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FINAL Report

ON THE POSSIBLITIES OF DETERMINING THE BASIN CHARACTERISTICS BY MEANS OF SATELLITE IMAGES

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15. Abstract

ERTS-1 data was analyzed to find out, whether it is possible to determine the basin characteristics of river basins in Finland solely by means of satellite images. The ERTS-1 images used in this study were taken 30.8.1972 and 31.8.1972, and the test site is situated in Western Finland near Vaasa. Percentage of cultivated land, volume of growing stock, percentage of peat land and coarse soils were interpreted and the results were compared with topographic and soil maps. Cultivated lands and peatlands are the most easy ones to interpret while the interpretation of the volume of groving stock and coarse soils is more difficult. It is obvious that the basin characteristics mentioned above can be interpreted with sufficient accuracy by means of ERTS-images.

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On the possiblities of determining the basin characteristics by means of satellite images

Abstract

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1 Background

When making runoff forecasts and models the basin characteristics are one thing the knowledge of which improves the results and the usability of the forecasts and models. In Finland, effects of meteorologic and basin characteristics of runoff and disharge have been investigated by means of small basins (area 0,12 - 122,00 km^2). According to these studies, land slope, percentage of cultivated land, volume of groving stock, percentage of peat land and coarse soils are the most important basin characteristics in Finland.

The aim of this study is to investigate whether it is possible to determine the basin characteristics solely by means of satellite images, because the determination of the basin characteristics of large basins by means of maps and aerial photos is laborious and slow. The test site is situated in Southern Bothnia near Vaasa and it consist of Närvinjoki and Teuvanjoki basins. The total area of Närvinjoki basin is 996 km^2 and Teuvanjoki basin 530 km^2. The lake percentages are correspondingly 0,07 and 0,12 (see Appendix 1).

2 Methods of analysis

The interpretation of satellite images was based on a ground inventory, made

in summer 1973, and on interpretation experiments outside the test site. These experiments were made by means of topographic maps (scale 1:20000), the general map of Finland (scale 1:400000), a soil map (scale 1:400000) and a ground inventory. In Figure 1, there is a sematic figure of a typical Finnish terrain of those areas been under water after the latest glacial period. This kind of order of terrain types and soils, either complete or partly complete, exists at the whole test site and the interpretation of basin characteristics was mainly based on the interpretation of different kinds of terrain types.

In this study, following ERTS-1 images were used:

ID number	type of image	
1038-09275	9,5" x 9,5" bulk B&W, MSS	bands 4, 5, 6, 7
1038-09275	9,5" x 9,5" bulk color, MSS	
1039-09333	9,5" x 9,5" bulk color, MSS	

The images were taken 30.8.1972 and 31.8.1972 and their quality was exellent.

By investigating one bog and terrain types around it, it was possible to make suitable color composites for the interpretation. The investigation was done as follows:

Positive MSS B&W transparency images (bands 4,5 and 7) were printed on Agfa Geavert's lithographic film, Gevalit Ortho 0 38 P, so that the scale become about 1:20000.

On the basis of the topographic map, test lines were selected, the densities of which were measured by means of Quanta Log diffuse densitometer in the B&W transparent photos. The terrain types of these test lines were interpreted using the topographic map and the ground inventory. In the Appendix 2, there is a map including these test lines and in Appendix 3, the results of the density measurements are presented.

On the basis of these density measurements, color composites were made so that spruce forest got dark green color. Thus, the color differences of other terrain types were very good. The scale of color composites was about 1:400000 and they were made on Kodak Ektacolor Print Film and Kodak Ektacolor 37 RC paper . These images and color composites 1:1000000 from NASA were used in the final interpretation. In Appendix 4, there is an example of a

color composite made on Kodak Ektacolor 37 RC paper.

The images were interpreted by means of Interpretoskop II made by VEB Carl Zeiss JENA. The magnifications used were 2-5 or the interpretation was made in scales 1:1000000 - 1:80000.

3 Results

The error in area measurements of terrain types was about 10 % consisting manly of the error in determining the borders exact. It was possible to determine the total area of the test site with the accuracy of 5 percent.

In the test site following things were interpreted:

- cultivated lands
- swamps, which were divided into open bogs and spruce-hardwood swamps
- forest land, which was divided into pine and spruce forests, spruce-hardwood forests and spruce-hardwood swamps. (According to the standards of the Finish forest inventory forest land has the potential quality for producing a mean annual increment of at least 1 m^3/ha of steam wood including barck, during a rotation of 100 years and under favorable stand conditions).
- soils, which were divided into peatlands, coarse soils and other soils (fine soils). Boulders, gravel soils, gravel moraine soils, sand soils and sand moraine soils were included in coarce soils. Finesand soils, finesand moraine soils, silt soils, silt moraine soils, clay soils and clay moraine soils were included in fine soils.

Because of the small scale of the images it was necessary to generalize the description of the interpretation results. If the scale of the prints of the satellite images had been for example 1:100000, the results might have been more accurate as can be seen in the map in Appendix 5.

Cultivated lands are presented in Figure 2. Cultivated lands are easy to interprete provided they are not too small and they are not in the middle of a forest or a swamp, in which case they are easily mixed with open bogs (see Appendix 5, Number 1). Percentage of cultivated land is 28 measured in images. The same percentage is 26 measured in maps.

Open bogs are easy to interprete. It is, however, impossible to distinguish a ditched swamp from spruce-hardwood swamps, because the vegetation of swamps is changed by draining, so that they get vegetation like spruce-hardwood swamps (see Appendix 5, Number 2). Open bogs cover 30 % (129 km^2) of the total swamp area and spruce-hardwood swamps and ditched swamps 70 % (299 km^2) of the total swamp area. Percentage of swamp is 28 in the test site measured in the images. According to the 4th national inventory of Finnish forests in 1961 the swamp percentage is 39 %. When ditched swamps are excluded the percentage is 30 %. Most of these ditched swamps have changed so much in eleven years, that they can be included in spruce-hardwood forests in 1972.

As a rule, spruce-hardwood swamps and ditched swamps are easy to distinquish from open bogs and other forest types, excluding bushes and in some cases hardwood forests. These forests were, however, very small in number in the test site. Swamp types are presented in Figure 3.

On the basis of the volume of growing stock, forests were divided into three classes:

- coniferous forests consisting of pine forests and spruce forests on mineral soils. These types were quite easy to interprete because of their dark color in the image. The mean volume of growing stock is in these forest types about 180 m^3/ha (see Appendix 5, Number 3). These forests cover 10 % (99 km^2) of the total forest area and the total volume of growing stock was 17820000 m^3.

- spruce-hardwood forests consisting mainly of spruce and birch. The soil type of these areas is in part mineral in part organic soil (small ditched or spruce-hardwood swamps). The mean volume of growing stock of these forests is about 130 m^3/ha (see Appendix 5, Number 4). Most of the forests of the test site belonged into this group. These forests cover 59 % (582 km^2) of the total forest area, and about 10 % of this area is cleared by cutting (volume of growing stock 0 m^3/ha). The total volume of growing stock was 68094000 m^3.

- spruce-hardwood swamps, which were relatively easy to interprete (see Appendix 5, Number 5). The mean volume of growing stock of these swamps is about 80 m^3/ha. These areas cover 31 % (299 km^2) of the total forest area and about 10 % of this area is cleared by cutting (volume of growing stock 0 m^3/ha). The total volume of growing stock was 21520000 m^3.

The total forest area is 980 km^2 and the mean volume of growing stock is 109 m^3/ha by means of this interpretation. According to the 5th national inventory of Finlands forest resources in year 1968 the mean volume of growing stock was in this area 91 m^3/ha. The change in growing is according to the earlier inventories about +17 % in 14 years in this area (1). Thus the volume of growing stock is nowadays about 96 m^3/ha in the test site.

In Figure 5 the three forest classes are presented and in Appendix 5 an example of the interpretation of these three classes and open areas are presented. Open areas consist manly of cultivated lands, areas cleared by cutting, open bogs and roads.

The interpretation of soil types was mainly based on the interpretation of vegetation and terrain types, and the interpreted soil types were coarse soils, peatlands and other soils (fine soils). In Figure 4, these three groups of soils in the test site are presented, and in Appendix 6, there is a soil map of the test site. Peatlands were the most easy ones to interpret. Coarse and fine soils could also be distinguished as well, but sometimes, the limit between them was impossible to determine. Peatlands cover 33 % (503 km^2), coarse soils 42 % (641 km^2) and fine soils 25 % (382 km^2) of the total area. The total area of peatlands is changig all the time because of the drainage. According to the general geological map of Finland (1954) the area of peatland cover about 35 % of the total area. Open bogs cover 25-35 % and spruce-hardwood swamps 65-75 % of the total swamp area. It is not possible to compare the results of the interpretation of coarse and fine soils with the general geological map. The soil map in Appendix 6 is quite much generalized and thus, it is possible by means of satellite images to determine the limits between peatlands and mineral soils better. It may also be noted that in the general map (Appendix 1) the swamps are sometimes different from the peatlands in the soil map. It is obvious that the utilization use of satellite images in making general maps and soil maps would improve the right generalization of these maps.

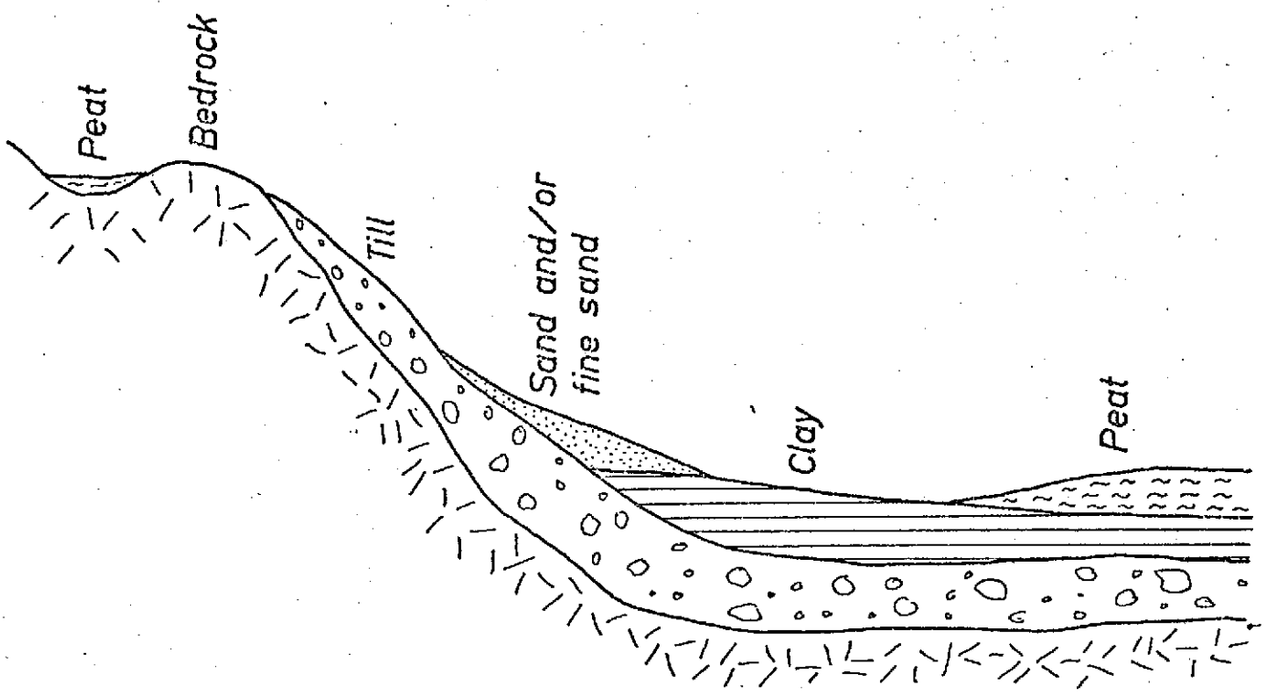
4 Conclusions

The interpretation of the basin characteristics based only on ERTS-1 images gives adequately good results in Finland. It is possible to detrmine cultivated lands, forests and swamps exactly enough. By using only three categories, it obviously is possible to approximate the volumes of growing stocks. Peatlands and mineral lands are distinguishable very well, while it is sometimes rather difficult to distinguish coarse soils from fine soils, but it is obvious that satisfactory results can be achieved. Lakes and rivers are easy to interpret.

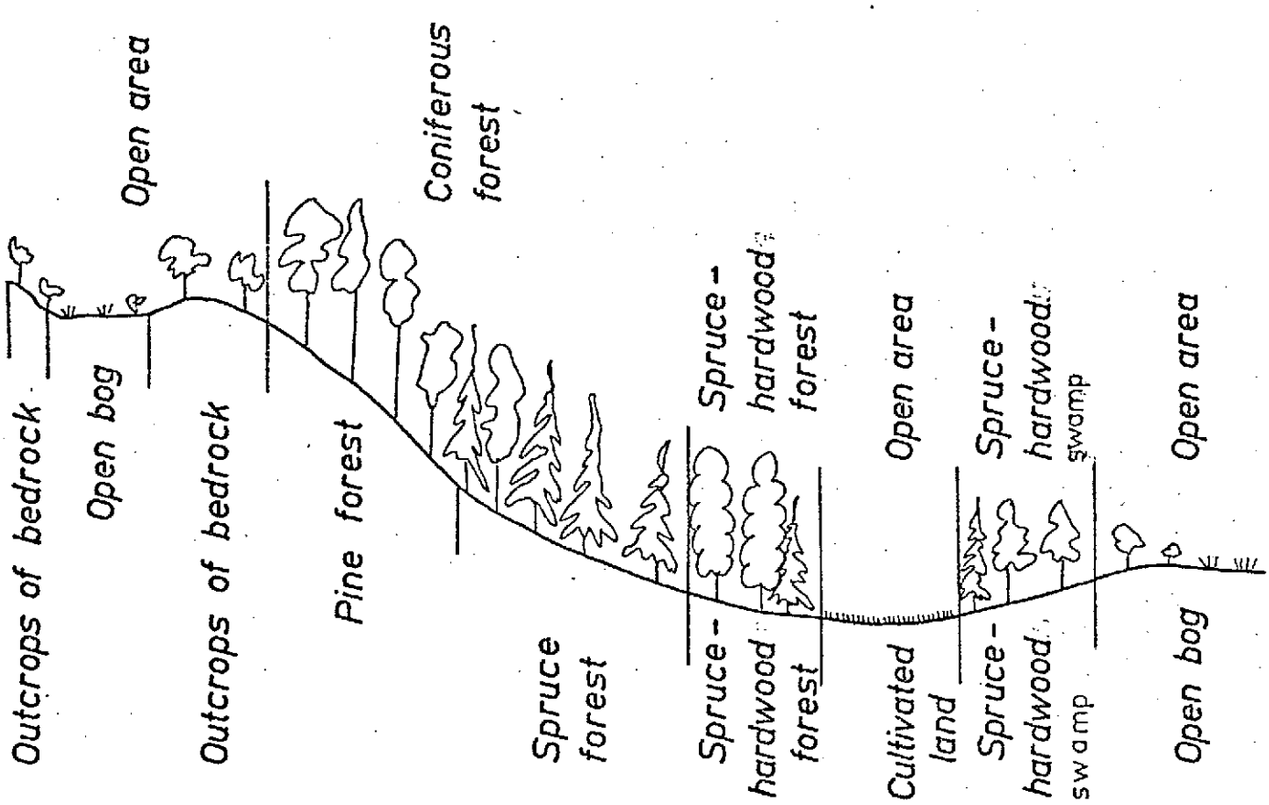
If it is possible to use suitable maps with satellite images, the results will obviously be better in some cases than solely by means of satellite images. On the other side, suitable maps may sometimes reduce the need of satellite images. Because the determination of the areas of terrain and soil types is an essential part of the determination the basin characteristics, the satellite images must be precisen processed. It is obvious that by improving interpretation technics by using digital interpretation of satellite images, it is possible to determine the basin characteristics of the river basins of Finland in the most suitable way. In 1974 Technical Research Center of Finland has started a study, one aim of which is to find out the possibilities of automated pattern recognition in determining basin characteristics. The data used in this investigation is ERTS vido data and Bendix M^2S scanner data. After this investigation it is possible to say, how we will use ERTS imagery in watershed studies.

References: Kuusela, K. 1970. Forest recources in Southern half of Finland in 1964-1968 and their development. Metsäntutkimus-laitoksen julkaisuja 71.1. Helsinki. /1/.

Figure 1



1 Soil types



2 Vegetation and terrain types

Figure 2

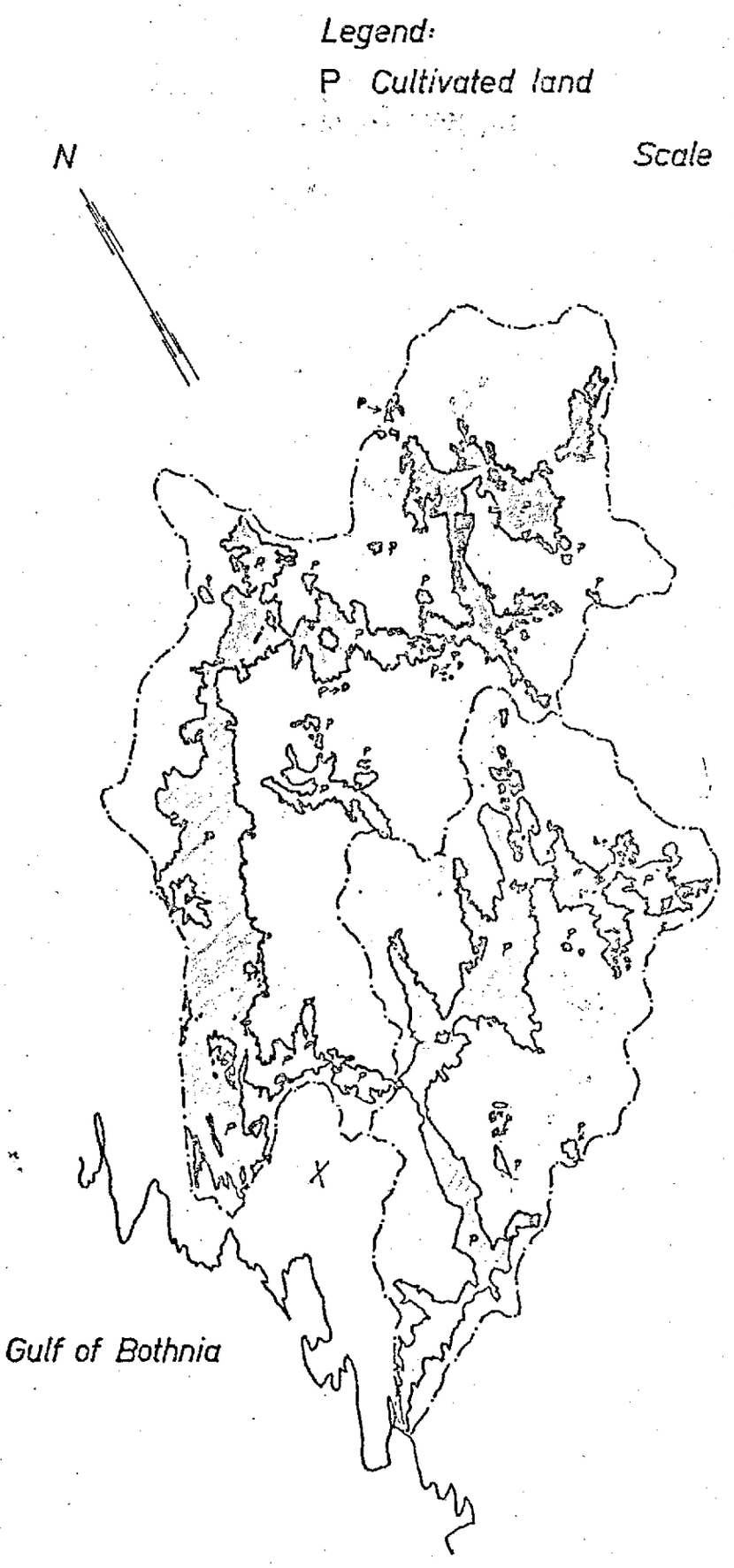


Figure 3

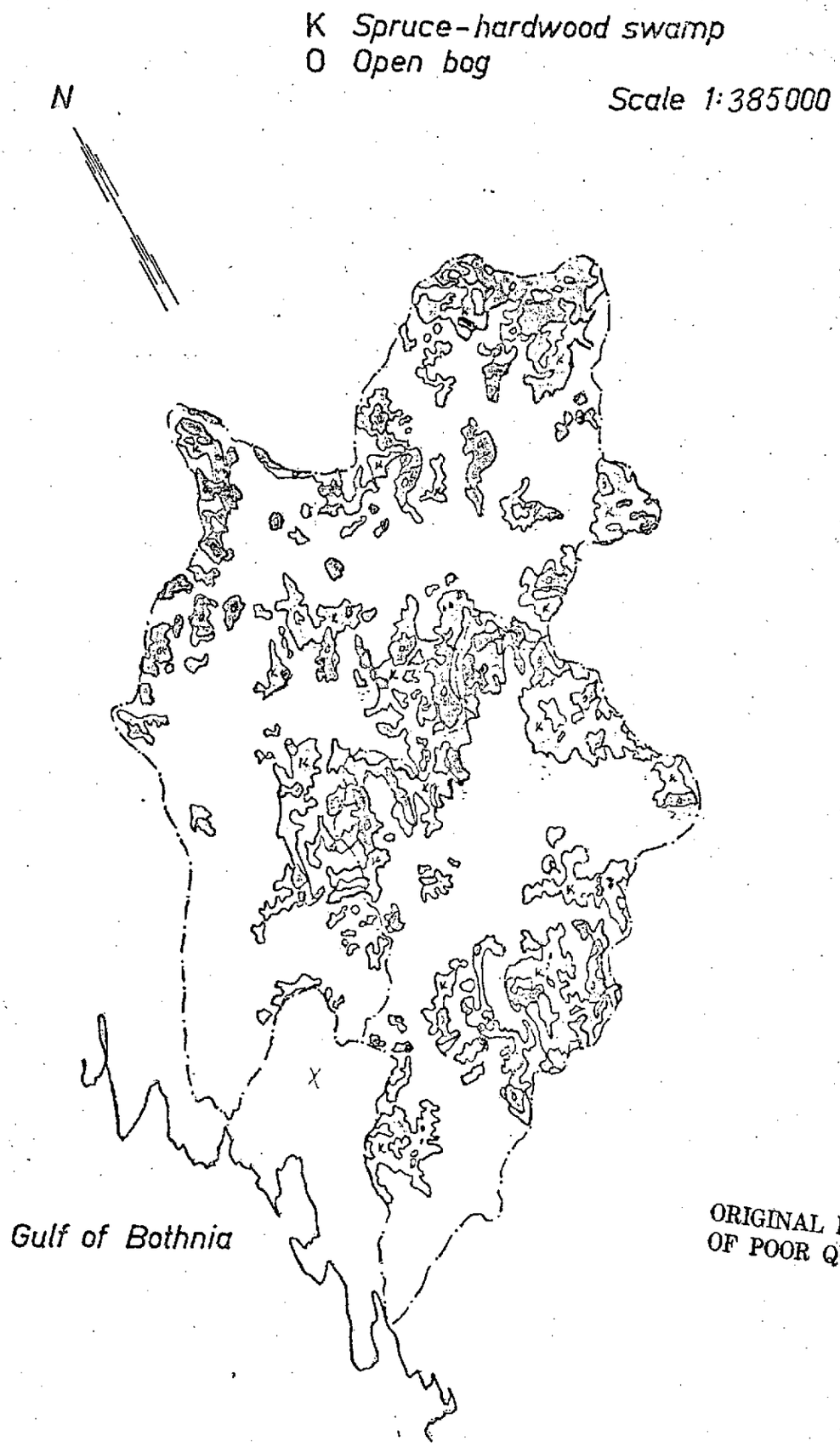


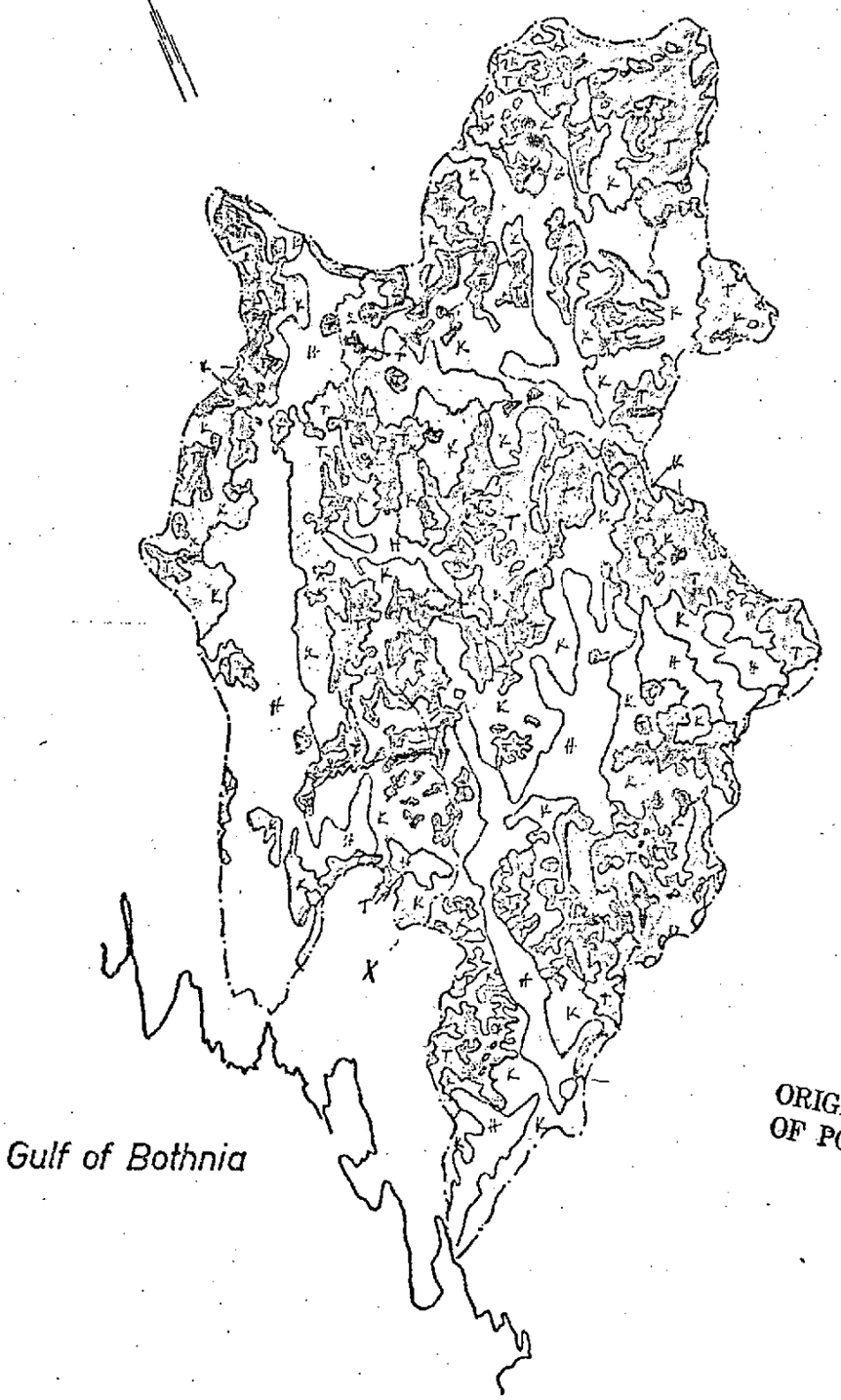
Figure 4

Legend:

K Coarse soil
T Peat
H Fine soil

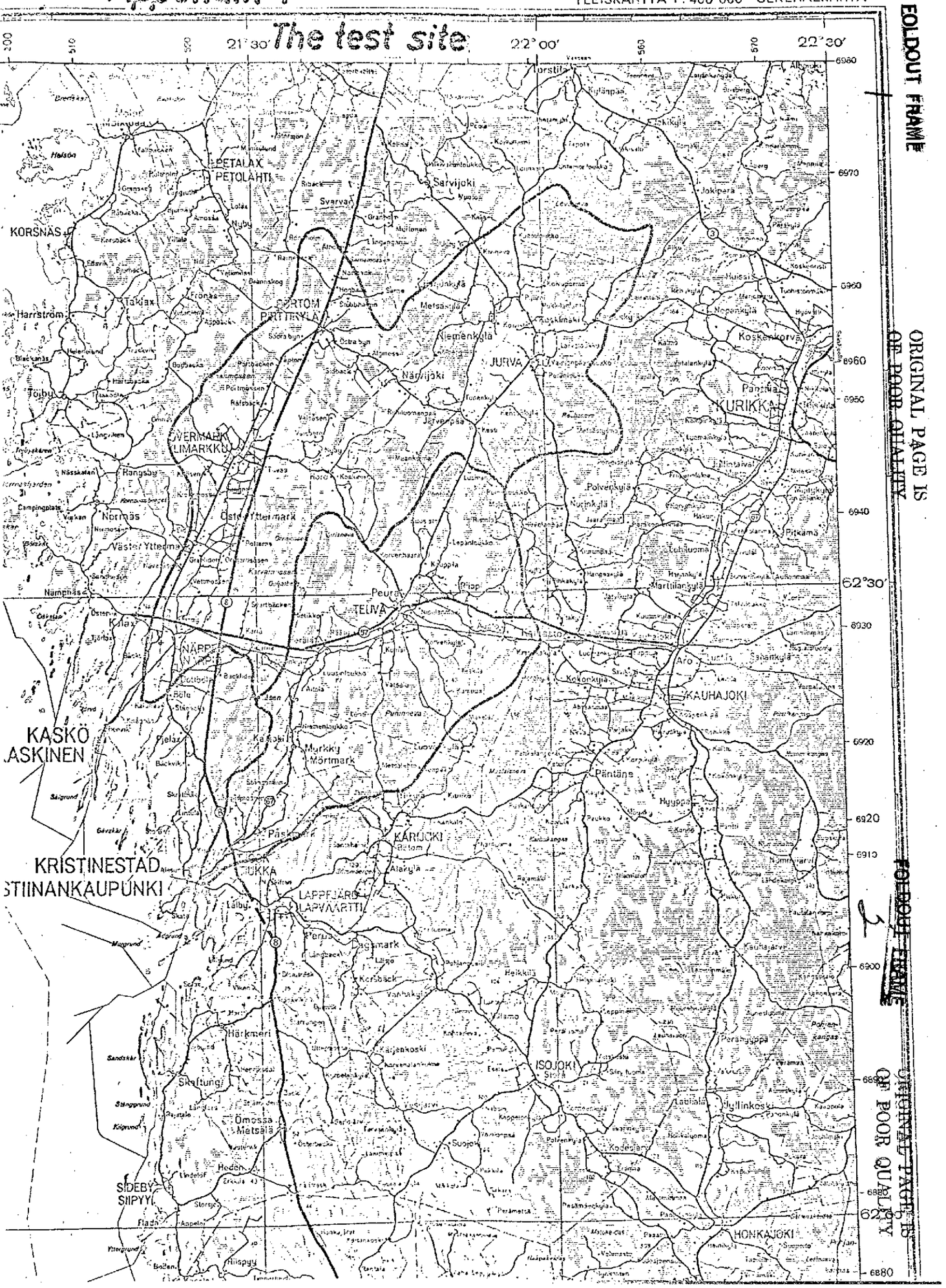
N

Scale 1:385000



Gulf of Bothnia

Appendix 1



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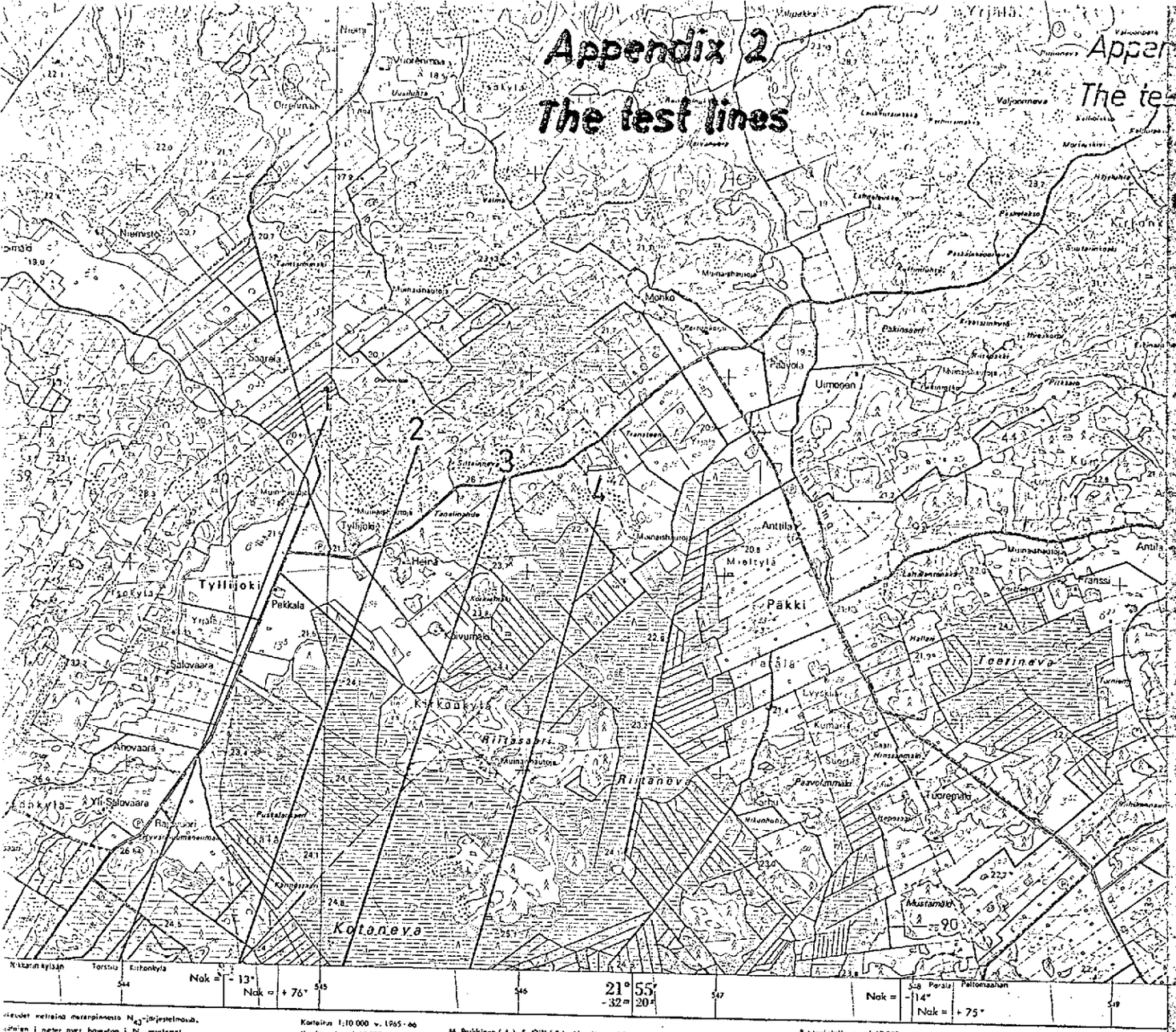
Appendix 2
The test lines



Mittakaava 1:20000 Skala

1 cm kartalla vastaa 200 metriä maastosta — 1 cm på kartan motsvarar 200 m i terrängen

pelto ja niitty
åker och äng

puutarha, puisto ja puistokäytävä
trädgård, park och parkvägar

mäntymetsä
tallskog

kuusimetsä
granskog

lehtimetsä
lövskog

pensaikko tai taimikko
buskmark eller plantbestånd

hakattu ja palanut metsä
avverkad och brandskadad skog

metsälinja, leveys alle ja yli 10 m
skogslinje, bredd under och över 10 m

huomattava havu- ja lehtipuu
dominerande barr- och lövträd

soistuva maa
försumpning

metsäinen ja aukea suo, helppokulkuinen
skogbevuxen och öppen torvmark, beträdbar

varsinkulkuinen ja ylipäätsemättön aukea suo
torvmark, svår att beträda och ej beträdbar

avokallioita ja iso kivi
kala berg och stor sten

louhikko tai kivikko ja hietikko
gryt och sandfält

asuin-, liike-, tehdas- ja yleisiä rakennuksia
bostads-, affärs-, fabriks- och allmänna byggnader

talous- ja varastorakennuksia
uthus och magasiner

rakennuskuvausa suljetun rakennustavan alueilla, sluten bebyggelse i tätort

kirkko, kellotapuli, muistomerkki
kyrka, klocktapel, minnesmärke

tuulimylly, tuulimoottori, näkötorni
väderkvarn, vindmotor, utsiktstorn

varastoalue ja savupiippu ottovalain
förrådsplats och skorsten med skyddsljus

muinaisjäännös ja luonnonmuistomerkki
fornlämning och naturminne

luonnonsuojelualueen raja
gräns för naturskyddsområdet

puu- tai rautatanka, kivilatta
trä- eller järnstängsel, stengärde

pensas- ja kuusiaita
häck

suurjännitelinja ja muuntaja
högspänningslinje med transformator

puhelinlinja
telefonledning

louhos ja soran- tai hiekanottopaikka
stenbrott och grus- eller sandtäkt

saven- ja mudan- tai turpeenottopaikka
ler- och dy- eller torvtäkt

Ia lk. nopea autotie, kaksiajoratainen
kl. snabb bilväg med dubbla körbanor

Ib lk. nopea autotie, 2—3 kaistainen
kl. snabb bilväg med 2—3 körfilar

IIa–IIb lk. autotie, kaksikaistainen
kl. bilväg med två körfilar

IIIa–IIIb lk. autotie, yksikaistainen
kl. bilväg med en körfil

kertopäällyste (I b) ja kilometripylväs
permanentbelaggning (I b) och km-stolpe

rakenteilla oleva autotie
bilväg under byggnad

moottoritie
motorväg

valta- tai kantatie sekä muu maantie
huvud- eller stamväg samt annan landsväg

paikallistie ja yksityinen tie
bygdeväg och enskild väg

auto- tai traktoritalvitie
bil- eller traktorvintervig

kärrytie
körväg

kärrypolku ja kapulatie
körstig och kavelväg

polku tai hevostalvitie sekä pikkupuut
stig eller vinterkörväg, spångad stig

polkupyörätie
cykelväg

yksiraiteinen rautatie
enkelspårig järnväg

kaksiraiteinen rautatie
dubbelspårig järnväg

rakenteilla oleva rautatie
järnväg under byggnad

johtoksyrä (20 m) ledkurva
välikyrä (10 ja 5 m) mellankurva
apukyrä (2,5 m) hjälpkurva

luonnonjyrkänne, yli ja alle 2 m
naturlig brant, över och under 2 m

tekojyrkänne, yli 1 : 1 ja yli 2 m
konstgjord brant, över 1 : 1 och över 2 m

luiska pankereessä ja teikkauksessa
bank och skärning

kolmiopisteet ja monikulmiopiste
triangelpunkter och polygonpunkter

korkeuskiintopiste, korkeusluku
höjdfixpunkt, höjdsiffra

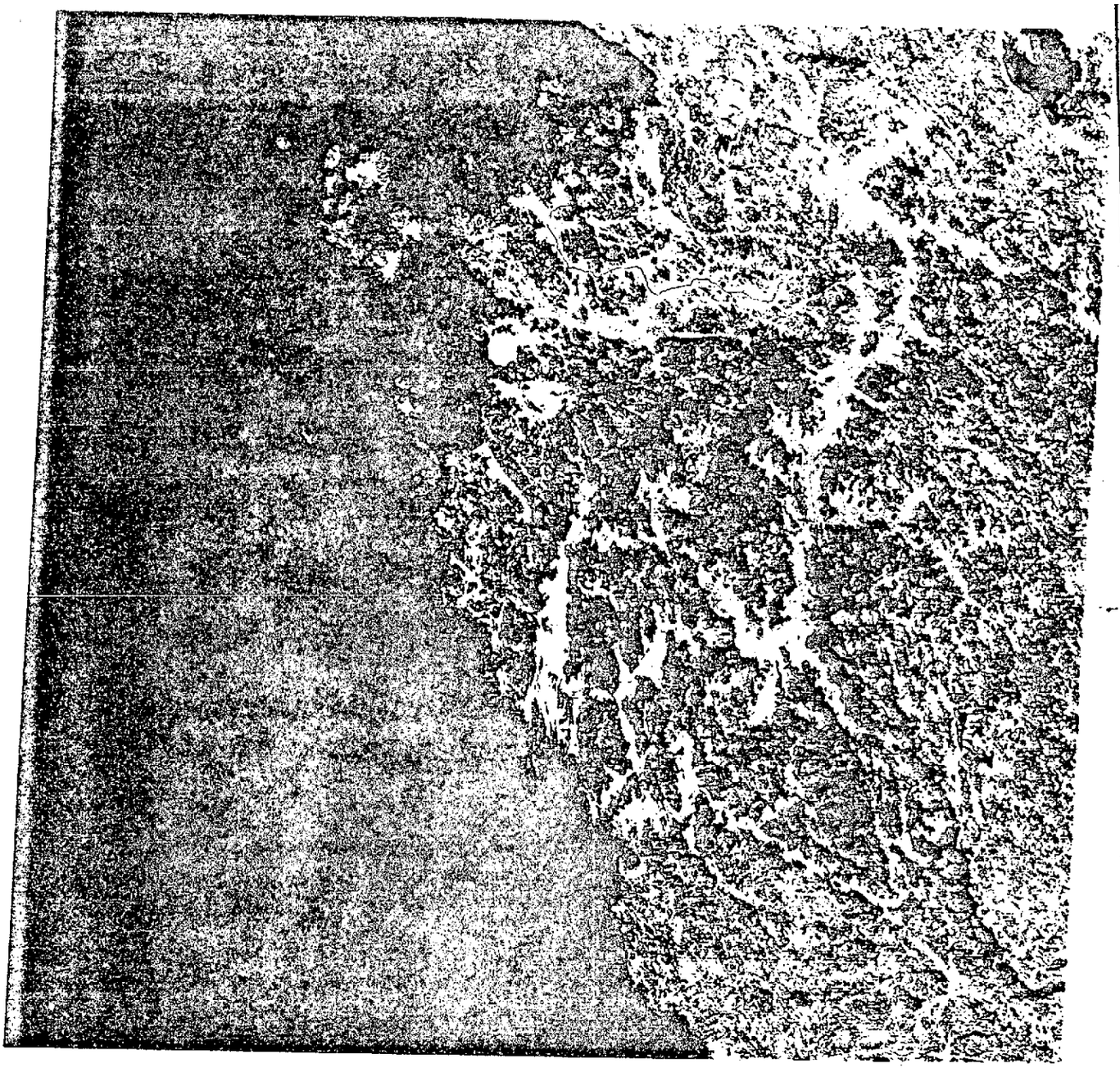
valtakunnanraja
riksgräns

lääninraja
länsgräns

kunnanraja ja huomattava rajapyykki
sockengräns och större rese

kylänraja
bygräns

tilanraja ja rekisterinumero
lagenhetsgräns och registernummer



Appendix 4

Color composite made on Kodak Ektacolor RC 37 paper

Scale 1:385000

FOLDOUT FRAME 1

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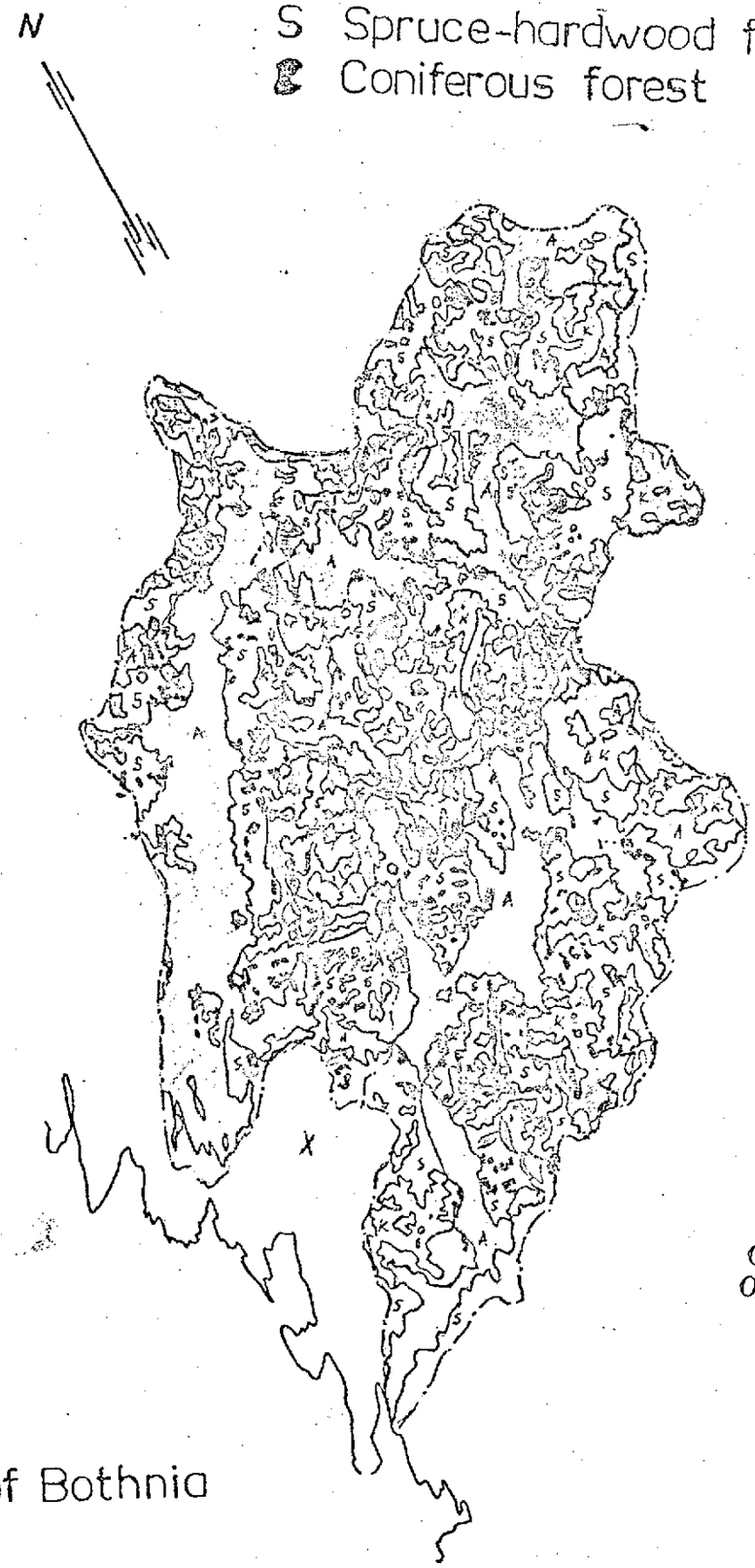
Figure 5

Legend:

A Open area
K Spruce-hardwood swamp
S Spruce-hardwood forest
C Coniferous forest

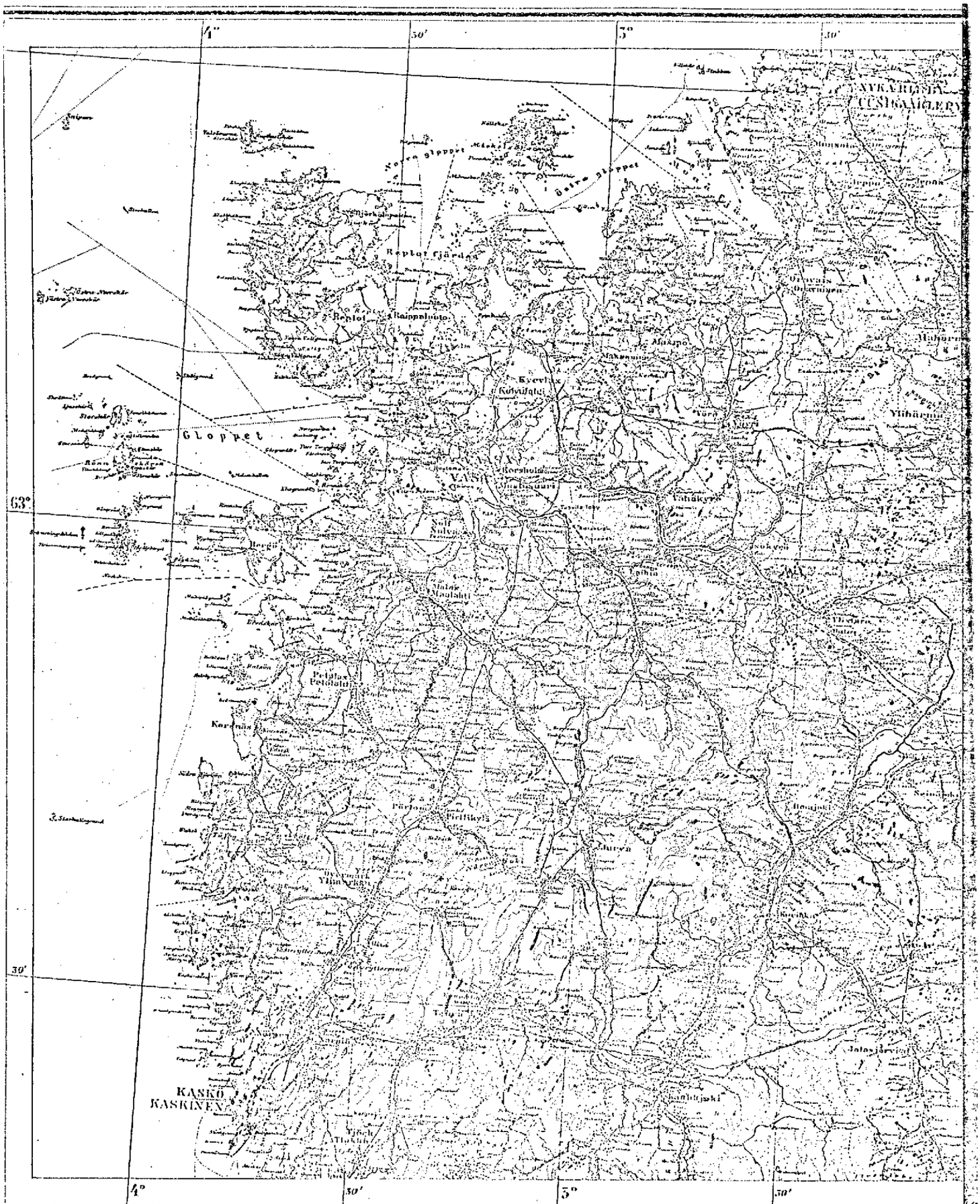
Scale 1:385 000



Appendix 6

MAAPERÄKARTTA

Vaasa (Lehti B 3)



Pohjana Maanmittaushallituksen Yleiskartta
Based on the General Board of Survey Map

MAANMITTAUSHALLITUKSEN KIRJAPAINO 1955

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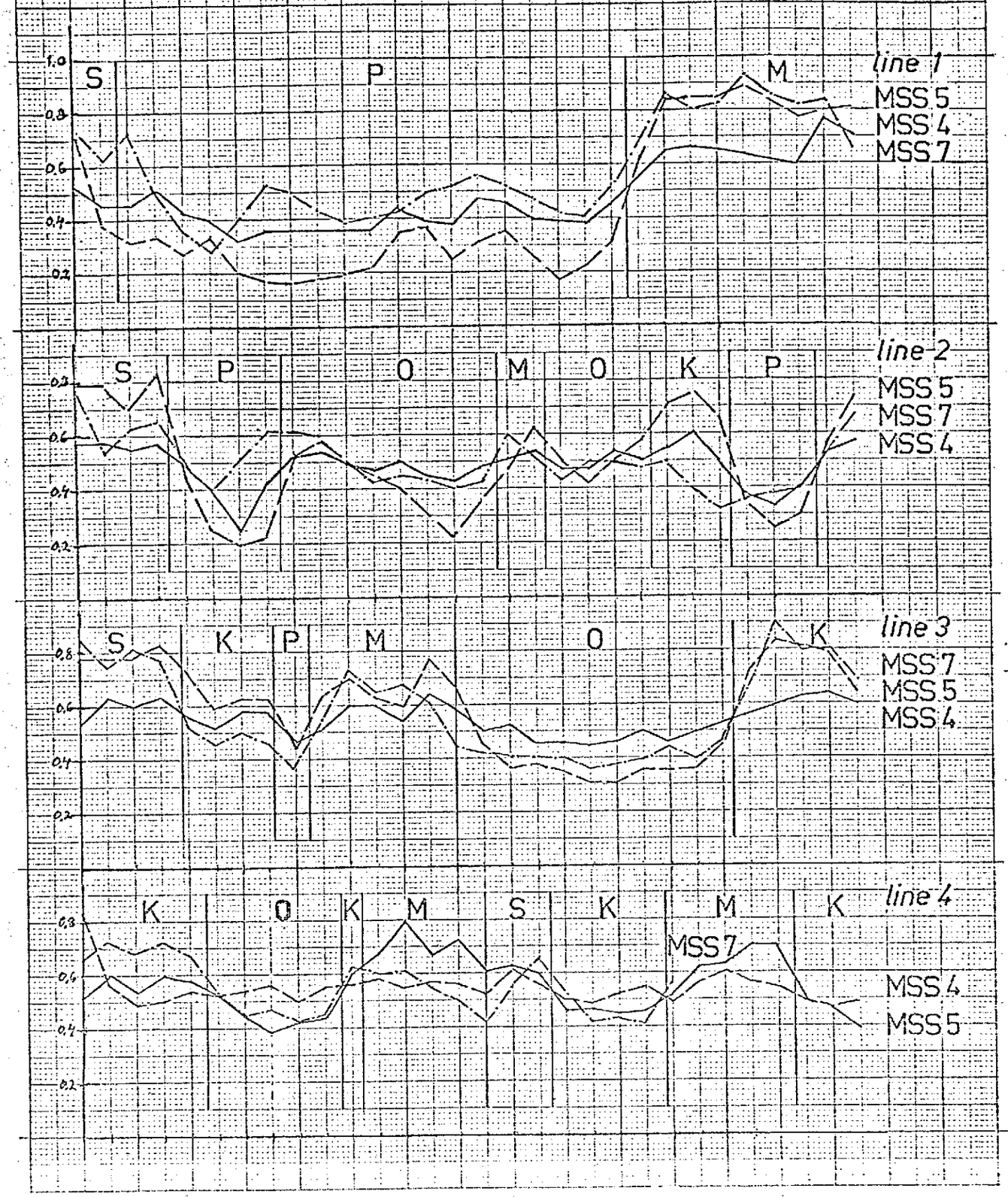
Mittakaava 1:400,000 Scale 1:400,000

The densities of the testlines measured in the B & W transparent photos



Legend:

K *Spruce-hardwood swamp*
M *Spruce and pine forest*
0 *Open bog*
P *Cultivated land*
S *Spruce-hardwood forest*

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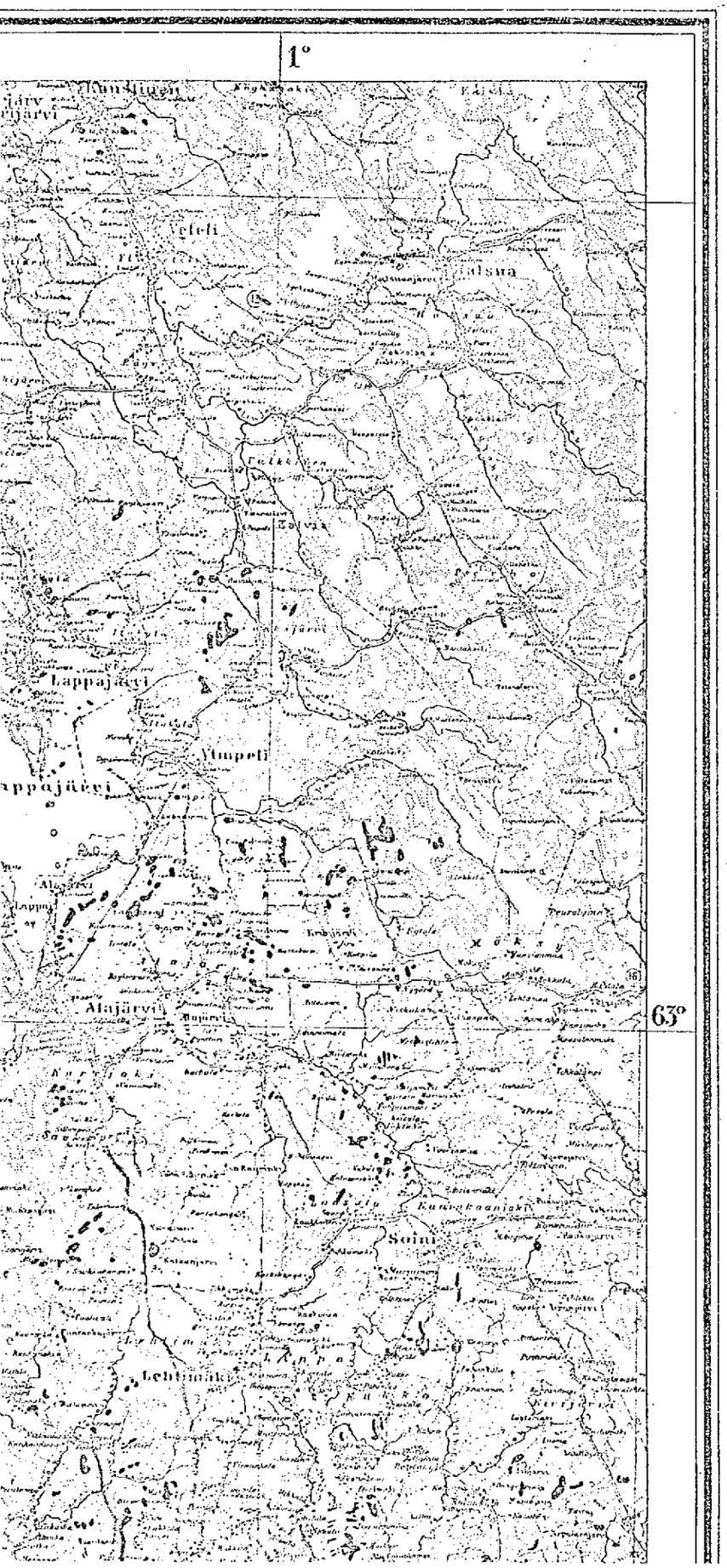
Vaasa (Sheet B 3)



VÄRIEN SELITYS
EXPLANATION OF COLOURS

- Turvetta — Peat
- Savea ja hiesua — Clay and silt
- Hietaa, hiekkaa ja soraa — Fine sand, sand and gravel
- Harjuja ja muita glasifluviaalista selänteitä — Eskers and other glacifluvial ridges
- Moreenia — Till
- Kallioita — Rocks

C-46

C-46

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