influenced by flooding.

Behind, another belt can often be found, in which other woody species (Ash, Elm, Oak) are present in the wood. The substratum of this last belt can either be the natural levee or it can be the transition from the channel to the higher lying land. In broader channels, the alder belt is found behind the levee, in back swamp basins.

OBERDORFER (1953) has given a fine general idea of the synsystematic classification of the woods associated with the rivers (Auenwälder). He groups these woods in central and western Europe together in the alliance *Alno-Ulmion*.

In the schemes of table U, the position of the tidal forests is given, both in the system of OBERDORFER and in the older system (see TÜXEN, 1937; WESTHOFF c.s., 1946).

With the exception of the tidal forests-community with *Carex remota* and *Circaea lutetania* (V0), all the other wood communities described belong to the willow belt, and in fact, to the alliance *Salicion* (see OBERDORFER, 1953) and to the association of this grouping *Salicetum albae* (ISSLER, 1922). This last association is identical with the *Saliceto-Populetum* (MEIJER DREES, 1936), which is not a *Populetum*, but a *Salicetum*.

The following species, which normally occur as important species in the tidal forests we have described, are scarcely if at all mentioned in the literature on woodland of the willow belt: *Salix dasyclados* (brought in from the Scheldt estuary), *Cardamine amara*, *Anthriscus silvestris*, *Heracleum sphondylium* and *Rumex obtusifolius (ssp. silvester)*. The *Salicetum albae* "Auenwälder" along the Donau in Austria, which have been fairly well described ecologically by WENDELBERGER-ZELINKA (1952), are closely related to the tidal forests. The community with *Salicetum purpureae*, described by the same author, differs very strongly from the community with *Salix purpurea* which we have described. The dominating occurrence of the ubiquitous willow which gives its name to the community, is the only thing these communities have in common.

One normally finds in the willow forests various species, which also occur outside the woodland, in all sorts of rough herbage (Hochstauden) vegetations, and which are even sometimes described as characteristic species for the woodland. The orthodox French-Swiss system is thus found to be more or less inadequate. TÜXEN (see i.a. 1950 pp. 161, 163 and 164) calls these rough herbage plants "contaminators". This seems to us incorrect; in both the natural willow forest and in the much more common cultivated forms such as osier marsh, such "weeds" constitute an integral part of the willow woodland. The distinction between characteristic species within and outside the woodland formation can clarify this position.

The distinguishing of "Schleiergesellschaften" (see TÜXEN, 1950 i.a. p. 163) is also too subjective, particularly in the willow woodland community. The species composing this further sub-division form a too integral part of the willow woodland itself (i.a. *Calystegia sepium*).

The willow coppice community of *Carex remota* and *Circaea lutetiana* (V0) is closely related to the *Cariceto remotae-Fraxinetum* (KOCH, 1926). The woody storey is usually replaced by willow, but oak and ash seedlings were, however, found. One distinction is, among others, the occurrence of *Anthriscus silvestris*, *Heracleum sphondylium*, *Rumex obtusifolius ssp. silvester*, *Carex riparia* and *Ranunculus auricomus*. So, too, is the absence of *Lamium galeobdolen*, *Lysimachia memorum*, *Primula elatior* and *Oxalis acetosella*, which are elsewhere fairly common. The *Chrysosplenium*-species, which are dependant on a constant spring water temperature (see i.e. F. M. MAAS), are also absent: the only regularly occuring characteristic species is *Carex remota*.

It is characteristic that in the Biesbosch, the community can occur over wide areas. Elsewhere, it is present only as extremely narrow belts along streams and small rivers ("Bach-Eschenwald"). The occurrence of some of the species enumerated above, can perhaps be related to this fact. "Vicinism" (contiguity or proximity) in the connotation of NORDHAGEN can easily lead to the penetration of species from the surrounding areas into narrow zones of this vegetation.

The occurrence of this community is, like that of the *Glycerieto-Sparganion* vegetations, an indication of the relationship between the rivulet milieu and the tidal area.

A relationship also exists with the *Poa palustris*-variant of the *Alnetum incanae*, which was described by WENDELBERGER-ZELINKA. According to OBERDORFER's system (1953), this last association belongs to the same sub-division as the *Cariceto remotae-Fraxinetum* namely the *Alnion (glutinosae) incanae*.

It is interesting that WENDELBERGER-ZELINKA considers the difference between the *Alnetum incanae* and the *Salicetum albae* which can occur under similar conditions of flooding, as an autogenic rather than an allogenic succession.

"Bodenreifung", which is not further discussed could be the cause of this fact. This entirely agrees with the conclusion which we ourselves have come to, that the difference between the community V0 and the other tidal forests communities is a result more of physical ripening (soil formation process under the influence, too, of vegetation – autogenic succession) rather than of higher elevation because of sedimentation (allogenic succession). See also ZONNEVELD (1958).

FIG. 144.

Rand van een vegetatie van een brak milieu bestaande uit *Scirpus maritimus f. compactus* (Heen), *Atriplex hastata* (Spiesbladige Melde), *Aster tripolium* (Zeeaster) (bij Bath, Zeeland).

Outside edge of a vegetation of a brackish milieu, existing of Scirpus maritimus f. compactus Atriplex hastata and Aster tripolium (near Bath, Zeeland).

Cliché: Natuur en Landschap

FIG. 145.

Vegetatie uit een brak milieu van *Typha angustifolia* (Kleine Lisdodde) en *Aster tripolium* (Zeeaster). (Eendenplaat, bij de dam in het Helle-gat, ten westen van Willemstad).

Vegetation from a brackish milieu of Typha angustifolia and Aster tripolium. (Eendenplaat, near the dam in the Hellegat, west of Willem-stad).

TABEL V. Suggestie tot een indeling van het *Scirpeto-Phragmitetum* KOCH (1926).
TABLE V. *Proposal to a division of the Scirpeto-Phragmitetum* KOCH *(1926)*.

Milieu *Milieu*	Mesotroof à eutroof stilstaand water *Mesotrophic to eutrophic dead water*	Eutroof al of niet stromend water *Eutrophic water yes or not running*	Eutroof water met getijdebeweging (amplitude > 1½ m) *Eutrophic water with tides over 1½ meter*
Subassociatie met: *Subassociation with:*	(typische subassociatie) [1] *(typical subassociation)* [1]	*Oenanthe aquatica* [2]	*Caltha palustris*
Hoog resp. ondiep *High resp. bar*			
variant met *variant with*	*Stachys palustris*	*Stachys palustris*	*Stachys palustris* (Reh + Re × b)
			typische variant (Re + Rce) *typical variant* (Re + Rce)
variant met *variant with*	*Sagittaria* *Sagittifolia* voorn. } *f. sagittifolia* *predom.* {	*Sagittaria* *Sagittifolia* voorn. } *f. sagittifolia* *predom.* {	*Sagittaria sagittifolia* (Rf + Rdf) uitsluitend f. *sagittifolia* *exclusively* f. *sagittifolia*
variant met *variant with*	Limnofyten (*Sagittaria* voorn. } f. *Vallisneri-* *predom.* { *ifolia*)	Limnofyten (*Sagittaria* voorn. } f. *Vallisneri-* *predom.* { *ifolia*)	Komt niet voor; in plaats hiervan *Scirpetum triquetri et maritimi typicum en Potamion*. *Does not occur; instead of it Scirpetum triquetri et maritimi typicum and Potamion*
Laag resp. diep *Low resp. deep*			
Differentiërende soorten voor de subassociaties *Differentiating species for the subassociations*			
Comarum palustre	(+)	—	—
Ranunculus linqua	+	+	—
Equisetum fluviatile	+	+	—
Oenanthe aquatica	—	+	—
Phalaris arundinacea	—	+	+
Caltha palustris	—	—	+
Vaucheria div. sp.	—	—	+

[1] ± „Teichröhricht" = *Sc.-Phr. typhetosum angustifoliae* Tx. *and* Pr. (1942).
[2] ± „Fluszröhricht" = *Sc.-Phr. phalaridetosum* Tx. *and* Pr. (1942).

APPLICATION OF THE RESULTS OF SOIL AND VEGETATION STUDY

XIV. CULTIVATION IN THE BIESBOSCH AND THE POSSIBILITIES OF APPLYING TO THE RESULTS OF THE SOIL AND VEGETATION INVESTIGATIONS

The autecology of various types of rushes can be gleaned from the description of the vegetation units and their ecology.

As a result of regular cutting in the growing season, "weeds" are kept down. Cutting more than once every two years is, however, detrimental to the rushes as well.

REED CULTIVATION

It is clear from the facts given in chapter III, V, X and XI that the growth of the reeds is encouraged by the digging of ditches and that yearly cutting in the winter season fosters a good crop of reeds.

The net yields can be very considerable (see fig. 147 and table P) and bear comparison with arable crops. The total production is very great (table P). Matting reed is the main product. The extremely stiff hard stems are very well suited to this material.

The growth locations of the reed communities G6, G5q, G5 and G3 are usually favourable to the growth of good crops of reeds as can be seen from the heights of the plants. Tennants, owners and reed cutters could confirm this for us in the field. G5r can also be favourable, but indicates an insufficiently aerated sub-stratum. G3 is still good, but indicates that the optimum height and the related flooding influence will quickly be exceeded (see fig. 135E). In G6 very low, too less aerated marshes can locally occur. The surface area of these is rather small. G4 indicates that the stand of reeds is too sparse. This is caused by a disease of the reed, without anything being lacking in the ditching or the elevation.

It can also indicate the beginnings of neglect – cessation of reed cutting for economic reasons, or damage by starlings. R types in the reed marsh indicate neglect (see also type Gr which was not used in the mapping since the most closely related rough herbage type was given). The types G2 and G2h and G1 are too high for a good growth of reeds. In G1 the reed is even so low and thin that various plants which flower in summer can establish themselves, while in G2h and G2, spring plants are still the only ones which appear.

Combatting weeds by chemical means is only worth while when even on the highest types, a reasonable crop of thatching (small size) reeds is desired. In all other cases, it is not the weeds which causes the poor growth of the reeds. But the poor growth of the reeds as a result of deficiencies in the edaphic and hydrological factors is the cause of the appearance of weeds. Good normal cultivation techniques are the best means of combatting the weeds.

Several races of reed varying in size exist. The races were not investigated in detail. The principe form is *Phragmites communis f. latifolia.*

THE CULTIVATION OF WILLOWS AND VARIOUS OTHER SORTS OF WOOD

The willow coppices of the Biesbosch have for centuries formed the cradle of the Dutch "rijswerkers" – men who made the renowned willow mats which are used in land reclamation (fig. 148) – who worked here in the winter and who carried out water and land reclamation works during the summer season in all parts of the world.

The principe product which the tidal willow coppices have always produced is "hoephout", that is the wood which was used to make the hoops for the barrel industry. For a

long time barrels with hoops of *Salix alba* from the Biesbosch served as a trade mark for Dutch herring.

At the present-day, the hoop industry is of much little more significance because of the rise of iron hoops.

The cultivation of willow, therefore, gives nowadays only more or less a bare living. Spade handles, bean poles, "rijshout", thin and crooked willow wood (formerly principally by-products) along with a little "hoephout" are now the chief products. A shortage of good workers (the true "rijswerkers" are now employed on the coastal works nearly the whole year round) is also significant.

From the general experience of these familiar with the willow coppice, and from the appearance of the woodland, it seems that types V3q, V3r, V3, V2 and V1 can produce good wood. The willows can also achieve a fairly good growth in V4, V5 is definitely too wet, and V0 is no longer optimal for willow. Type V3r indicates that the drainage and therefore the aeration of the soil is not entirely in order. Since an ecological hiatus exists between the optimal growth of reed and of willow (see Chapter X and XI) this is overcome by embanking high reed-marsh and converting it into willow coppice. A too limited discharge of the drainage culverts can also lead to the development of type V3r.

Type 4 and 5 were once used as "bittergrienden" *(Salix purpurea)*. This cultivation has been almost abandoned. Locally willow marsh with *Salix dasyclados* occurs, specially for the cultivation of "band" (binding twigs). Type V6 should not be included in the cultivated area; it is the extreme form of neglect and only *Salix purpurea* and *Salix dasyclados* manage to survive there (back swamp tidal forest).

From the experimental plot on the Beversluisplaat (see table W and fig. 150 and 151) and from the widespread planting of poplars as trees and shelter belts, it appears that a good growth of poplar is obtained in types V2, V1 and V0 – i.a. *Populus serotina erecta*, *Populus gelrica*, *Populus robusta*, *Populus serotina* and *Populus marylandica* (table W). In V2, however, the physical ripening is not yet far enough advanced; the soil is still relatively weak and the trees soon fall over (fig. 149). Type V0 is suited to the cultivation of poplars. In this type, the cultivation of poplar should be strongly recommended rather than the cultivation of willow. The cultivation of ash is to be recommended in these locations.

ARABLE AND GRASSLAND CULTIVATION

On the well developed polders, yields are obtained which are comparable with those obtained in the better marine clay areas (table X). The crop rotation is similar to that of the marine clay.

Beets constitute one of the principle products. Far too much beet used to be grown, and a good deal of the land has therefore become unsuitable for beet cultivation. The low content of potassium which was described in chapter VI is the reason that more potatoes are not grown.

The height of the dikes of the good arable polders is about 330 to 360 cm above N.A.P. There does exist the risk of breaching of the dikes during very high storm floods (fig. 154). The drainage is natural by means of sluices, but sometimes, during a very wet period, a small pumping unit is made use of.

In various polders, the water regime is not in good conditions, usually because the sluices are not low enough. Sometimes the drainage channel outside the dike has become too shallow, and sometimes the drainage ditches leading to the sluice are no longer wide enough. This neglect is usually caused by the uncertainty about the future in connection

with the "inpoldering" or diking of the whole area, which has already been mooted for a great many years. The Delta Plan (the scheme for diking off the sea arms in the south-west Netherlands) has again had a great influence on these proposals. Though previously there was talk of one huge polder with natural drainage, pumping would now be necessary, since after the carrying out of the Delta Plan, there will no longer be periods of low water to allow natural drainage.

If the polders are ever combined into one or into a number of large polders with a common pumping system, the soil conditions will have to be very much taken into account. A drainage level which is favourable for the thick clay topsoils (G-types) is dangerous for the thin clay topsoils (P-types).

The significance of the thickness of the clay topsoil is discussed in Chapter VII. Under present circumstances, drought occurs only in the elevated type P1. The remaining types never become dry as a result of the fluctuating water table (Chapter III).

It is suggested that, where thick and thin clay topsoils occur side by side, a fluctuating water table is more favourable than a constant level which gives conditions which, for the thin type, is still a little too dry, and for the thick type, too wet.

Mixing the thin clay topsoil with the sand subsoil is to be considered, in order to increase the thickness of the silt-containing layer. Where the topsoil is ploughed through, however, the farmers say that no intimate mixing occurs, because the clay is too heavy and the sand too coarse.

Other possible techniques for land improvement are a system of irrigation and partial pumping. Sprinkler irrigation is also another ultimate solution, but it is one which requires lengthy and costly capital investment.

The land improvement engineers and the agricultural economists will have to work out together which methods are to be applied. Experimental investigations into yields would, in this connection, be of great importance.

In table Y, the ideal groundwater table levels are given for each soil type, according to the generally accepted ideas at the present-day for comparable soils elsewhere.

In appendix 3, a map is given on which the elevation of the sand subsoil in the P-types is given in relation to N.A.P. Assuming that the whole area would be diked into a single polder, the danger of one drainage level can be seen at a glance.

It is clear from chapter V that the drainage depth of the land which will eventually be diked, determines the shrinkage (see fig. 57). With fairly deep drainage, most of the willow coppice will yield land comparable to the land which predominates in the present-day polders. The high sand flat soil (P) complexes outside the dikes can also be grouped in this category. Longer sedimentation will be able to give these areas only a very slightly thicker clay layer. All the reed-marshes will yield rather low ground (see table I) which, if lying between higher soils, will serve principally as pasture land. Eventually, however, with deeper drainage, it will be able to be converted into arable land. Rush-marshes, silt banks and some sand banks will only be able to be put under grass, which in the youngest stages will be of only moderate quality. What is open water at low tide (see the soil and the vegetation map, appendix 1 and 2) will remain open water, but will depending on the water level to a great or less extent become filled in with rush and reed growth.

The question of whether to dike in the whole area or not is not one which depends only on the suitability of the soil. Hydrological factors, general agricultural factors, and the steadily increasing importance of the claims of nature conservancy and recreation, all have an important role to play, especially in the Biesbosch.

In ZONNEVELD (1951b, 1952a, 1955a and 1957a and b) the problems of nature conservancy before and after completion of the Delta Scheme is discussed.

Particularly in ZONNEVELD (1955a and 1957a) a discussion is given on the future significance of the land outside the dikes with regard to the various cultivations after completion of the Delta Scheme, as a result of which tidal fluctuations will be considerably reduced.

Attention has to be paid to the fact, that the prognosis given in the mentioned papers are based on estimations of the hydrology after execution of the Delta Scheme, the actual data being still unknown.

However if in the future mean high and low water levels will deviate, e.g. rise several dms, this will cause radical changes in the reed and willow cultivation. Continuation of the willow coppice management will be impossible in many places if the average water level will rise several dms higher than proposed in the publications mentioned.

FIG. 147.
Een rietlengte van 3½ à 4 meter is normaal.
A reed lenght of 10 to 13 feet is quite normal.
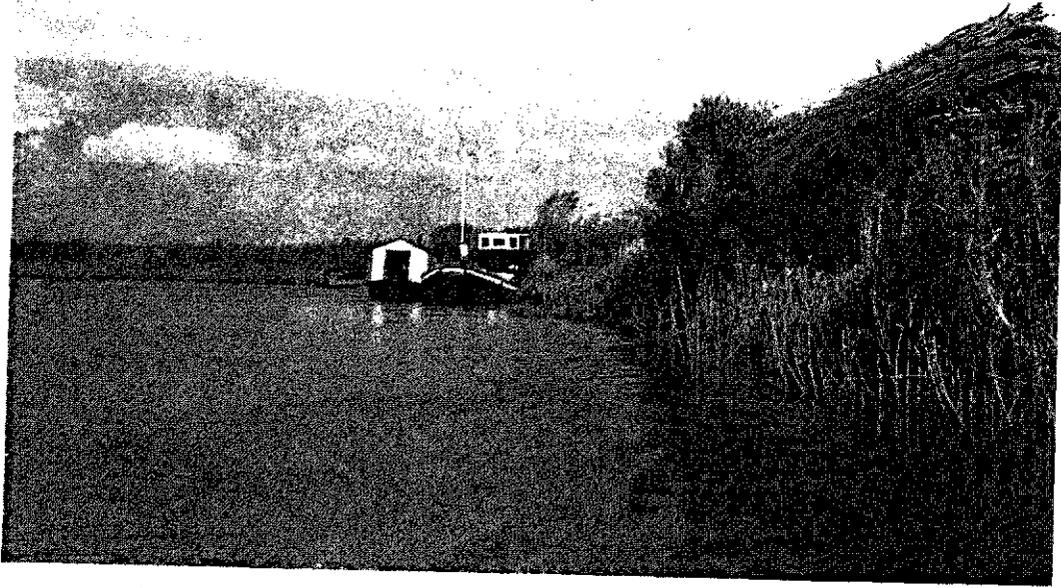
FIG. 148.

Griendbedrijf. De ark is het griendwerkersverblijf. (Buitenkooigat).
Willow coppice business. The ark is the sojourn of the willow coppice worker. (Buitenkooigat).

FIG. 149.

Aanplant van populieren (*Populus gelrica*) in type V2. De groei is goed, maar door de slappe bodem bestaat kans op omvallen.

Verder kunnen worden herkend: *Urtica dioica* (Brandnetel), *Ranunculus repens* (Kruipende Boterbloem), *Rumex obtusifolius ssp. silvester* (Bosridderzuring).

(Proefveld Beversluisplaat; november, 1954).

Stand of cotton-wood (Populus gelrica) in the community V2.

The growth is excellent, but in consequence of the muddy soil the chance of fall is high.

Further recognizable are: Urtica dioica, Ranunculus repens, Rumex obtusifolius ssp. silvester.

(Experimental field Beversluisplaat; November 1954).

FIG. 150.

Populierenproefveld, Beversluisplaat.
Duidelijk kan er een afname in vitaliteit worden geconstateerd, gaande van oeverwal (voor) naar kom (achter).
Anthriscus sylvestris (Fluitekruid), die kenmerkend is voor de oeverwal, kan duidelijk tussen de twee voorste bomen worden herkend. Voorts veel *Ranunculus repens* (Kruipende Boterbloem), *Rumex obtusifolius ssp. silvester* (Bosridderzuring) en *Poa trivialis* (Beemdgras).

Cotton-wood experimental field, Beversluisplaat.
From foreground (creek levee) down to background (back swamp) vitality decreases sharply.
Characteristic for the levee is Anthriscus silvestris (between the first two trees).
Further recognizable are: Ranunculus repens, Rumex obtusifolius ssp. silvester and Poa trivialis.

Foto: Directie Akker- en Weidebouw
Ministerie van Landbouw en Visserij

Fig. 151.

Vegetatiekaart van het populierenproefveld op de Beversluisplaat. De figuur geeft tevens de dikte van de bomen, gemeten op borsthoogte. (Oktober 1953).

Vegetation map of the cotton-wood experimental field on the Beversluisplaat. The map shows also the girth of the trees, measured at breastheight. (October 1953).

1 = Type V2   Gemeenschap van *Salix alba* (Wilg) en *Heracleum sphondylium* (Bereklauw).
Community of Salix alba and Heracleum sphondylium.

2 = Type V3   Gemeenschap van *Salix alba* (Wilg), *Cardamine amara* (Bittere Veldkers) en *Anthriscus sylvestris* (Fluitekruid).
Community of Salix alba, Cardamine amara and Anthriscus sylvestris.

3 = Type V3q Gemeenschap van *Salix alba* (Wilg), *Cardamine amara* (Bittere Veldkers) en *Vaucheria sp.* (Nopjeswier).
Community of Salix alba, Cardamine and Vaucheria sp.

4 = steile oever.
steep bank.

5 = stamomtrek op borsthoogte: 50 cm.
girth at breastheight: 50 cm.

6 = stamomtrek op borsthoogte: 12 cm.
girth at breastheight: 12 cm.

7 = dode of niet aangeslagen exemplaren.
died or not struck specimen.

De volgorde van de vakken is van links naar rechts:
The sequence of the different sectors is from left to right:
P. serotina, P. serotina erecta, P. robusta, P. gelrica, P. serotina erecta, P. serotina, P. gelrica, P. robusta.
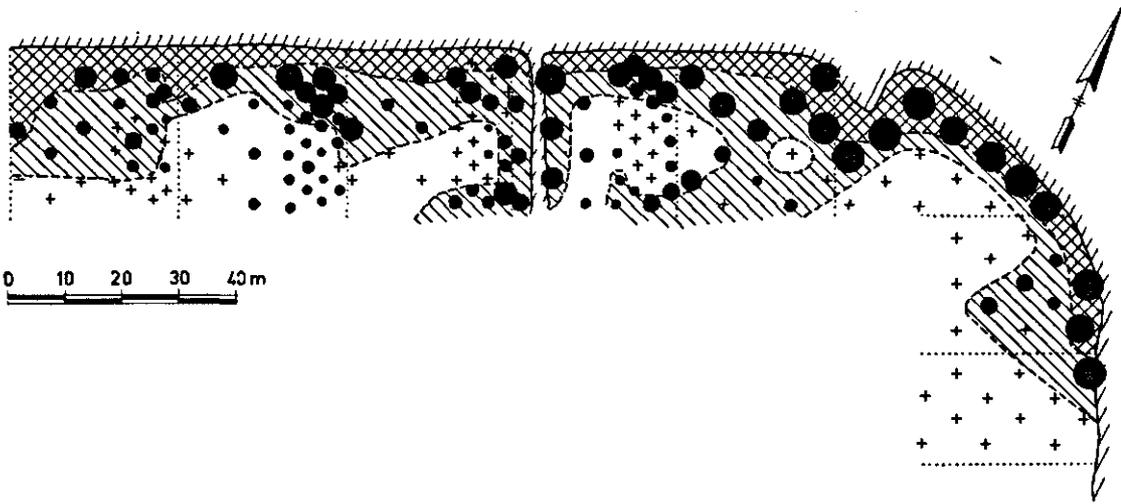
0   10   20   30   40 m
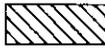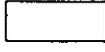
1
2
3
4
5
6
7

FIG. 154.

Augustus 1955. Dijkdoorbraak, gefotografeerd uit mast nr. 34. Hoogwater. De ringkade keert het water. Het nieuwgespoten dijklichaam komt reeds boven.

August 1955. *Dike-burst, recorded out of electricity pylon nr. 34. High tide. The provisional "ringdike" stems the water. The new dike, in construction, rises already above water surface.*

TABEL W. Populierenproefveld Beversluisplaat.

TABLE W. *Cotton-wood experimental field Beversluisplaat.*

A. Gemiddelde stamomvang van de populieren (poten en heesters), waarvan de gehele stam in leven is gebleven. Per vegetatietype berekend (okt. 1953).

Mean girth of cotton wood trees (cuttings and shrubs), of which the total trunk is still alive. Calculated per vegetation type (Oct. 1953).

Boomsoort *Tree species*	*Populus serotina*	*Populus serotina erecta*	*Populus gelrica*	*Populus robusta*
Vegetatietype *Vegetation type*				
V 2	32,2 (10)	33,5 (2)	42,0 (3)	33,0 (2)
V 3	22,0 (10)	27,5 (17)	24,7 (12)	25,7 (12)
V 3q	13,0 (2)	16,2 (18)	15,0 (13)	10,3 (3)

B. In leven gebleven exemplaren (inclusief overlevende door opslag) in procenten van het totaal aangeplante poten en heesters (okt. 1953).

Survived specimen (inclusive survivors by shoots), in percentage of the total number of planted cuttings and shrubs (Oct. 1953).

Boomsoort *Tree species*	*Populus serotina*	*Populus serotina erecta*	*Populus gelrica*	*Populus robusta*
Vegetatietype *Vegetation type*				
V 2	100 (10)	100 (2)	100 (3)	67 (3)
V 3	85 (13)	100 (20)	100 (13)	88 (17)
V 3q	28 (18)	96 (23)	56 (25)	35 (23)

C. Omvang van enkele bomen, gemeten in okt. 1953 en okt. 1954.

Girth of some trees, measured in Oct. 1953 and Oct. 1954.

Boomsoort en nummer *Tree species and number*	Vegetatietype *Vegetation type*	Meting *Measuring* October 1953	Meting *Measuring* October 1954
Populus serotina 4	V 3	34	43
Populus serotina 2	V 2	43	52
Populus serotina 1	V 2	34	46
Populus gelrica 6	V 2	48	59
Populus gelrica 1	V 2	41	50
Populus robusta 10	V 3	32	42

Alle waarden gelden op borsthoogte (130 cm). De tussen haakjes geplaatste cijfers geven het aantal bomen aan, waarover het gemiddelde berekend is. Een indruk van de spreiding der dikte krijgt men uit de vegetatiekaart van het proefveld (fig. 151).

All values apply to breast height (130 cm). Numbers in parentheses suggest the number of trees, of which the mean has been calculated. One gets an impression of the deviation of the girths from the vegetation map of the experimental field (fig. 151).

TABEL X. Enkele gegevens over bebouwde oppervlakte en produktie in de Biesbosch.

	Bebouwde oppervlakte in % *Cultivated surface in %*		Globale gemiddelde opbrengsten in kg/ha in 1955 *Roughly averaged yields in kg/ha in 1955*
	1952	1956	
Granen (tarwe, gerst en haver) *Cereals (wheat, barley and oats)*	41,2	45	wintertarwe *winter wheat* 4 500
			zomertarwe *summer wheat* 4 000
			zomergerst *summer barley* 4 100
			haver — *oats* 4 000
Suikerbieten — *Sugar beets*	20,4	16,8	±50 000
Vlas — *Flax*	15,6	10,8	7 000
Peulvruchten — *Pulses*	6,1	6,9	erwten — *peas* 3 000
Aardappelen — *Potatoes*	6,6	5,2	30 000
Graszaad — *Grass-seed*	5,1	5,4	—
Koolzaad — *Colza*	1,1	3,5	3 000
Overige — *Other crops*	3,9	6,4	—
	100 %	100 %	

TABLE X. *Some data of cultivated surface and yields in the Biesbosch.*

TABEL IJ. Gewenste grondwaterstanden in cm beneden maaiveld, na nivellering van de schommelingen; bij een veronderstelde goede waterbeheersing en een gebruik als bouwland (naar algemeen geldende normen).

De cijfers gelden voor bodemprofielen met een gemiddelde laagdikte en werden opgesteld in overleg met de hydrologische commissie van de Stichting voor Bodemkartering.

TABLE IJ. *Ideal groundwater tables in cm below surface, after levelling of the groundwater fluctuations. Drainage control and arable land use are supposed to be good (according to the generally accepted opinion).*

The numbers refer to soil profiles with a mean thickness of the layers. They have been determined in consultation with the hydrological committee of the Soil Survey Institute.

Bodemtype *Soil unit*	Zomerpeil *Summer level*	Winterpeil [1] *Winter level*
P1b — e (en P2b)	45	> 80
P2c—e (en P3b)	65 (75)[2]	> 90 (100)[2]
P3c—f	90 (100)	>100 (110)
PLa	(30)	(> 50)
PL1c	45	> 80
PL1d	50	> 90
PL2c—d	75	> 90
PL3c—d2	100	>110
G1, G1c—d, G2b, G3b	120 (160)	>130 (140)
G2c—e	120	>120
G3c—f	120	>120
GO2c—d en GO2b (d)	65	> 90
GO2c (d)	90	>110
GO3c—d	90	>110
G4c—f	> 120	>120
Ga	60	> 90
G4b	70	> 90
Gronden met k en kk ⎱ *Soils with k and kk* ⎰	—	zo diep en zo vroeg mogelijk *as deep and early as possible*

[1] Peilen, die bereikt moeten kunnen worden na een flinke periode van droogte in de winter.
Levels to be reached after a considerably dry period in winter time.

[2] De tussen haakjes geplaatste cijfers hebben betrekking op de gronden, die aan de randen van het „zandplaatgrondengebied" zijn gelegen.
The numbers between brackets refer to soils situated on the fringe of the sand-flat soil area.

XV. THE SIGNIFICANCE OF THE RESULTS OF THE INVESTIGATIONS FOR THE RECONSTRUCTION OF THE NATURAL LANDSCAPES IN THE NETHERLANDS AND THEIR SOIL FORMING PROCESSES

Despite the strong influence of man on the vegetation and soil development, there are still in the Biesbosch, many elements of a natural freshwater coastal lowland. As a study area, where all types of process can be studied, this area is of great importance to the natural field sciences (geology, pedology, biology, ecology). The study of the extreme tidal influence in its present form is very interesting. After the completion of the Delta Plan, the landscape corresponding to much of the coastal lowland of Holland before diking, will be able to be reconstructed. Then, as a result of the absence of dikes, strong ebb and flood tides of the order of those at present found in the Biesbosch, were found over only small areas, close by the coast.

The elements of the tidal rivers, such as were described by EDELMAN (1950), are well seen in the Biesbosch.

BENNEMA (1953) gives a description of a pre-historic inhabited tidal landscape near Hekelingen (Putten). In this description, many similarities with the present-day Biesbosch environment can be discovered.

Parts of the topsoil of the Westland, as described by VAN LIERE (1948) and EDELMAN (1953) must have been laid down in a freshwater tidal milieu. The high content of organic matter in reed-marsh soils in the Biesbosch indicates that even at a short distance from the main river current in a tidal milieu, considerable quantities of organic matter can be formed. At a somewhat greater distance – a situation which does not at the present-day exist in the Biesbosch – this process could lead to peat formation.

In its present state, the soil of the reed-marsh is termed a „modderklei" (very plastic, very humose clay). With a rising sea level, this clay will continue to build up and will remain plastic. In the vicinity of the rivers, "modderklei" is encountered in the subsoil over great areas of the West Netherlands.

The lime content of soils is described in Chapter VI. Investigations in this seminatural freshwater area have strenghtened us in the opinion that most of the low soils which are poor in calcium, of which the extreme forms are "knipklei" and "laklagen", owe their lack of calcium to processes during sedimentation as well as to decalcification in reducing conditions ("gley" phenomenon), rich in decomposing organic matter. "Knipklei" and "laklagen" can become decalcified to such an extent because, as can be seen from their high content of particles smaller than 2 mu and from their location in very sheltered conditions, they were laid down very gradually over a long period, allowing large quantities of organic matter to be formed. "Knipklei" soils can very early deprived of the protecting Ca-ions, under the influence of certain ion concentrations in the soil water and in the flood water, obtain their infavourable Mg-content, that according to SCHUYLENBORGH and VEENENBOS (1951) should be the cause of the bad soil structure.

"Laklagen", which were formed entirely under freshwater conditions, obtained their unfavourable characteristics in analogous way, and influenced by the climate.

Further study of geological, pedological, ecological and general biological projects has been benefitted by the setting up of a few strictly-maintained not to small reservations which have free contact with an active river. Side by side with the reservations, a cultivated landscape outside the dikes (reed, willow, woodland) will be able to continue to function as a recreation area, next to a prosperous arable land inside the dikes.

LITERATURE

T.K.N.A.G = *Tijdschrift Koninklijk Nederlandsch Aardrijkskundig Genootschap*

ACARLA, A. H. en   1952   De bodemkartering van enkele polders nabij Willemstad.
G. G. L. STEUR   *Boor en Spade* **5**, 93–102.

ADRIANI, M. J.   1945   Sur la phytosociologie, la synécologie et le bilan d'eau de halophytes de la région néerlandaise méridionale, ainsi que de la Méditerranée française. Diss. Amsterdam. Groningen.

ALLORGE, P.   1922   Les associations végétales du Vexin français. Thèses à la faculté des Sciences de Paris.

ANDEL, TJ. H. VAN, and   1955   Recent sediments of the Gulf of Paria. Reports of the
H. POSTMA   Orinoco shelf expedition. *Verh. Kon. Akad. Wet. Afd. Natuurkunde. Eerste reeks* **20** (5).

BAKKER, D.   1954   Miscellaneous notes on Scirpus lacustris L. sensu lat. in the Netherlands. *Acta Botanica Neerlandica* **3**, 425–445.

—— en A. C. BOER   1954   Mattenbiezen. *De Levende Natuur* **57**, 30–35.

BAKKER, G. DE   1950   De bodemgesteldheid van enkele Zuidbevelandse polders en hun geschiktheid voor de fruitteelt. Diss. Wageningen. Serie: De bodemkartering van Nederland, dl. 6. *Versl. Landbouwk. Onderz.* **56**. 14. 's-Gravenhage.

BARKMAN, J. J.   1953   Over de mosvegetatie van onze getijdengrienden. *Buxbaumia* **7**, 42–49.

BEEK, G. A. A. VAN   1952   Over cultuur van biezen, griend en riet in de Biesbosch. In: Een bos van biezen, 13–16. Dordrecht.

BEEKMAN, A. A.   1932   Geschiedkundige atlas van Nederland. Tekst bij kaart IV. De gewesten van Noord- en Zuid-Nederland in 1300. Den Haag.

BENDEGOM, L. VAN   1950   Enkele beschouwingen over de vorming en vervorming van wadden. *T.K.N.A.G.* **67**, 66–73.

BENNEMA, J.   1949   Het oppervlakteveen in West-Nederland. *Boor en Spade* **3**, 139–149.

——   1953a   De ontkalking tijdens de opslibbing bij Nederlandse alluviale gronden. *Boor en Spade* **6**, 40–51.

——   1953b   De bodemkundige onderzoekingen in de Vrieslandpolder bij Hekelingen, naar aanleiding van een oudheidkundige opgraving aldaar. *Ber. Rijksd. Oudheidk. Bodemonderz.* **4** (2), 10–19.

——   1954a   Holocene movements of land and sea-level in the coastal area of the Netherlands. *Geol. en Mijnb.* **16**, 254–264.

——   1954b   Bodem- en zeespiegelbewegingen in het Nederlandse kustgebied. Diss. Wageningen. *Boor en Spade* **7**, 1–93.

——, E. C. W. A. GEUZE,   1954a   Inklinkingsdag van de Nederlandse Bodemkundige Ver-
H. SMITS en A. J. WIGGERS   eniging. *Landbouwk. Tijdschr.* **66**, 459–467.

——, ——, —— en ——   1954b   Soil compaction in relation to quaternary movements of the the sea-level and subsidence of the land, especially in the Netherlands. *Geol. en Mijnb.* **16**, 173–178.

—— en K. VAN DER MEER   1952   De bodemkartering van Walcheren. Serie: De bodemkartering van Nederland, dl. 12. *Versl. Landbouwk. Onderz.* **58**. 4. 's-Gravenhage.

—— en L. J. PONS   1952   Donken, Fluviatiel Laagterras en Eemzee-afzettingen in het westelijk gebied van de grote rivieren. *Boor en Spade* **5**, 126–138.

BITTMANN, E.   1953   Das Schilf (Phragmites communis Trin.) und seine Verwendung im Wasserbau. *Angewandte Pflanzensoziologie* **7**, Stolzenau/Weser.

BIJHOUWER, J. T. P.   1950   Landschap en recreatie. *Wetenschap en Samenleving* **4**, 115–116 en 126–128.

BLOOMFIELD, C. 1950 Some observations on gleying. *Journ. of Soil Sci.* 1, 196–211.

——— 1951 Experiments on the mechanism of gley formation. *Journ. of Soil Sci.* 2, 196–211.

——— 1952 The distribution of iron and alluminium oxides in gley soils. *Journ. of Soil Sci.* 3, 167–171.

BOER, A. C. 1942 Plantensociologische beschrijving van de orde der Phragmitetalia. *Meded. no.* 44 *Zuiderzeecommissie.*

——— 1945 Riet- en biescultuur. Stencil. Plantkundig Laboratorium, Dir. Wieringermeer (N.O.P.-werken). Kampen.

BOTERENBROOD, A. J., 1956 Vergelijkend botanisch onderzoek van een aantal oude
P. J. SCHROEVERS, E. E. VAN DER rivierlopen in Nederland. Utrecht.
VOO en M. F. MÖRZER BRUYNS

BRAUN-BLANQUET, J. 1939 Lineares oder vieldimensionales System in der Pflanzensoziologie. *Chronica Botanica* 5, 391–395.

——— 1942 Sur l'importance pratique d'une carte détaillée des Associations végétales de la France. *Communication no.* 86 *de Montpellier.*

———, G. D. FULLER and 1932 Plant sociology. New York/Londen.
H. S. CONARD

——— J. PAVILLARD en 1930 Vocabulaire der Plantensociologie. *Versl. en Meded. Inst.*
W. C. DE LEEUW *Vegetatie-onderzoek Nederland*, 1.

BRUIN, P. 1938 De aanwezigheid van calcium-magnesium-carbonaat naast calciumcarbonaat in kleigronden en de ontleding dezer carbonaten onder invloed van zoutzuur, azijnzuur en de bodemzuren. *Versl. Landbouwk. Onderz.* 44 (15)A. 's-Gravenhage.

CAJANDER, A. K. 1926 The theory of forest types. *Acta Forestalia Fennica* 29, 1–108.

CONTACTCOMMISSIE VOOR 1950 Memorandum betreffende de plannen tot inpoldering van
NATUUR- EN LANDSCHAPS- de Brabantse Biesbosch. Amsterdam.
BESCHERMING

DALEN, J. L. VAN 1925 De St. Elizabethsvloed (18 November 1421) na vijf eeuwen
(pseud. JAN VAN DE MAAS) herdacht. 3e dr. (Overdruk uit: Dordrechtse Courant van 12–14 november 1921).

DELTA-COMMISSIE 1954 Afdamming zeearmen. Derde interim-advies uitgebracht aan de Minister van Verkeer en Waterstaat. 's-Gravenhage.

DENDERMONDE, M., en 1954 De Dijken. Amsterdam.
H. A. M. C. DIBBITS

DIEPEN, D. VAN 1952 De bodemgesteldheid van de Maaskant. Diss. Wageningen. Serie: De bodemkartering van Nederland, dl. 13. *Versl. Landbouwk. Onderz.* 58. 9. 's-Gravenhage.

DOEGLAS, D. J. 1952 Afzettingsgesteenten. Den Haag.

DOING KRAFT, H. 1955 Over de systematiek van plantengemeenschappen en de herziening van het systeem der Nederlandse bosassociaties. Ingenieursscriptie plantengeografie. Landbouwhogeschool, Wageningen.

———, J. BARKMAN, 1955 De tegenwoordige opvatting omtrent het associatiebegrip
I. S. ZONNEVELD, R. W. BECKING, en de systematiek van plantengemeenschappen volgens de
F. M. MAAS, W. G. B. BEEFTINK, methode Braun-Blanquet. Rondschrijven, inleiding en dis-
V. WESTHOFF en C. DEN HARTOG cussie op de 36e dag voor biosociologie en palaeobotanie van de Kon. Ned. Bot. Ver. op 22 december 1955.

DOMINGO, W. R. 1951 De physische rijping van de jongere Zuiderzeeafzettingen in de Noordoostpolder. *Van Zee tot Land* 2. Zwolle.

DONSELAAR, J. VAN en 1956 Het vegetatiekundig onderzoek van oude rivierlopen.
M. F. MÖRZER BRUYNS *Natuur en Landschap* 10, 203–212.

DROST, P. J. 1934 Een en ander betreffende de griendcultuur in ons land. *Ned. Boschbouw Tijdschr.* 7, 338, 378, 420 en 470.

——— 1948 Gaat de griendcultuur in ons land verdwijnen? *Tijdschr. Ned. Heidemaatschappij* 59, 464–468.

DULK, A. DEN — 1951 — Zeldzame ostracoden in de Biesbosch. *De Levende Natuur* 54, 176–178.

DU RIETZ, G. E. — 1932 — Vegetationsforschung mit soziationsanalytischen Grundlage. *Abderhaldens Handbuch der Biologischen Arbeitsmethoden* 11 (5), 293–480.

EDELMAN, C. H. — 1945 — Overslaggronden. Gedenkboek Dr. Ir. P. Tesch. *Verh. Geol. Mijnbouwk. Gen. Ned. en Kol., Geol. Ser.* 14, 167–173.

—— — 1946 — Over knipgronden en bodemkartering. Frysk Lânboublêd no. 34, 12 april. Herdrukt in: *Boor en Spade* 1 (1948), 176–182.

—— — 1950 — Soils of the Nederlands. Amsterdam.

—— — 1953 — De sub-atlantische transgressie langs de Nederlandse kust. *Geol. en Mijnbouw* 15, 351–364.

——, L. ERINGA, K. J. HOEKSEMA. J. J. JANTZEN en P. J. R. MODDERMAN — 1950 — Een bodemkartering van de Bommelerwaard boven den Meidijk. Serie: De bodemkartering van Nederland, dl. 7. *Versl. Landbouwk. Onderz.* 56. 18. 's-Gravenhage.

—— en W. J. VAN LIERE — 1951 — Over de woudgronden op de zeeklei van westelijk en noordelijk Nederland. *Boor en Spade* 4, 14–21.

—— en L. A. H. DE SMET — 1951 — Over de ontkalking van de Dollardklei. *Boor en Spade* 4, 104–114.

EGBERTS, H. — 1950 — De bodemgesteldheid van de Betuwe. Serie: De bodemkartering van Nederland, dl. 8. *Versl. Landbouwk. Onderz.* 56. 19. 's-Gravenhage.

ELLENBERG, H. — 1939 — Über Zusammensetzung, Standort und Stoffproduktion Bodenfeuchter Eichen- und Buchenwaldgesellschaften Nordwestdeutschlands. *Mitt. Florist.-soziol. Arbeitsgem. Niedersachsen* 5, 135.

ETTER, H. — 1949 — De l'analyse statistique des tableaux de végétation. *Vegetatio* 1, 147–154.

FEEKES, W. — 1936 — De ontwikkeling van de natuurlijke vegetatie in de Wieringermeerpolder, de eerste groote droogmakerij van de Zuiderzee. Diss. Wageningen.

—— en D. BAKKER — 1954 — De ontwikkeling van de natuurlijke vegetatie in de Noordoostpolder. *Van Zee tot Land* 6. Zwolle.

FEEN, P. J. VAN DER en G. KORTENBOUT VAN DER SLUIS — 1952 — Skeletresten uit de opgraving te Hekelingen. *Ber. Rijksd. Oudheidk. Bodemonderz.* 4 (2), 24–26.

FELBER, TH. — 1910 — Natur und Kunst im Walde. Frauenfeld.

FLORSCHÜTZ, F. — 1953 — Palaeobotanisch onderzoek in verband met de opgravingen in de polder Vriesland bij Hekelingen. *Ber. Rijksd. Oudheidk. Bodemonderz.* 4 (2), 19–24.

FOCKEMA ANDREAE, S. J. — 1950 — Studiën over Waterschapsgeschiedenis. III. De Grote of Zuidhollandse Waard. Leiden.

FUNKE, G. L. — 1951 — Waterplanten. Noorduijn's wetenschappelijke reeks 32. Gorinchem.

GASTKEMPER. F. J. — 1943 — De Brabantse Biesbosch. *De Levende Natuur* 47, 145–150 en 165–169.

GLÜCK, H. — 1936 — Pascher's Die Süsswasserflora Mitteleuropas. Heft 15.

GOEDEWAAGEN, M. A. J., C. VAN DEN BERG, D. VAN DEN BOSCH, J. BUTIJN, J. J. JONKER, D. VAN DER SCHAAF, J. J. SCHUURMAN — 1955 — Wortelgroei in gronden, bestaande uit een bovengrond van klei en een ondergrond van zand. *Versl. Landbouwk. Onderz.* 61. 7. 's-Gravenhage.

HEUKELS, H. — 1909–1911 — De flora van Nederland. Dl. 1, 2 en 3. Leiden/Groningen.

—— en W. H. WACHTER — 1942 — Geïllustreerde schoolflora voor Nederland. 12e dr. Groningen.

——, —— en S. J. VAN OOSTSTROOM — 1952 — Beknopte schoolflora voor Nederland. 8e dr. Groningen.

HEYBROEK, H. H. — 1954 — Standplaatseisen en onderlinge beïnvloeding van planten. Lezing 33e Sociologendag, georganiseerd door de Kon. Ned. Bot. Ver.

HEYLIGERS, P. C. 1954 Insecten en plantengemeenschappen. *Kruipnieuws* 16, 5-9.
—— 1955 Onderzoek naar de levensgemeenschappen van de grienden in de Brabantse Biesbosch. Practische werk van het doctoraalexamen plantengeografie en oecologie. Rijksuniversiteit, Utrecht. Stencil R.I.V.O.N.

HINGMAN, J. H. 1885 De Maas en de dijken van den Zuid-Hollandschen Waard in 1421. 's-Gravenhage.

HISSINK, D. J. 1926 Rivierkleigronden. *Versl. Landbouwk. Onderz. Rijkslandbouwproefstat.* 31. 's-Gravenhage.
—— 1935 De bodemkundige gesteldheid van de achtereenvolgens ingedijkte Dollardpolders. Bijdrage tot de kennis van het verouderingsproces van de zware zeekleigronden. *Versl. Landbouwk. Onderz.* 41 (B), 47-172. 's-Gravenhage.
—— 1952 Het gehalte aan koolzure kalk van het Dollardslib vanaf 1545 tot heden en de ontkalkingssnelheid van achtereenvolgens ingedijkte Dollardpolders. *Landbouwk. Tijdschr.* 64, 365-371.

HOEBEE, P. 1952 Watersport in de „Brabantse Biesbosch". In: Een bos van biezen, 17-19. Dordrecht.

HOEKSEMA, K. J. 1953 De natuurlijke homogenisatie van het bodemprofiel in Nederland. *Boor en Spade* 6, 24-30.
—— De verspreiding van roest in bodemprofielen in verband met de biologische homogenisatie (nog niet gepubliceerd).

HOFSTEE, W., en A. W. VLAM 1952 Opmerkingen over de ontwikkeling van de perceelsvormen in Nederland. *Boor en Spade* 5, 195-235.

HUIZINGA, I. T. K. 1940 De bodemdaling van Nederland, bezien van grondmechanisch standpunt. *Geol. en Mijnbouw* 2, 94-106.

ISSLER, E. 1926 Associations végétales des Vosges méridionales et de la Plaine Rhénane avoisinante. I. Fin.-Colmar.

IVERSEN, J. 1936 Biologische Pflanzentypen als Hilfsmittel in der Vegetationsforschung. Diss. Köbenhavn. *Meddelelser fra Skalling-Laboratoriet.* 4. Köbenhavn.

KAMER VAN KOOPHANDEL 1950 Memorandum inzake waterstaatkundige toestand in noordelijk Noord-Brabant. Tilburg.
EN FABRIEKEN VOOR
NOORD-BRABANT

KAMPS, L. F. 1950 Enige gegevens over de sedimentatie in het Waddengebied ten noorden van de provincie Groningen. *T.K.N.A.G.* 67 (Waddensymposium-nummer), 369-373.

KAMPS, L. F. 1956 Slibhuishouding en landaanwinning in het oostelijk waddengebied. Baflo.

——, W. KOOPER, 1952 Verslag van een studiereis naar de landaanwinningswerken
B. VERHOEVEN, A. J. WIGGERS langs de westkust van Sleeswijk-Holstein en Jutland.
en A. J. ZUUR Baflo/Kampen.

KIMSTRA, K. 1952 Basydiomyceten. Med. Comm. Natuurwetenschap. onderzoek in de Biesbosch. Dordrecht.

KIPPERS, M. en L. VELLEKOOP 1953 De vegetatiekartering van de rietgorzen in de Brabantse Biesbosch. Ingenieursscriptie Plantengeografie. Landbouwhogeschool, Wageningen.

KLAPP, E. 1950 Taschenbuch der Gräser. Berlin.

KLINKENBERG, W. 1943 Het Filipenduletum. *Kruipnieuws* 5, 2-3 en 7-15.

KOCH, W. 1926 Die Vegetationseinheiten der Linthebene unter Berücksichtigung der Verhältnisse in der Nordostschweiz. Systematisch-kritische Studie. Diss. Zürich. *Jahrb. d. St. Gall. naturwiss. Ges.* 61. II.

KOORNNEEF, H. 1945 De bodemgesteldheid van Niervaart, Zwaluwen en omstreken. *Versl. Landbouwk. Onderz.* 51 (11) A. 's-Gravenhage.

KRUSEMAN, G. en J. VLIEGER 1941 Plantensociologische notities in de omstreken van Gouda. *Ned. Kruidk. Archief* 51, 43-46.

KUBIËNA, W. 1953 Bestimmungsbuch und Systematik der Böden Europas. Stuttgart.

KUIPER, K. en   1954   Verslag van het onderzoek van de kalifixatie in Biesbosch-
TJ. P. WIJNGAARDEN   gronden. Ingenieursscriptie Landbouwscheikunde. Land-
bouwhogeschool, Wageningen.

KUIPERS, S. F.   1946   Tholen en Schouwen. Legenda oude polders. Intern rapport
Stichting voor Bodemkartering, Wageningen.

——   1948   De verschillen in „rijpheid" ten tijde van de bedijking van de
Nieuwlandpolders op Schouwen-Duiveland en Tholen.
Lezing gehouden voor Commissie Landaanwinning T.N.O.
Intern rapport Stichting voor Bodemkartering, Wageningen.

LANDMETER, F.   1929   Physisch-geografische verschijnselen in den Biesbosch. *Hand.
22e Natuur- en Geneesk. Congres*, 259 e.v.

——   1929   Uit het gebied van den voormaligen en tegenwoordigen
Biesbosch. *T. Econ. Geogr.* 729.20, 225–269.

——   1938   De Brabantse Biesbosch en de afsluitingsplannen. *T.K.N.A.G.*
55, 354–396.

LEBRET, T. en C. J. VERHEY   1954   De avifauna van de Biesbosch. *Wetenschapp. Meded. Kon.
Ned. Natuurhist. Ver.* **12**.

LEEPER, G. W.   1947   The forms and reactions of manganese in the soil. *Soil
Science* **63**, 79–94.

LEEUW, G. DE   1946   Sleeuwijk (en omgeving) van 1594 tot 1654. Hoofdzakelijk
naar aantekeningen van Sleeuwijks eerste predikant Ds.
Johannes Cuperus. Sleeuwijk.

LEIBUNDGUT, H.   1948   Aufbau und waldbauliche Bedeutung der wichtigsten natür-
lichen Waldgesellschaften in der Schweiz. Bern.

LELY, C.   1887   Nota over de uitkomsten der waarnemingen van het slib-
gehalte der Nederlandsche rivieren. 's-Gravenhage.

LIERE, W. J. VAN   1948   De bodemgesteldheid van het Westland. Diss. Wageningen.
Serie: De bodemkartering van Nederland, dl. 2. *Versl.
Landbouwk. Onderz.* **54**. 6. 's-Gravenhage.

——   1951   Upper holocene transgressions in the neighbourhood of the
mouth of the Meuse. *Boor en Spade* **4**, 238–243.

LINDE, J. VAN DER   1953   Bodemkundige verkenning van het Eiland van Dordrecht.
Intern rapport Stichting voor Bodemkartering, Wageningen.

LOHMEYER, W.   1953   Beitrag zur Kenntnis der Pflanzengesellschaften in der
Umgebung von Höxter a.d. Weser. *Mitt. Florist.-Soziol.
Arbeitsgem., N.F.* **4**, 59–76.

MAAS, F. M.   1953   De vegetatie van de grienden in de Brabantse Biesbosch.
Ingenieursscriptie Plantengeografie. Landbouwhogeschool,
Wageningen.

MASCHHAUPT, J. G.   1947   Opmerkingen over de ontkalkingssnelheid van Nederlandse
zeekleigronden. *Landbouwk. Tijdschr.* **64**, 372–377.

——   1948   Bodemkundige onderzoekingen in het Dollardgebied. *Versl.
Landbouwk. Onderz.* **54**. 4. 's-Gravenhage.

——   1950   Het koolzure-kalkgehalte der Dollardgronden. *T.K.N.A.G.*
67 (Waddensymposium-nummer), 374–381.

—— en D. J. HISSINK   1924   Onderzoek naar de gesteldheid van den bodem in den Zuid-
Hollandschen Biesbosch. *Versl. Landbouwk. Onderz. Rijks-
landbouwproefstat.* **29**. 's-Gravenhage.

MASSART, J.   1908   Essai de géographie botanique des Districts littoraux et
alluviaux de la Belgique. *Rec. Inst. Botanique Leo Errera* **7**,
167–584.

MEER, K. VAN DER   1952   De Bloembollenstreek. Resultaten van een veldbodem-
kundig onderzoek in het bloembollengebied tussen Leiden
en het Noordzeekanaal. Diss. Wageningen. Serie: De
bodemkartering van Nederland. dl. 11. *Versl. Landbouwk.
Onderz.* **58**. 2. 's-Gravenhage.

MELTZER, J. en V. WESTHOFF   1942   Inleiding tot de plantensociologie. Uitgave Bibl. Neder-
landse Natuurhistorische Vereniging no. 6. 's-Graveland.

MEIJER DREES, E.	1936	De bosvegetatie van de Achterhoek en enkele aangrenzende gebieden. Diss. Wageningen. Wageningen.
——	1951	Verklarende lijst van termen uit de plantensociologie en synoecologie. Rapport Bosbouwproefstation (Bogor) no. 48. Serie Vegetatie-onderzoek 2.
MODDERMAN, P. J. R.	1953	Een Neolithische woonplaats in de polder Vriesland onder Hekelingen (eiland Putten) (Zuid-Holland). *Ber. Rijksd. Oudheidk. Bodemonderz.* 4 (2), 1-19.
MOLENDIJK, L.	1947	Landaanwinningswerken in het Hollandsch Diep. *Polytechnisch Tijdschr.* (B), 226–256.
MÜLLER-STOLL, R. W.	1936	Über die Legehalme des Schilfrohres Phragmites communis Trin. *Beihefte zum Botanischen Centralblatt.* 55, Abteilung A, 61-74.
NEUMANN, A.	1952	Vorläufiger Bestimmungsschlüssel für Carex-Arten Nordwestdeutschlands in blütenlosen Zustande. *Mitt. Florist. Soziol. Arbeitsgem.* N. F. 3, 44-78.
NORDHAGEN, R.	1936	Versuch einer neuen Einteilung der subalpinen-alpinen Vegetation Norwegens. Bergens Museum Arbok, 7, 1-88.
OBERDORFER, E.	1953	Der europäische Auenwald. Beiträge zur naturkundlichen Forschung in Südwestdeutschland 12 (1).
OVERWATER, A. J.	1922	Gorzen en aanwassen van den landen van Essche. Strijensas.
PALLIS, M.	1915-1917	The structure and history of Plav. *Journ. Linnean Soc. Botany* 43.
PALLMAN, H.	1933	Die Bodentypen der Schweiz. *Mitt. a.d. Gebiete der Lebensmittel und Hygiene* 24.1.2.
PASSARGÉ, H.	1956	Die Wälder des Oberspreewaldes. *Archiv für Forstwesen* 5 (1/2).
PASSCHIER, H. en V. WESTHOFF	1942	De plantengroei in en bij het dal van de Beerze. *Natura,* 41, 91-94.
PAVILLARD, J.	1935	Eléments de sociologie végétale (phytosociologie) I. Paris.
PEARSALL, W. H.	1952	The pH of natural soils and its ecological significance. *The Journ. of Soil Sci.* 3, 41-51.
PIERCE, R. S.	1953	Oxidation-reduction potential and specific conductance of ground water: their influence on natural forest distribution. *Soil Sci. Soc. of Amer. Proc.* 17, 61-65.
PONS, L. J.	1957	De geologie, de bodemvorming en de waterstaatkundige ontwikkeling van het Land van Maas en Waal en een gedeelte van het Rijk van Nijmegen. Diss. Wageningen. Serie: Bodemkundige Studies 3. *Versl. Landbouwk. Onderz.* 63. 11. 's-Gravenhage.
—— en I. OVAA	1950	De bodemkartering van de Kraayertpolders. Intern rapport Stichting voor Bodemkartering, Wageningen.
RAMAER, J. C.	1899	Geographische geschiedenis van Holland bezuiden de Lek en Nieuwe Maas in de Middeleeuwen. *Verh. Kon. Akad. Wet.,* Afd. Letterkunde, N.R. 2 (3). Amsterdam.
RAUNKIAER, C.	1934	The life forms of plants and statistical plant geography. Oxford.
RIJKSLANDBOUWCONSULENTSCHAP VOOR DE GRIEND- EN RIETTEELT TE UTRECHT	1953	Meer riet, beter en minder kosten.
RIJKSLANDBOUWCONSULENTSCHAP ZEVENBERGEN	z.j.	Archief van grondmonsteranalysen.
RIJKSWATERSTAAT, ALGEMENE DIENST VAN DEN	1937	Beschrijving van de Provincie Zuidholland behoorende bij de Waterstaatskaart. 's-Gravenhage.
—	1946	Beschrijving van de Provincie Noordbrabant behoorende bij de Waterstaatskaart. 's-Gravenhage.
RIJKSWATERSTAAT, DIRECTIE BENEDENRIVIEREN	1944	Tienjarig overzicht der waterhoogten, 1930-1939. 's-Gravenhage.
——	1955	Afvoermetingen in de Benedenrivieren 1955. 's-Gravenhage.

ROEBROEK, A. 1950 Enige gegevens ter nadere oriëntering omtrent de indijking van de Brabantse Biesbosch. *Maandblad Landbouwvoorlichtingsd.* 7, 548–553.

SALISCH, I. VON 1902 Forstästhetik. Berlin.

SANDERS, P. en B. VERHOEVEN 1956 Verslag over een reis ter bestudering van de landaanwinning in West-Duitsland en Jutland. Baflo/Kampen.

SANTEMA, P. 1953 Enkele beschouwingen over het slibtransport van de Rijn. *De Ingenieur* 65 (7) B 37–B 41.

—— 1953 Coagulatie van rivierslib bij ontmoeting met zeewater. *De Ingenieur* 65 (16) B 70–B 72.

SCHEELE, J. 1946 Kalkafzettingen door Nederlandsche stroomen. Intern rapp. Rijkswaterstaat, Directie Benedenrivieren. 's-Gravenhage.

SCHENK, E. 1950 Archangelica im Kreise Celle. *Mitt. Florist.-Soziol. Arbeitsgem.* N.F. 2, 11.

SCHIJEN, J. M. 1948 De bodemkartering in het Land van Heusden en Altena. *Boor en Spade* 2, 49–51.

SCHÖNHAGE, H. A. 1943 De Brabantse Biesbosch en zijn bewoners. Blz. 173. Diss. Amsterdam.

SCHOTSMAN, H. D. 1954 A taxonomic spectrum of the section eu-callitriche in the Netherlands. *Acta Botanica Neerlandica* 3, 314–384.

SCHUFFELEN, A. C. en H. W. VAN DER MAREL 1955 Potassium fixation in soils. Kaliumsymposium 1955. 157–201. Bern.

SCHUILING, R. 1929 Het mooie Biesboschlandschap van heden. *Weekbl. voor Gymnasiaal en Middelb. Onderw.* October, no. 6.

SCHUURMAN, J. 1952 De invloed van kleilaagdikte, grondwaterstand en U-waarden van het zich beneden de kleilaag bevindende zand op groei en beworteling van tarweplanten. Intern rapport T.N.O.

SCHUYLENBORGH, J. VAN en J. S. VEENENBOS 1951 Over de invloed van magnesium op de structuur van sedimenten. *Landbouwk. Tijdschr.* 63, 709–714.

SIEBEN, W. H. 1951 De ontwatering van de zavelgronden in de Noordoostpolder. *Van Zee tot Land*, 3. Zwolle.

SISSINGH, G. 1950 Onkruid-associaties in Nederland; een sociologisch-systematische beschrijving van de klasse Rudereto Secalinetea Br.-Bl. Diss. Wageningen. *Versl. Landbouwk. Onderz.* 56. 15. 's-Gravenhage.

—— 1952 Ethologische synoecologie van enkele onkruidassociaties in Nederland. *Meded. Landbouwhogeschool* 52 (6).

SMET, L. A. H. DE 1954 Enkele opmerkingen over kalkarme zeekleiafzettingen. *Boor en Spade* 7, 169–173.

SMITH, G. M. 1938 Cryptogamic Botany U.I. *Algae and Fungi* 1 (6).

SMITS, H. 1953 Over de inklinking van oostelijk Flevoland. Directie Wieringermeer (Noordoostpolderwerken), Kampen.

SMITS, J. 1822 Verhandeling over de inbraak en overstroming van den Grooten Zuid-Hollandschen Waard op den 18en November 1421 (op 29 November 1821 in de Verg. v. Dordrechtsche Dep. Tot Nut van 't Algemeen). Dordrecht.

SOIL SURVEY MANUAL U.S. Dept. Agriculture Handbook 18. Washington, 1951.

SOMEREN, REYER HENDRIK VAN 1841 De St. Elizabeths Nacht Ao 1421. Dichtstuk in drie zangen. Bosch en zoon. Utrecht.

SONNEVELD, F. 1954 Enkele aantekeningen betreffende de opbouw van de bodem in het Land van Heusden en Altena. *Boor en Spade* 7, 137–150.

SPEK, J. VAN DER 1934 Bijdrage tot de kennis van zure gronden in het Nederlandsche alluvium. *Versl. Landbouwk. Onderz.* 40, 409–503.

—— 1948 Het ijzer in grond en bodem. *Chemisch Weekbl.* 44, 493–498 en 505–511.

—— 1950 Katteklei. *Versl. Landbouwk. Onderz.* 56. 2. 's-Gravenhage.

—— 1952 Over het verdwijnen van koolzure kalk uit zeeklei-afzettingen tengevolge van de oxydatie van hierin aanwezige sulfiden. *Landbouwk. Tijdschr.* 64, 473–478.

STEEN, J. C. VAN DER 1934 Over onze grienden. *De Levende Natuur* **38**, 122–126.

STRAATEN, L. M. J. U. VAN 1950 Environment of formation and facies of the Wadden sea sediments. *T.K.N.A.G.* **67**, 354–368.

—— 1953 Megaripples in the Dutch Wadden sea and in the Basin of Arcachon (France). *Geol. en Mijnbouw* **15**, 1–12.

—— 1954 Composition and structure of recent marine sediments in the Netherlands. *Leidse Geol. Meded.* **19**, 1–110.

TANSLEY, A. G. 1920 The classification of vegetation and the concept of development. *Journ. of Ecology* **8**, 118–148.

—— 1946 Introduction to plant ecology. London.

TEMME, J. en H. W. VAN DER MAREL 1952 Kaliumfixatie en verstoorde kaliumhuishouding. *Versl. Landbouwk. Onderz.* **58**. 6. 's-Gravenhage.

TUINSTRA, U. 1951 Bijdrage tot de kennis van holocene landschapsontwikkeling in het noordwesten van Noord-Brabant. Diss. Amsterdam. Groningen.

TUINZING, W. D. J. 1940 Verslag over het Rijksgriendproefveld te Langbroek en de andere griendproefvelden van 1931–1938.

—— 1951 Bestrijding van de haagwinde in het riet. Brochure Min. Landbouw, Visserij en Voedselvoorziening. 's-Gravenhage.

TÜXEN, R. 1937 Die Pflanzengesellschaften Nordwestdeutschlands. *Mitt. Florist.-Soziol. Arbeitsgem. in Niedersachsen* **3**.

—— 1950 Grundriss einer Systematik der nitrophilen Unkraut-gesellschaften in der Eurosiberischen Region Europas. *Mitt. Florist.-Soziol. Arbeitsgem.*, N.F. **2**, 94–176.

—— 1953 Sagittaria, sagittifolia-Sparganium simplex Ass. *Mitt. Florist.-Soziol. Arbeitsgem.*, N.F. **4**, 14.

—— und E. PREISING 1942 Grundbegriffe und Methoden zum Studium der Wasser- und Sumpfpflanzengesellschaften. *Deutsche Wasserwirtschaft* **37**, 10–17.

VEEN, J. VAN 1936 Onderzoekingen in de Hoofden, in verband met de gesteldheid der Nederlandsche kust. Diss. Delft. 's-Gravenhage.

—— 1940 Is de heerschende windrichting te Amsterdam sedert 1700 gekrompen? *T.K.N.A.G.* **57**, 686–706.

—— 1950 Eb- en vloedschaarsystemen in de Nederlandse getijwateren. *T.K.N.A.G.* **67** (Waddensymposium-nummer) 303–326.

VEENENBOS, J. S. en J. VAN SCHUYLENBORGH 1951 Het knip- of knikverschijnsel van kleigronden. *Boor en Spade* **4**, 24–39.

VERHEY, C. J. 1949 Het voorkomen van de Steur (Acipenser sturiol) in de Nieuwe Merwede tussen 1900 en 1931. *De Levende Natuur* **52** (8).

—— 1950 De Biesbosch in gevaar. *De Levende Natuur* **53**, 181–188.

—— 1953 Ontdekking in de Biesbosch: Een nieuwe plant op ons eiland (Cuscuta lupuliformis tr.). *Dordtse Courant*, 5 september 1953.

VERHOEVEN, A. G. 1929 Het ontstaan en de inpoldering van den Zuidhollandschen Biesbosch. *De Ingenieur*, **49**. Bouw en Waterbouw, 17.

VERHOEVEN, B. 1952 Embankment and cultivation of marine foreland. *Soil Science* **74**, 91–96.

—— 1954 Enkele opmerkingen over de groei van de schorren in de Brakman. *Langs gewonnen velden* (facetten van Smeding's werk), 88–95. Wageningen.

VERHOOP, J. A. D. 1940 Chemische en microbiologische omzettingen van ijzersulfiden in de bodem. Diss. Leiden. Wageningen.

VIS, J. A. 1928 De inpoldering van den Zuid-Hollandschen Biesbosch.

—— 1936 Het ontstaan van de polder „De Biesbosch". De inpoldering van den Zuid-Hollandschen Biesbosch. Dordrecht.

VISSCHER, J. 1949 Veenvorming. Noorduyn's Wetenschapp. Reeks 33. Gorinchem.

VINK, H. 1931 De Biesbosch. *De Wandelaar* **2**.

VLAM, A. W. 1947 Voorlopers van de bodemkartering. *T.K.N.A.G.* **64**, 773–778. Herdrukt in: *Boor en Spade* **2** (1948) 176–181.

WEEVERS, TH. 1940 De flora van Goeree en Overflakkee dynamisch beschouwd. *Ned. Kruidk. Archief.* **50**, 285–354.

WENDELBERGER-ZELINKA, E. 1952 Die Vegetation der Donauauen bei Wallsee. Eine soziologische Studie aus dem Machland. Wels.

WERFF, A. VAN DER 1939 De betekenis van de lagere algen in de sociologie. *Ned. Kruidk. Archief* **49**, 238–242.

WESTENBERG, J. 1937 Some ecological observations on Caltha palustris L. *Ned. Kruidk. Archief* **47**, 155–169.

WESTHOFF, V. 1947 The vegetation of dunes and salt marshes on the Dutch islands of Terschelling, Vlieland, and Texel. Diss. Utrecht. 's-Gravenhage.

—— 1949a Fytocoenologie. *Eerste Ned. Syst. Ingerichte Encyclopaedie* **6**, 143–149.

—— 1949b Landschap, flora en vegetatie van Botshol. Uitg. St. Commissie voor de Vecht en het oostelijk en westelijk Plassengebied. Baambrugge.

—— 1950 An analysis of some concepts and terms in vegetation study or phytocenology. *Synthese* **8**, 194–205.

—— 1954a Die Vegetationskartierung in den Niederlanden. *Angewandte Pflanzensoziologie*, Festschrift Aichinger, **2**, 1223–1231. Wien.

—— 1954b Some remarks on synecology. *Vegetatio* **5–6**, 120–128.

—— J. W. DIJK, 1946 Overzicht der plantengemeenschappen in Nederland. Amsterdam.
H. PASSCHIER en G. SISSINGH

WISBOOM VAN GIESSENDAM, 1878 De teelt van griend en teenhout in Nederland en het naburige Vlaanderen. Schiedam.
D. W. P.

ZONNEVELD, I. S. 1951a De vegetatie van het buitendijkse gebied van de Brabantse Biesbosch: een zoetwatergetijdendelta. Scriptie Plantengeografie. Landbouwhogeschool, Wageningen.

—— 1951b De Brabantse Biesbosch een natuurgebied van internationale betekenis. *Toeristen Kampioen* **4**, 101–103.

—— 1951c Vloedbossen in Nederland. *Kruipnieuws* **13**, 5–7.

—— 1952a De Biesbosch, een zoetwatergetijdendelta. *Natuur en Landschap* **6**, 170–182 en 204–221.

—— 1952b „Bodem en Vegetatie" in de Biesbosch. In: Een bos van biezen, 2–8. Dordrecht.

—— 1952c Toelichting bij de voorlopige overzichtsbodemkaart van het bedijkte gedeelte van de Brabantse Biesbosch. Intern rapport Stichting voor Bodemkartering, Wageningen.

—— 1954a De Biesbosch, *Erts* **6**, 122–127.

—— 1954b Skleromorphie als criterium bij levensvormen. Voordracht. K.N.B.V.

—— 1954c Quelques remarques sur la synecologie du delta à marées d'eau douce. *Rapports du 8ième Congrès Botanique à Paris.*

—— 1955a Natuurreservaten in de Biesbosch en het Deltaplan. *Natuur en Landschap* **9**, 113–128.

—— 1955b De geschiedenis van het ontstaan van de Brabantse Biesbosch in verband met de waterstaatkundige, bodemkundige en landbouwkundige toestand. Lezing voor de Commissie Landaanwinning T.N.O.

—— 1056a Physical ripening of fresh-water-tidal sediments (in the Biesbosch). *VIe Congrès International de la Science du Sol.* Paris. *Rapports Vol. B.*, 281–290.

—— 1956b Connections between soil survey and vegetation survey. *VIe Congrès International de la Science du Sol.* Paris. *Rapports Vol. E*, 337–342.

—— 1957a Het deltaplan en de gevolgen voor de Biesbosch. Verandering van levensmilieu. *Land en Water* 1957, no. 3 184–191.

ZONNEVELD, I. S.   1957b De betekenis van de Biesbosch voor de natuurwetenschap in het bijzonder de biologie. Akademiedagen X, 93–113.

—— 1957c Der Biesbosch in der Provinz Nord-Brabant (Niederlande). Die Landschaftsentwicklung und die Planungsaufgaben in einem Süszwassergezeitendelta. *Erdkunde XI*, 3, 223–232.

—— 1958 Bodenbildung und Vegetation im Alluvialen Gebiet. Symposion für Pflanzensoziologie und Bodenkunde. *Angewandte Pflanzensoziologie* 15. Stolzenau/Weser.

ZONNEVELD, J. I. S.   1944 Een voormalige Rijnloop bij Alphen a/d Rijn. Gedenkboek Dr. Ir. P. Tesch. *Verh. Geol.-Mijnbouwk. Gen. Ned. Kol., Geol. serie* 14, 557–566.

—— 1947 Het kwartair van het Peelgebied en de naaste omgeving (een sediment-petrologische studie). Diss. Leiden. Maastricht. *Med. Geol. Stichting, Serie C-VI*, 3.

ZUUR, A. J.   1932 Over de ontzilting van den bodem in den Andijker Proefpolder. *Meded. 2 Comm. v. Advies omtrent landbouw-techn. aangelegenheden betr. Proefpolder nabij Andijk*, 185–275.

—— 1939 Bodemvorming in Nederland uit jonge zeeafzettingen. *T.K.N.A.G.* 56, 62–80.

—— 1951 Ontstaan en aard van de bodem van de Noordoostpolder. *Van Zee tot Land* 1. Zwolle.

—— 1954 Bodemkunde der Nederlandse Bedijkingen en Droogmakerijen. Deel A (in voorbereiding) en Deel B: De hoofdsamenstelling en enkele andere z.g. chemische bestanddelen van de op het water gewonnen gronden. Kampen.

—— e.a. 1948 Over de eisen, welke de landbouw stelt aan de samenstelling van aan te winnen grond met name aan het kleigehalte en aan de dikte van de kleihoudende laag. Rapport Werkgroep uit de Commissie Onderzoek Landaanwinning. Kampen.

—— G. BAKKER en H. R. LUBBERS 1955 Over de betekenis van de fractie 0–2 en 0–16 mu voor de indeling der zwaardere gronden in de Noordoostpolder. *Langs gewonnen velden (facetten van Smeding's werk)*, 131–142. Wageningen.

SUPPLEMENTED LITERATURE

DOPPERT, J. W. CHR. en J. I. S. ZONNEVELD 1955 Over de stratigrafie van het Fluviatiele Pleistoceen in W. Nederland en Noord-Brabant (voorlopige mededeling). *Meded. van de Geologische Stichting.* N.S. No. 8: 13–30.

GROOT, A. J. DE 1956 Influence of age and organic matter on the availability of manganese in marine and estuary soils. *VIe Congrès Int. de la Sci. du Sol. Paris. Rapports vol.* B, 531–541.

NORDHAGEN, R. 1940 Studien über die maritime Vegetation Norwegens. I. Die Pflanzengesellschaften der Tangwälle. *Bergens Museum Arbok 1939/40, Naturvidenskapelig Rekke*, 1 (2) 1–123.