# Holocene vegetation history and the palaeoecology of Pinus sylvestris in northern Scotland

In two volumes.

## Volume 2.



By

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This thesis results from entirely my own work and has not been previously submitted for any other degree.

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# CONTENTS OF VOLUME 2

## LIST OF TABLES

(The majority of the tables can be found in Volume 2 of this thesis)

## LIST OF FIGURES

(All the figures can be found in Volume 2 of this thesis)

## LIST OF PLATES

(All the plates can be found in Volume 2 of this thesis)

TABLE 2.1

Climatological data from northern Scotland

| Satation | Average annual precipitation (*mm*) | Average min. January temp. (°C) | Average max. January temp. (°C) | Average July min. temp. (°C) | Average July max. temp. (°C) |
|---|---|---|---|---|---|
| Strathy point | 1018 | -7.3 | 10.4 | 12.8 | 22.9 |
| Cape Wrath | 1156 | -2.2 | 10.6 | 15.0 | 19.4 |
| Lairg | 1106 | -11.3 | 10.0 | 13.3 | 23.0 |

TABLE 3.1

**The qualities of the sensors used in mapping the present vegetation and pollen rain in northern Scotland**

| Sensor | Scale of resolution (metres) | Temporal resolution | Area covered | Sensitivity |
|---|---|---|---|---|
| Thematic Mapper | 25x25 | 1 day in May 1987 | 30 x 38 km (NC5135 to NC8965) | Coarse resolution vegetation mapping |
| Surface pollen (lakes) | $10^1$ to $10^4$ | Integrated picture for the last 3-5 years | 35 x 50 km (NC5020 to NC8570) | Discriminates between treeless, non treeless, and intensively managed areas |
| Phytosociological survey | 2 x 2 | Representative of field seasons 1988 and 1989 | spatially descrete points within 120 x 130 km area | Detailed descriptons of the structure, and distribution of plant communities |

**TABLE 3.4**

**Conspectus of vegetation units**

Class Oxycocco-Sphagnetea Braun-Blanquet and R. Tüxen 1943

Order Ericetalia tetralicis Moore (1964) 1968

Alliance Ericion tetralicis Schwickwerath 1933

Association Tricophoreto-Callunetum (McVean and Ratcliffe, 1962)

..... **Nodum 24** – *Calluna vulgaris* nodum

Association Molinieto-Callunetum (McVean and Ratcliffe, 1962)

Alliance Erico-Sphagnion Moore (1964) 1968

Association Tricophoreto-Eriophoretum (McVean and Ratcliffe, 1962)

..... **Nodum 21** – *Calluna vulgaris-Eriophorum angustifolium* nodum

.....**Nodum 22** – *Erica tetralix-Sphagnum* nodum

.....**Nodum 23** – *Trichophorum cespitosum-Myrica gale* nodum

Class Elyno-Seslerietea Braun-Blanquet 1948

Order Elyno-Dryadetalia Braun-Blanquet 1948

Alliance Kobresio-Dryadion Nordhagen (1936) 1943

*Dryas octopetala* nodum (McVean and Ratcliffe, 1962)

.....**Nodum 1** – *Dryas octopetala* nodum

Class Caricetea curvulae Braun-Blanquet 1948

Order Caricetalia curvulae Braun-Blanquet 1926

Alliance Arctostaphyleto-Cetrarion nivalis Dahl 1956

Juniperetum nanae (McVean and Ratcliffe, 1962)

..... **Nodum 6** – *Juniperus communis* nodum

Class Nardo-Callunetea Preising 1948

Order Nardetalia (Oberdorfer 1949)

Alliance Nardo-Galion saxatilis Preising 1949

Association Agrosto-Festucetum (species poor) (McVean and Ratcliffe, 1962)

.....**Nodum 20** – *Calluna vulgaris-Agrostis canina* nodum

Association Agrosto-Festucetum (species rich) (McVean and Ratcliffe, 1962)

Association Nardetum sub-alpinum (McVean and Ratcliffe, 1962)

.....**Nodum 7** – *Anthoxanthum odoratum-Rhytidiadelphus squarrous* nodum

Alliance Ericion cinereae Böcher 1943

Association Callunetum vulgaris (McVean and Ratcliffe, 1962)

.....**Nodum 19** – *Calluna vulgaris-Potentilla erecta* nodum

Association Cladineto-Callunetum (McVean and Ratcliffe, 1962)

.....**Nodum 25** – *Calluna vulgaris-Cladonia impexa* nodum

Class Betulo-Adenostyletalia Braun-Blanquet 1948

Order Adenostyletalia Braun-Blanquet 1931

Alliance Mulgedion alpini Nordhagen 1943

*Salix lapponum-Luzula sylvatica* nodum (McVean and Ratcliffe, 1962)

.....**Nodum 14** – *Betula pubescens-Thuidium tamariscinum* nodum

Class Molinio-Betuletea Pass. et Hoffman 1968

Order

Alliance

Community *Sphagnum palustre-Betula pubescens* (Birse, 1982)

Class Alnetea Glutinosae Braun-Blanquet and R. Tüxen 1943

Order Alnetalia glutinosae R. Tüxen 1937

Alliance Alnion glutinosae (Malcuit 1929) Meijer-Drees 1936

community *Alnus glutinosa* woods (Birks, 1973)

..... **Nodum 5** – *Alnus glutinosa* nodum

Class Vaccinio-Piceetea Braun-Blanquet, Sissingh and Vileger (1939)

Order Vaccinio-Piceetalia Braun-Blanquet, Sissingh and Vileger (1939)

Alliance Dicrano-Pinion (Libb 1933) Matusz 1962

Association Pinetum Scoticae (Steven and Carlisle, 1959) Birse 1980

Association Pinetum Hylocomieto-Vaccinietum (McVean and Ratcliffe 1962)

.....**Nodum 15** – *Pinus sylvestris-Deschampsia cespitosa* nodum

..... **Nodum 16** – *Pinus sylvestris-Molinia caerulea* nodum

.....**Nodum 17** – *Pinus sylvestris-Vaccinium myrtillus* nodum

Association Pinetum Vaccineto-Callunetum (McVean and Ratcliffe 1962)

..... **Nodum 18** – *Pinus sylvestris-Calluna vulgaris*nodum

Alliance

community *Molinia caerulea-Pinus sylvestris* Plantation (Birse, 1988)

Class Quercetea Robori-Petraeae Braun-Blanquet and R. Tüxen 1943

Order Quercetalia Robori-Petraeae R. Tüxen (1931) 1937

Alliance Quercion robori-petraeae (Malcuit, 1929) Braun-Blanquet 1932

Association *Betula pubescens-Vaccinium myrtillus* (Birks, 1973)

Association Betuletum Oxaleto-Vaccinium (McVean and Ratcliffe, 1962)

..... **Nodum 12** – *Betula pubescens-Vaccinium myrtillus* nodum

.....**Nodum 13** – *Betula pubescens-Juniperus communis* nodum

*Betula*-herb nodum (McVean and Ratcliffe, 1962)

.....**Nodum 3** – *Betula pubescens-Rumex acetosa* nodum

.....**Nodum 8** – *Betula pubescens-Potentilla erecta* nodum

.....**Nodum 9** – *Betula pubescens-Rhytidiadelphus squarrosus* nodum

.....**Nodum 10** – *Betula pubescens-Deschampsia flexuosa* nodum

Association Trientali-Betuletum pendulae (Birse, 1982)

.....**Nodum 11** – *Betula pendula* nodum

Association Blechno-Quercetum (Braun-Blanquet, 1952; Birse, 1982)

.....**Nodum 4** – *Salix* nodum

community *Pteridium aquilinum-Pinus sylvestris* plantation (Birse, 1988)

Association *Oxalis acetosella-Rhytidiadelphus loreus* (Birks, 1973)

Order Pteridio-Rubetalia Doing 1962

Alliance Usici-Sarothomnion Doing 1962

Association

community *Holcus mollis-Pteridium aquilinum* (Birse, 1984; 1988)

community *Pteridium aquilinum-Salix aurita* (Birse, 1988)

## TABLE 3.5

### Summary of the affinities of noda to published vegetation types

| Nodum | Affinities to vegetation types defined |
|---|---|
| 1 | *Dryas octopetala* nodum (McVean and Ratcliffe, 1962) |
| 2 | None |
| 3 | *Betula*-herb nodum (McVean and Ratcliffe, 1962) |
| 4 | Blechno-Quercetum (Braun-Blanquet and Tüxen, 1952) |
| 5 | Alnus glutinosa woods (Birks, 1973) |
| 6 | Juniperetum nanae (McVean and Ratcliffe, 1962) |
| 7 | Nardetum sub-alpinum (McVean and Ratcliffe, 1962) |
| 8 | Betula-herb nodum (McVean and Ratcliffe, 1962) |
| 9 | Betula-herb nodum (McVean and Ratcliffe, 1962) |
| 10 | Betula-herb nodum (McVean and Ratcliffe, 1962 |
| 11 | Trientali-Betuletum pendulae (Birse, 1982) |
| 12 | Betuletum Oxaleto-Vaccinium (McVean and Ratcliffe, 1962) |
| 13 | Betuletum Oxaleto-Vaccinium (McVean and Ratcliffe, 1962) |
| 14 | *Salix lapponum-Luzula sylvatica* nodum (McVean and Ratcliffe, 1962) |
| 15 | Pinetum Hylocomieto-Vaccinietum (McVean and Ratcliffe, 1962) |
| 16 | Pinetum Hylocomieto-Vaccinietum (McVean and Ratcliffe, 1962) |
| 17 | Pinetum Hylocomieto-Vaccinietum (McVean and Ratcliffe, 1962) |
| 18 | Pinetum Vaccineto-Callunetum |
| 19 | Callunetum vulgaris |
| 20 | Agrosto-Festucetum (McVean and Ratcliffe, 1962) |
| 21 | Tricophoreto-Eriophoretum (McVean and Ratcliffe, 1962) |
| 22 | Tricophoreto-Eriophoretum (McVean and Ratcliffe, 1962) |
| 23 | Tricophoreto-Eriophoretum (McVean and Ratcliffe, 1962) |
| 24 | Tricophoreto-Callunetum (McVean and Ratcliffe, 1962) |
| 25 | Cladineto-Callunetum (McVean and Ratcliffe, 1962) |

## TABLE 3.17

**Thematic colour(s) assigned to noda.** The numbers in the table refer to the number of relevés assigned a Thematic Mapper colour in a given nodal class.

| Noda number | Thematic Mapper colour 19 | 18 | 2 | 6 | 8 | 9 | 11 | 20 | 23 | 21 | 22 | 14 | 13 | 7 | 12 | 10 | 4 | 15 | 16 | 17 | 24 | 5 | 1 | 3 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 1 | | | | | | | | | | | | | | | | 1 | | | | | | | | |
| 16 | 3 | 1 | | | | | | | | | | | 1 | | | | | 1 | 1 | | | 1 | | | |
| 18 | 1 | 1 | | 1 | 1 | | | | | | | | | | | 2 | | | | | | | | | |
| 14 | | | 4 | 1 | 1 | 1 | 2 | | | | | 1 | 1 | | | | | | 1 | | | | 1 | | |
| 19 | 1 | 2 | 4 | 5 | 1 | 3 | | | | | | | 2 | 1 | 3 | | | 1 | | | | | | | |
| 1 | | | | | | 1 | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | 2 | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | 8 | | | | | | | | | | 1 | | | | | | | 1 | |
| 15 | | | | | | | 3 | | | | | | 1 | | | | | | 1 | | | | | | |
| 2 | | | | | | | | 2 | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | 3 | 1 | 1 | | | | | | 1 | 1 | 1 | | | | |
| 4 | 1 | | | | | | | 1 | 1 | 2 | 3 | | | | | | | | | | | | | | |
| 5 | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | |
| 8 | | | | | 1 | | 1 | | | | 5 | 3 | 7 | 1 | | | | 3 | | | 1 | | | | |
| 9 | | | | | | | | | 2 | | 3 | 1 | 7 | | | | | | | | | | | | 1 |
| 10 | 1 | | | | | | | | 3 | 3 | 3 | 2 | 5 | | | | | | | | 1 | | | | |
| 11 | | | | | | | | | | 5 | 2 | 1 | 5 | | | | | | | 1 | | | | | |
| 12 | | | 1 | | | | | | | | | | 3 | | | | 2 | | | | | | | | |
| 17 | 1 | | | | 1 | 1 | 1 | | | | | | 3 | | 1 | 2 | | | | | | | | | |

## TABLE 3.18

**Probability table for obtaining a given Thematic colour for a given nodal class.** The numbers in the table are the probability for obtaining a given Thematic Mapper colour for a given nodal class.

| | Thematic Mapper colour | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 19 | 18 | 2 | 6 | 8 | 9 | 11 | 20 | 23 | 21 | 22 | 14 | 13 | 7 | 12 | 10 | 4 | 15 | 16 | 17 | 24 | 5 | 1 | 3 | 25 |
| Noda number | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | 0.11 | | | | | | | | | | | | | | | | 0.25 | | | | | | | | |
| 16 | 0.33 | 0.25 | | | | | | | | | | | 0.02 | | | | | 0.20 | 0.25 | | | 1.0 | | | |
| 18 | 0.11 | 0.25 | | 0.14 | 0.20 | | | | | | | | | | | 0.50 | | | | | | | | | |
| Total | 0.55 | 0.50 | | 0.14 | 0.20 | | | | | | | | 0.20 | | | 0.50 | 0.25 | 0.20 | 0.25 | | | 1.0 | | | |
| 14 | | | 0.44 | 0.14 | 0.20 | 0.12 | 0.13 | | | | | 0.11 | 0.02 | | | | | | 0.25 | | | | 1.0 | | |
| 19 | 0.11 | 0.50 | 0.44 | 0.71 | 0.20 | 0.37 | | | | | | | 0.05 | 0.50 | 0.75 | | | 0.20 | | | | | | | |
| Total | 0.11 | 0.50 | 0.88 | 0.85 | 0.40 | 0.44 | 0.13 | | | | | 0.11 | 0.09 | 0.5 | 0.75 | | | 0.20 | 0.25 | | | | 1.0 | | |
| 1 | | | | | | 0.12 | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | 0.25 | | | | | | | | | | | | | | | | | | | |
| Total | | | | | | 0.37 | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | 0.53 | | | | | | | | | | 0.25 | | | | | | | 1.0 | |
| 15 | | | | | | | 0.20 | | | | | | 0.02 | | | | | | 0.25 | | | | | | |
| Total | | | | | | | 0.73 | | | | | | 0.02 | | | | 0.25 | | 0.25 | | | | | 1.0 | |
| 2 | | | | | | | | 0.66 | | | | | | | | | | | | | | | | | |
| Total | | | | | | | | 0.66 | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | 0.15 | 0.11 | 0.02 | | | | | | 0.25 | 0.50 | 0.33 | | | | |
| 4 | 0.11 | | | | | | | 0.33 | 0.14 | 0.18 | 0.15 | | | | | | | | | | | | | | |
| 5 | | | | | | | | | 0.14 | 0.09 | | | | | | | | | 0.25 | 0.50 | 0.33 | | | | |
| Total | 0.11 | | | | | | | 0.33 | 0.28 | 0.27 | 0.30 | 0.11 | 0.02 | | | | | | | | | | | | |
| 8 | | | | | 0.20 | | 0.06 | | | | 0.26 | 0.38 | 0.19 | 0.50 | | | | 0.6 | | | 0.53 | | | | 1.0 |
| 9 | | | | | | | | | 0.28 | | 0.15 | 0.11 | 0.19 | | | | | | | | | | | | |
| 10 | 0.11 | | | | | | | | 0.42 | 0.27 | 0.15 | 0.22 | 0.13 | | | | | | | | 0.33 | | | | |
| 11 | | | | | | | | | | 0.45 | 0.10 | 0.11 | 0.13 | | | | | | | 0.50 | | | | | |
| 12 | | 0.11 | | | | | | | | | | | 0.08 | | | | 0.50 | | | | | | | | |
| 17 | 0.11 | | | | 0.20 | 0.12 | 0.06 | | | | | | 0.08 | | 0.25 | 0.50 | | | | | | | | | 1.0 |
| Total | 0.22 | 0.11 | | | 0.40 | 0.12 | 0.12 | | 0.70 | 0.72 | 0.66 | 0.77 | 0.8 | 0.50 | 0.25 | 0.50 | 0.50 | 0.60 | | 0.50 | 0.66 | | | | 1.0 |

TABLE 3.19

Data on surface sample sites

| Site | Loch | *Ordnance survey grid* reference | Altitude (metres) | Loch size (m) |
|---|---|---|---|---|
| 1 | East of Loch Warrender | NC 755491 | 213 | 75 x 37 |
| 2 | Lochan by Feusaige | NC 748477 | 246 | 125 x 62 |
| 3 | Loch Leoid | NC 686504 | 205 | 62 x 25 |
| 4 | Loch Mefag | NC 678500 | 193 | 425 x 100 |
| 5 | Lochan Grummore | NC 610375 | 209 | 150 x 52 |
| 6 | Strathmore | NC 576388 | 167 | 50 x 52 |
| 7 | Roundhill | NC 675399 | 83 | 75 x 75 |
| 8 | Lochan by Meadie | NC 512377 | 144 | 25 x 25 |
| 9 | Palm loch | NC 710410 | 165 | 425 x 200 |
| 10 | Loch Rosail | NC 715400 | 144 | 400 x 225 |
| 11 | Lochan Carnachadh | NC 699517 | 182 | 250 x 75 |
| 12 | Kinbrace | NC 729404 | 137 | 75 x 75 |
| 13 | Altnabreac | NC 765503 | 190 | 125 x 50 |
| 14 | Bettyhill | NC 705624 | 30 | 100 x 50 |
| 15 | Loch Mòr | NC 718609 | 99 | 575 x 175 |
| 16 | Loch Salachaidh | NC 733621 | 83 | 175 x 175 |
| 17 | Dalchork | NC 600134 | 200 | 300 x 100 |
| 18 | Torrobie | NC 593023 | 160 | 100 x 125 |
| 19 | Lochan a'Choire | NC 685603 | 22 | 150 x 100 |
| 20 | Lochan Chuibhe | NC 696608 | 106 | 250 x 200 |
| 21 | Loch Mer | NC 704600 | 7 | 400 x 87 |
| 22 | Loch Chealamy | NC 722506 | 38 | 125 x 75 |
| 23 | Lochan by Rosail | NC 721397 | 137 | 75 x 37 |
| 24 | Lochan Dubh | NC 625593 | 68 | 375 x 175 |
| 25 | Loch Dubh Beul na Fàire | NC 647593 | 106 | 300 x 175 |
| 26 | Loch ma Nàire | NC 726537 | 22 | 300 x 125 |
| 27 | Loch Vasgo | NC 580645 | 56 | 150 x 125 |
| 28 | Loch nam Faoilleag | NC 730551 | 68 | 175 x 75 |
| 29 | Modsarie | NC 649615 | 68 | 700 x 275 |
| 30 | Lochan Ealoch | NC 820650 | 91 | 225 x 150 |
| 31 | Gaineamhach | NC 514258 | 220 | 200 x 150 |
| 32 | Swordly loch | NC 730629 | 83 | 100 x 50 |
| 33 | Loch Duinte | NC 715583 | 7 | 375 x 288 |
| 34 | Lochan na Uimheachd | NC 609543 | 175 | 250 x 150 |

**TABLE 3.20**

**The relationship between percentage vegetation cover (established from the Thematic Mapper using a 2.5 km radius around each site) and percentage pollen data**

| Taxa | Linear regression value 'r' | $r^2$ | df | significance level |
|---|---|---|---|---|
| *Betula* | 0.18014 | 0.03 | 29 | not significant |
| Gramineae | 0.58953 | 0.34 | 29 | 99% level |
| *Calluna* | 0.27225 | 0.07 | 29 | not significant |
| Cyperaceae | -0.1944 | 0.03 | 29 | not significant |
| *Pinus* | 0.30970 | 0.10 | 27 | not significant |
| *Pteridium* | -0.09899 | 0.00 | 29 | not significant |

TABLE 4.1

**Radiocarbon dates and sediment accumulation rates for Loch Mer**

| Laboratory Code | Sample Code | Conventional age years B..P. +/- one *sigma* | Calender Years B.P. +/- one *sigma** | Sediment accumulation rates yr. $cm^{-1}$ |
|---|---|---|---|---|
| SRR-3399 | LM/010 | 1830 +/- 70 | 1863 to 1700 | 27.7 |
| SRR-3400 | LM/009 | 2685 +/- 70 | 2857 to 2753 | 8.9 |
| SRR-3401 | LM/008 | 2890 +/- 70 | 3202 to 2941 | 0.9 |
| SRR-3402 | LM/007 | 3545 +/- 70 | 3964 to 3723 | 3.1 |
| SRR-3403 | LM/006 | 4545 +/- 70 | 5316 to 5051 | 25.0 |
| SRR-3404 | LM/005 | 5565 +/- 70 | 6418 to 6300 | 21.2 |
| SRR-3405 | LM/004 | 7730 +/- 70 | 8570 to 8411 | 45.1 |
| SRR-3406 | LM/003 | 7920 +/- 70 | 8982 to 8625 | 3.9 |
| SRR-3407 | LM/002 | 7830 +/- 120 | 8963 to 8463 | - |
| SRR-3408 | LM/001 | 7380 +/- 80 | 8327 to 8060 | - |

* Reference for the data sets (and intervals) used in calibration is Pearson and Stuiver (1986)

**Table 4.2 THE MACRO-FOSSIL RECORDS FROM LOCH MER IN RELATION TO THE LOCHMER LOCAL POLLEN ZONES.** A * represents the presence of a macro-fossil within a pollen zone.

| Macro-fossil type | LM-1 | LM-2 | LM-3a | LM-3b | LM-3c | LM-4a | LM-4b |
|---|---|---|---|---|---|---|---|
| *Sphagnum* unid. | | | | | | | |
| leaf | * | * | * | * | * | * | * |
| *Pleurozium scheberi* | | | | | | | |
| leaf | | | | | * | | |
| *Betula pubescens* | | | | | | | |
| fruit | | | | * | | | |
| catkin | | | | * | | | |
| seed | | | | | * | | |
| Juncus | | | | | | | |
| seed | | | | * | * | * | * |
| Cyperaceae | | | | | | | |
| seed | * | | | | | | |
| Gramineae | | | | | | | |
| seed | * | | | | | | |
| Labiatae | | | | | | | |
| seed | | | | | | * | |
| *Calluna vulgaris* | | | | | | | |
| seeds | | | | * | * | * | * |
| Selaginella megaspore | | | | | * | | * |
| Isoetes megaspore | | | | | * | * | * |

**TABLE 4.3**

**Fire indices for Loch Mer**

| *Radiocarbon years* B.P. | *Pollen zone* | Total number of samples | S' | $P_F$ | T | $C_i$ | $F_1$ | $F_2$ |
|---|---|---|---|---|---|---|---|---|
| 8330-8000 ? | LM-1 | 5 | 2 | 0.4 | 30.4 | 5 | 0.16 | 0.06 |
| 8000-5500 | LM-2 | 8 | 4 | 0.5 | 1276.7 | 6 | $4.6^{-03}$ | $3.13^{-03}$ |
| 5500-3500 | LM-3a | 5 | 0 | 0 | 940 | 0 | 0 | 0 |
| 3500-2900 | LM-3b | 10 | 3 | 0.3 | 251.2 | 6 | 0.02 | 0.11 |
| 2900-2600 | LM-3b | 19 | 12 | 0.6 | 138.3 | 30 | 0.21 | 0.08 |
| 2600-1830 | LM-4a | 3 | 1 | 0.3 | 364.1 | 1 | $2.74^{-03}$ | $2.74^{-03}$ |
| 1830-0 | LM-4b | 6 | 0 | 0 | 1108.8 | 0 | 0 | 0 |

TABLE 4.4

*Comparison of fire indices from* north-east Caithness (Robinson, 1987) and Loch Mer

| Radiocarbon years B.P. | Loch Mer Fire index | Radiocarbon years B.P. | Ackhorn (Robinson, 1987) Fire index |
|---|---|---|---|
| 7920-7730 | HIGH | 8000-7800 | HIGH |
| 7730-5565 | VERY LOW | 7800-5500 | LOW |
| 5565-3545 | LOW | 5500-3500 | LOW |
| 3500-2685 | MODERATE | 3500-1000 | MODERATE |
| 2685-1830 | LOW | | |
| 1830-0 | VERY LOW | 1000-0 | VERY LOW |

**TABLE 5.1**

**THE RELATIONSHIP BETWEEN THE DISTRIBUTION OF SUB-FOSSIL PINUS SYLVESTRIS, SAMPLED AREA AND SOIL TYPES PER 10 KM GRID EASTING FOR THE AREA OF THE INTENSIVE SURVEY**

| | PER 100 1 KM GRID SQUARES | GRID EASTING BETWEEN NC 7045 AND ND 2055 | | | | |
|---|---|---|---|---|---|---|
| | | NC 7 | NC 8 | NC 9 | ND 0 | ND 1 |
| A | No. not searched | 17 | 53 | 64 | 53 | 46 |
| B | No. where no pine was found | 53 | 25 | 18 | 43 | 51 |
| C | No. where pine was found | 30 | 22 | 18 | 4 | 3 |
| D | % of grid squares searched in which pine were found ((C/B+C)*100) | 36.1 | 48.8 | 50.0 | 8.5 | 5.5 |
| E | Total No. of 1 km grid squares searched which were dominated by category 1 soils | 35 | 3 | 8 | 4 | 11 |
| F | No. of 1 km grid squares which contained category 1 soils and pine | 12 | 3 | 5 | 0 | 0 |
| G | Percentage of category 1 soils which contained pine (F/E)*100 | 34.2 | 100 | 62.5 | 0 | 0 |
| P | No. of category 1 soils which contained pine calculated as a % of the total number of pine records (F/C)*100 | 40.0 | 13.6 | 27.7 | 0 | 0 |
| H | Total No. 1 km grid squares searched which were dominated by category 2 soils | 42 | 39 | 28 | 43 | 28 |
| I | No. of 1 km grid squares which contained category 2 soils and pine | 16 | 18 | 13 | 4 | 3 |
| J | Percentage of category 2 soils which contained pine (I/H)*100 | 38.0 | 46.1 | 46.4 | 9.3 | 10.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Q | No. of category 2 soils which contained pine calculated as a % of the total number of pine records (I/H)*100 | 53.3 | 81.8 | 72.2 | 100 | 1 |
| K | Total number of 1 km grid squares searched which were dominated by category 3 soils | 6 | 5 | 0 | 0 | 4 |
| J | No. of 1 km grid squares which contained category 3 soils and pine | 2 | 1 | 0 | 0 | 0 |
| L | Percentage of category 3 soils which contained pine (J/K)*100 | 33.3 | 20.0 | 0 | 0 | 0 |
| U | No. of category 3 soils which contained pine calculated as a % of the total number of pine records (J/C)*100 | 6.6 | 4.5 | 0 | 0 | 0 |
| M | Total No. of 1 km grid squares searched which were dominated by category 4 soils | 0 | 0 | 0 | 0 | 11 |
| N | No. of 1 km grid squares which contained category 4 soils and pine | 0 | 0 | 0 | 0 | 0 |
| O | Percentage of category 4 soils which contained pine ((N/M)*100 | 0 | 0 | 0 | 0 | 0 |
| R | No. of category 4 soils which contained pine calculated as a % of the total number of pine records (N/C)*100 | 0 | 0 | 0 | 0 | 0 |

**Table 5.2 Modern tree density and percentage canopy cover**

| Site | Number of trees n-1 | Intertree distance (m) | Mean intertree distance (m) | Area occupied by one tree | Number of trees per hectare | Mean Basal Area ($m^2$) | Basal Area per hectare ($m^2$) | % Canopy Cover |
|---|---|---|---|---|---|---|---|---|
| Amat | | | | | | | | |
| site 1 | 40 | 194.08 | 4.85 | 65.65 | 152.3 | 0.16036 | 24.42 | 80 |
| site 2 | 50 | 107.63 | 2.62 | 19.14 | 522.4 | 0.0859 | 3.082 | 2 |
| Einig | 16 | 246.6 | 15.56 | 675.2 | 14.81 | 0.247 | 3.655 | 80 |
| Rhiddoch | | | | | | | | |
| site 1 | 29 | 123.95 | 4.13 | 47.5 | 210.5 | 0.137 | 28.832 | 60 |
| site 2 | 24 | 123.1 | 4.92 | 67.5 | 148.1 | 0.108 | 15.994 | 5 |
| Vaich | | | | | | | | |
| site 1 | 14 | 108.9 | 7.77 | 168.37 | 59.39 | 0.226 | 19.39 | 70 |
| site 2 | 14 | 53.6 | 3.829 | 40.87 | 44.68 | 0.286 | 61.978 | 70 |
| Shieldaig | 31 | 131.55 | 4.11 | 47.1 | 212.3 | 0.1202 | 25.518 | 70 |
| Clyneliss Moss | 39 | 87.67 | 2.19 | 13.3 | 751.8 | 0.00659 | 4.954 | 2 |

**Table 5.3 Sub-fossil tree density and estimated percentage canopy cover**

| Site | Number of trees n-1 | Intertree distance (m) | Mean intertree distance (m) | Area occupied by one tree | Number of trees per hectare | Mean Basal Area ($m^2$) | Basal Area per hectare ($m^2$) | Estimated % Canopy Cover |
|---|---|---|---|---|---|---|---|---|
| Badanloch | | | | | | | | |
| site 1 | 176 | 727.97 | 4.13 | 47.56 | 210.26 | 0.0201 | 4.226 | 2.9 |
| site 2 | 74 | 176.9 | 2.39 | 15.93 | 627.74 | 0.0341 | 21.40 | 6.04 |
| Inchkinloch | 20 | 20 | 73.14 | 3.48 | 296.12 | 0.0414 | 12.25 | 7.79 |
| Loyal | 88 | 245.4 | 2.78 | 21.55 | 464.03 | 0.0294 | 13.64 | 5.09 |
| Melness | 49 | 145.5 | 2.96 | 24.43 | 409.33 | 0.0355 | 14.53 | 6.46 |
| Vasgo | 17 | 106.65 | 6.27 | 109.63 | 91.21 | 0.1345 | 12.26 | 28.79 |
| Lochstrathy | | | | | | | | |
| site A | 51 | 155.2 | 3.044 | 25.84 | 386.99 | 0.0120 | 4.64 | 1.16 |
| site B | 12 | 45.68 | 3.806 | 40.27 | 248.32 | 0.0143 | 3.55 | 1.68 |
| site C | 34 | 88.70 | 2.608 | 18.85 | 530.50 | 0.0312 | 16.55 | 5.49 |
| site D | 6 | 24.03 | 4.005 | 44.62 | 224.11 | - | - | - |

**Table 6.1 THE PRESENCE OF MACRO-FOSSILS IN RELATION TO THE LOCHSTRATHY LOCAL POLLEN ZONES FOR THE COARSE AND FINE RESOLUTION POLLEN DIAGRAMS. The results are combined from both the 4 x 10 mm macro-fossil samples and the 1 mm pollen washings.** * indicates that a macro-fossil was found in that pollen zone.

| Macro-fossil type | Before Ls-1a | Ls-1a | Ls-1b | Ls-2 | Ls-3a | Ls-3b | Ls-3c | Ls-3d | Ls-4a | Ls-4b | Ls-5 | Ls-6 | AfterLs-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Erica tetralix* | | | | | | | | | | | | | |
| leaves | * | * | * | | | | | | * | | * | * | * |
| seeds | * | * | | | | | | | * | | | | * |
| *Calluna vulgaris* | | | | | | | | | | | | | |
| leaves | * | * | | | | | | | * | * | * | * | * |
| seeds | * | * | * | * | * | * | * | * | * | * | * | * | * |
| *Polygala* | | | | | | | | | | | | | |
| leaf | * | | | | | | | | * | * | * | * | |
| Compositae | | | | | | | | | | | | | |
| tubiflorae | | | | | | | | | | | | | |
| flower | | | | | | | | | | | | | * |
| *Pinus sylvestris* | | | | | | | | | | | | | |
| bark? | | | | | | | * | * | | | | | |
| needles | | | | | | | | * | | | | | |

**TABLE 6.2**

**The results from the summary sheet output of CROSSDAT for the crossmatching of SO50 with S246**

Fixed was S050

radius 4 with 221 rings

Match was S246

radius 1 with 151 rings

Best match for standardised log values was at 9

with muliple probability of 0.00001 for an overlap of 151 rings

- individual probability 0.00000 with 273 tests -

(next best at 6; multiple probability 0.00001: probability ratio 1.01802)

Best match for B&P normalised values was at 152

with muliple probability of 0.32051 for an overlap of 66 rings

- individual probability 0.00146 with 265 tests -

(next best at 157; multiple probability 0.42850: probability ratio 1.33692)

Best match for Fritts high-pass values was at 152

with muliple probability of 0.37305 for an overlap of 58 rings

- individual probability 0.00187 with 249 tests -

(next best at 88; multiple probability 0.70673: probability ratio 1.89450)

Best match for Munrow 10-year values was at 88

with muliple probability of 0.44831 for an overlap of 112 rings

- individual probability 0.00259 with 229 tests -

(next best at 30; multiple probability 0.45870: probability ratio 1.02319)

Best match for BH's 9-point values was at 152

with muliple probability of 0.23087 for an overlap of 62 rings

- individual probability 0.00102 with 257 tests -

(next best at 157; multiple probability 0.50685: probability ratio 2.19536)

**Table 6.5 The number of births and deaths in 25 year intervals. The left hand side of each / represents the number of individuals born in a 25 year period. The right hand side of each / at the top of each column represents the number of individuals born during a 25 year period. Subsequently, the figures at the left hand side of each slash represent the number of those individuals still alive at the beginning of each subsequent 25 year period. The figure at the right of each slash indicates the number of those individuals that died during each subsequent 25 year period.**

| | Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-25 | 26-50 | 51-75 | 76-100 | 101-125 | 126-150 | 151-175 | 176-200 | 201-225 | 226-250 | 251-275 | 276-300 | 301-325 |
| Year | | | | | | | | | | | | | |
| 0-25 | 3/0 | | | | | | | | | | | | |
| 26-50 | 3/0 | 7/0 | | | | | | | | | | | |
| 51-75 | 3/0 | 7/3 | 7/0 | | | | | | | | | | |
| 76-100 | 3/2 | 4/2 | 7/2 | 2/0 | | | | | | | | | |
| 101-125 | 1/1 | 2/1 | 5/1 | 2/0 | 7/0 | | | | | | | | |
| 126-150 | 0/ | 1/0 | 4/2 | 2/0 | 7/1 | 5/0 | | | | | | | |
| 151-175 | | 1/0 | 2/1 | 2/0 | 6/2 | 5/3 | 2/0 | | | | | | |
| 176-200 | | 1/0 | 1/0 | 2/1 | 4/2 | 2/0 | 2/1 | 8/0 | | | | | |
| 200-225 | | 1/0 | 1/1 | 1/1 | 2/1 | 2/2 | 1/1 | 8/1 | 2/0 | | | | |
| 226-250 | | 1/0 | 0/ | 0/ | 1/0 | 0/ | 0/ | 7/4 | 2/1 | 1/0 | | | |
| 251-275 | | 1/1 | | | 1/1 | | | 3/2 | 1/1 | 1/0 | | | |
| 276-300 | | 0/ | | | 0/ | | | 1/0 | 0/ | 1/1 | | | |
| 301-325 | | | | | | | | 1/0 | | 0/ | | | |
| 326-350 | | | | | | | | 1/1 | | | | | |
| 351-375 | | | | | | | | 0/ | | | | | |

TABLE 6.7

**Fire frequency at Lochstrathy in 25 year intervals based on fire scars**

| Floating years | Number of fires recorded | Number of trees recorded alive | A/B | Number of births | Number of deaths | Log D/E | Mean fire interval (years) |
|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G |
| 0-25 | 1 | 3 | 0.33 | 3 | 0 | 0.47 | 25.00 |
| 26-50 | 2 | 10 | 0.20 | 7 | 0 | 0.84 | 12.50 |
| 51-75 | 3 | 17 | 0.17 | 7 | 3 | 0.36 | 8.30 |
| 76-100 | 5 | 16 | 0.31 | 2 | 6 | -0.47 | 5.00 |
| 101-125 | 5 | 16 | 0.31 | 2 | 6 | -0.47 | 5.00 |
| 126-150 | 12 | 17 | 0.70 | 5 | 3 | 0.22 | 2.00 |
| 151-175 | 4 | 18 | 0.22 | 2 | 6 | -0.47 | 6.25 |
| 176-200 | 6 | 20 | 0.30 | 8 | 4 | 0.30 | 4.16 |
| 201-225 | 7 | 18 | 0.38 | 2 | 7 | -0.54 | 3.57 |
| 226-250 | 4 | 12 | 0.33 | 1 | 5 | -0.69 | 6.25 |
| 250-275 | 0 | 7 | 0 | 0 | 5 | - | - |
| 276-300 | 0 | 2 | 0 | 0 | 1 | - | - |
| 301-325 | 0 | 1 | 0 | 0 | 0 | - | - |
| 325-350 | 0 | 0 | 0 | 0 | 1 | - | - |

**TABLE 6.8**

**Radiocarbon dates and sediment accumulation rates for Lochstrathy**

| Laboratory Code | Sample Code | Conventional age years B..P. +/- one sigma | Calender Years B.P. +/- one sigma* | Sediment accumulation rates cm. $yr^{-1}$ |
|---|---|---|---|---|
| SRR-3495 | LS/001 | 3275 +/-65 | 3619 to 3460 | - |
| SRR-3496 | LS/002 | 3525 +/-65 | 3897 to 3709 | 0.0144 |
| SRR-3497 | LS/003 | 3495 +/-65 | 3858 to 3692 | - |
| SRR-3498 | LS/004 | 3510 +/- 65 | 3881 to 3696 | 0.0400 |
| SRR-3499 | LS/005 | 3600 +/- 55 | 3985 to 3838 | 0.0133 |
| SRR-3500 | LS/006 | 3930 +/- 55 | 4506 to 4313 | 0.0151 |
| SRR-3501 | LS/007 | 4225 +/- 60 | 4862 to 4651 | - |

* Reference for the data sets (and intervals) used in calibration is Pearson and Stuiver (1986)

Samples LS/001-LS/006 inclusive are peat. Sample LS/007 is a wood fragment of *Pinus sylvestris* (part of the root system) which was associated with the monolith.

Fig. 1.1 Map illustrating the location of northern Scotland and its treelessnes in comparison with other areas of Britain and Europe

Fig. 1.1a The percentage of woodland cover in relation to the total area for each country in 1977 (after Mitchie, 1985). Note the figure in the Irish Sea refers to the U.K.

Fig. 1.1b The volume of deciduous timber in woodlands > 5 acres for each geographical area in 1949. The size of the pie charts is proportional to the volume of broadleaved timber per geographic area (from the Atlas of Britain and Northern Ireland, 1963)

Fig. 1.1c The location of the study area - northern Scotland.

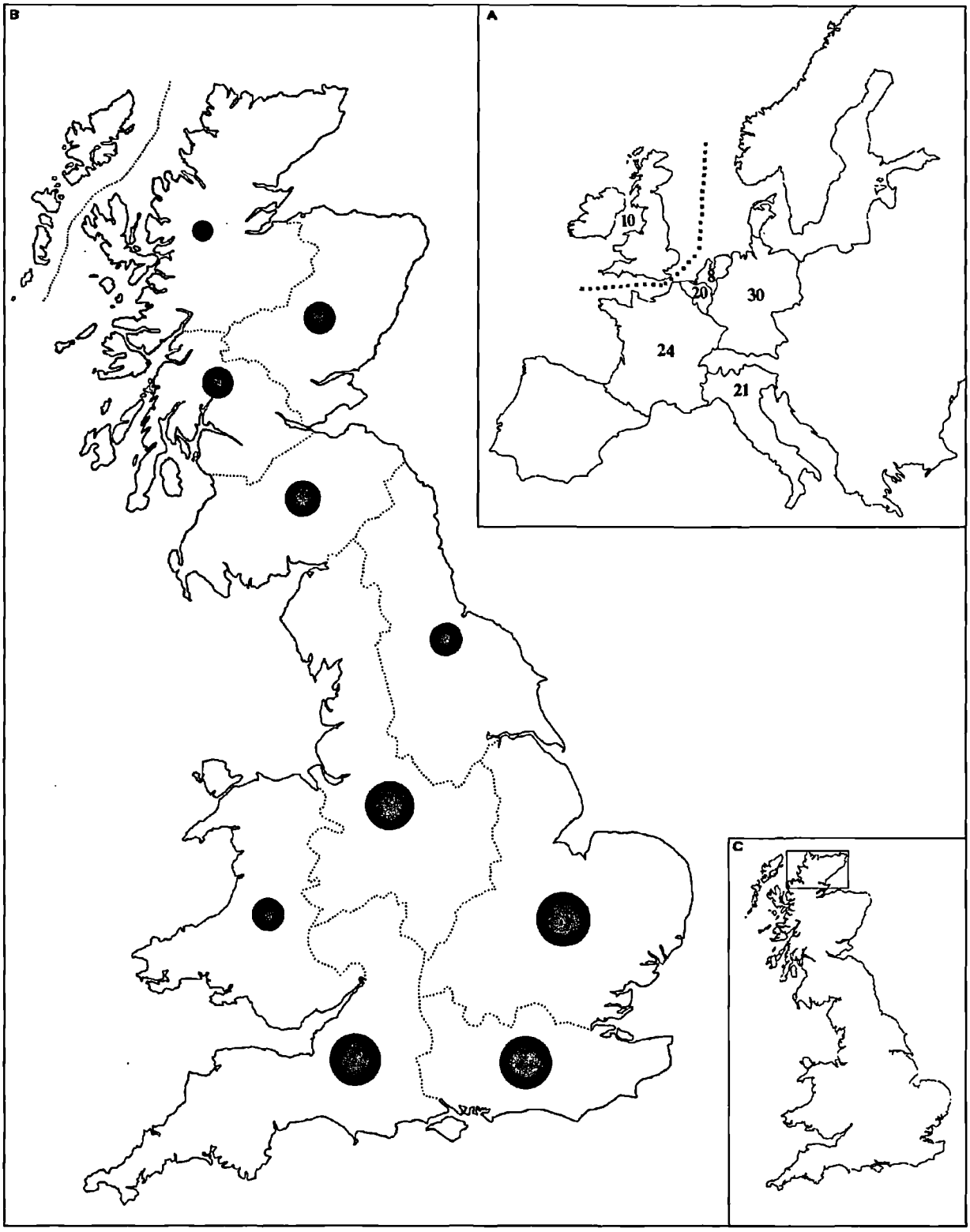

B
A
10
8
20
30
24
21
C

Fig. 2.1a The location of the study area. Northern Scotland, Far northern, north-western, north-eastern, and central-northern Scotland are defined on the map

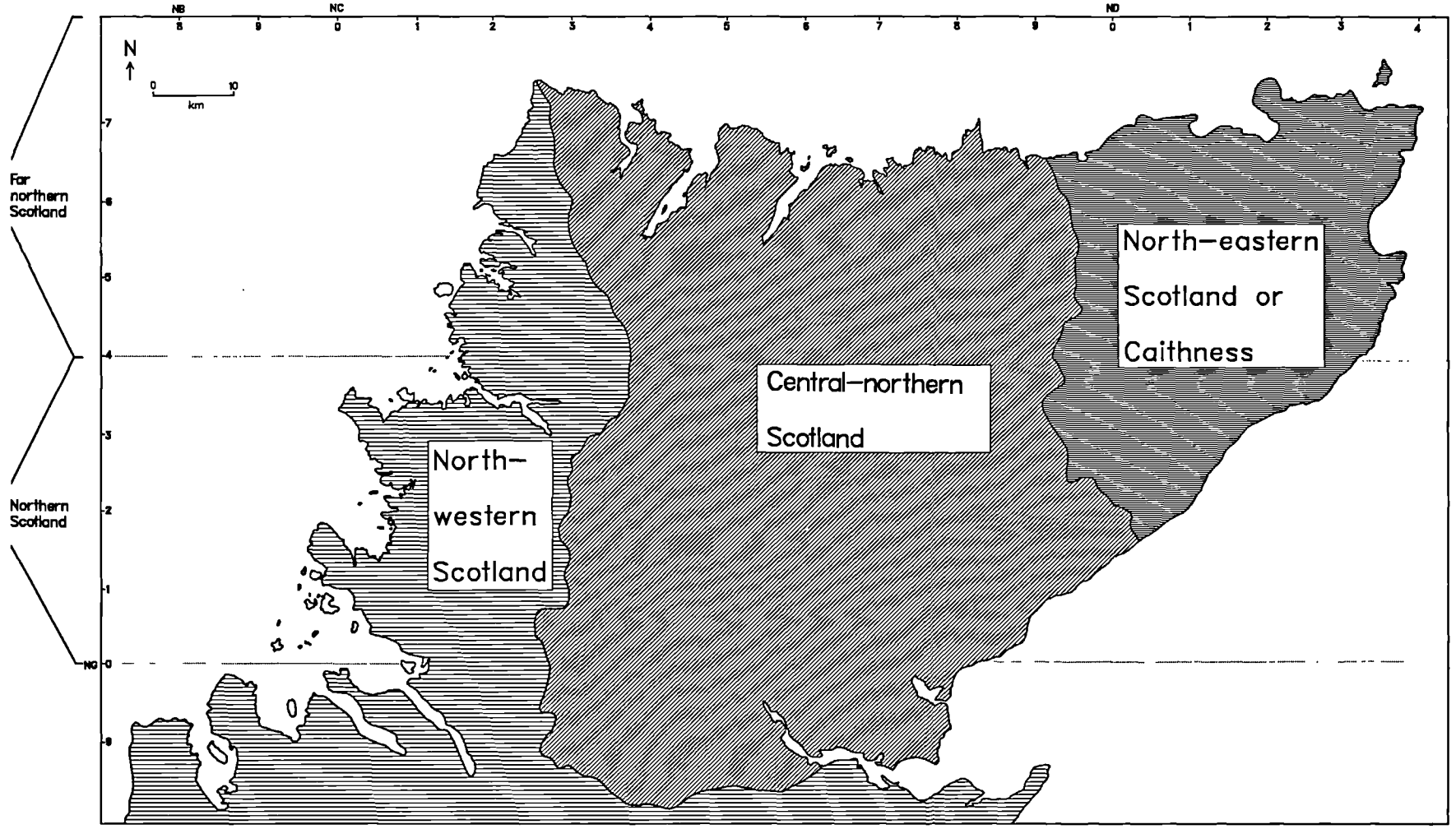

NB
NC
ND
N
0
10
km
Far northern Scotland
Northern Scotland
NG
North-western Scotland
Central-northern Scotland
North-eastern Scotland or Caithness

Fig. 2.1b The location of places mentioned in the text

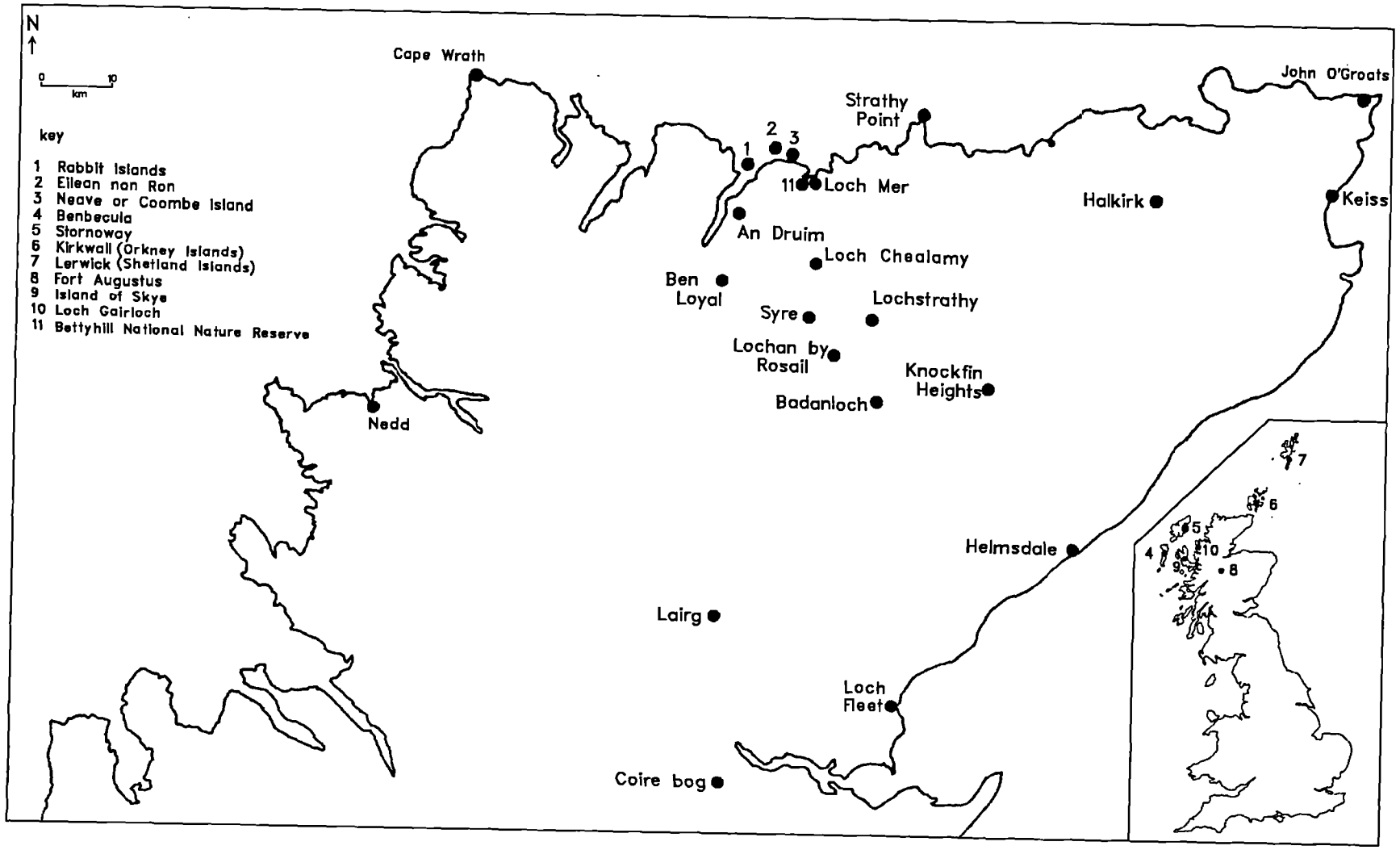

N
0
10
km
key
1 Rabbit Islands
2 Eilean nan Ron
3 Neave or Coombe Island
4 Benbecula
5 Stornoway
6 Kirkwall (Orkney Islands)
7 Lerwick (Shetland Islands)
8 Fort Augustus
9 Island of Skye
10 Loch Gairloch
11 Bettyhill National Nature Reserve
Cape Wrath
John O'Groats
Strathy Point
Loch Mer
Halkirk
Keiss
An Druim
Loch Chealamy
Ben Loyal
Lochstrathy
Syre
Lochan by Rosail
Knockfin Heights
Badanloch
Nedd
Helmsdale
Lairg
Loch Fleet
Coire bog

Fig. 2.2a Generalised relief map of northern Scotland

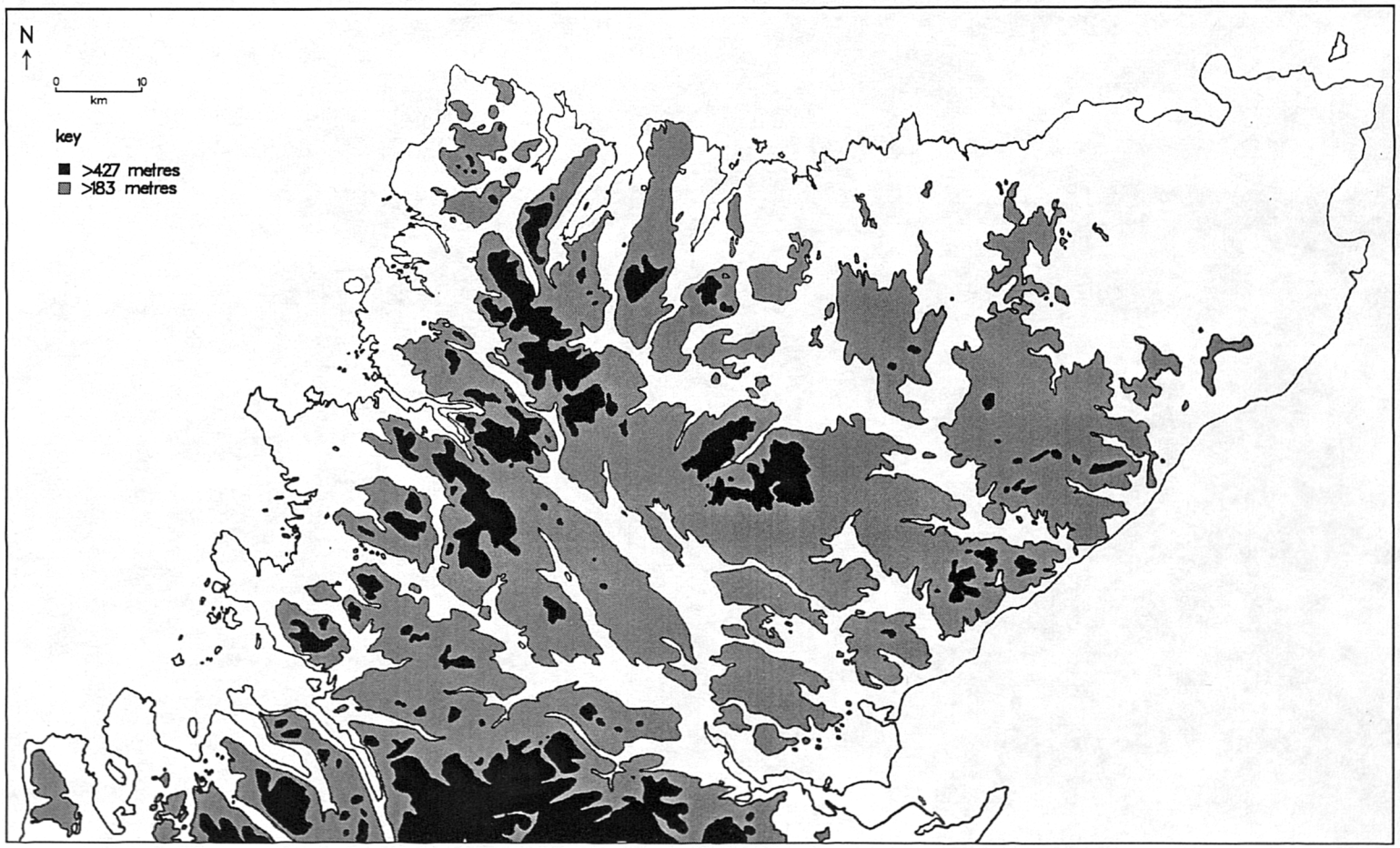

N
0
10
km
key
>427 metres
>183 metres

Fig. 2.2b Principal lochs and rivers of northern Scotland

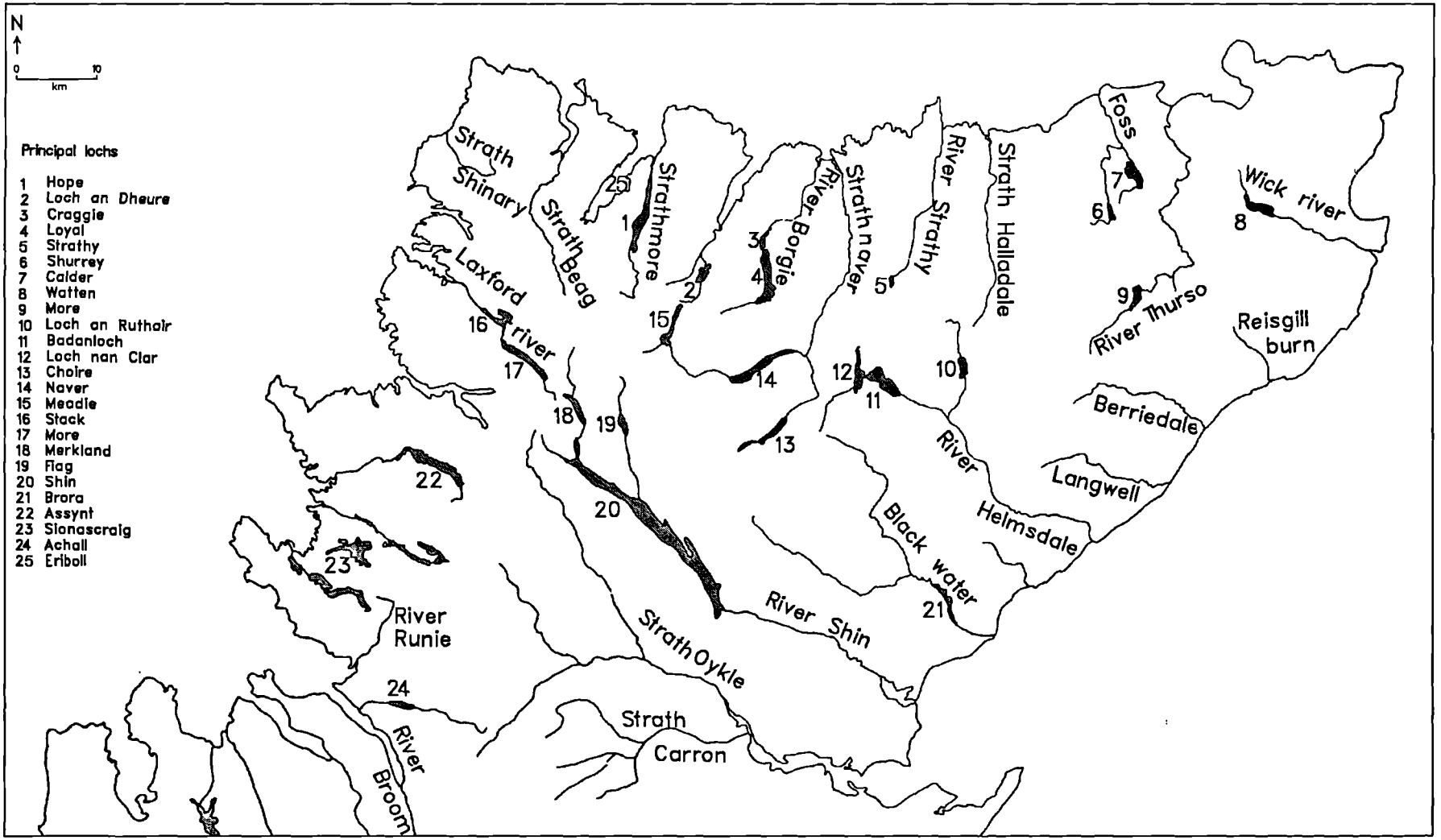

N
0
10
km
Principal lochs
1 Hope
2 Loch an Dheure
3 Craggie
4 Loyal
5 Strathy
6 Shurrey
7 Calder
8 Watten
9 More
10 Loch an Ruthair
11 Badanloch
12 Loch nan Clar
13 Choire
14 Naver
15 Meadie
16 Stack
17 More
18 Merkland
19 Flag
20 Shin
21 Brora
22 Assynt
23 Sionascraig
24 Achall
25 Eriboll
Strath Shinary
Strath Beag
Strathmore
River Borgie
Strath naver
River Strathy
Strath Halladale
Foss
Wick river
Laxford river
River Thurso
Reisgill burn
Berriedale
Langwell
River Helmsdale
Black water
River Shin
Strath Oykle
River Runie
Strath Carron
River Broom

Fig. 2.3a Generalised solid geology of northern Scotland (redrawn from Futty and Towers, 1982)


N
0
10
KM
KEY
Old Red Sandstone
Granites and allied rocks
Moine granulites and schists
Lewisian gneisses
Cambrian/Ordovician quartzities and limestones
Torridonian sandstones
Jurassic sandstones, shales and limestones

Fig. 2.3b Superficial geology and Quaternary deposits of northern Scotland (redrawn from the Geological Survey Ten Mile Map. North Sheet, 1st. edition, Quaternary, 1977. 1:625,000).

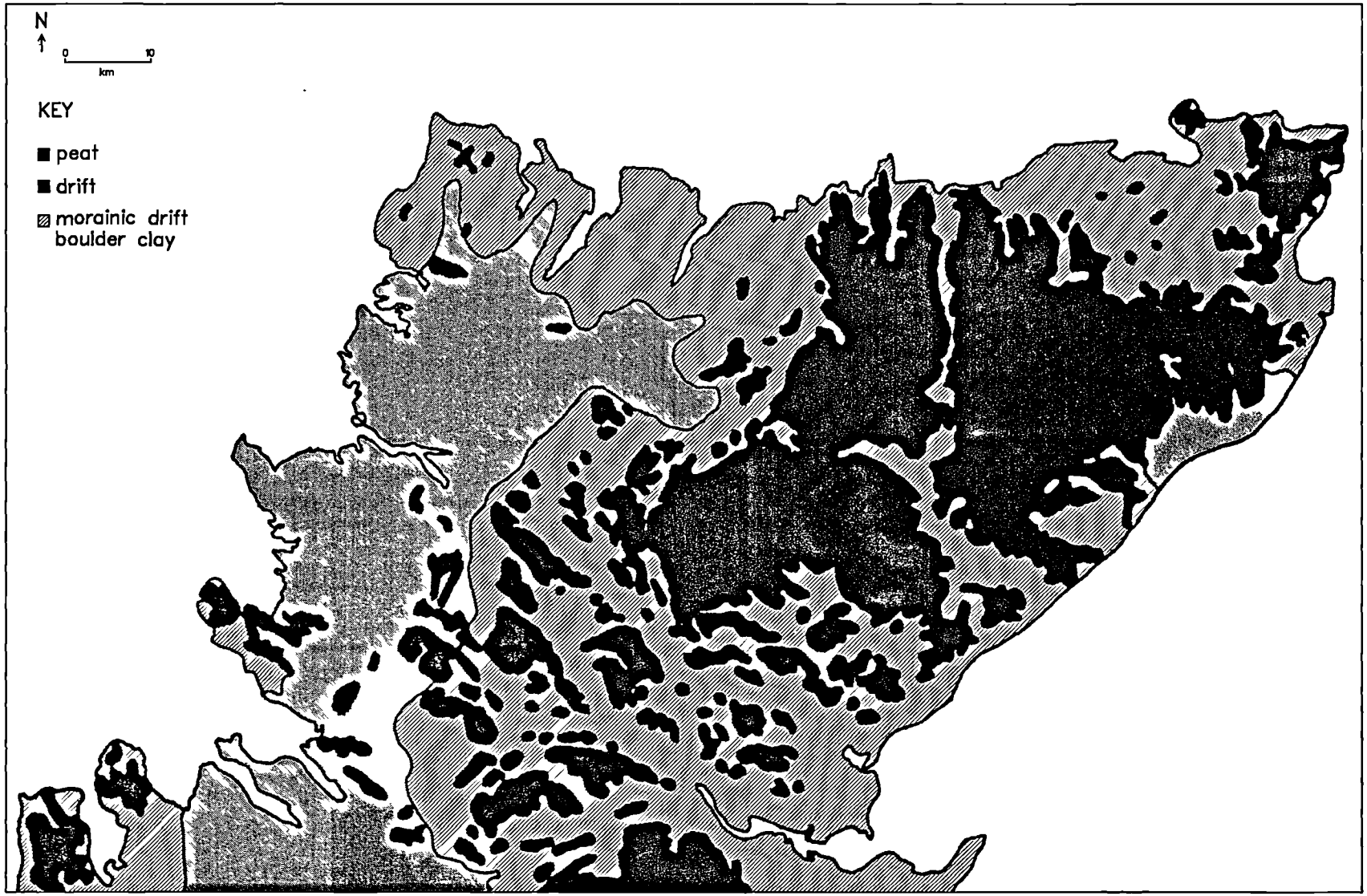

N
0
10
km
KEY
peat
drift
morainic drift
boulder clay

Fig. 2.4 Generalised soil map of northern Scotland (redrawn from the Atlas of Britain and Northern Ireland, 1949).

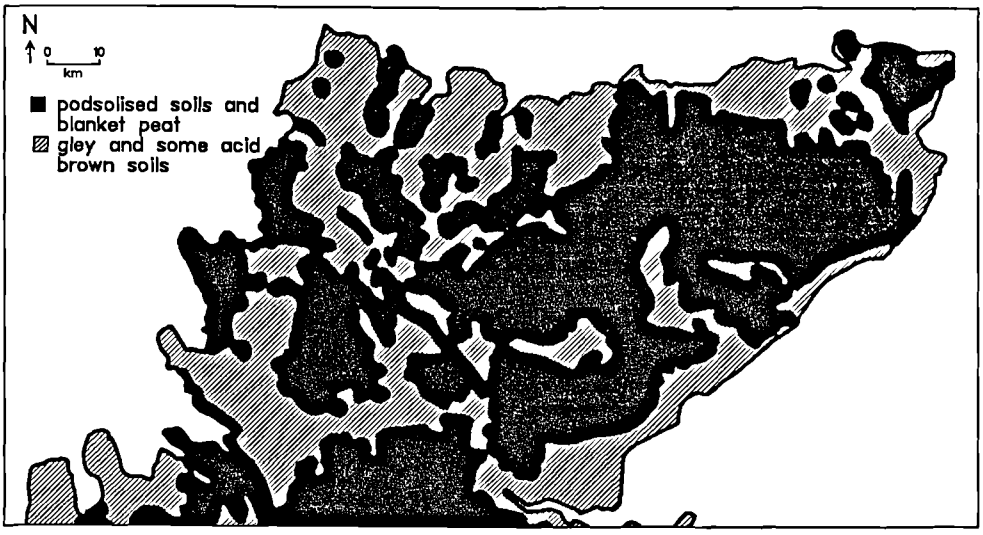
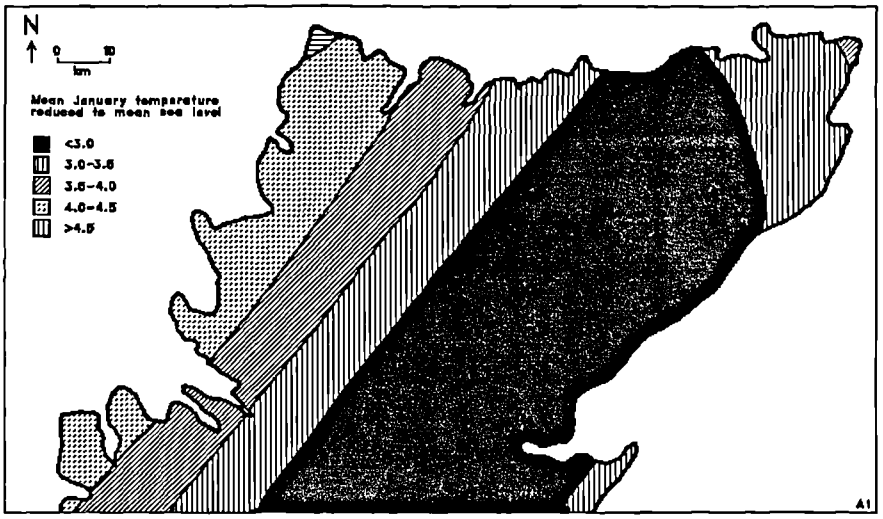
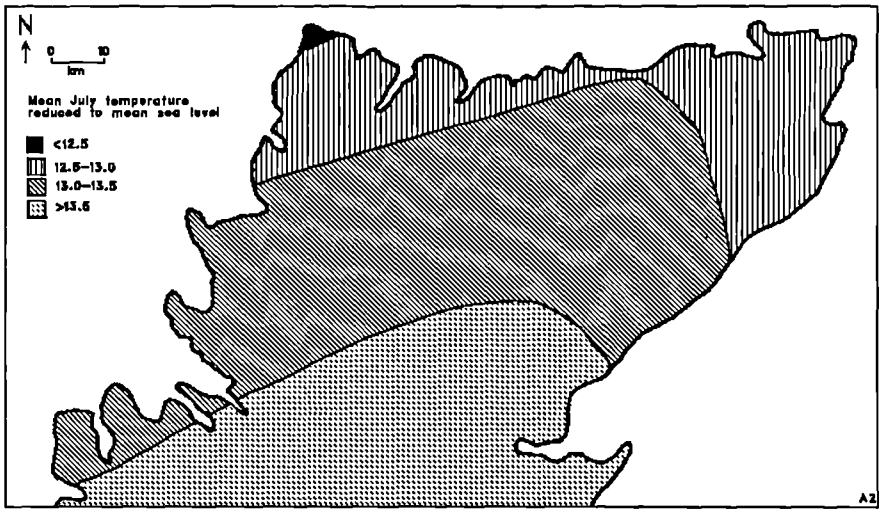

N
0
10
km
podsolised soils and blanket peat
gley and some acid brown soils

Fig. 2.5ai Mean January temperature in northern Scotland (redrawn from Omand, 1985)

Fig. 2.5aii Mean July temperature in northern Scotland (redrawn from Omand, 1985

Fig. 2.5b Average annual precipitation in northern Scotland (redrawn from Futty and Towers, 1982)


N
0
10
km
Mean January temperature reduced to mean sea level
<3.0
3.0–3.5
3.5–4.0
4.0–4.5
>4.5
A1


N
0
10
km
Mean July temperature reduced to mean sea level
<12.5
12.5–13.0
13.0–13.5
>13.5
A2

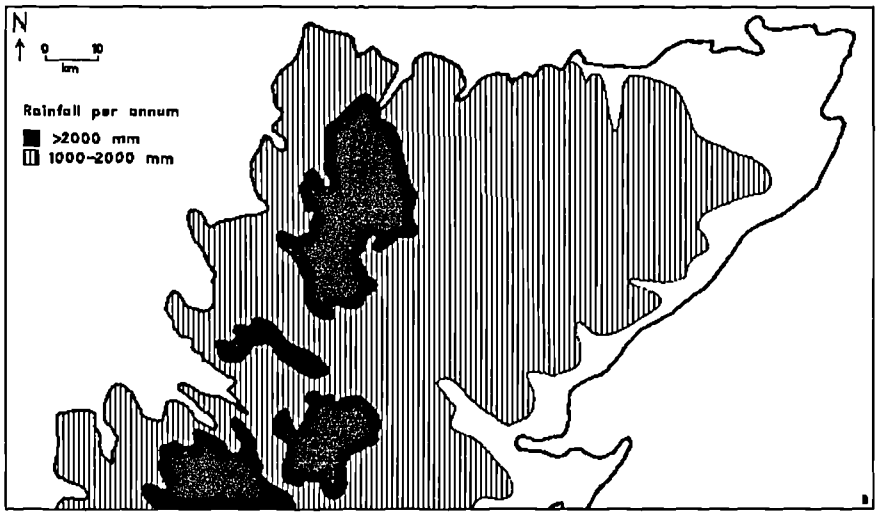

N
0
10
km
Rainfall per annum
>2000 mm
1000–2000 mm
B

Fig. 2.6a Generalised vegetation map of northern Scotland (redrawn from the New Oxford Atlas, 1975)

Fig. 2.6b Present extent of birch woodlands in northern Scotland (redrawn from McVean and Ratcliffe, 1962)

Fig. 2.6c The distribution of native *Pinus sylvestris* woodlands (redrawn from Steven and Carlisle, 1959)

Fig. 2.6d The main tendencies in woodland composition in northern Scotland (redrawn from Perring and Walters, 1962)

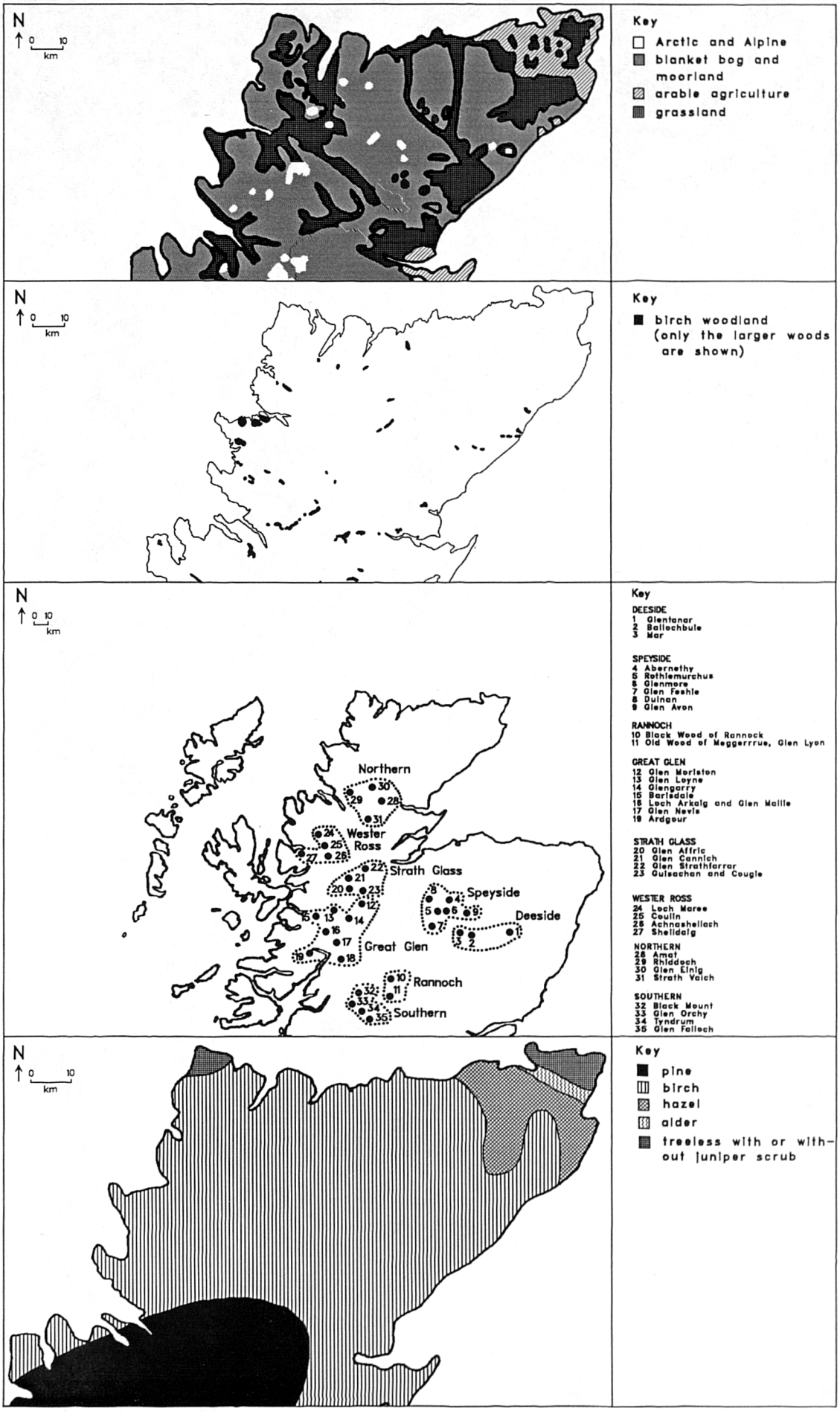

N
0 10
km
Key
Arctic and Alpine
blanket bog and moorland
arable agriculture
grassland
N
0 10
km
Key
birch woodland (only the larger woods are shown)
N
0 10
km
Northern
Wester Ross
Strath Glass
Speyside
Deeside
Great Glen
Rannoch
Southern
Key
DEESIDE
1 Glentanar
2 Ballochbule
3 Mar
SPEYSIDE
4 Abernethy
5 Rothiemurchus
6 Glenmore
7 Glen Feshie
8 Dulnan
9 Glen Avon
RANNOCH
10 Black Wood of Rannoch
11 Old Wood of Meggerrrue, Glen Lyon
GREAT GLEN
12 Glen Moriston
13 Glen Loyne
14 Glengarry
15 Barisdale
16 Loch Arkaig and Glen Mallie
17 Glen Nevis
18 Ardgour
STRATH GLASS
20 Glen Affric
21 Glen Cannich
22 Glen Strathfarrar
23 Gulsachan and Cougie
WESTER ROSS
24 Loch Maree
25 Coulin
26 Achnashellach
27 Shieldaig
NORTHERN
28 Amat
29 Rhiddoch
30 Glen Einig
31 Strath Valch
SOUTHERN
32 Black Mount
33 Glen Orchy
34 Tyndrum
35 Glen Falloch
N
0 10
km
Key
pine
birch
hazel
alder
treeless with or without juniper scrub

Fig. 2.7a The locations of pre-historic burial chambers in Sutherland (redrawn from Henshall, 1985)

Fig. 2.7b The locations of early-Christian settlements in Sutherland (redrawn from Omand and Talbot, 1985)

Fig. 2.7c The clearance settlements of Strathnaver (redrawn from Bangor-Jones, 1987)

Fig. 2.7d The principal contemporary settlements of Sutherland

Note the dotted lines demarkate the area under consideration on each map.

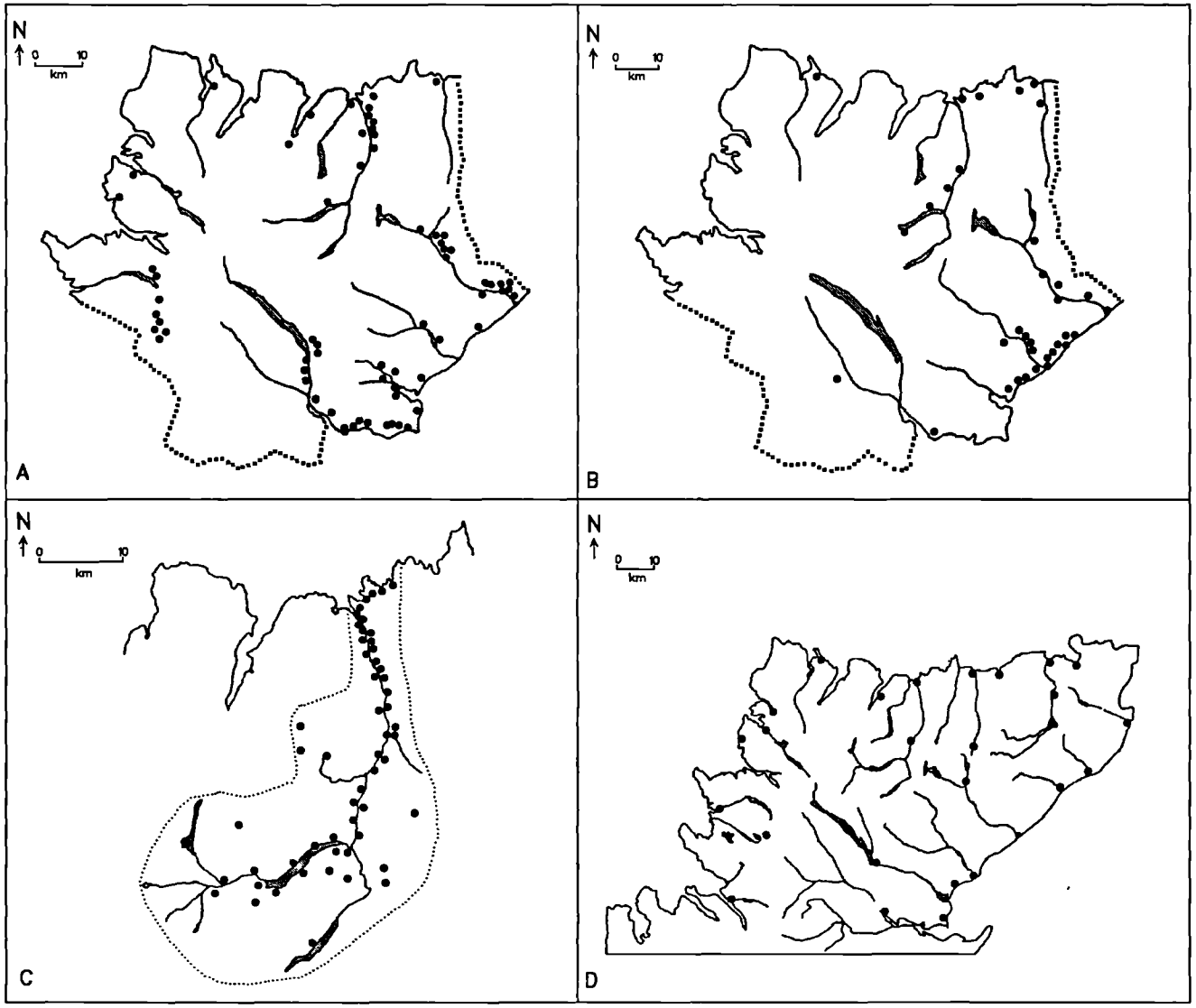

N
0
10
km
A
N
0
10
km
B
N
0
10
km
C
N
0
10
km
D

Fig. 2.8 Predicted average July wind speeds in northern Scotland (redrawn from White and Smith, 1982)

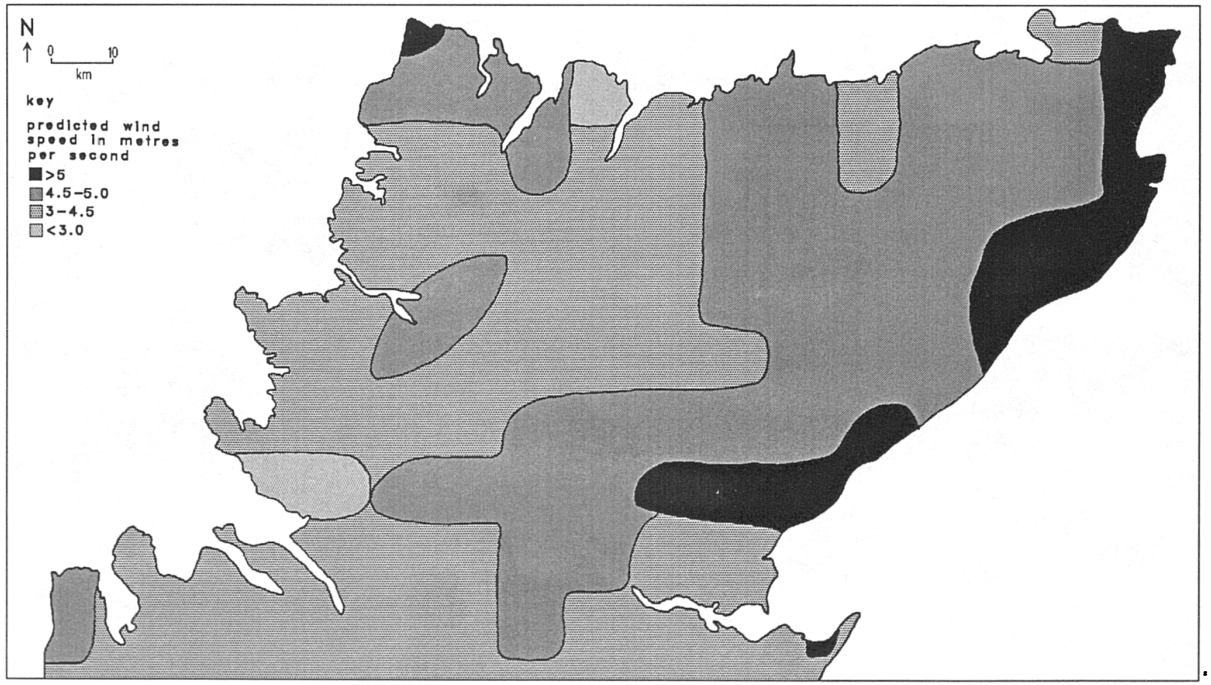

N
0
10
km
key
predicted wind speed in metres per second
>5
4.5–5.0
3–4.5
<3.0

Fig. 3.1 The geographical areas covered by the three sensors used in this project

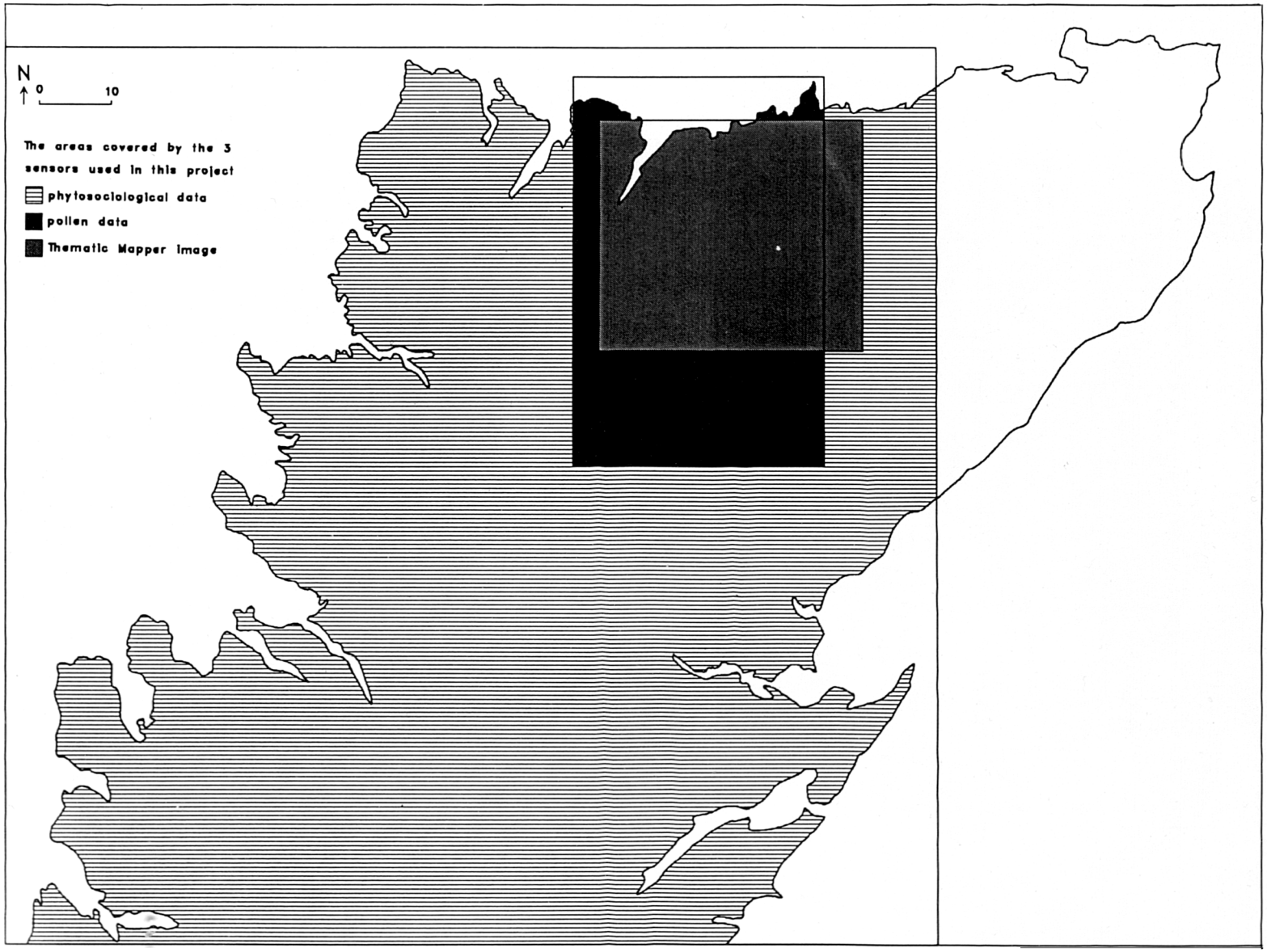

N
0
10
The areas covered by the 3 sensors used in this project
phytosociological data
pollen data
Thematic Mapper image

Fig. 3.2 The geographical location of all the relevés plotted on a 10 km grid square basis

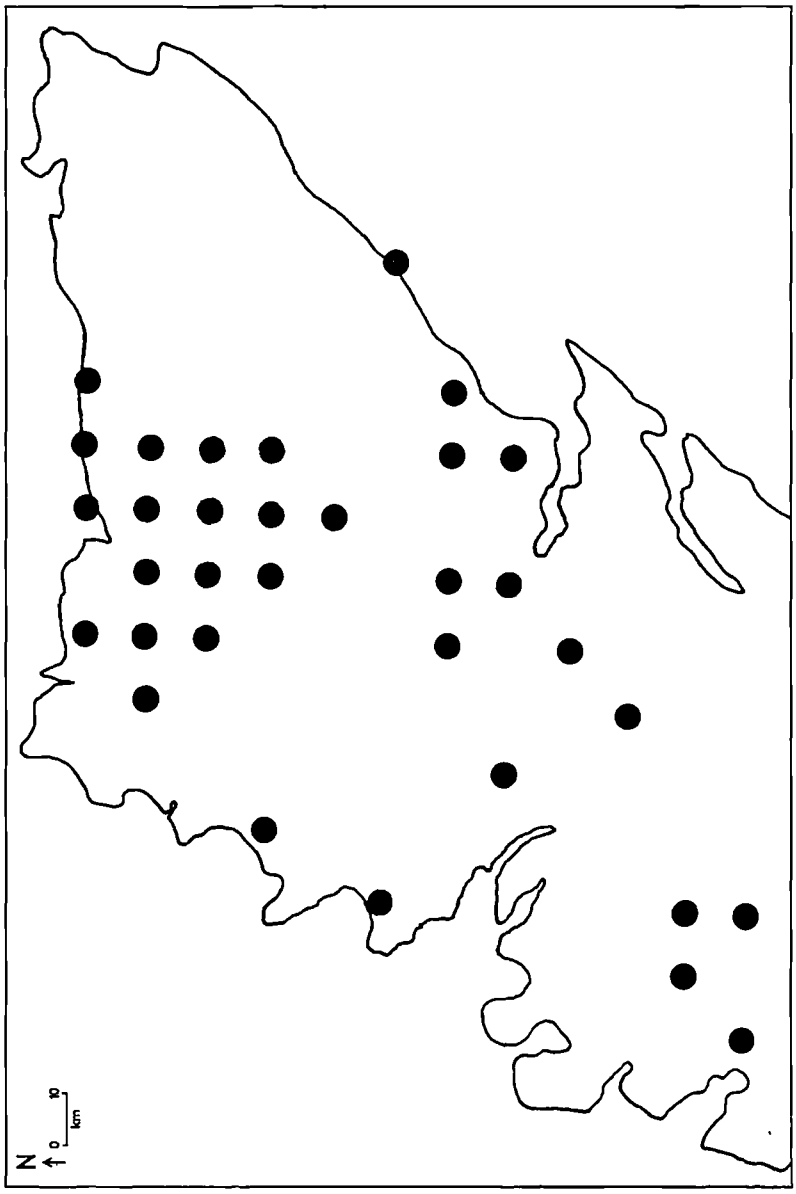

N
0
50
km

Fig. 3.3 Altitude of sites located within each nodum. The noda have been plotted along the x axis and are grouped into the following categories: birch woods, willow scrub, alder woods, dwarf-shrub heath or bog and grasslands.

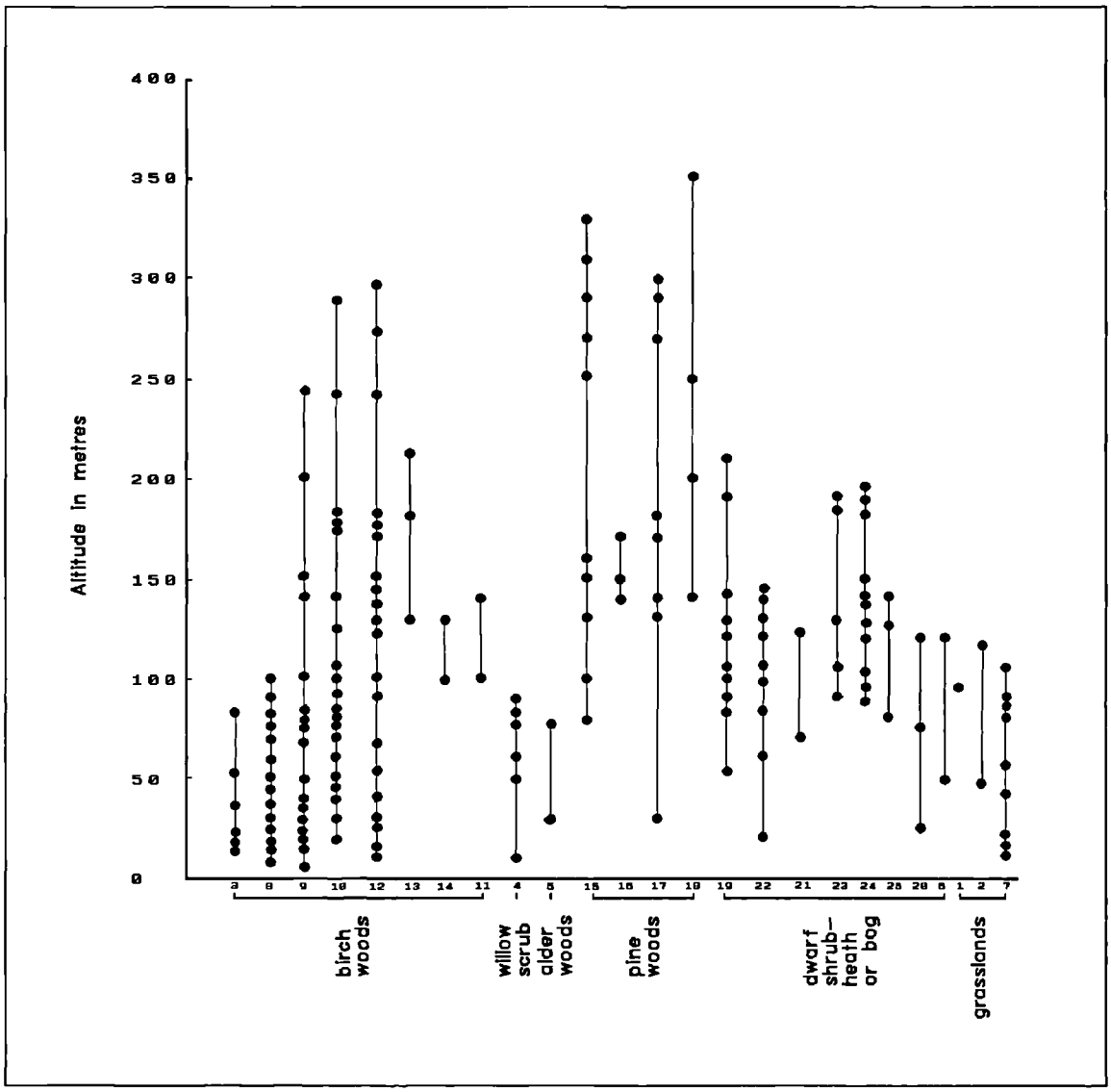

Altitude in metres
400
350
300
250
200
150
100
50
0
birch woods
willow scrub
alder woods
pine woods
dwarf shrub-heath or bog
grasslands

Fig. 3.4 Splitting diagram of the vegetation classification based on TWINSPAN

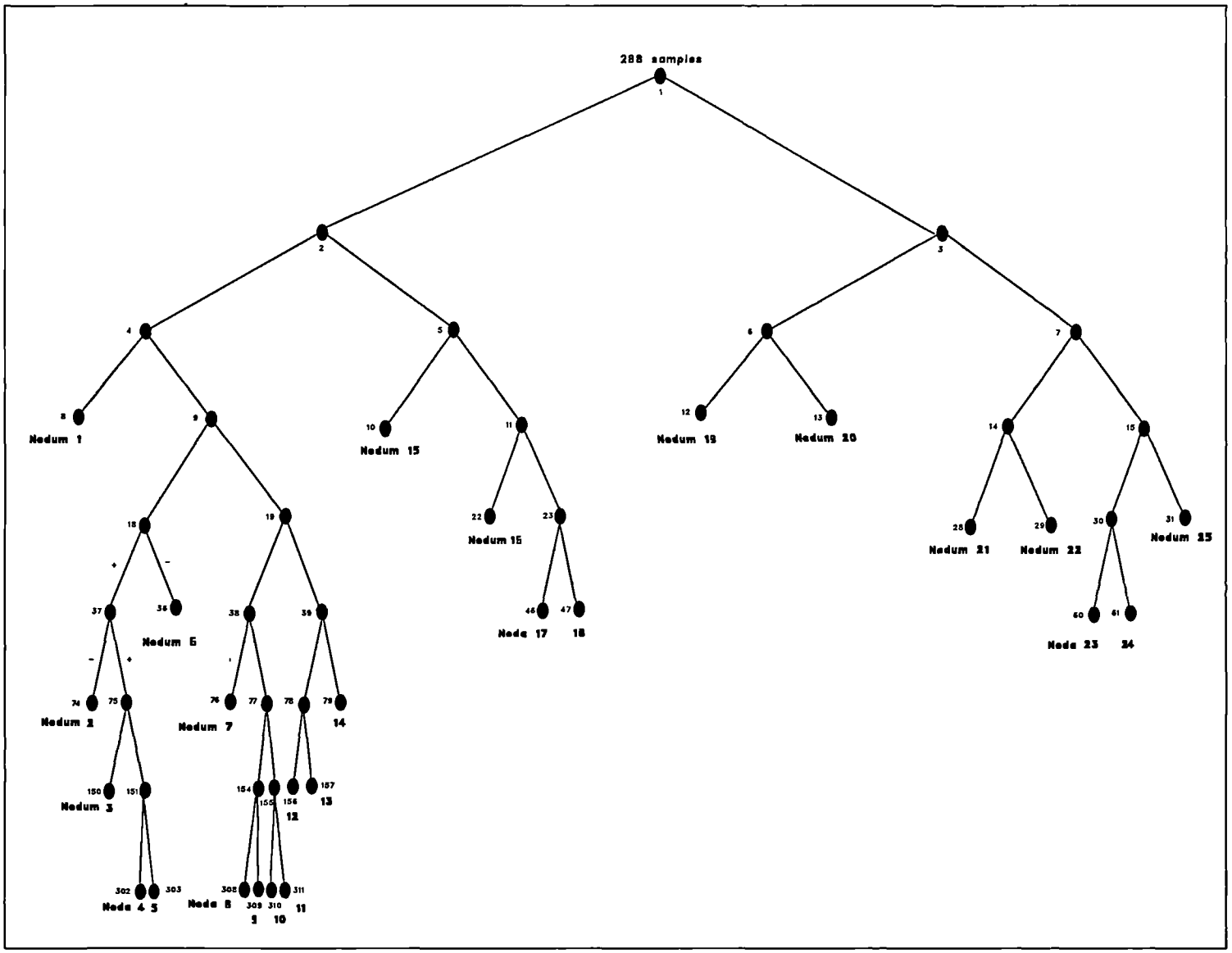
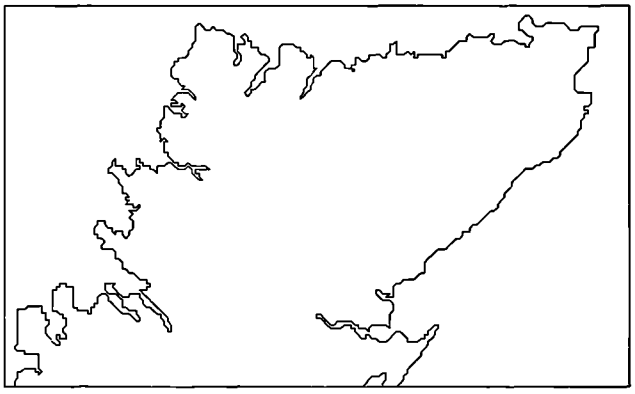
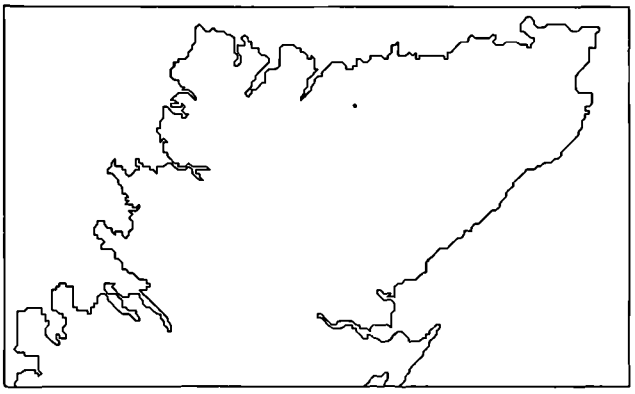

288 samples
1
2
3
4
5
6
7
8
Nodum 1
9
10
Nodum 15
11
12
Nodum 19
13
Nodum 20
14
15
16
17
18
19
22
23
Nodum 15
28
Nodum 21
29
Nodum 22
30
31
Nodum 25
37
36
Nodum 6
38
39
46
47
Node 17
18
50
61
Node 23
24
74
75
Nodum 2
76
77
Nodum 7
78
79
14
150
151
Nodum 3
154
155
156
12
157
13
302
303
Node 4 5
305
309
310
311
Node 8
9
10
11

Fig. 3.5a-h The geographical location of the relevés for each nodum plotted on a 1 km grid square basis

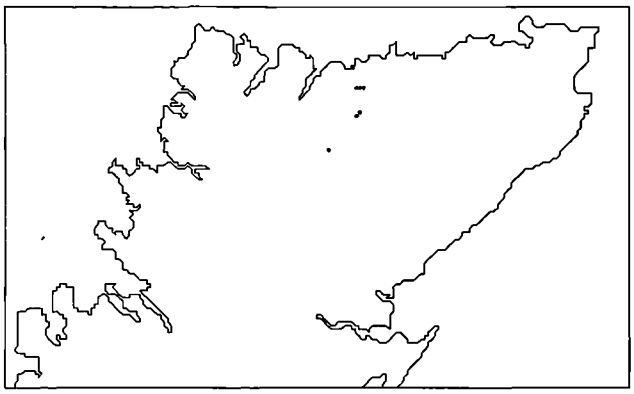
Nodum 1



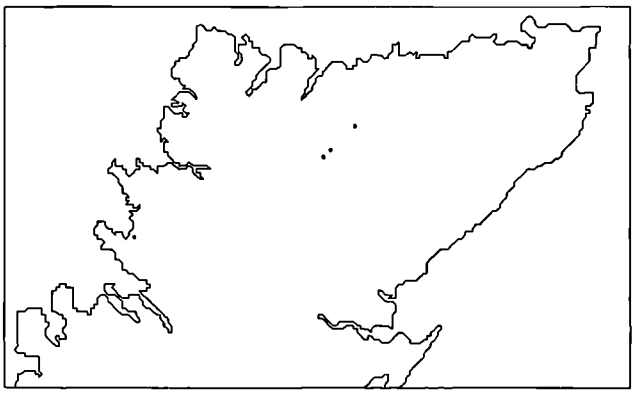
Nodum 2



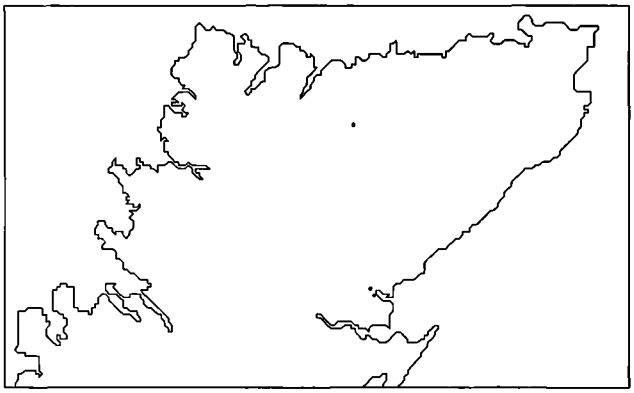
Nodum 3



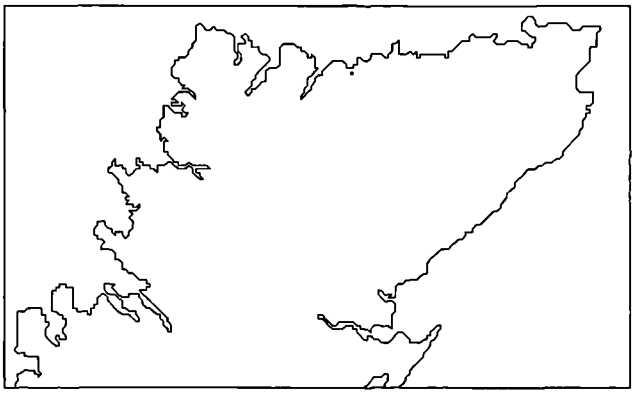
Nodum 4



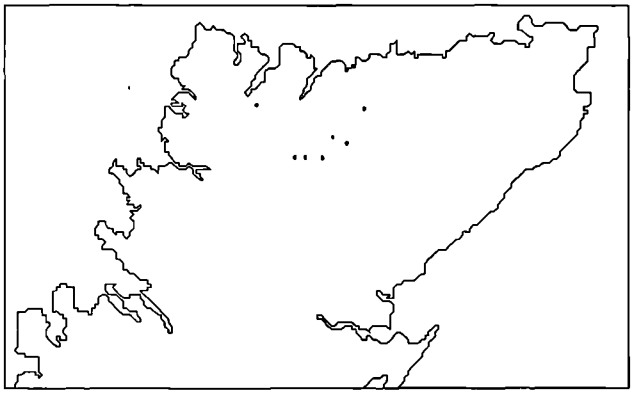
Nodum 5



Nodum 6



Nodum 7



Nodum 8

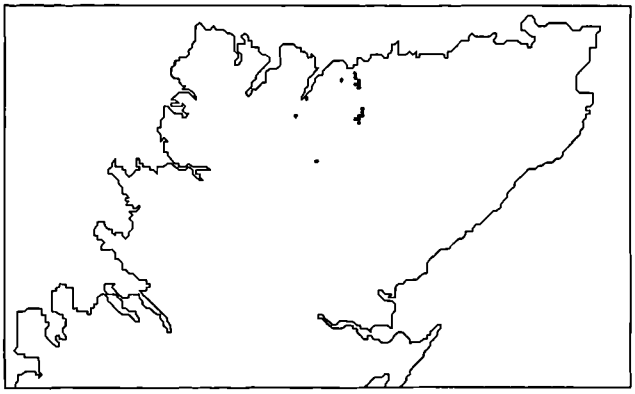
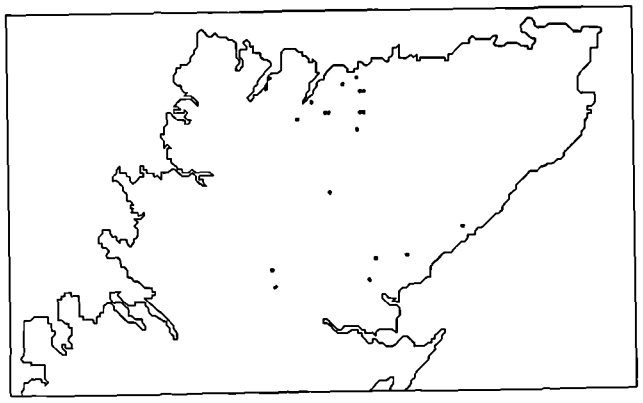
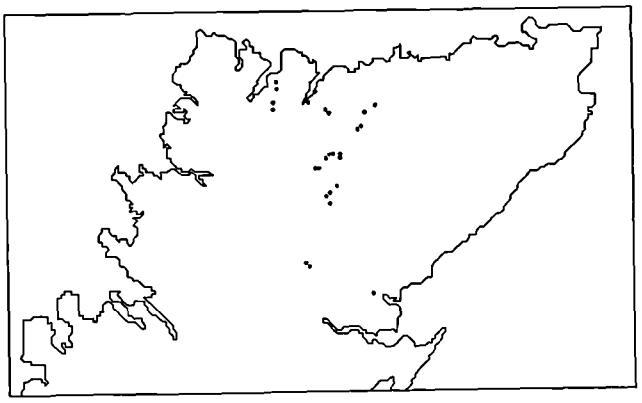


Fig. 3.5i-n The geographical location of the relevés for each nodum plotted on a 1 km grid square basis

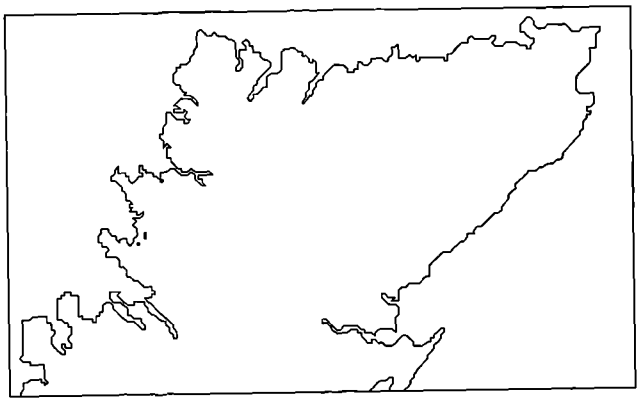
Nodum 9



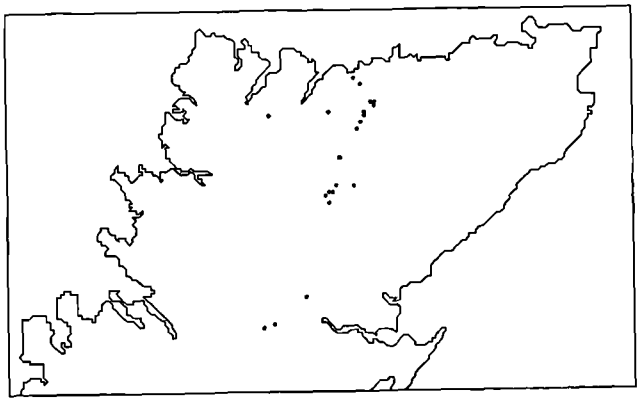
Nodum 10



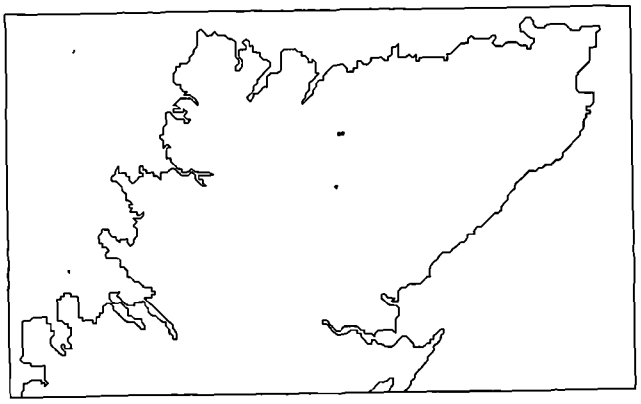
Nodum 11



Nodum 12



Nodum 13



Nodum 14

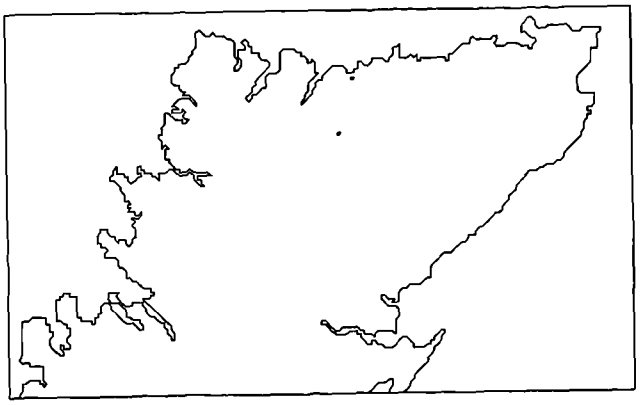
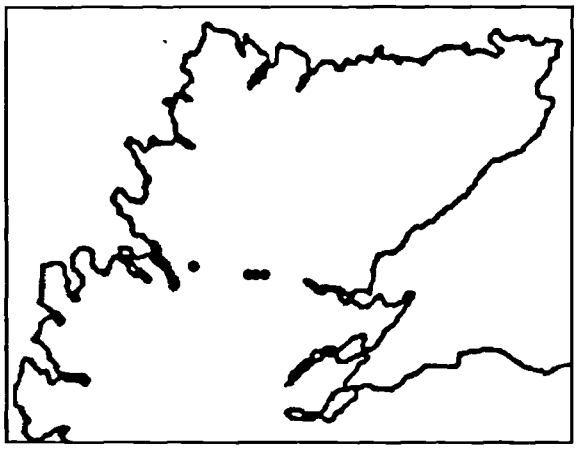
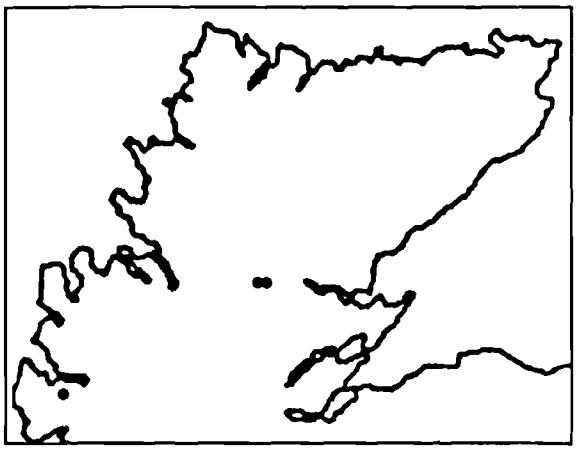


Fig. 3.5o-r The geographical location of the relevés for each nodum plotted on a 1 km grid square basis

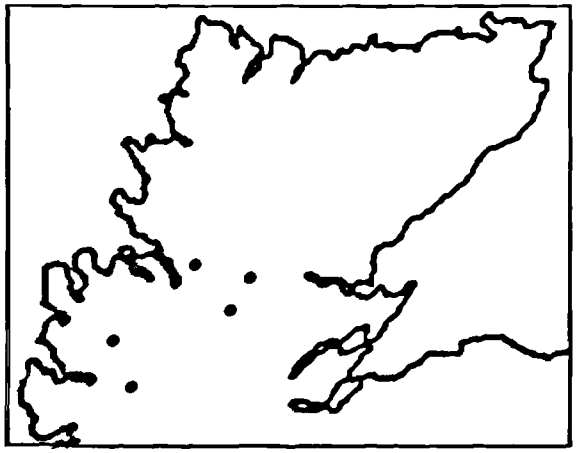
Nodum 15



Nodum 16



Nodum 17



Nodum 18

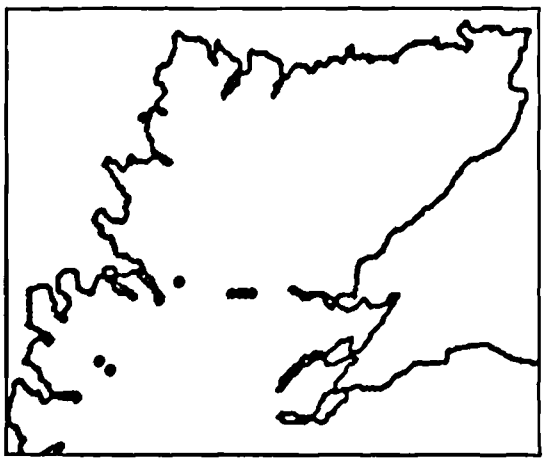
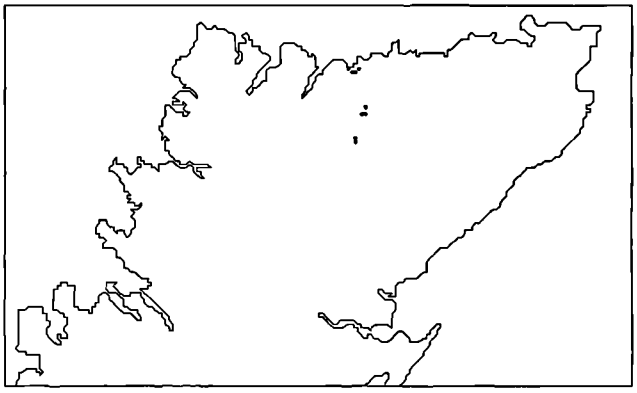
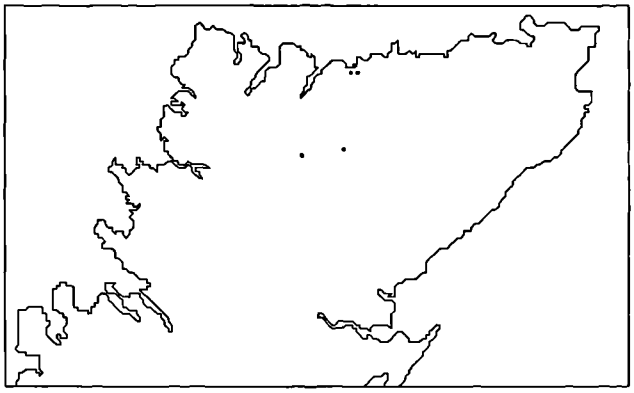


Fig. 3.5s-y The geographical location of the relevés for each nodum plotted on a 1 km grid square basis

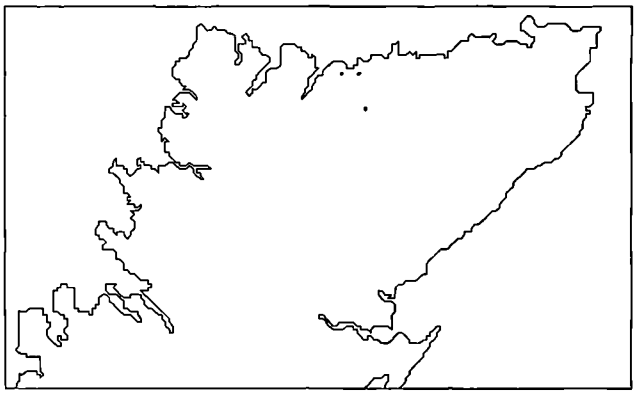
Nodum 19



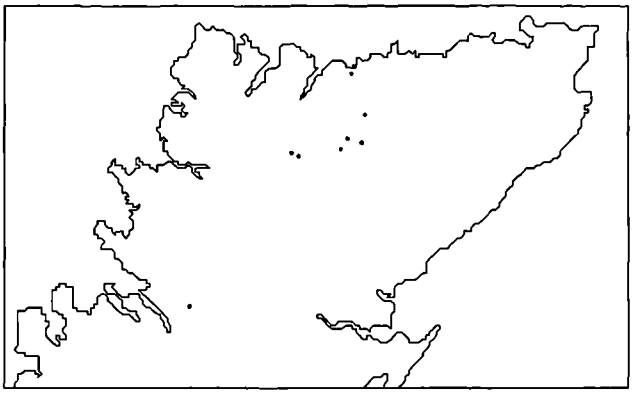
Nodum 20



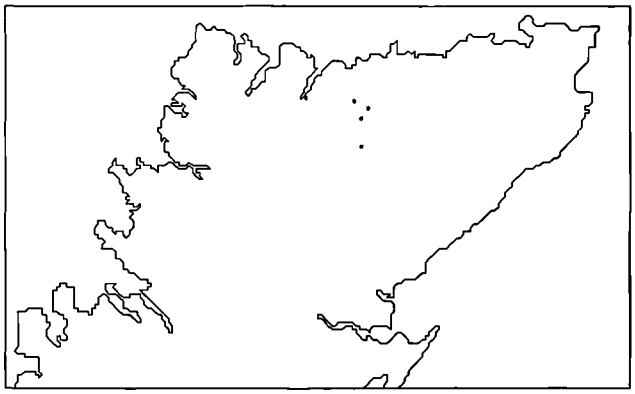
Nodum 21



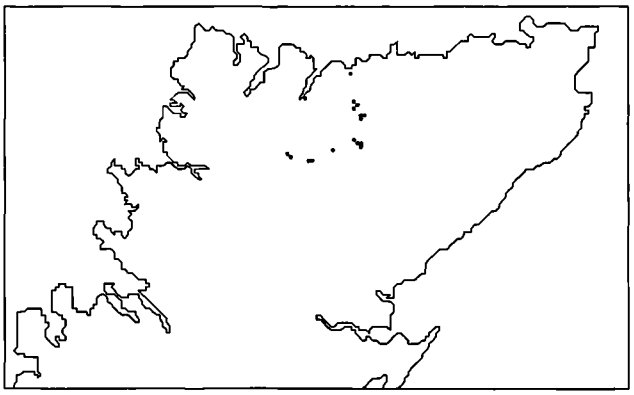
Nodum 22



Nodum 23



Nodum 24



Nodum 25

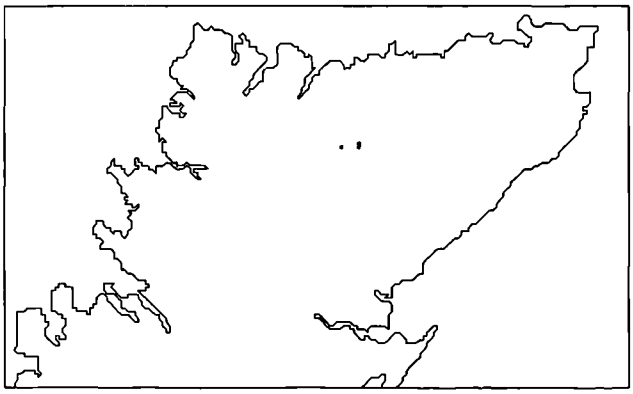


Fig. 3.6 Noda 1-25 plotted separately on axes 1 and 2 of DECORANA. The numbers in the figure are the noda code numbers found in Table 3.3. Note that group A has been divided into two sub-groups al and all.

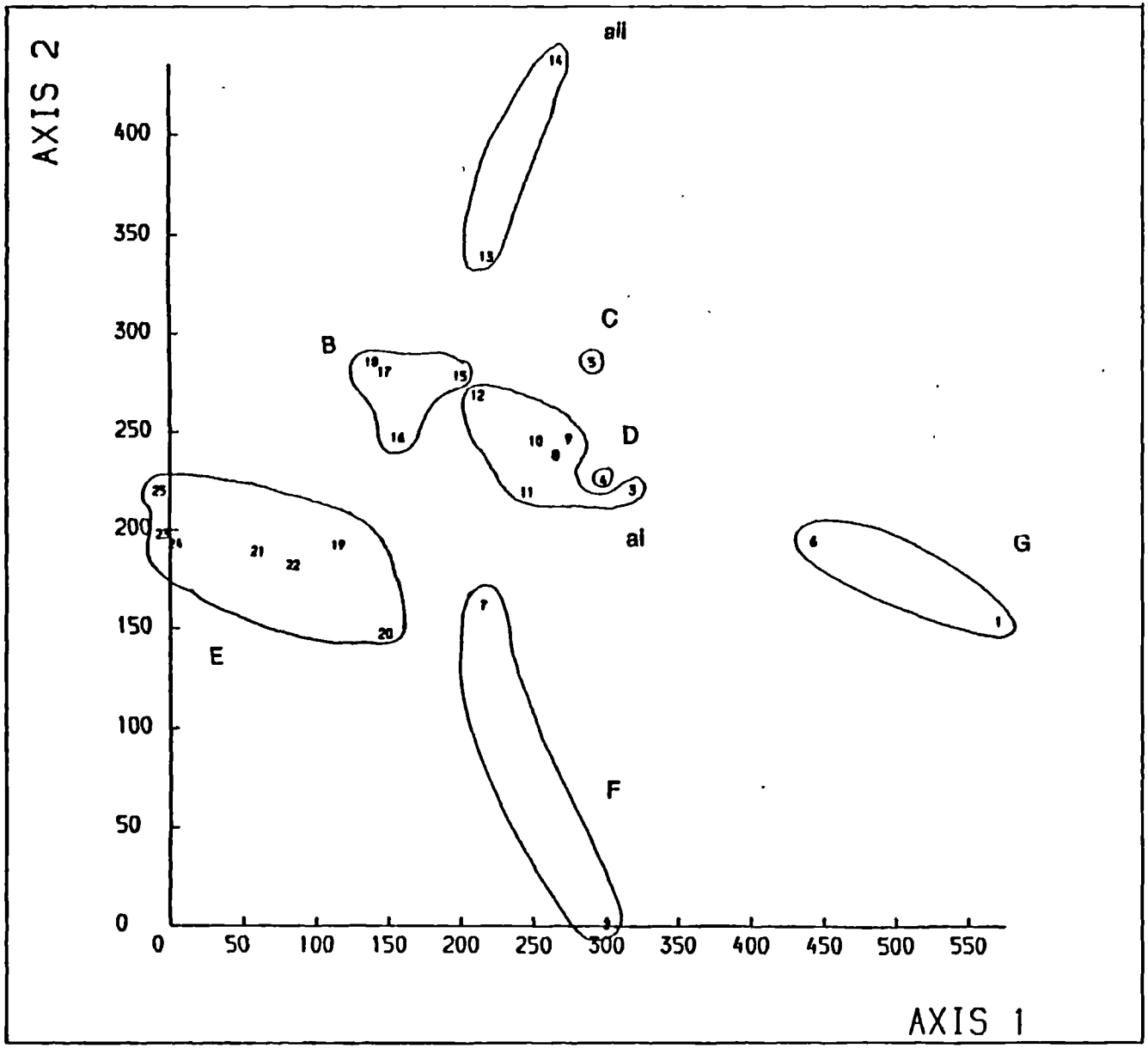
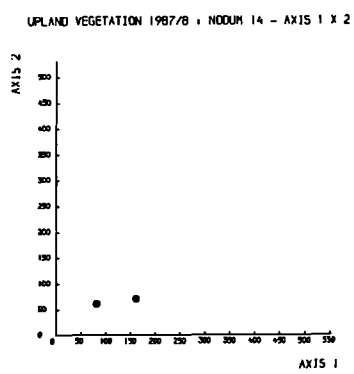
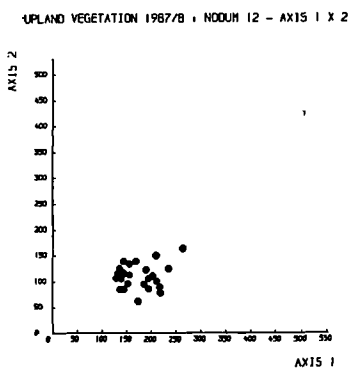
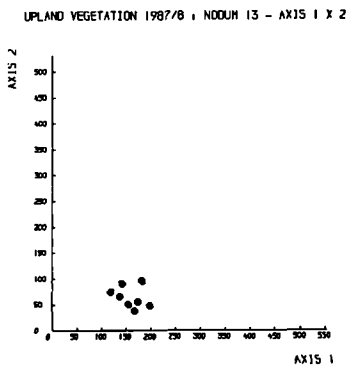
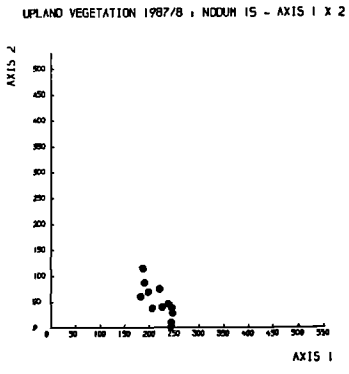

AXIS 2
AXIS 1
all
ai
A
B
C
D
E
F
G
0
50
100
150
200
250
300
350
400
450
500
550

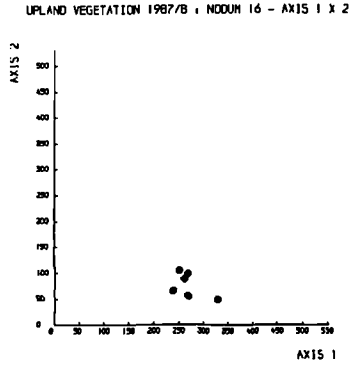
Fig. 3.7a-o The positions of the noda on the first and second axes of DECORANA

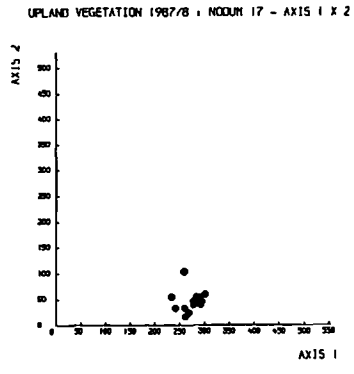

UPLAND VEGETATION 1987/8 : NODUM 14 - AXIS 1 X 2
AXIS 2
AXIS 1

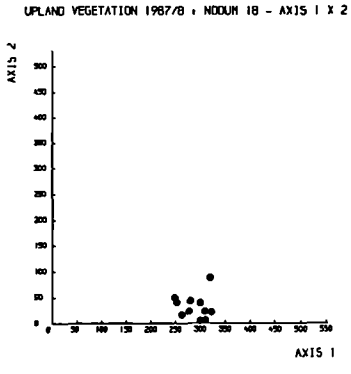

UPLAND VEGETATION 1987/8 : NODUM 12 - AXIS 1 X 2
AXIS 2
AXIS 1

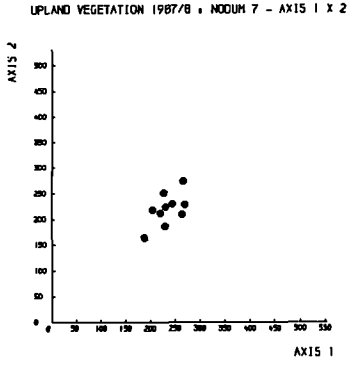

UPLAND VEGETATION 1987/8 : NODUM 13 - AXIS 1 X 2
AXIS 2
AXIS 1

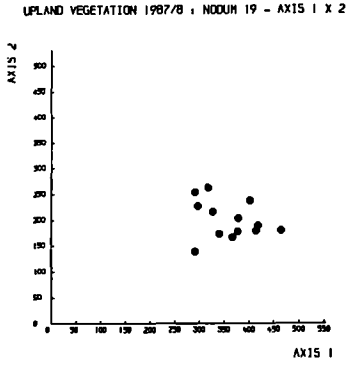

UPLAND VEGETATION 1987/8 : NODUM 15 - AXIS 1 X 2
AXIS 2
AXIS 1

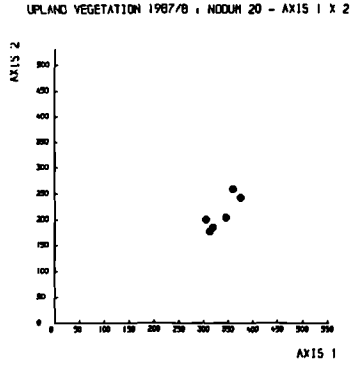

UPLAND VEGETATION 1987/8 : NODUM 16 - AXIS 1 X 2
AXIS 2
AXIS 1

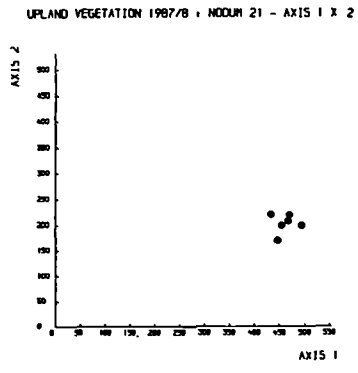

UPLAND VEGETATION 1987/8 : NODUM 17 - AXIS 1 X 2
AXIS 2
AXIS 1

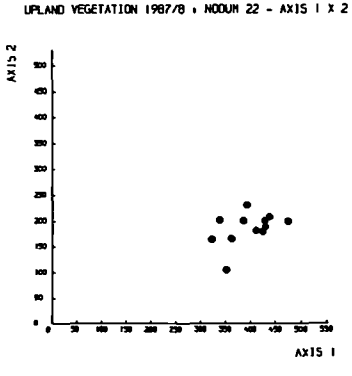

UPLAND VEGETATION 1987/8 : NODUM 18 - AXIS 1 X 2
AXIS 2
AXIS 1

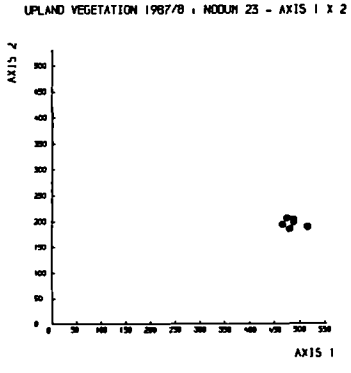

UPLAND VEGETATION 1987/8 : NODUM 7 - AXIS 1 X 2
AXIS 2
AXIS 1

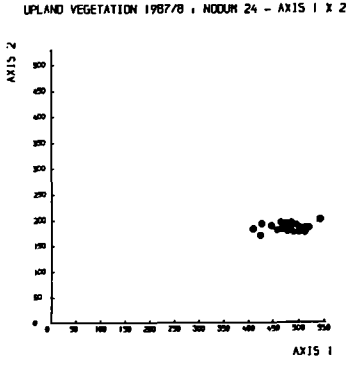

UPLAND VEGETATION 1987/8 : NODUM 19 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 20 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 21 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 22 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 23 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 24 - AXIS 1 X 2
AXIS 2
AXIS 1

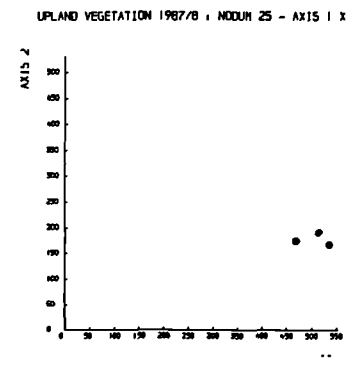
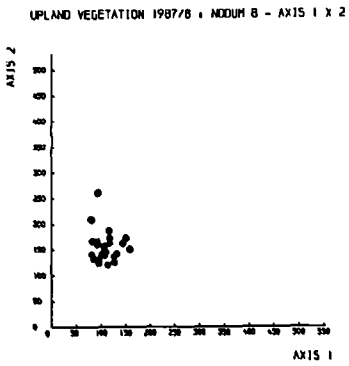
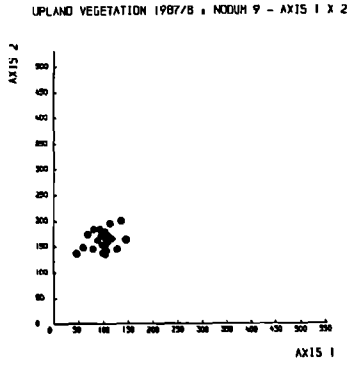
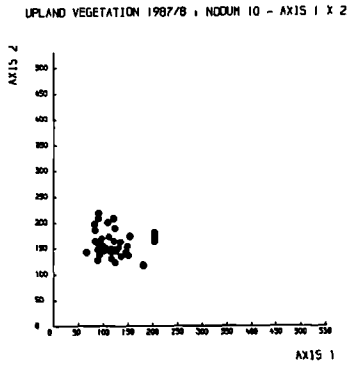
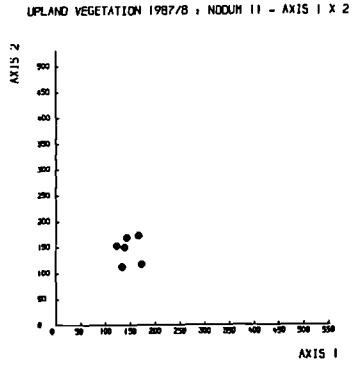

UPLAND VEGETATION 1987/8 : NODUM 25 - AXIS 1 X 2
AXIS 2
AXIS 1

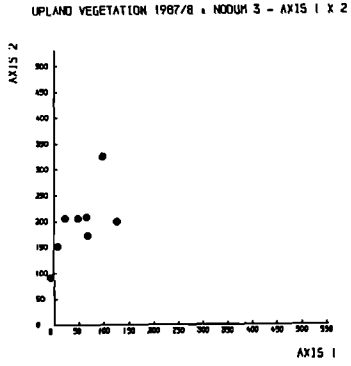
Fig. 3.7p-y The positions of the noda on the first and second axes of DECORANA (continued from previous page)

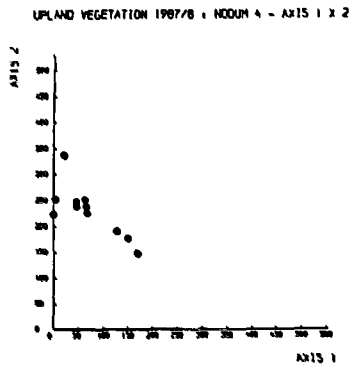

UPLAND VEGETATION 1987/8 : NODUM 8 - AXIS 1 X 2
AXIS 2
AXIS 1

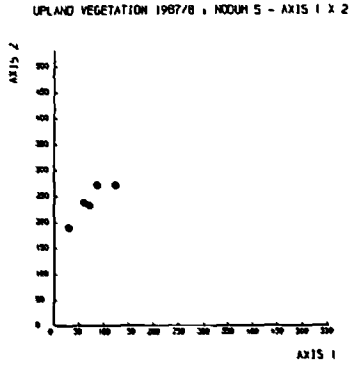

UPLAND VEGETATION 1987/8 : NODUM 9 - AXIS 1 X 2
AXIS 2
AXIS 1

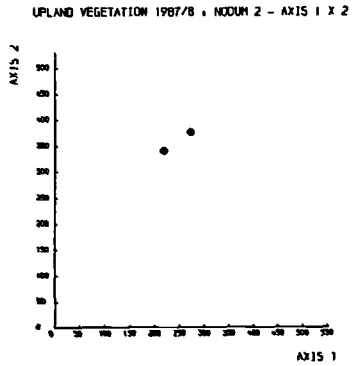

UPLAND VEGETATION 1987/8 : NODUM 10 - AXIS 1 X 2
AXIS 2
AXIS 1

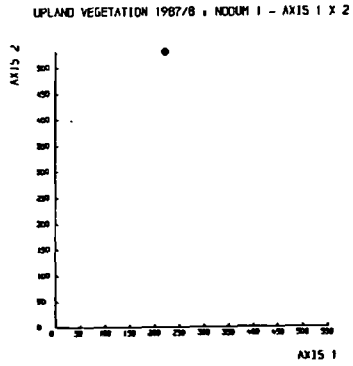

UPLAND VEGETATION 1987/8 : NODUM 11 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 3 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 4 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 5 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 2 - AXIS 1 X 2
AXIS 2
AXIS 1


UPLAND VEGETATION 1987/8 : NODUM 1 - AXIS 1 X 2
AXIS 2
AXIS 1

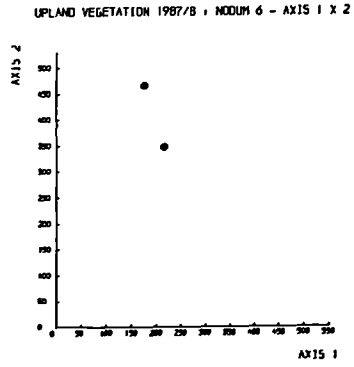

UPLAND VEGETATION 1987/8 : NODUM 6 - AXIS 1 X 2
AXIS 2
AXIS 1

Fig. 3.7z DECORANA plot of the birch relevés classified according to whether they were established before 1750 (characterised by large dots) or after 1750 (characterised by small dots).

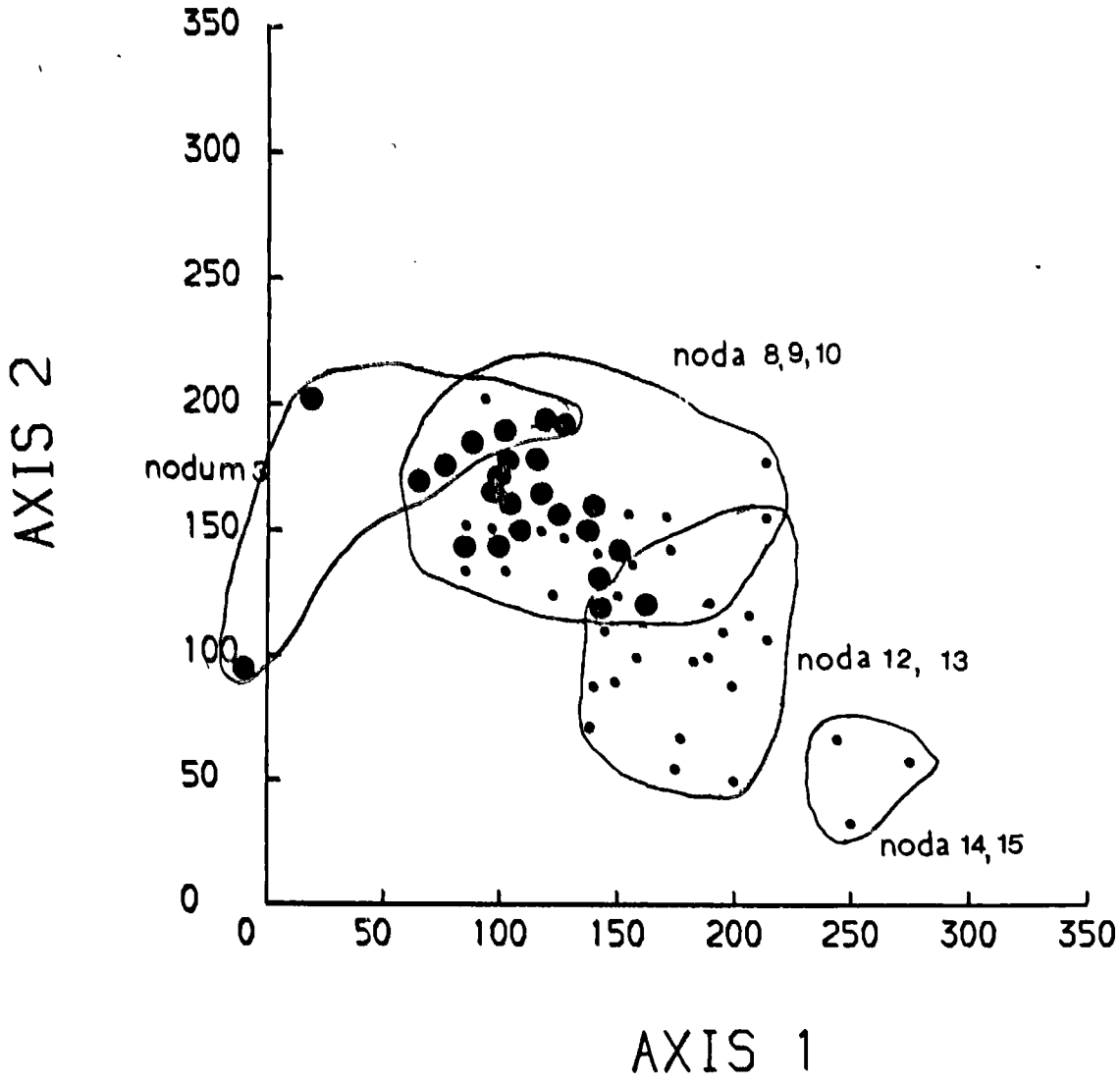

AXIS 2
350
300
250
200
150
100
50
0
nodum 3
noda 8,9,10
noda 12, 13
noda 14, 15
0
50
100
150
200
250
300
350
AXIS 1

Fig. 3.8 Noda classification by Thematic Mapper colour, Dendrogram of minimum variance clusters. The noda have been arbitarily grouped into 7 clusters labelled A to G.

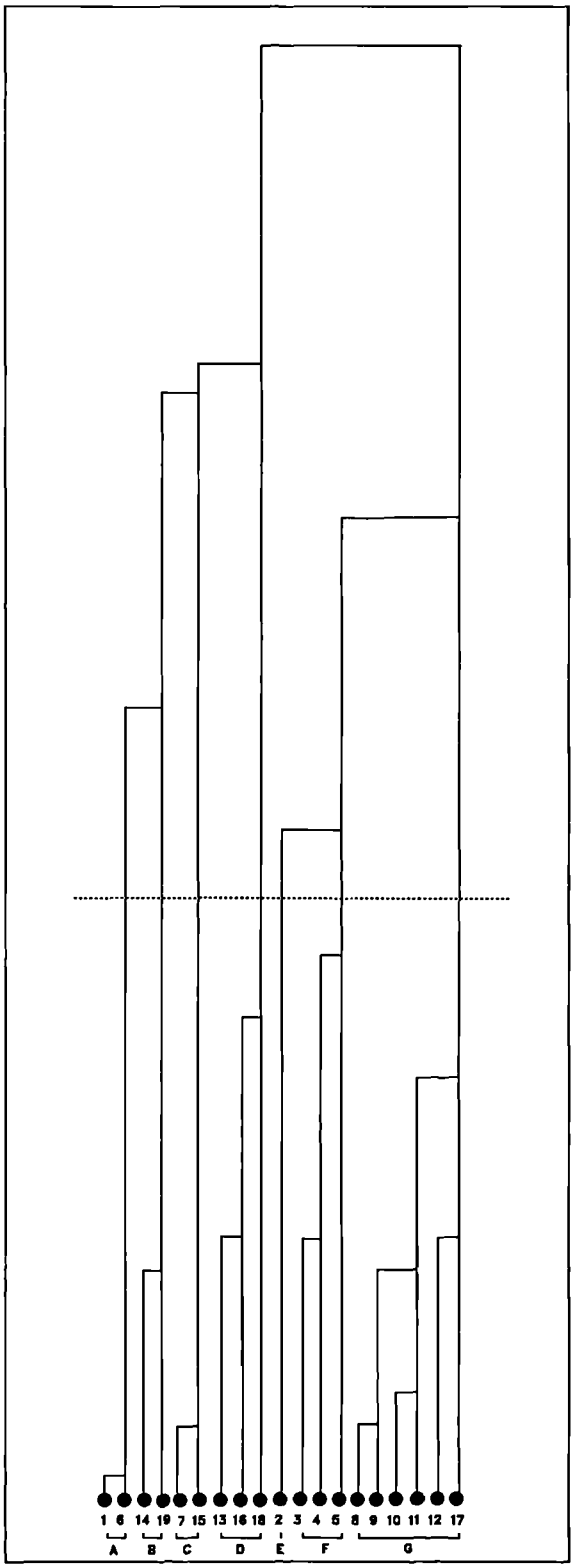
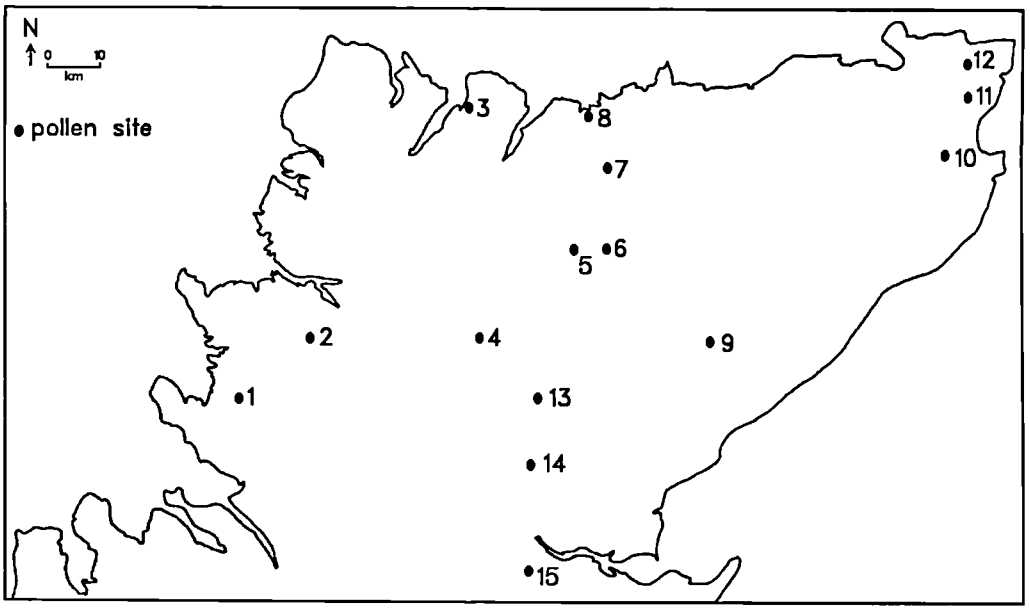

1 6 14 19 7 15 13 16 18 2 3 4 5 8 9 10 11 12 17
A
B
C
D
E
F
G

Fig. 3.9 Geographical location of the surface samples

Fig. 3.9a All sites used for the isopoll maps of northern Scotland. The sites are as follows: 1 = Loch Sionascraig (Pennington *et al*, 1972), 2 = Loch Assynt (Birks, 1980a), 3= An Druim (Birks, 1980a), 4 = Gaineamhach (site number 31 in table 3.19), 5 = Roundhill (site number 7), 6 = Lochan by Rosail (site number 23), 7 = Loch Chealamy (site number 22), 8 = Loch Mer (site number 21), 9 = Suisguill (Andrews *et al*, 1985), 10 = Loch Winless (Peglar, 1979), 11 = Ackhorn (Robinson, 1987), 12 = Hill of Harley (Huntley, J.P., 1989), 13=Dalcork, 14 = Torroble and 15 = Coire bog (Birks, 1975).

Fig. 3.9b Sites around Strathnaver. The numbers in this figure correspond to the site code numbers found in table 3.19.


N
0
10
km
• pollen site
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

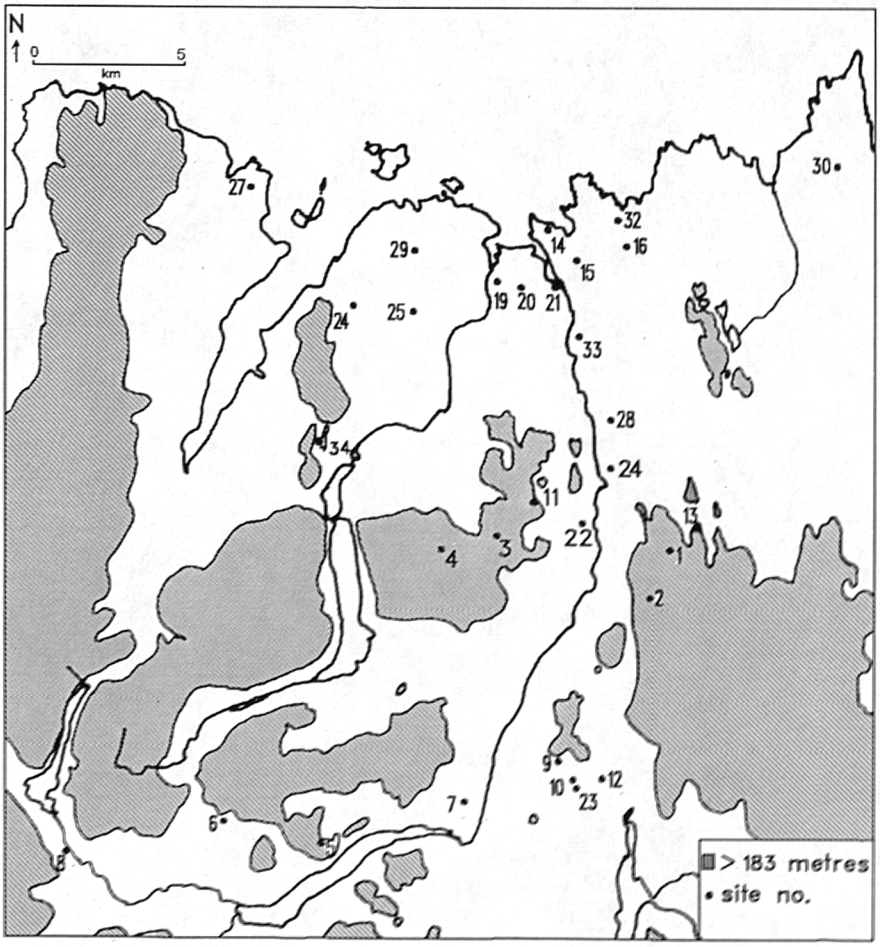

N
0
5
km
> 183 metres
• site no.

Fig. 3.10 Total land pollen diagram for the surface samples. The dots indicate the presence of birch woods within a 1 km radius

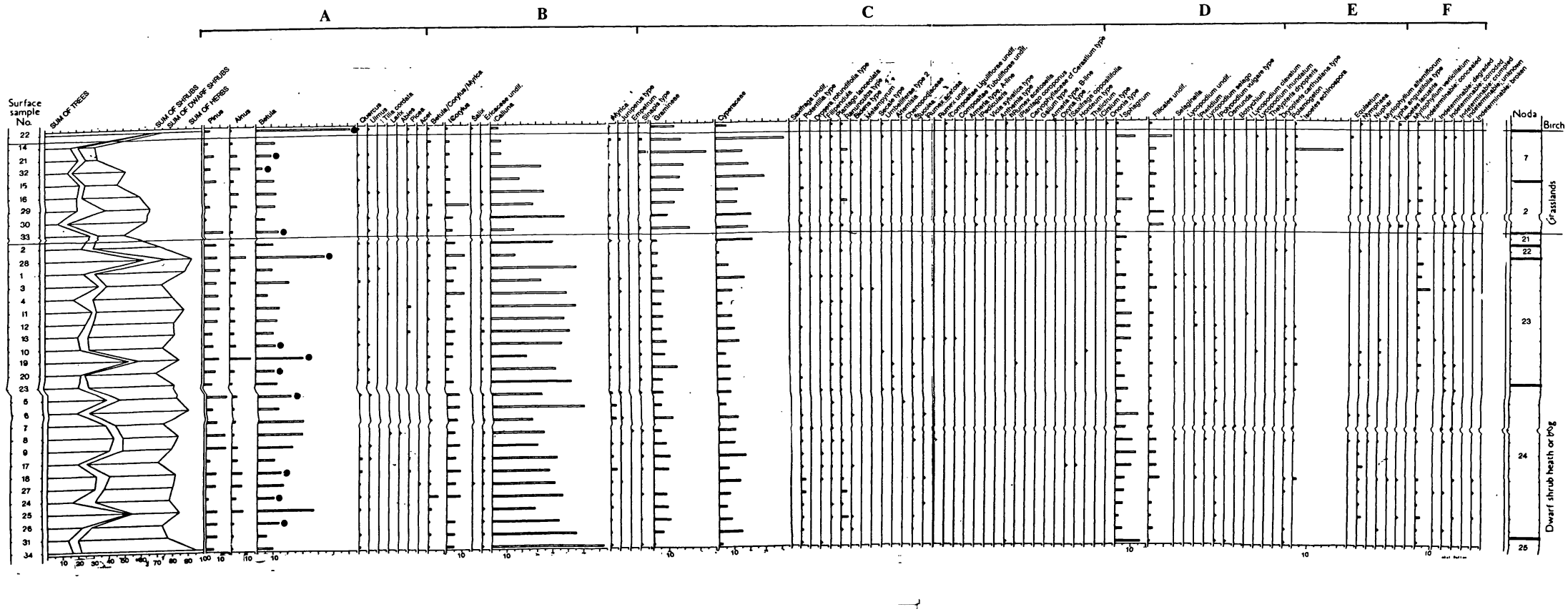

A
B
C
D
E
F
Surface sample No.
SUM OF TREES
SUM OF SHRUBS
SUM OF DWARF SHRUBS
SUM OF HERBS
Pinus
Alnus
Betula
Quercus
Ulmus
Tilia cordata
Larix
Abies
Picea
Acer
Betula/Corylus/Myrica
Corylus
Salix
Ericaceae undif.
Calluna
Myrica
Juniperus type
Empetrum
Simple type
Gramineae
Cyperaceae
Caryophyllaceae undif.
Potentilla type
Ranunculus repens type
Ranunculus lenguata type
Ranunculus type 1
Saxifraga type
Melampyrum
Succisa type
Umbelliferae type 2
Artemisia
Cruciferae undif.
Saxifraga oppositifolia
Rumex undif.
Rumex acetosa
Compositae undif.
Compositae Liguliflorae undif.
Compositae Tubuliflorae undif.
Thalictrum
Viola Myrica type
Anthemis type
Plantago maritima type
Plantago borealis
Caryophyllaceae coronatus
Galium type
Rumex type A-line
Rumex type B-line
Oxyria type
Ranunculus type d Ceratium type
Rumex type C-line
Thalictrum
Cirsium type
Oxyria type
Sparganium
Filicales undif.
Selaginella
Lycopodium undif.
Lycopodium annotinum
Lycopodium selago
Lycopodium alpinum type
Botrychium
Lycopodium clavatum
Polypodium vulgare type
Dryopteris dryopteris
Dryopteris carthusiana type
Polystichum
Isoetes echinospora
Equisetum
Nymphaea
Nuphar
Myriophyllum alterniflorum
Typha angustifolia type
Myriophyllum spicatum type
Myriophyllum verticillatum
Indeterminable: concealed
Indeterminable: degraded
Indeterminable: corroded
Indeterminable: crumpled
Indeterminable: unknown
Indeterminable: broken
Noda
Birch
Grasslands
Dwarf shrub heath or Pog
7
2
21
22
23
24
25

Fig. 3.11 Contour map of DECORANA surface sample scores for axis 1 for the area around Strathnaver

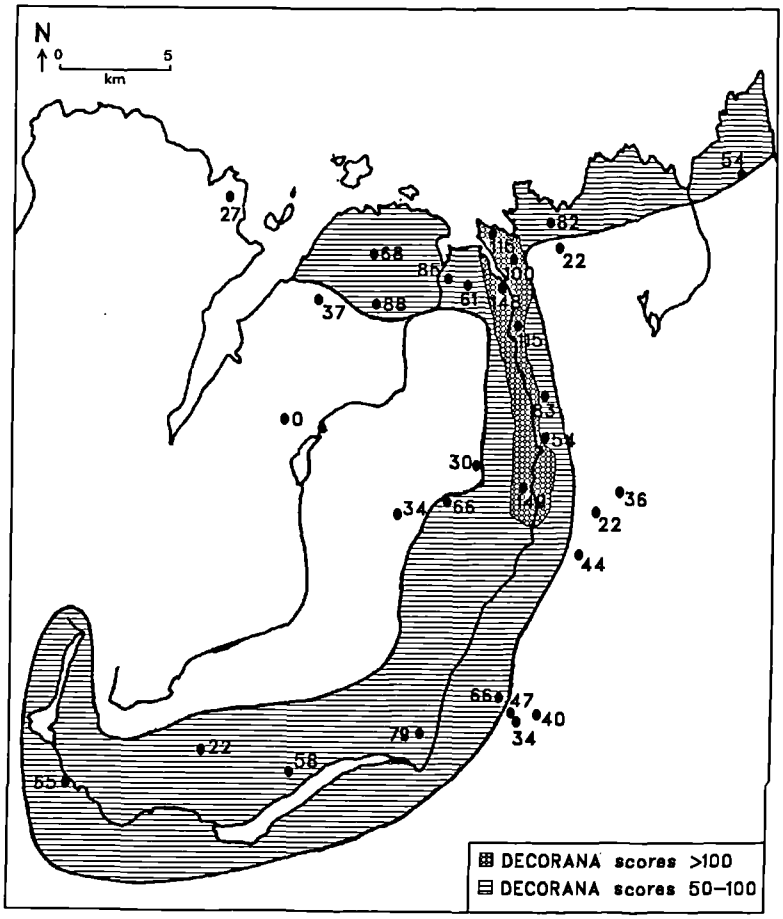
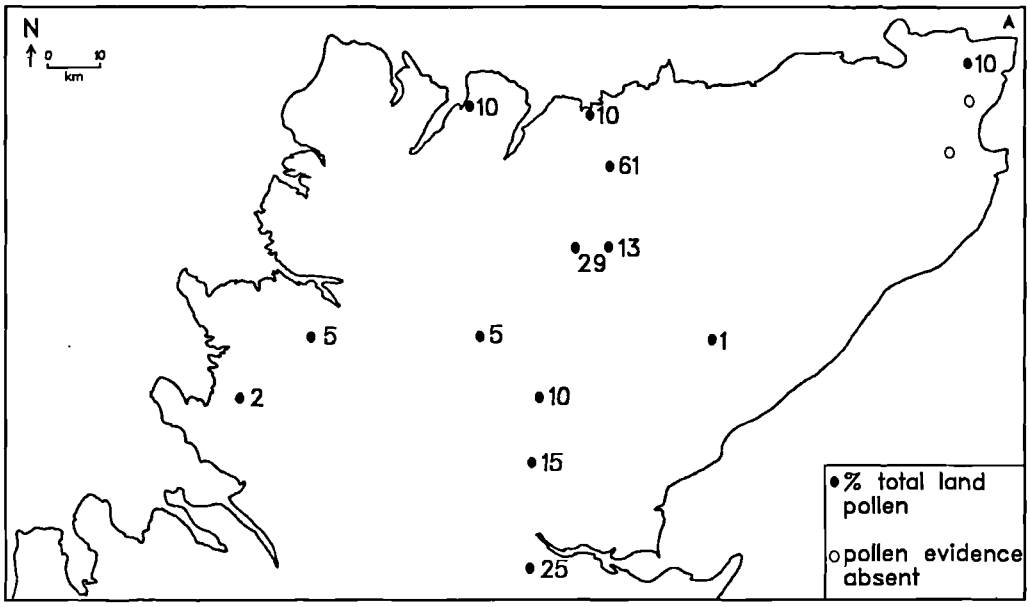

N
0
5
km
27
54
82
116
100
22
68
85
61
37
88
145
115
63
0
54
30
34
66
40
36
22
44
66
47
40
34
79
22
58
55
DECORANA scores >100
DECORANA scores 50–100

Fig. 3.12a *Betula* pollen values in northern Scotland

Fig. 3.12b Isopoll map of *Betula* pollen around Strathnaver


N
0
10
km
A
10
10
10
61
29
13
5
5
1
2
10
15
25
% total land pollen
pollen evidence absent

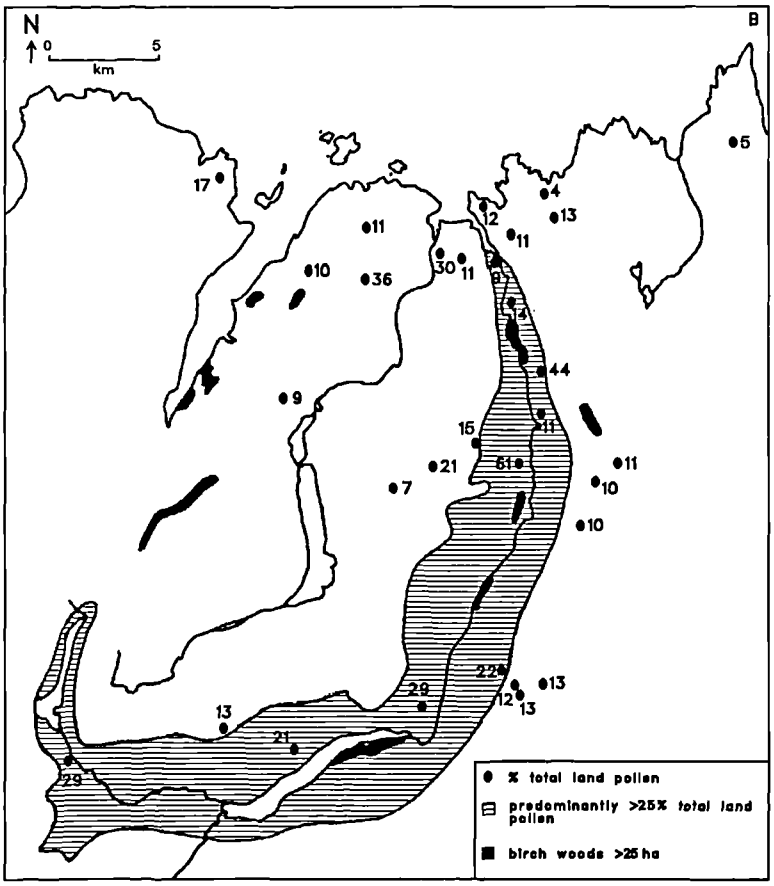
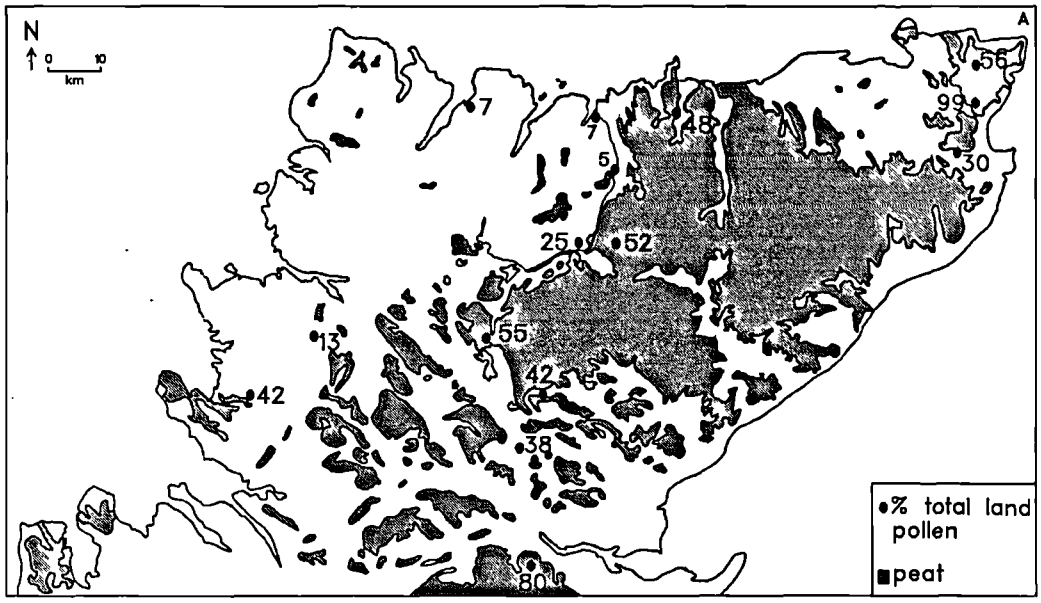

N
0
5
km
B
17
11
10
36
30
11
9
44
15
21
61
7
11
10
10
22
29
13
12
13
13
21
29
% total land pollen
predominantly >25% total land pollen
birch woods >25 ha

Fig. 3.13a *Calluna* pollen values in relation to peat distribution in northern Scotland

Fig. 3.13b *Calluna* pollen values in relation to peat distribution around Strathnaver


N
0
10
km
A
7
7
48
5
56
99
30
25
52
55
13
42
42
38
80
•% total land pollen
■peat

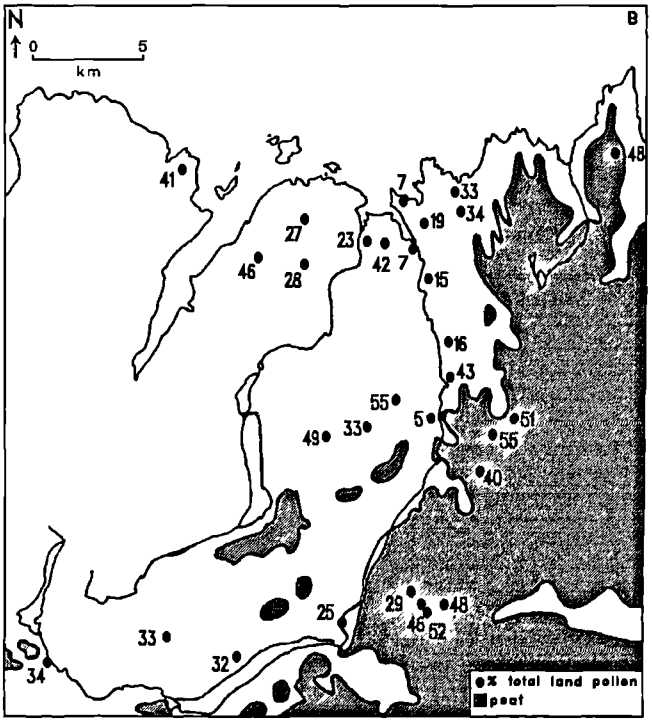
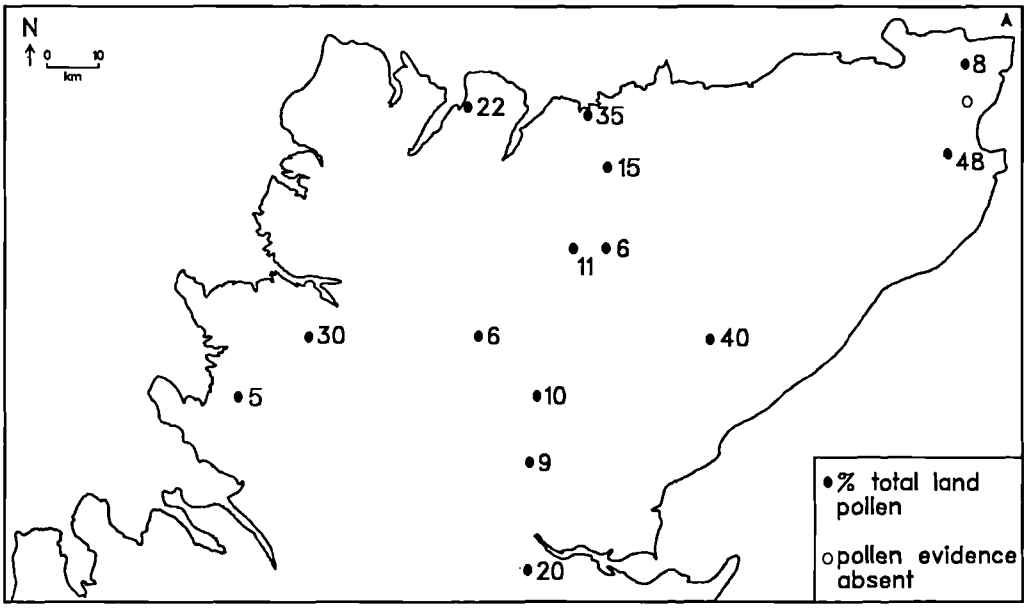

N
0
5
km
B
41
48
7
33
34
19
27
23
42
7
46
28
15
16
43
55
5
51
49
33
55
40
29
48
25
46
52
33
32
34
•% total land pollen
■peat

Fig. 3.14a Gramineae pollen values in northern Scotland

Fig. 3.14b Isopoll map of Gramineae pollen around Strathnaver


N
0
10
km
A
8
22
35
15
48
11
6
30
6
40
5
10
9
20
•% total land pollen
opollen evidence absent

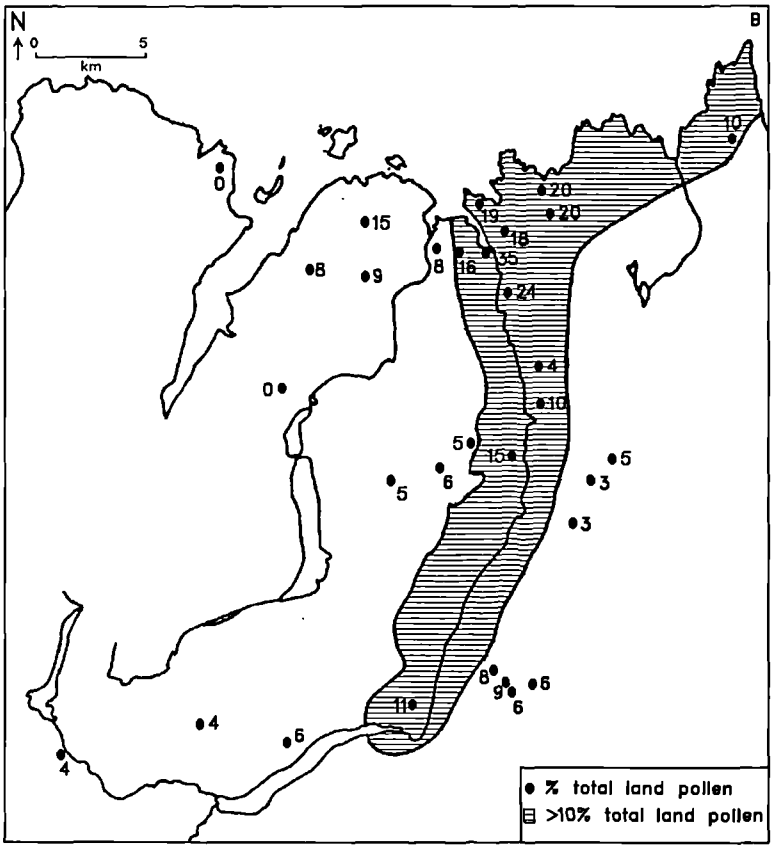
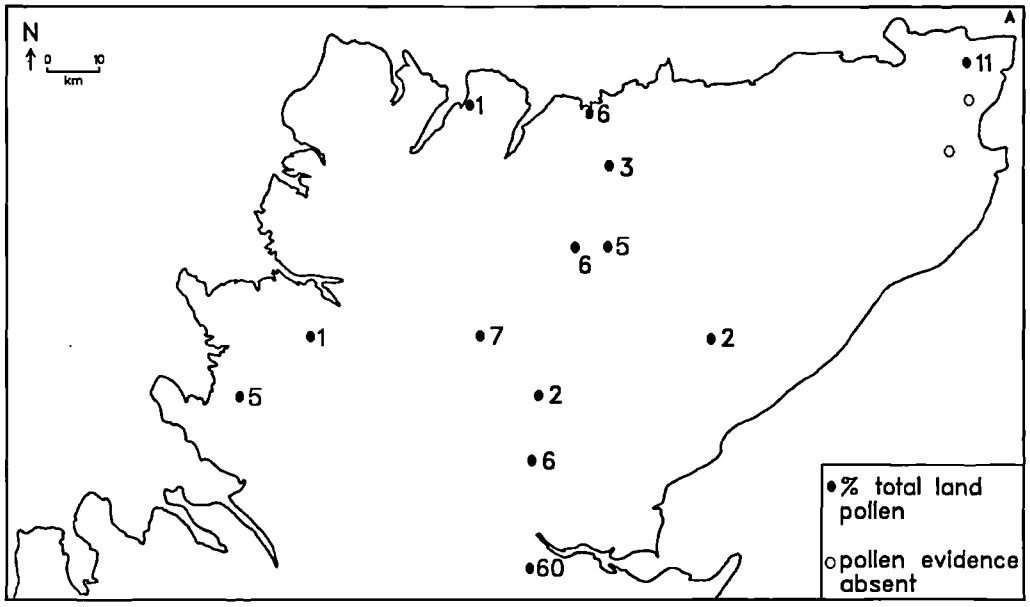

N
0
5
km
B
10
0
20
15
20
19
18
8
9
8
16
15
24
4
0
10
5
15
5
6
5
3
3
8
9
6
6
11
4
6
4
• % total land pollen
>10% total land pollen

Fig. 3.15a *Pinus* pollen values in northern Scotland

Fig. 3.15b *Pinus* pollen values around Strathnaver


N
0
10
km
A
11
1
6
3
6
5
1
7
2
5
2
6
60
% total land pollen
pollen evidence absent

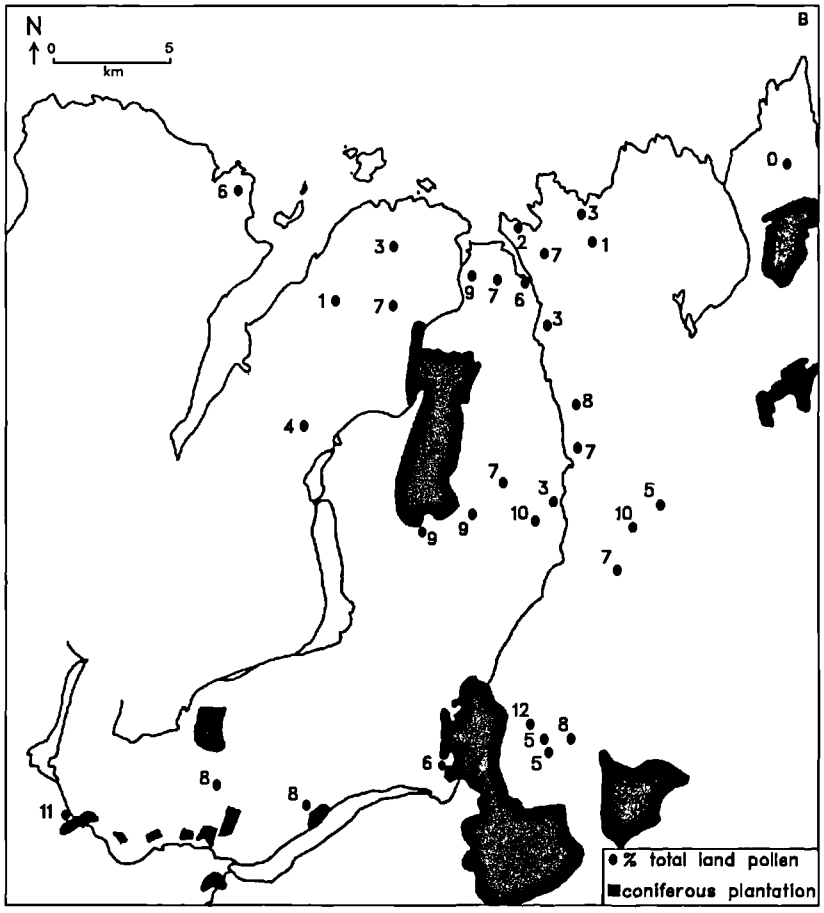
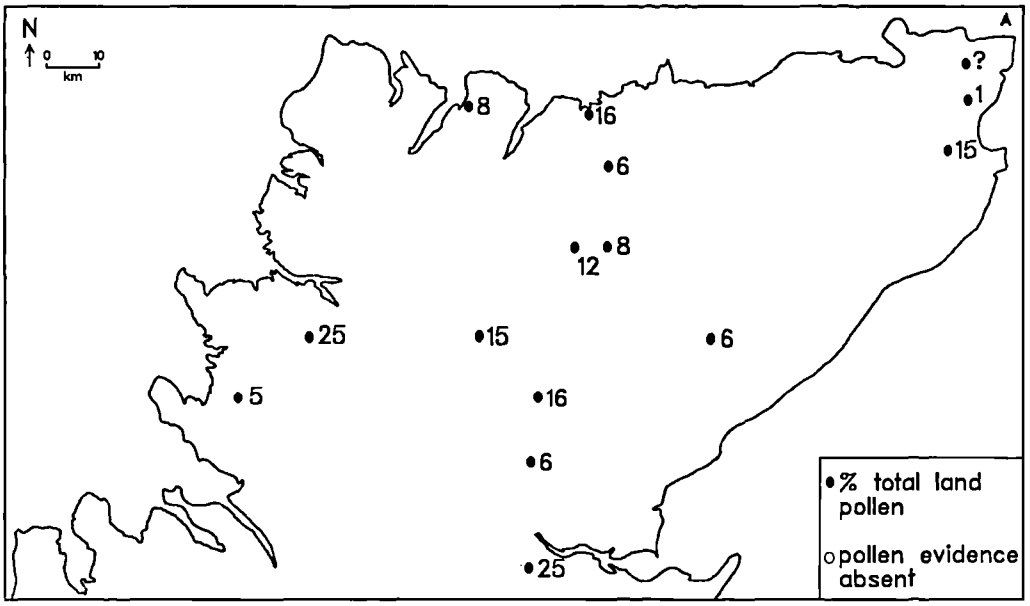

N
0
5
km
B
6
3
2
1
7
9
7
6
3
1
7
3
4
8
7
7
3
5
10
9
9
10
7
12
8
5
5
6
8
8
11
% total land pollen
coniferous plantation

Fig. 3.16a Cyperaceae pollen values in northern Scotland

Fig. 3.16b Isopoll map of Cyperaceae pollen around Strathnaver


N
0
10
km
A
?
1
15
8
16
6
12
8
25
15
6
5
16
6
25
% total land pollen
pollen evidence absent

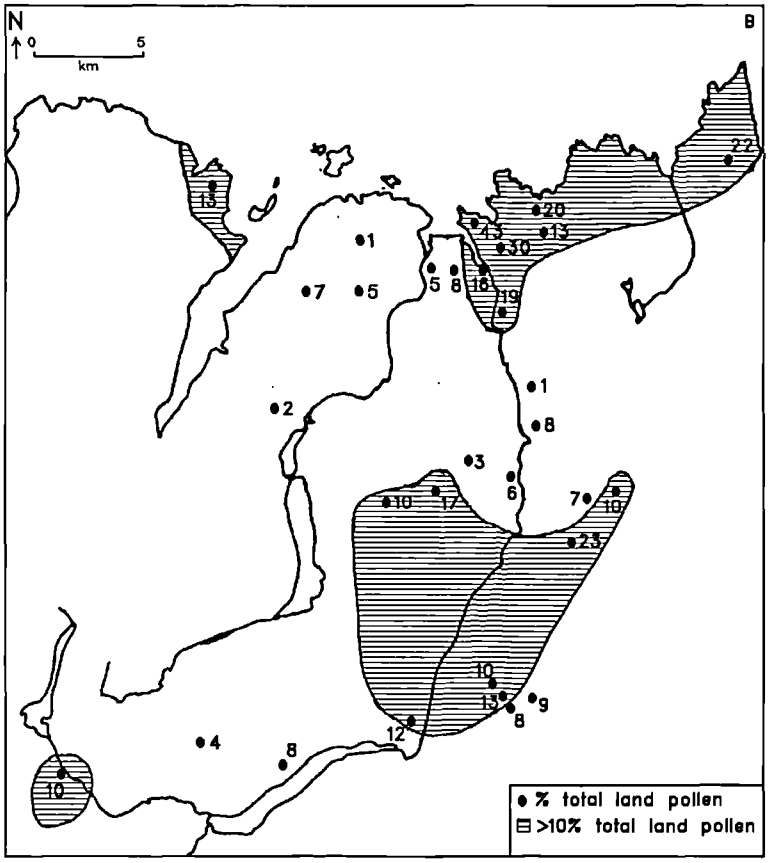
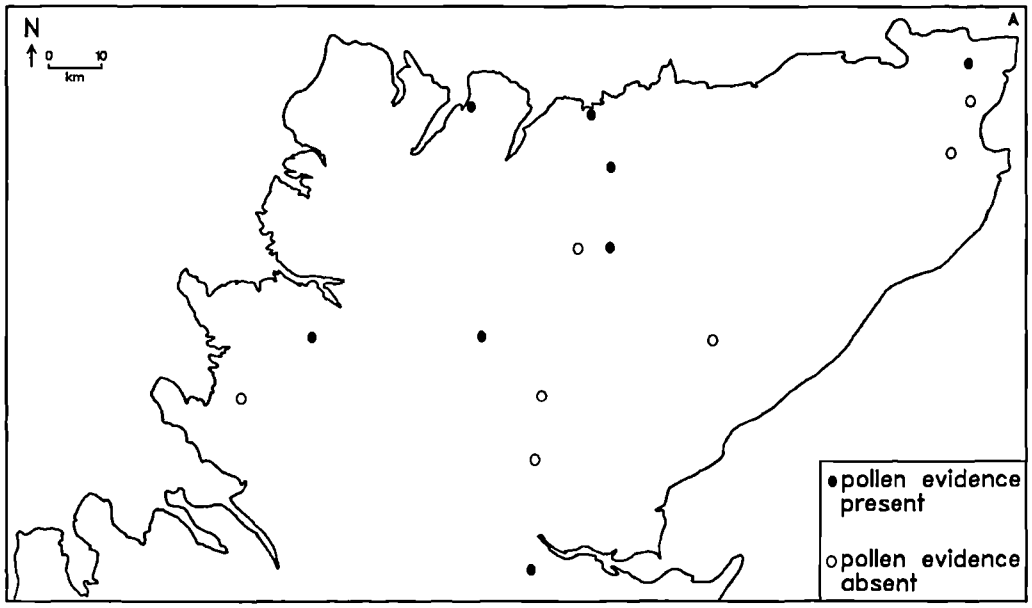

N
0
5
km
B
22
13
20
13
30
1
5
8
16
19
7
5
1
2
8
3
6
10
17
7
10
23
10
13
9
8
12
4
8
10
% total land pollen
>10% total land pollen

Fig. 3.17a *Pteridium* spore values in northern Scotland

Fig. 3.17b *Pteridium* spores values around Strathnaver


N
0
10
km
A
•pollen evidence present
○pollen evidence absent

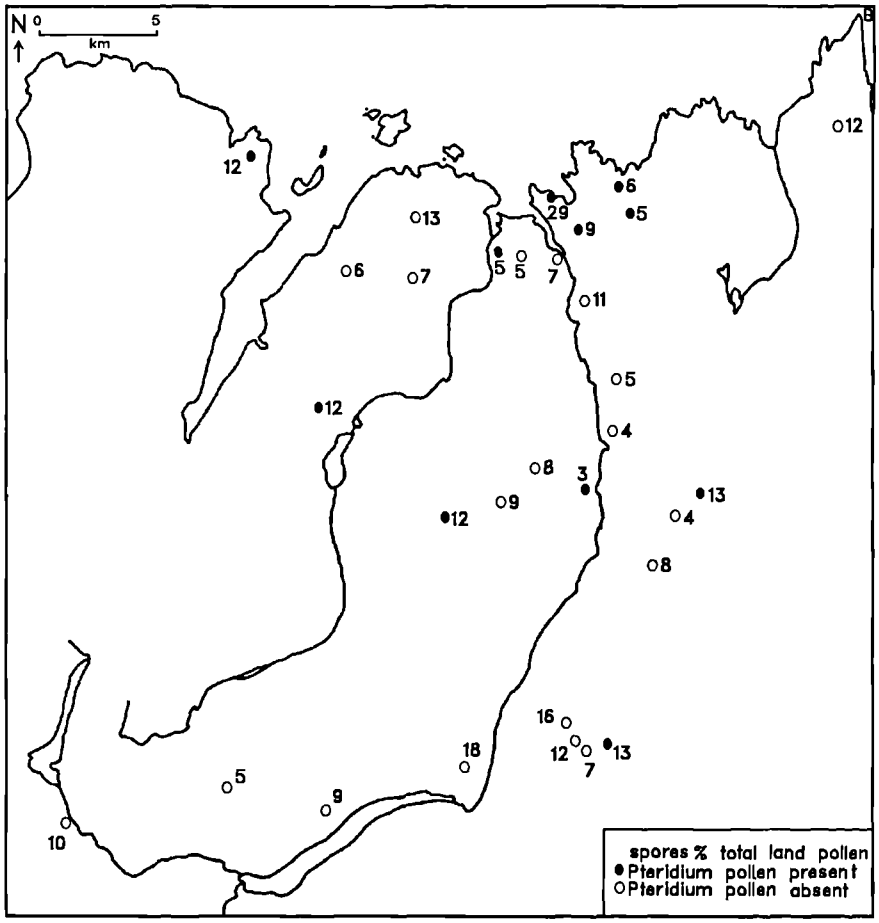

N
0
5
km
B
12
12
6
5
29
9
13
6
7
5
5
7
11
5
12
4
8
3
13
9
12
4
8
16
18
12
13
7
5
9
10
spores % total land pollen
•Pteridium pollen present
○Pteridium pollen absent

Fig. 3.18 TWINSPAN classification of the surface pollen samples - a splitting diagram. The figures to the left and the right hand sides of each black dot represent the cut-off values used to classify the noda. 1 = <4%, 2 = 4-25%, 3 = 25-50%, 4 = 50-75%, 5 = >75%. The numbers at the bottom of the diagram are the pollen surface sample code numbers which can be found in Table 3.19.

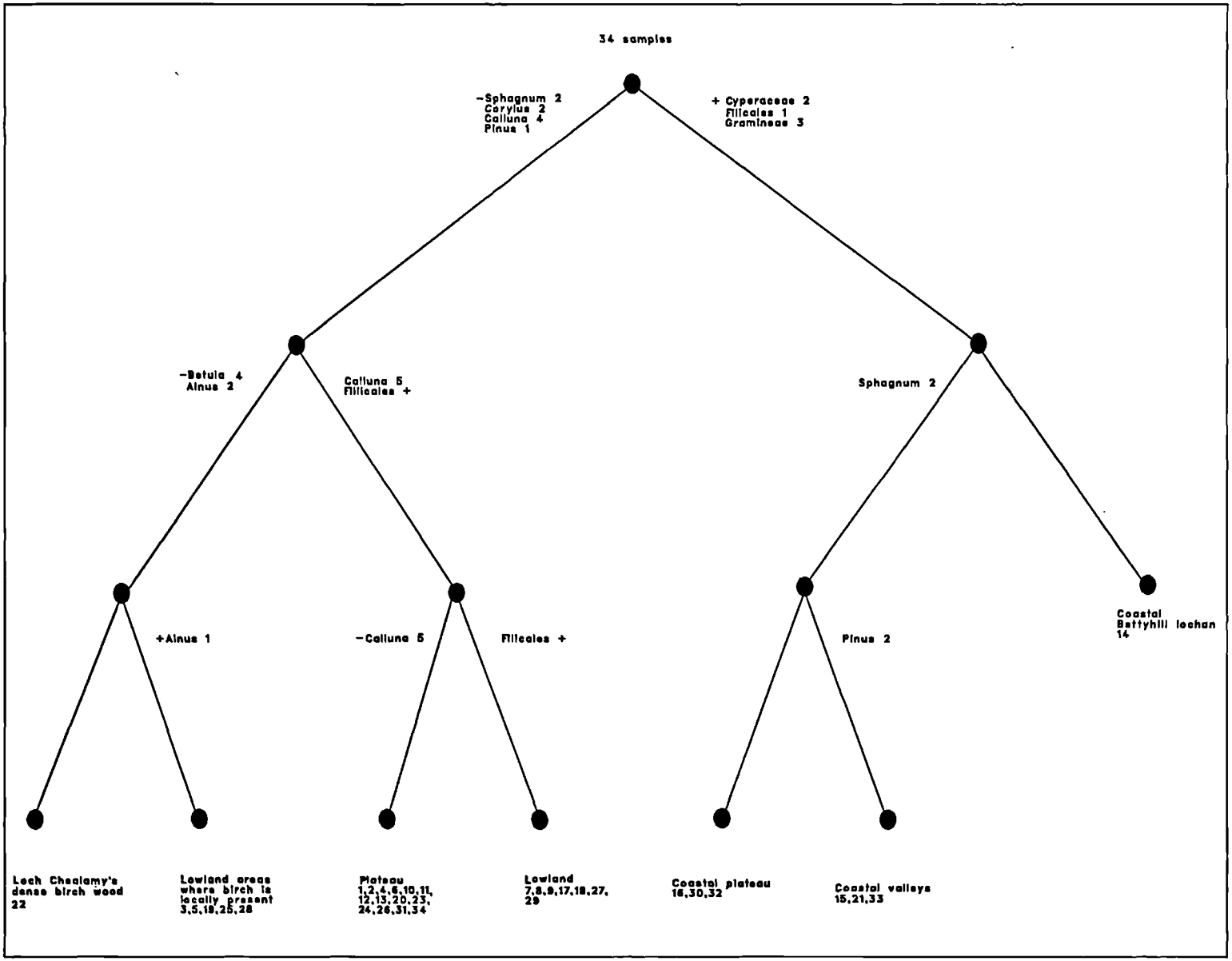
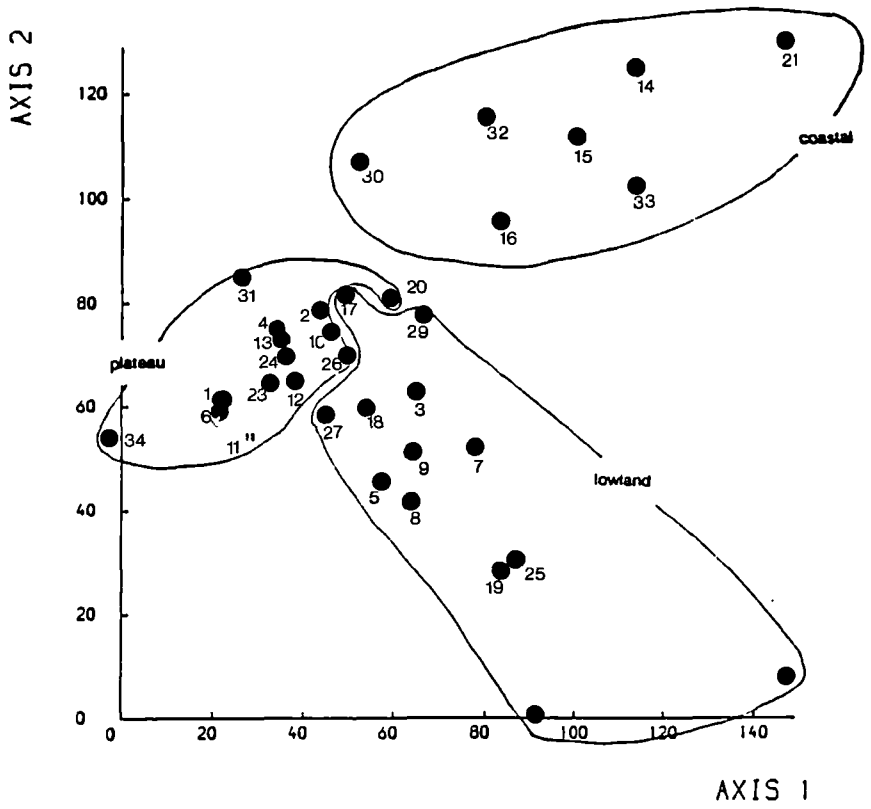

34 samples
−Sphagnum 2
Corylus 2
Calluna 4
Pinus 1
+ Cyperaceae 2
Filicales 1
Graminaeae 3
−Betula 4
Alnus 2
Calluna 5
Filicales +
Sphagnum 2
+Alnus 1
−Calluna 5
Filicales +
Pinus 2
Coastal
Bettyhill lochan
14
Loch Chealamy's
dense birch wood
22
Lowland areas
where birch is
locally present
3,5,19,25,28
Plateau
1,2,4,6,10,11,
12,13,20,23,
24,26,31,34
Lowland
7,8,9,17,18,27,
29
Coastal plateau
16,30,32
Coastal valleys
15,21,33

Fig. 3.19a Sample by sample ordination plot for the pollen surface samples - Axes 1 x 2. The numbers in the diagram are the surface sample code numbers which can be found in table 3.19.

Fig. 3.19b Species by species ordination plot for pollen surface sample data - Axes 1 x 2


AXIS 2
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
AXIS 1
coastal
plateau
lowland
21
14
32
15
30
33
16
31
20
17
2
29
4
13
10
24
26
1
23
12
6
11
3
18
27
34
9
7
5
8
19
25

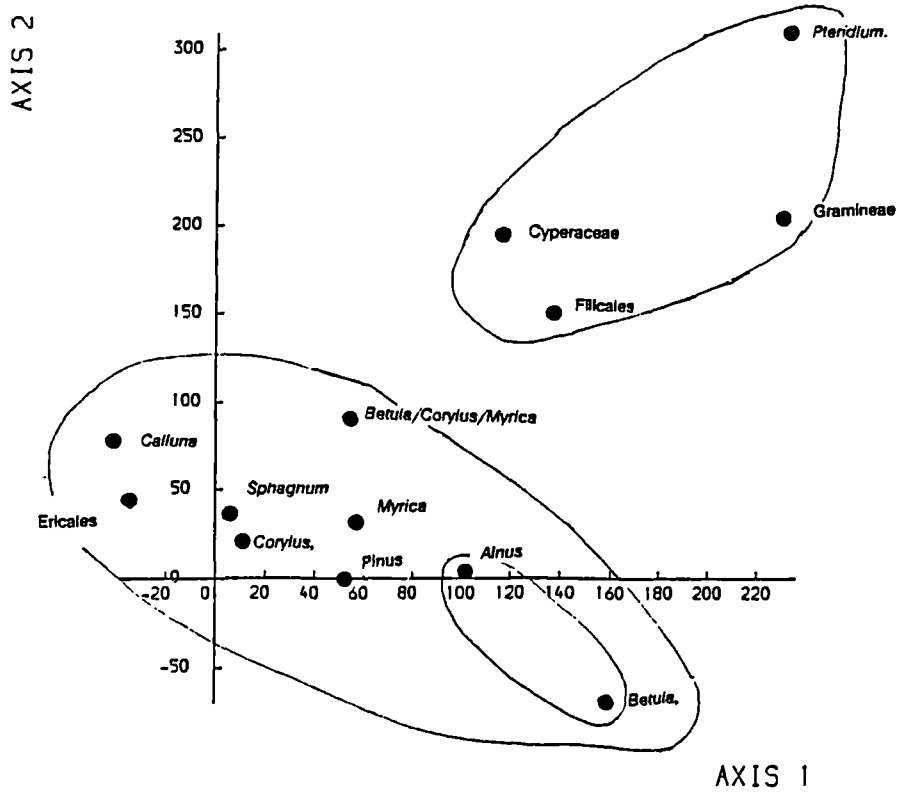

AXIS 2
300
250
200
150
100
50
0
-50
-20
0
20
40
60
80
100
120
140
160
180
200
220
AXIS 1
Pteridium.
Gramineae
Cyperaceae
Filicales
Betula/Corylus/Myrica
Calluna
Sphagnum
Ericales
Myrica
Corylus,
Pinus
Alnus
Betula,

Fig. 3.20 The relationship between vegetation cover and pollen % values

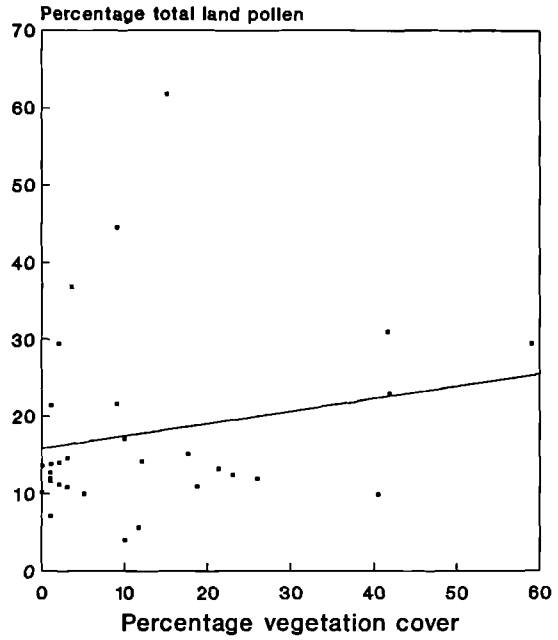
Fig. 3.20a Scatter plot and least squares regression line for *Betula*

Fig. 3.20b Scatter plot and least squares regression line for Gramineae

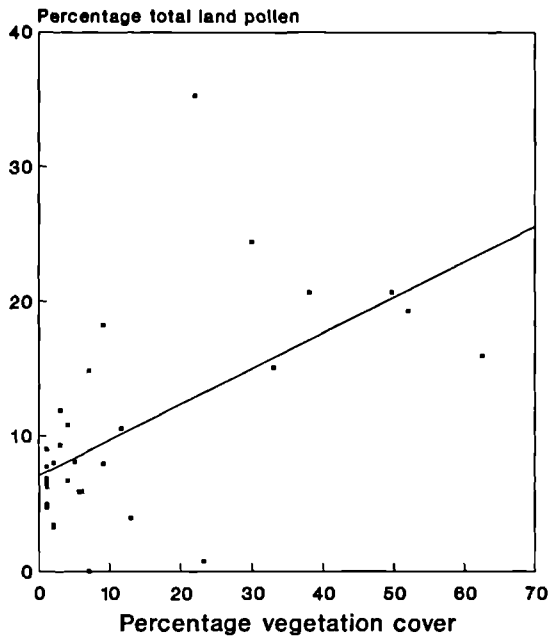
Fig. 3.20c Scatter plot and least squares regression line for *Calluna*

Fig. 3.20d Scatter plot and least squares regression line for *Pinus*

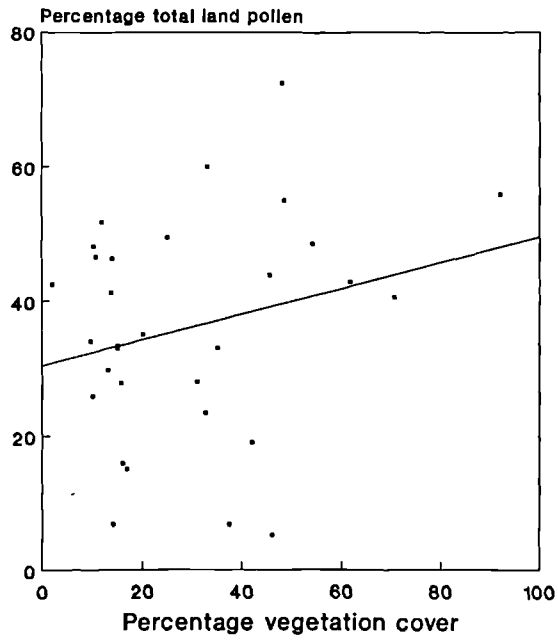
## Betula




## Gramineae




## Calluna




## Pinus

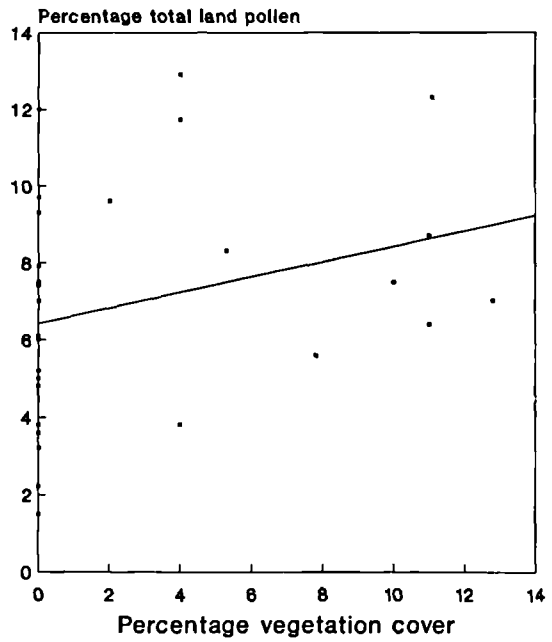


Fig. 4.1 Map illustrating all of published palynological sites known to the author in northern Scotland together with selected *Pinus sylvestris* and heath pollen curves

*Pinus* pollen is calculated as a percentage of total land pollen unless otherwise indicated by a T to the right of the site number at the bottom of each of the pollen curves. T indicates that *Pinus* pollen has been calucalated as a percentage of total tree pollen.

1 = Loch Maree (Birks, 1972a)
2 = Dromatt (refered to in Birks, 1984)
3 = Coire Bog (Birks, 1975)
4 = Badantarbet (Lamb, 1964)
5 = Sionascraig (Pennington *et al*, 1971)
6 = Cam Loch (refered to in Birks, 1984)
7 = Barralan (refered to in Birks, 1984)
8 = Craiggie (refered to in Birks, 1984)
9 = Duartbeg (Moar, 1969a)
10 = Assynt (Birks, 1980a)
11 = Loch an Smuraich (refered to in Birks, 1984)
12 = Lochan an Druim (Birks, 1984; Birks, 1980a)
13 = Winless (Peglar, 1979)
14 = Ackhorn (Robinson, 1987)
15 = Little Loch Roag (Birks and Madison, 1979)
16 = Glims Moss (Keatinge and Dickinson, 1979)
17 = Cnoc a Bhroillich (Durno, 1958)
18 = Loch na Moine (Durno, 1958)
19 = Braehour (Durno, 1958)
20 = Yeasnaby (Moar, 1969b)
21 = Cleat (Birks and Willams, 1983)
22 = Suisguill (Andrews *et al*, 1985)

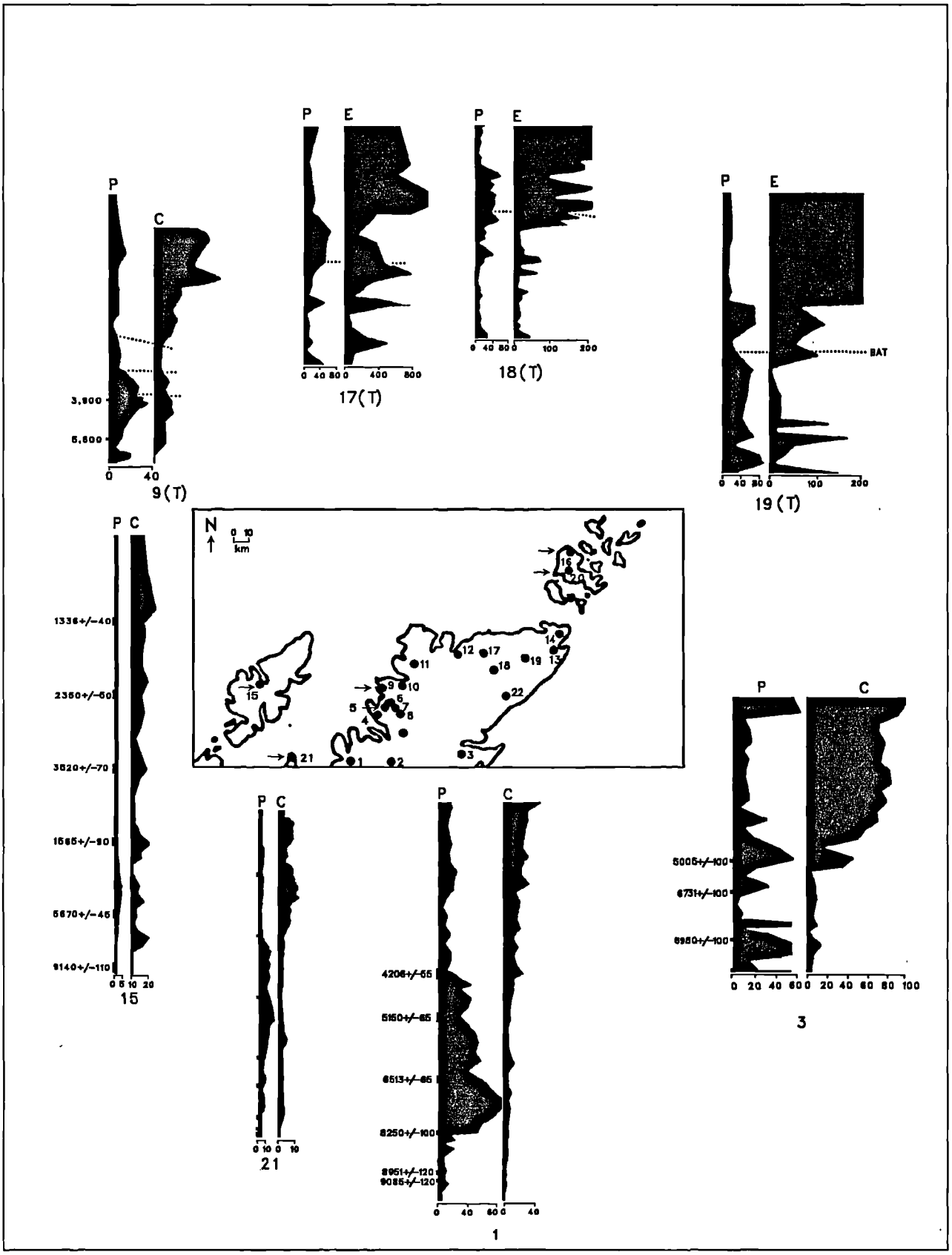

P
C
3,900
5,800
0
40
9(T)
P
E
0 40 80
0 400 800
17(T)
P
E
0 40 80
0 100 200
18(T)
P
E
BAT
0 40 80
0 100 200
19(T)
N
0 10
km
16
20
14
12
17
11
18
19
13
10
9
15
22
5
6
8
21
1
2
3
P C
1336+/-40
2350+/-50
3520+/-70
1565+/-30
5670+/-45
9140+/-110
0 5 10 20
15
P C
0 10 0 10
21
P C
4206+/-55
5150+/-65
6513+/-85
8250+/-100
8951+/-120
9085+/-120
0 40 80 0 40
1
P C
5005+/-100
6731+/-100
6950+/-100
0 20 40 60 0 20 40 60 80 100
3

Fig. 4.2a-e Series of pie charts displaying the percentages of pine, other woody, heath and herbaceous taxa for 0, 2000, 4000, 6000, and 8,000 B.P. for 8 sites in northern Scotland. The sites used are as follows: Glims Moss (Keatinge and Dickinson, 1976), Little Loch Roag (Birks and Madison, 1979), An Druim (Birks, 1980a), Loch Assynt (Birks, 1980a), Loch Winless (Peglar, 1979), Coire Bog (Birks, 1975), Loch Maree (Birks, 1972a), and Loch Sionascraig (Pennington *et al,* 1972).

Fig. 4.2a Series of pie charts displaying the percentages of pine, other woody, heath and herbaceous taxa for 8,000 years B.P. for 8 sites in northern Scotland

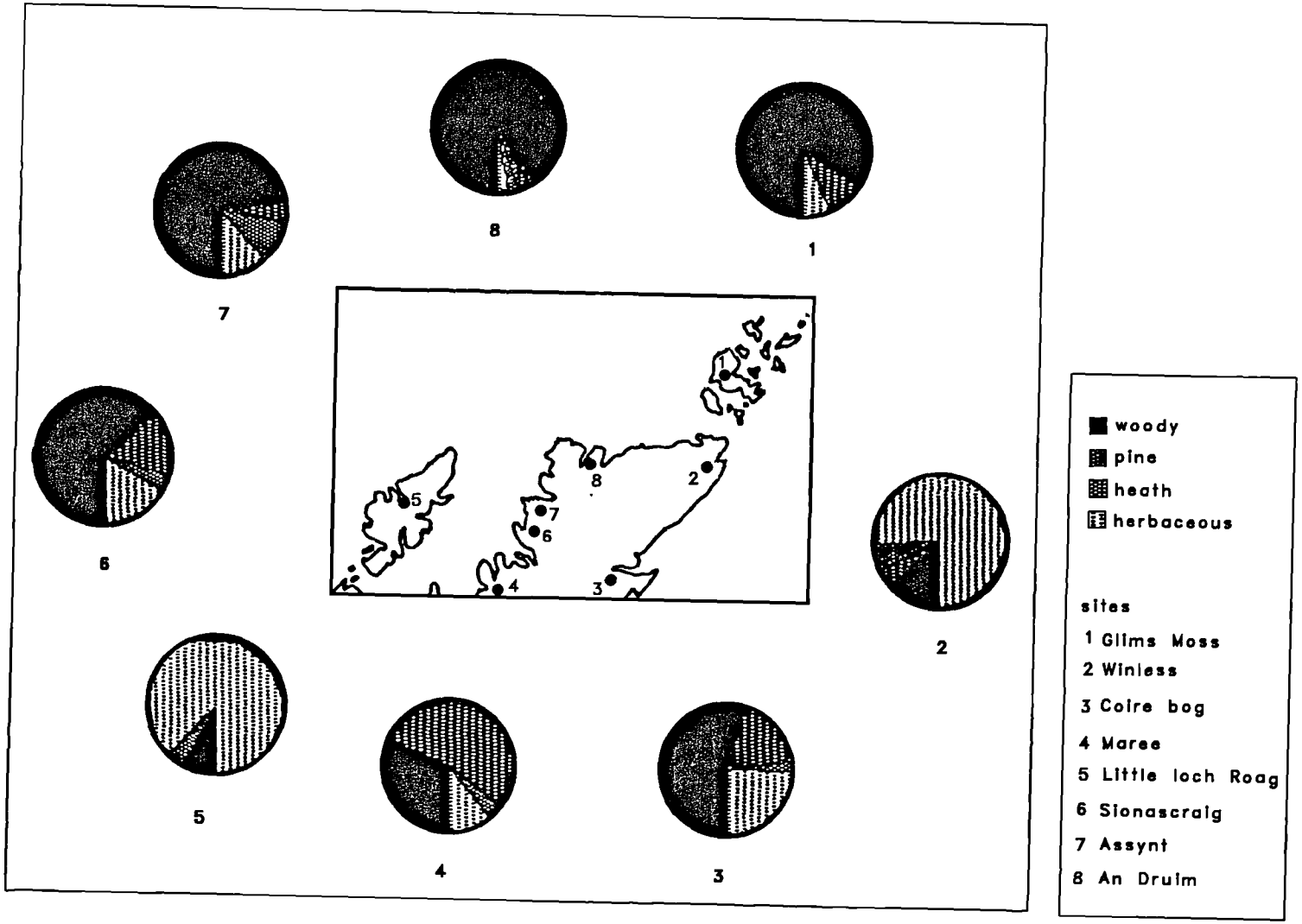

8
1
7
6
2
5
4
3
woody
pine
heath
herbaceous
sites
1 Glims Moss
2 Winless
3 Coire bog
4 Maree
5 Little loch Roag
6 Sionascraig
7 Assynt
8 An Druim

Fig. 4.2b Series of pie charts displaying the percentages of pine, other woody, heath and herbaceous taxa for 6,000 years B.P. for 8 sites in northern Scotland

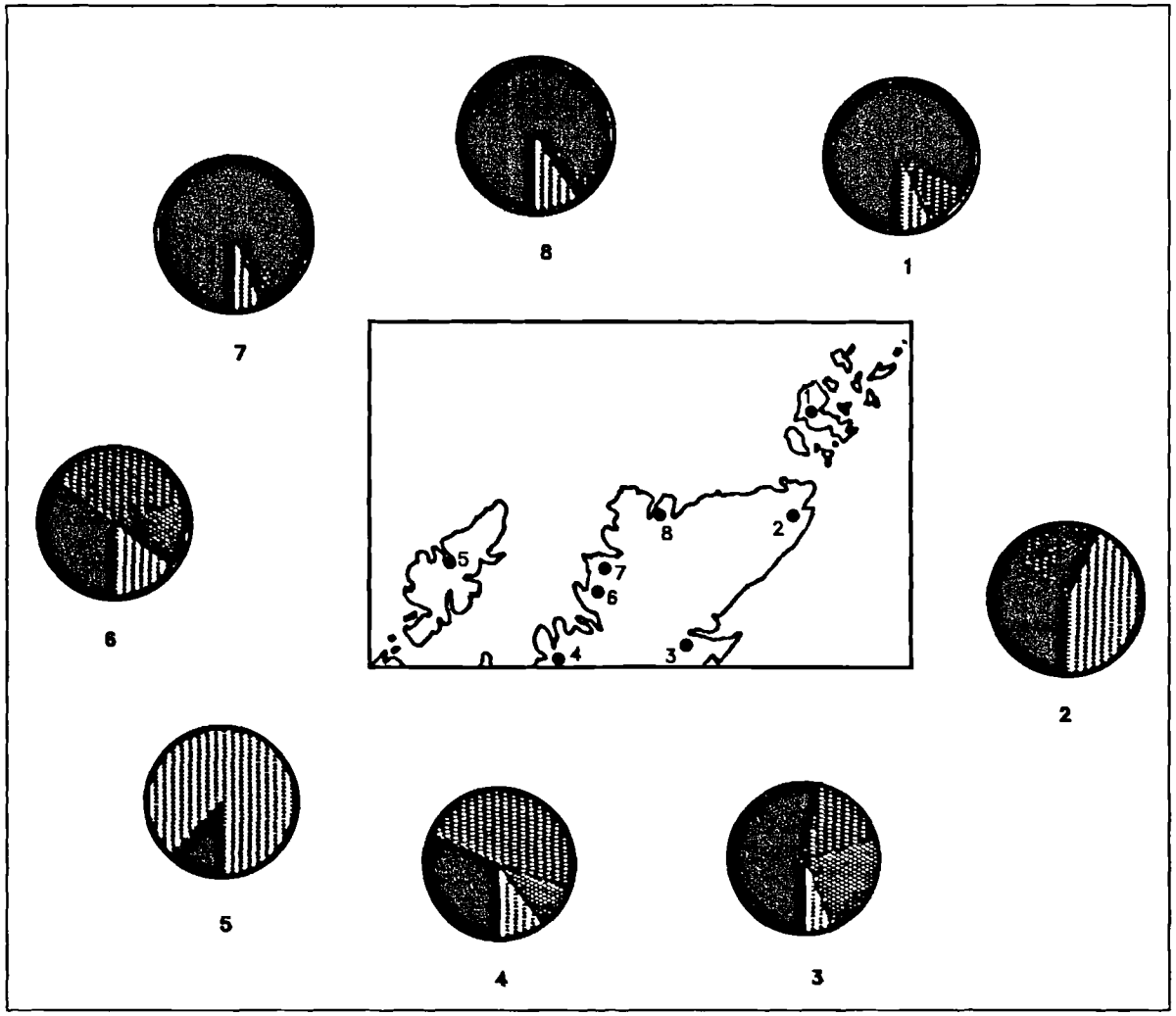

8
1
7
6
2
5
4
3
woody
pine
heath
herbaceous
sites
1 Glims Moss
2 Winless
3 Coire bog
4 Maree
5 Little loch Roag
6 Slonascraig
7 Assynt
8 An Druim

Fig. 4.2c Series of pie charts displaying the percentages of pine, other woody, heath and herbaceous taxa for 4,000 years B.P. for 8 sites in northern Scotland

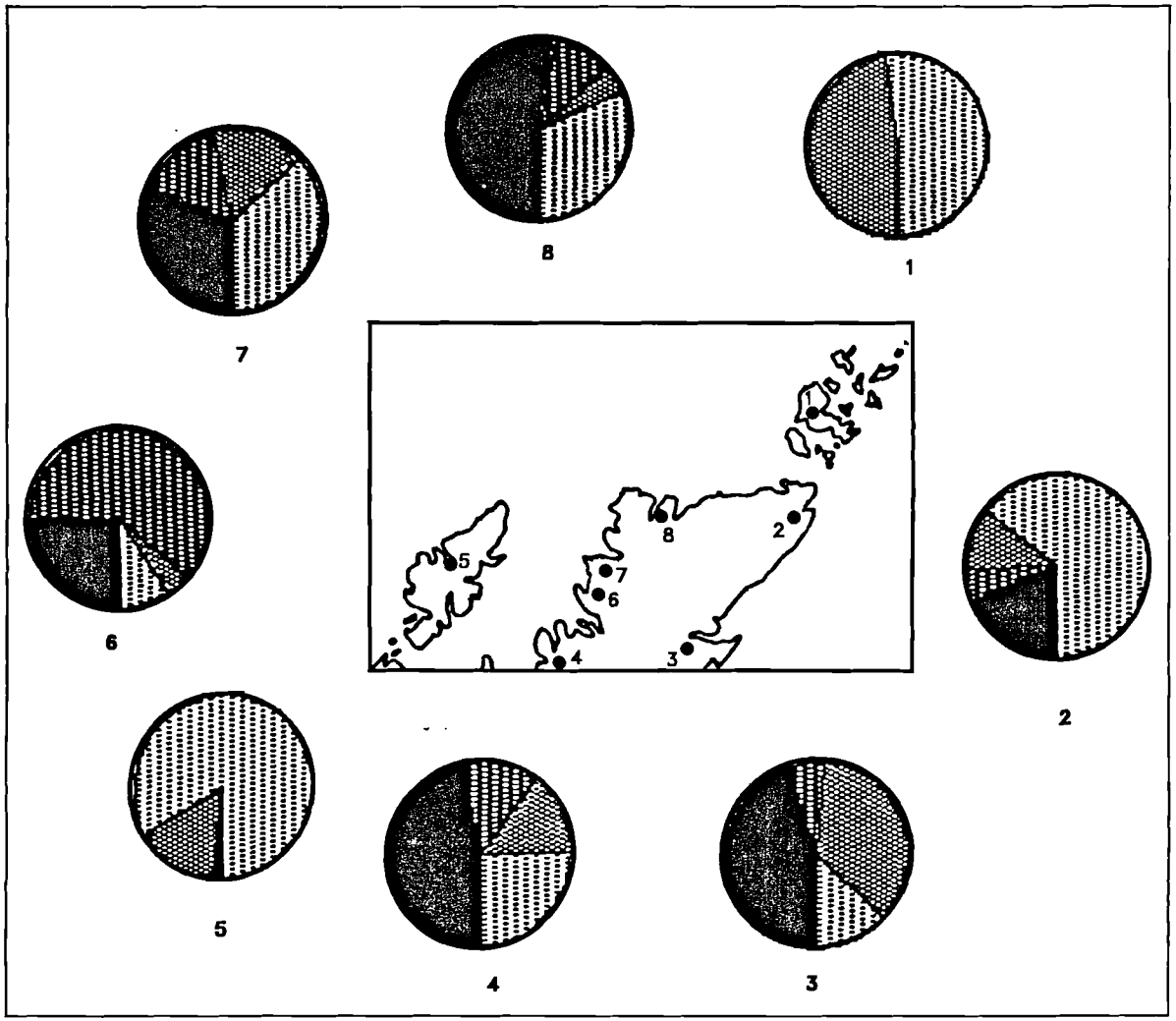

8
1
7
6
2
5
4
3
woody
pine
heath
herbaceous
sites
1 Glims Moss
2 Winless
3 Coire bog
4 Maree
5 Little loch Roag
6 Slonascraig
7 Assynt
8 An Druim

Fig. 4.2d Series of pie charts displaying the percentages of pine, other woody, heath and herbaceous taxa taxa for 2,000 years B.P. for 8 sites in northern Scotland

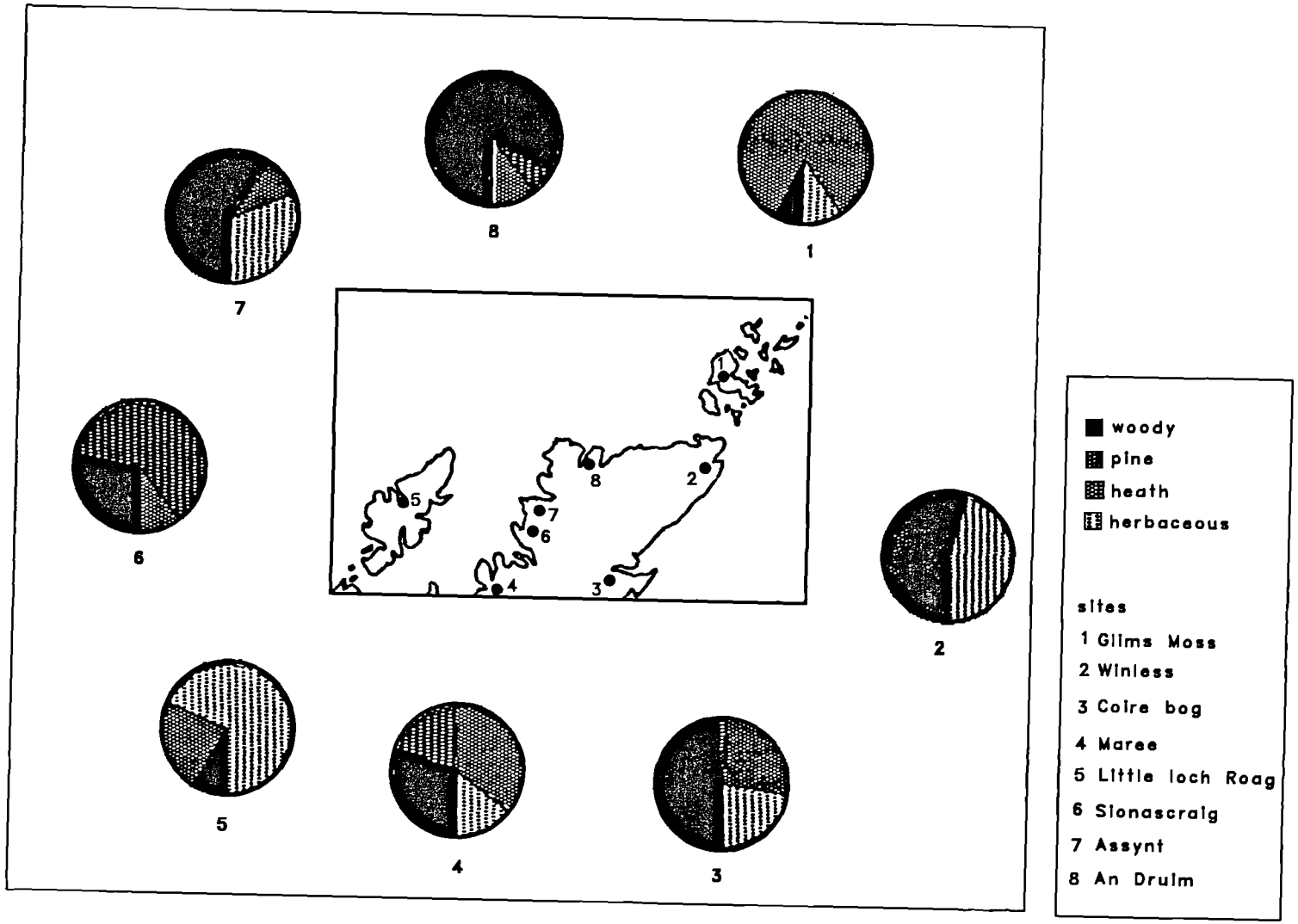

8
1
7
6
5
4
3
2
woody
pine
heath
herbaceous
sites
1 Glims Moss
2 Winless
3 Coire bog
4 Maree
5 Little loch Roag
6 Slonascraig
7 Assynt
8 An Druim

Fig. 4.2e Series of pie charts displaying the percentages of pine, other woody, heath and herbaceous taxa for 0 years B.P. for 8 sites in northern Scotland

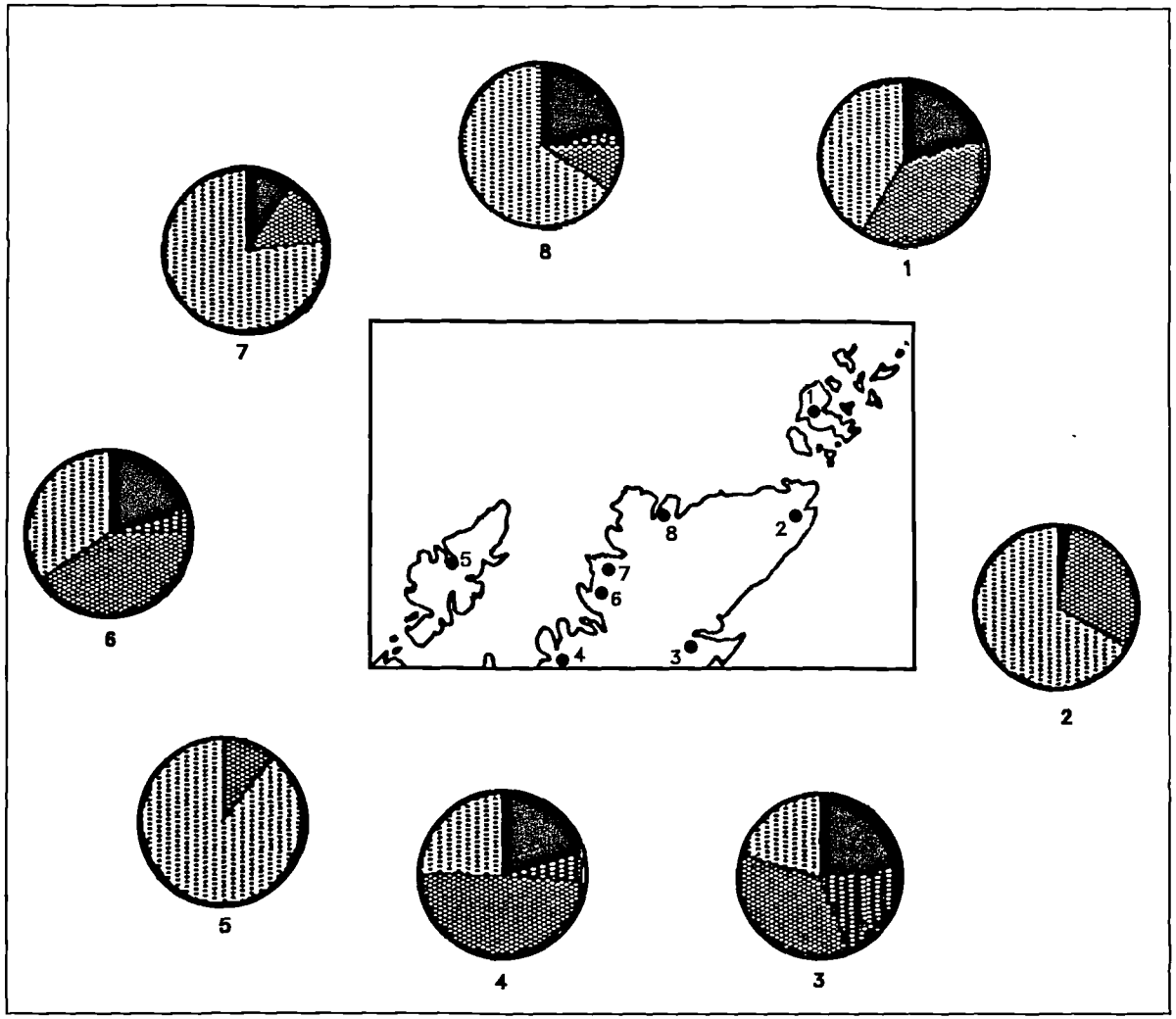

8
1
7
6
2
5
4
3
woody
pine
heath
herbaceous
sites
1 Glims Moss
2 Winless
3 Coire bog
4 Maree
5 Little loch Roag
6 Sionascraig
7 Assynt
8 An Druim

Fig. 4.3 The relative location of the three palynological sites Loch Mer, Lochan by Rosail and Lochstrathy

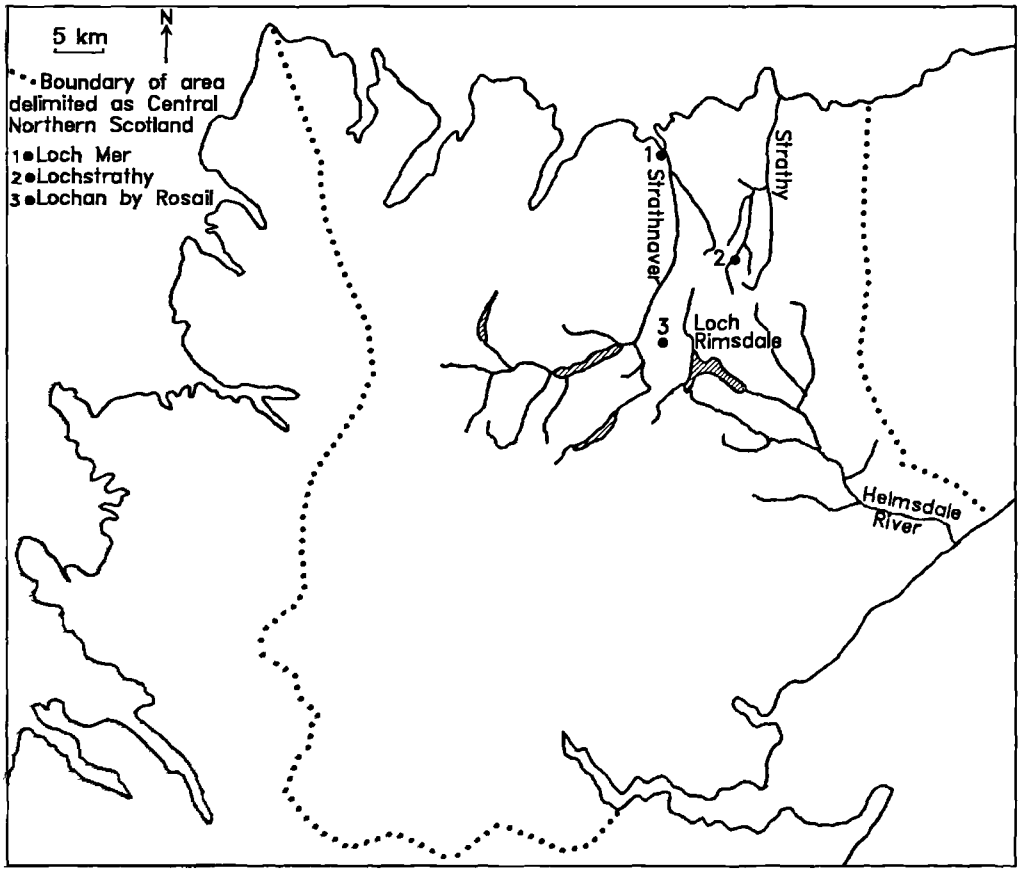

5 km
N
Boundary of area delimited as Central Northern Scotland
1 Loch Mer
2 Lochstrathy
3 Lochan by Rosail
Strathnaver
Strathy
Loch Rimsdale
Helmsdale River

Fig. 4.4a Sketch map of Loch Mer. To the east of the loch is enclosed to form a series of strip fields; the boundaries of these fields are indicated on the inset location map.

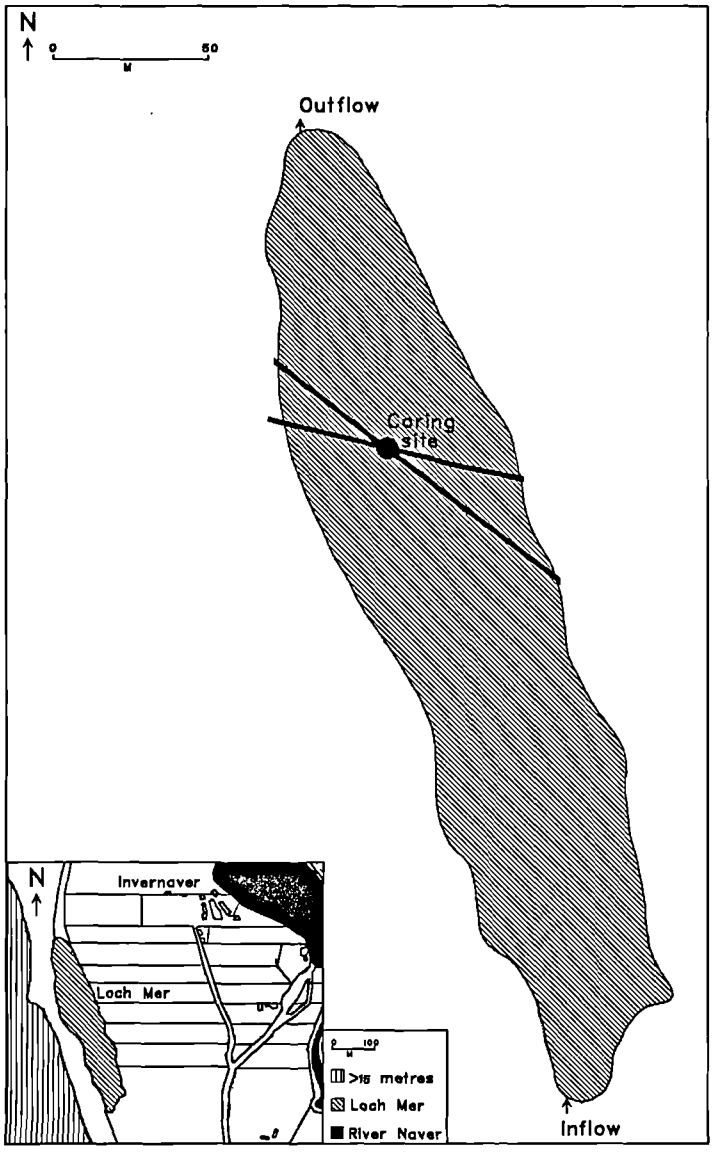

N
0
50
M
Outflow
Caring site
Inflow
N
Invernaver
Loch Mer
0
100
M
>15 metres
Loch Mer
River Naver

Fig. 4.4b The vegetation of the area surrounding Loch Mer (drawn from the Thematic Mapper image)

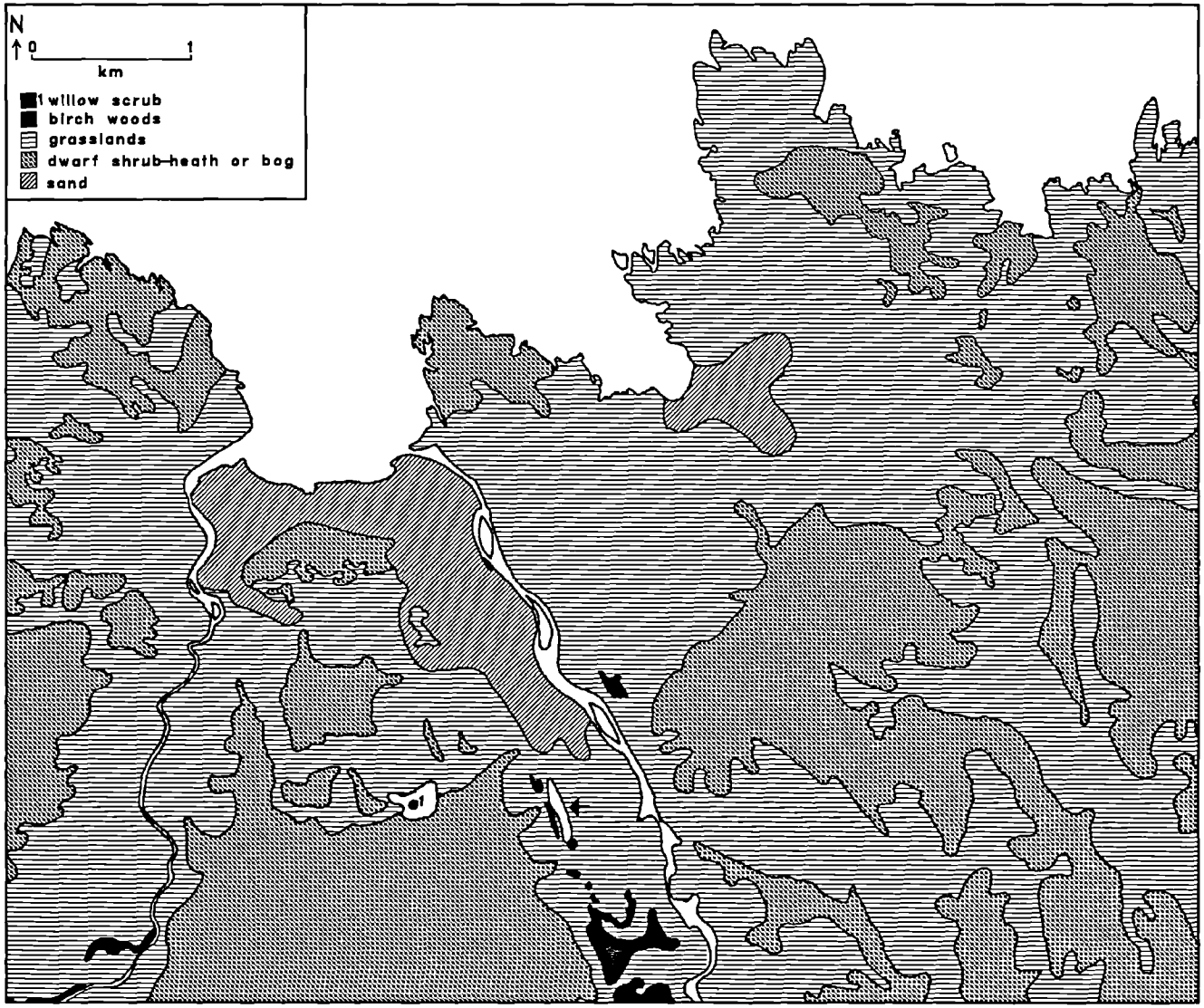

N
0
1
km
willow scrub
birch woods
grasslands
dwarf shrub-heath or bog
sand

Fig. 4.5 Sedimentological and chemical records records for Loch Mer. N.B. All depths are relative to the air/water interface.


Percentage Water Loss
Percentage Organic Loss
Percentage Carbonate Loss
Limus detritus
Detritus grenosus
Argilla steatodes
Argilla granosa
Grana arenosa
dichotomous leaf
Detritus herbosus
nigror
stratificatio
elasticitas
ploctitas
humeaitas
Black mineral unid.
Quartz
Schist
Olivine
Felspar
Grana saburralia
Pennate Diatoms
Elliptical Diatoms
Wavey edged Diatom unid.
CM
300
400
500
600
700
800
900
1000
1100
1200
10

Fig. 4.6b Pollen influx diagram for Loch Mer.

N.B. The pollen values have been divided by a factor of 3000.

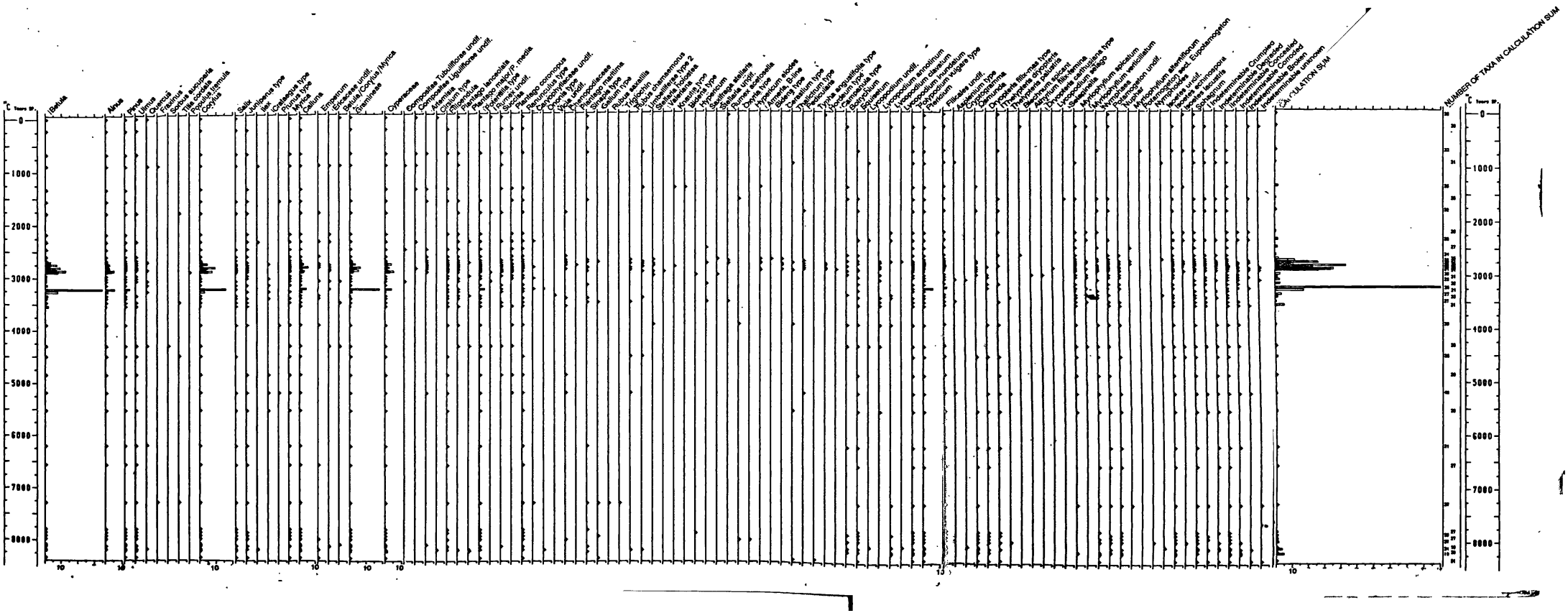

Betula
Alnus
Pinus
Ulmus
Quercus
Fraxinus
Sorbus aucuparia
Tilia cordata
Corylus avellana
Corylus
Salix
Juniperus type
Ilex
Castanea type
Prunus type
Myrica
Calluna
Empetrum
Ericaceae undif.
Betula/Corylus/Myrica
Sparganium
Cyperaceae
Compositae Tubuliflorae undif.
Compositae Liguliflorae undif.
Artemisia
Cirsium type
Cirsium/Carduus
Plantago lanceolata
Plantago major/P. media
Rumex undif.
Succisa
Plantago coronopus
Ranunculus type
Caryophyllaceae undif.
Chenopodiaceae
Viola undif.
Plantago maritima
Sinapis type
Galium type
Rubus saxatilis
Filipendula
Rubus chamaemorus
Umbelliferae type 2
Valeriana officinalis
Valeriana
Knautia type
Hydrocotyle
Saxifraga stellaris
Saxifraga undif.
Drosera rotundifolia
Drosera type
Hypericum elodes
Armeria, Silene
Lysimachia type
Gentiana type
Thalictrum type
Helianthemum
Typha angustifolia type
Typha latifolia type
Sparganium type
Equisetum
Lycopodium undif.
Lycopodium annotinum
Lycopodium clavatum
Lycopodium inundatum
Polypodium vulgare type
Pteridium
Filicales undif.
Botrychium type
Cryptogramma
Dennstaedtia
Thelypteris limbosperma
Thelypteris palustris
Blechnum spicant
Athyrium filix-femina
Dryopteris carthusiana type
Lycopodium selago
Selaginella selaginoides
Myriophyllum alterniflorum
Myriophyllum spicatum
Nymphaea
Nuphar
Potamogeton undif.
Myriophyllum alterniflorum
Potamogeton sect. Eupotamogeton
Myriophyllum undif.
Isoetes echinospora
Isoetes lacustris
Sphagnum
Indeterminable Crumpled
Indeterminable Degraded
Indeterminable Concealed
Indeterminable Corroded
Indeterminable Broken
Indeterminable Unknown
CALCULATION SUM
NUMBER OF TAXA IN CALCULATION SUM
cm
0
1000
2000
3000
4000
5000
6000
7000
8000
10
15

Fig. 4.7a Sketch map of Lochan by Rosail

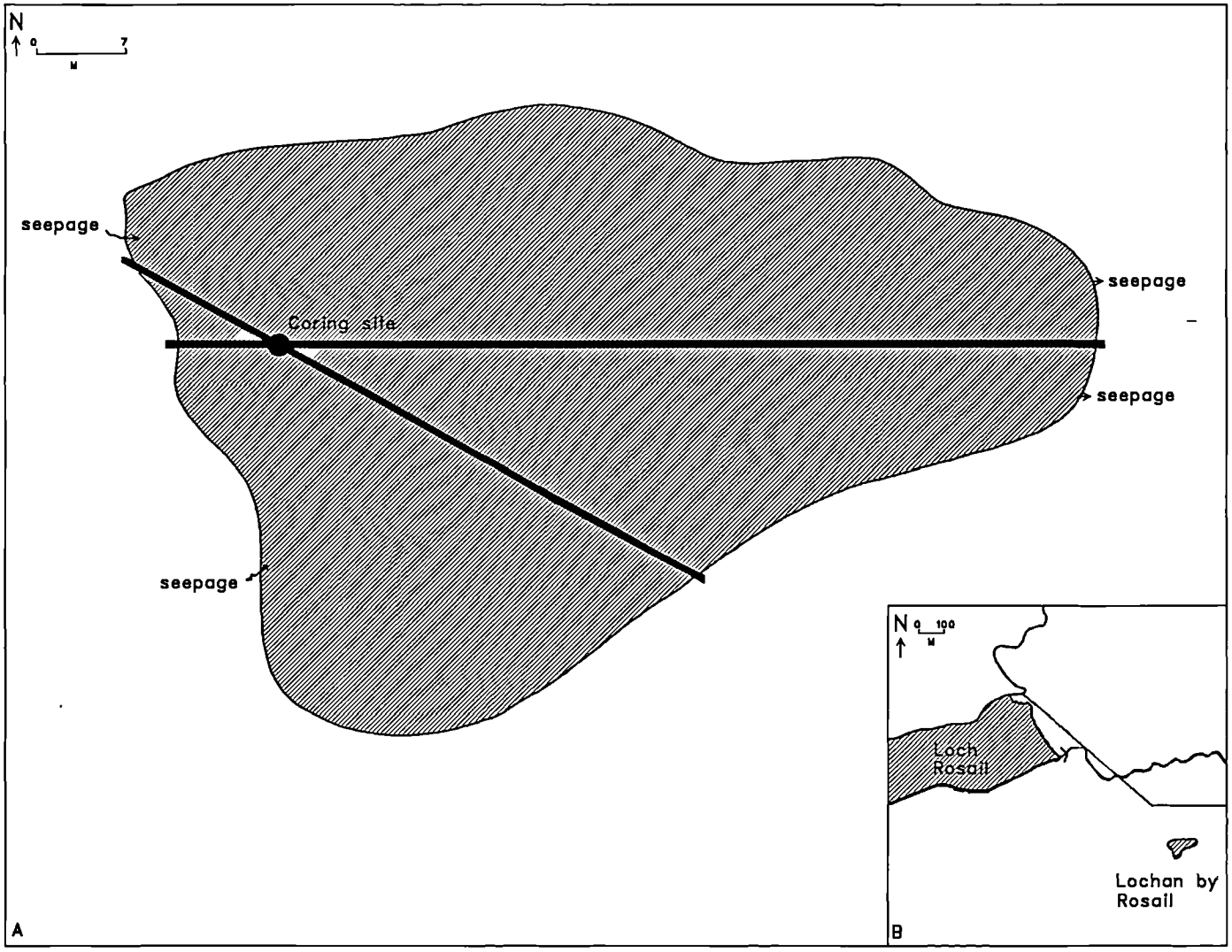

N
0
7
M
seepage
seepage
Coring site
seepage
seepage
A
N
0
100
M
Loch
Rosail
Lochan by
Rosail
B

Fig. 4.7b The vegetation of the area surrounding Lochan by Rosail (drawn from the Thematic Mapper image)

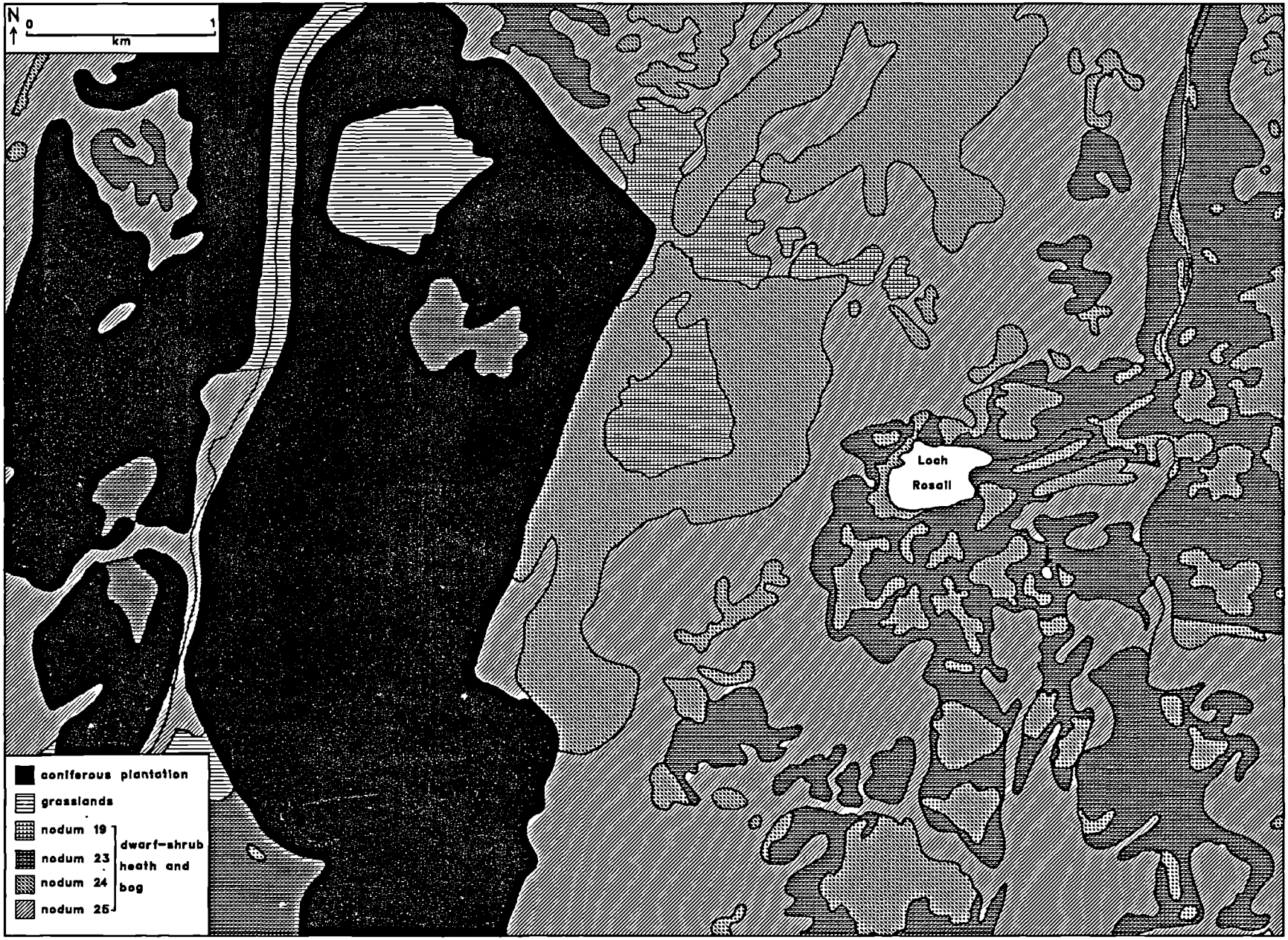

N
0
1
km
Loch
Rosall
coniferous plantation
grasslands
nodum 19
nodum 23
nodum 24
nodum 25
dwarf-shrub heath and bog

Fig. 4.8 Sedimentological and chemical records for Lochan by Rosail

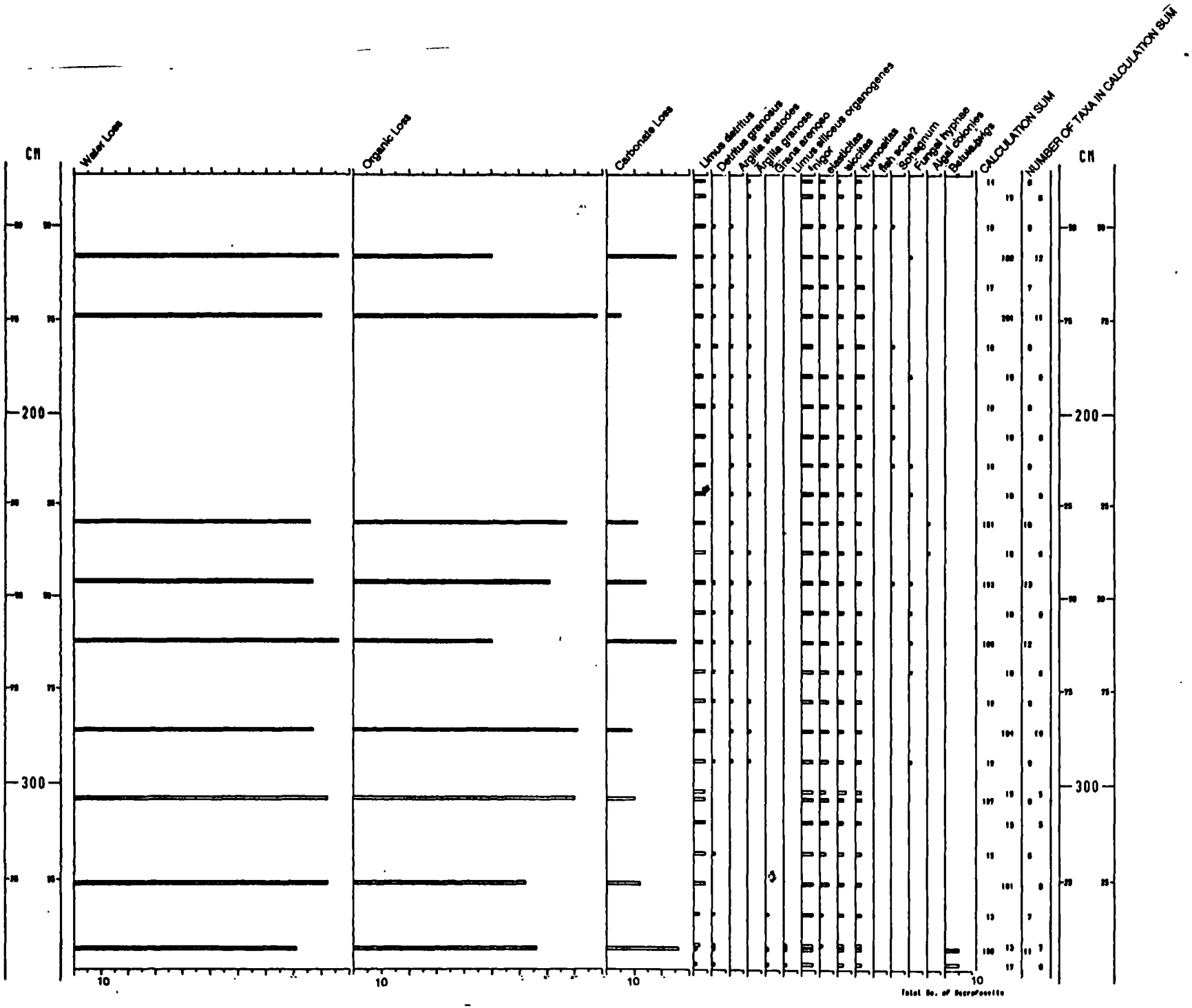

CM
Water Loss
Organic Loss
Carbonate Loss
Limus detritus
Detritus grenosus
Argilla steatodes
Argilla granosa
Grana arenoso
Limus siliceus organogenes
Inigor
elasticitas
siccitas
Humositas
fish scale?
Sphagnum
Fungal hyphae
Algal colonies
Betula twigs
CALCULATION SUM
NUMBER OF TAXA IN CALCULATION SUM
CM
200
300
10
10
10
10

Fig. 4.9 Percentage total land pollen diagram for Lochan by Rosail

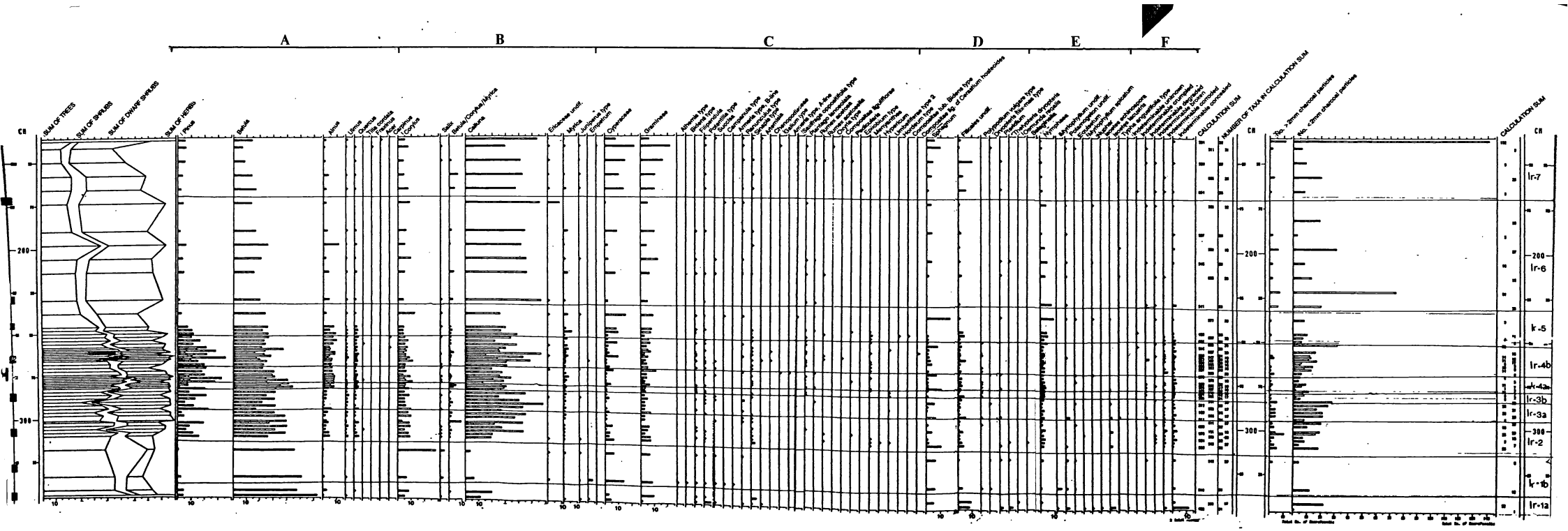
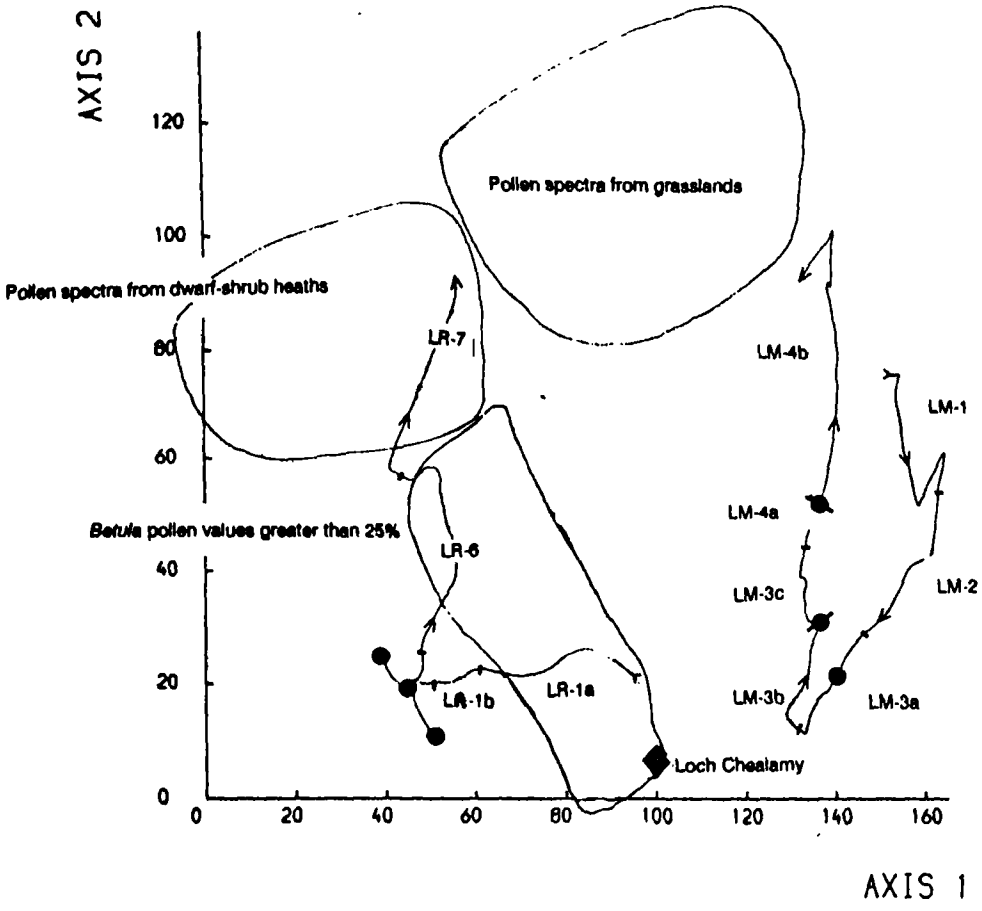

A
B
C
D
E
F
SUM OF TREES
SUM OF SHRUBS
SUM OF DWARF SHRUBS
SUM OF HERBS
Pinus
Betula
Alnus
Ulmus
Quercus
Tilia cordata
Fraxinus
Acer
Carpinus
Corylus
Salix
Betula (Corylus/Myrica
Calluna
Ericaceae undif.
Myrica
Juniperus type
Empetrum
Cyperaceae
Gramineae
Artemisia type
Botrychium type
Hippuris type
Sparganium type
Typha latifolia type
Typha angustifolia type
Potamogeton type
Sparganium type
Alisma type
Chenopodiaceae
Caltha type
Thalictrum type
Ranunculus type
Ranunculus hyperboreus type
Ranunculus acris type
Rumex acetosa type
Rumex acetosella type
Cruciferae
Filipendula type
Saxifraga type
Epilobium type
Umbelliferae type 2
Umbelliferae type 1
Compositae tub. Bidens type
Compositae lig. of Cerastium hostiodes
Sphagnum
Filicales undif.
Polypodium vulgare type
Dryopteris filix-mas type
Thelypteris
Thelypteris dryopteris
Osmunda
Lycopodium clavatum type
Selaginella
Nymphaea
Menyanthes
Nuphar
Potamogeton undif.
Potamogeton alpinus type
Potamogeton subg. Eupotamogeton
Potamogeton subg. Coleogeton
Sparganium emersum type
Sparganium subg. Xanthosparganium
Sparganium subg. Sparganium
Isoetes
Equisetum
Botryococcus
Pediastrum
Indeterminable concealed
Indeterminable exposed
CALCULATION SUM
NUMBER OF TAXA IN CALCULATION SUM
No. > 2mm charcoal particles
No. < 2mm charcoal particles
CALCULATION SUM
lr-7
lr-6
lr-5
lr-4b
lr-4a
lr-3b
lr-3a
lr-2
lr-1b
lr-1a
cm

Fig. 4.10 DECORANA plot for Strathnaver and its surrounding area surface samples and smoothed curve (5-sample moving average) connecting Loch Mer and Lochan by Rosail fossil samples in chronological order


AXIS 2
120
100
80
60
40
20
0
Pollen spectra from grasslands
Pollen spectra from dwarf-shrub heaths
LR-7
LM-4b
LM-1
LM-4a
Betula pollen values greater than 25%
LR-6
LM-3c
LM-2
LR-1b
LR-1a
LM-3b
LM-3a
Loch Chealamy
0
20
40
60
80
100
120
140
160
AXIS 1

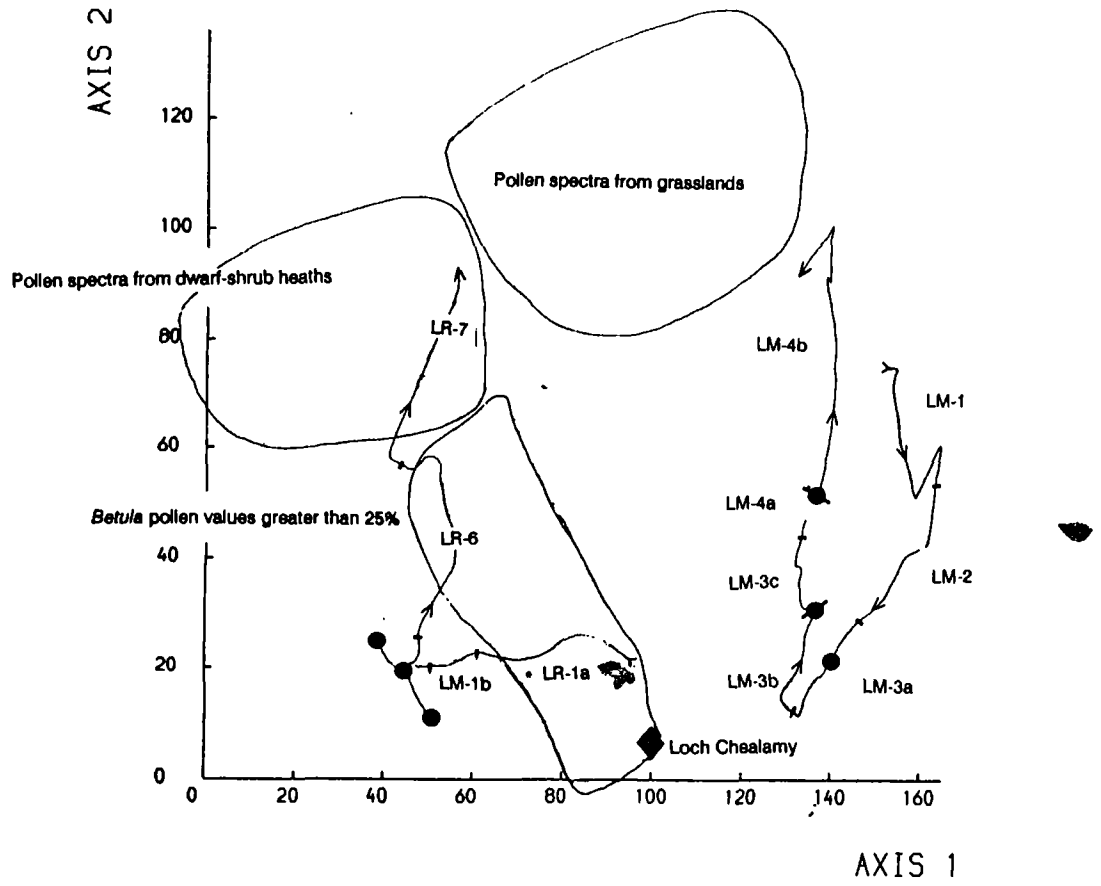

AXIS 2
120
100
80
60
40
20
0
Pollen spectra from grasslands
Pollen spectra from dwarf-shrub heaths
LR-7
LM-4b
LM-1
LM-4a
Betula pollen values greater than 25%
LR-6
LM-3c
LM-2
LM-1b
LR-1a
LM-3b
LM-3a
Loch Chealamy
0
20
40
60
80
100
120
140
160
AXIS 1

Fig. 5.1 Map illustrating the previously more extensive distribution of *Pinus sylvestris* on a 10 km grid square basis.

Key:

1 The present day native distribution of *Pinus sylvestris* (based on Steven and Carlisle, 1959).

2 The published distribution of sub-fossil *P. sylvestris* (Bennett, 1984). All of the macro-fossil records for far northern and northern Scotland have been confirmed unless otherwise indicated.

3 refers to 10 km grid squares where which have been searched, but within which no macro-fossils have been found to confirm the previously published distribution.

4 refers to 10 km grid squares that have been searched, but within which no *P. sylvestris* macro-fossils have been found.

5 refers to 10 km grid references where *P. sylvestris* macro-fossils have been first recorded in the course of this survey during 1987/1988.

6 refers to 10 km grid squares which have been searched, but within which no *P. sylvestris* macro-fossils have been found.

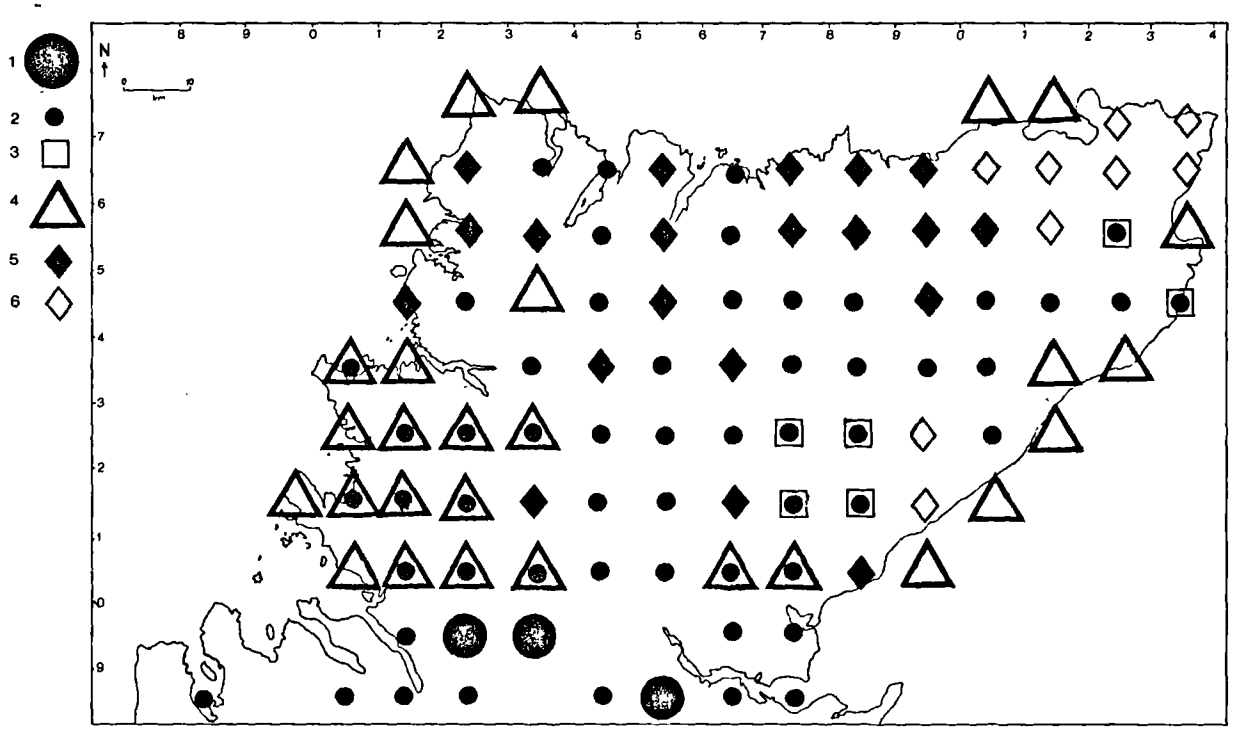

1
2
3
4
5
6
N
0
km

Fig. 5.2 The post glacial pollen evidence for the presence or absence of *Pinus sylvestris* in northern Scotland plotted on a 10 km grid square basis (after Bennett, 1984).

Key

1 refers to sites that have pollen evidence (>20% total land pollen) indicating presence of *P. sylvestris* during the Holocene

2 refers to the Lochstrathy and Lochan by Rosail pollen sites

3 refers to sites where the pollen evidence for the presence of *P. sylvestris* during the Holocene is absent.

4 refers to the Loch Mer pollen site

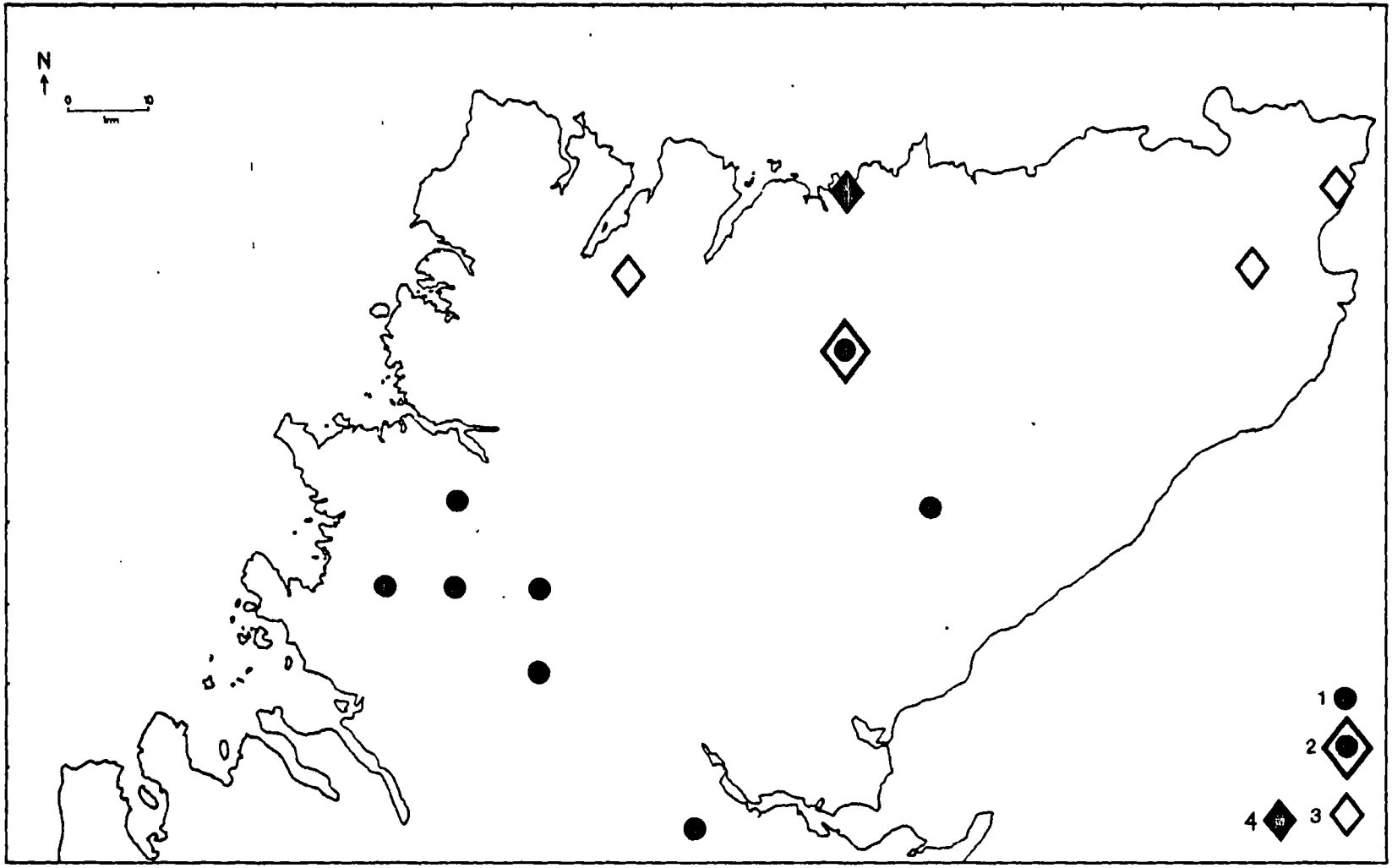

N
0
1m
1
2
3
4

Fig. 5.3 10 km map illustrating the locations of all previously known radiocarbon-dated pine macro-fossils (black diamonds) and the locations of the radiocarbon dates that are being processed for this project (black dots).

1 = 4,393 B.P.

2 = 4,420 B.P.

3 = 4,220 B.P.

4 = 4,163 B.P.

5 = 4,674 B.P

6 = 3,976 B.P

7 = 4,163 B.P

8 = 3,976 B.P.

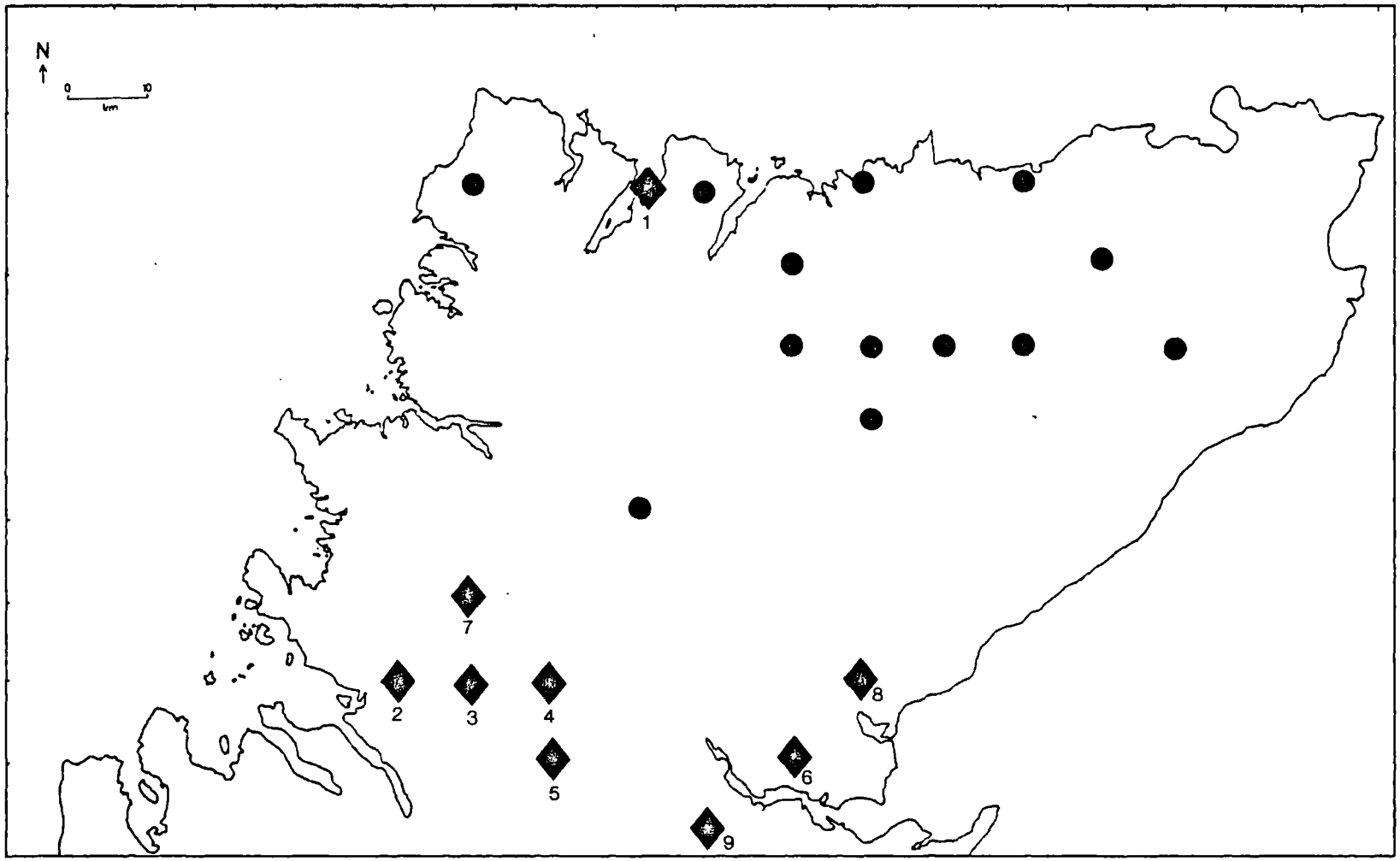
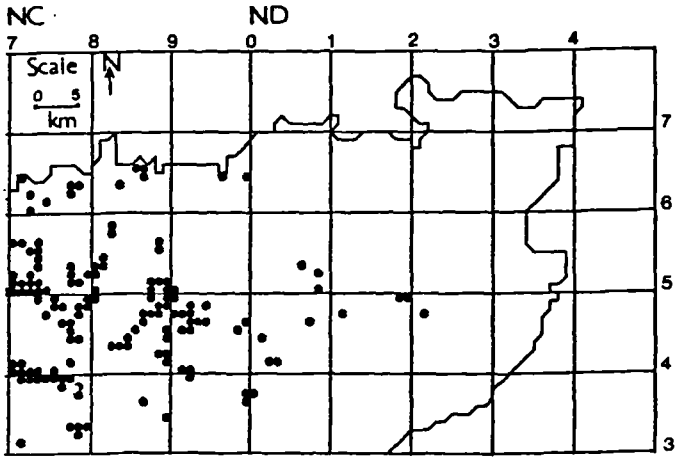

N
0
10
km
1
2
3
4
5
6
7
8
9

Fig. 5.4a 1 km map illustrating the changes in the frequency and distribution of *Pinus sylvestris* macro-fossil localities north-east of NC 73

Fig. 5.4b Histogram illustrating the changes in the frequency of sub-fossil *Pinus sylvestris* localities, per 10 km grid easting, north-east of NC 73


NC
ND
7
8
9
0
1
2
3
4
Scale
0 5
km
N
7
6
5
4
3

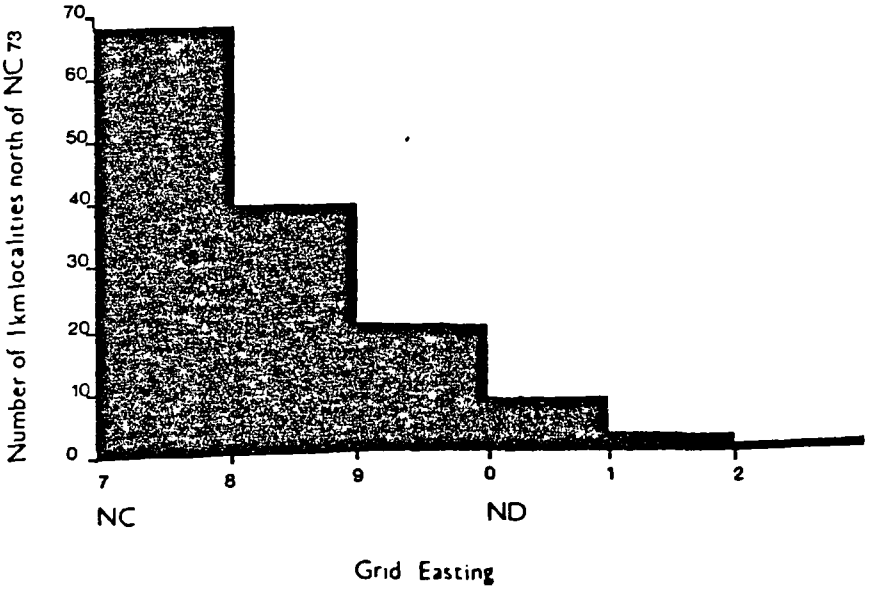

Number of 1km localities north of NC 73
70
60
50
40
30
20
10
0
7
8
9
0
1
2
NC
ND
Grid Easting

Fig. 5.5 A 10 km map illustrating the distribution of sub-fossil remains of *Salix* sp. and *Betula* sp. in the far north of Scotland

KEY

Black dots refer to the presence of *Betula* macro-fossils

Hollow boxes refer to the presence of *Salix* macro-fossils

A black dot is combined with a hollow box indicates that both *Betula* and *Salix* macro-fossils have been found within the same 10 km grid square.

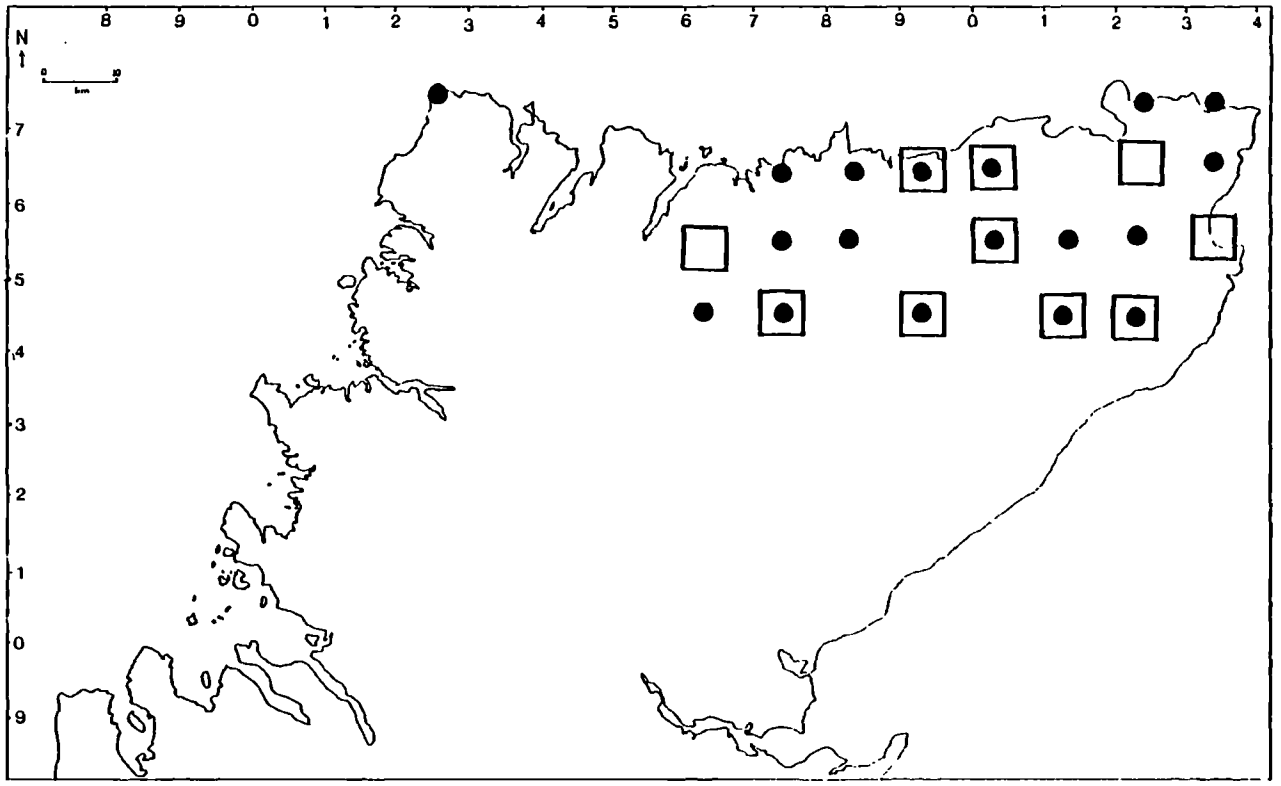

N
8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
7
6
5
4
3
2
1
0
9

Fig. 5.6 (part 1) 1 km map of the area of the intensive survey illustrating the location of the surveyed 1 km grid squares, pine stump distribution, and soil types

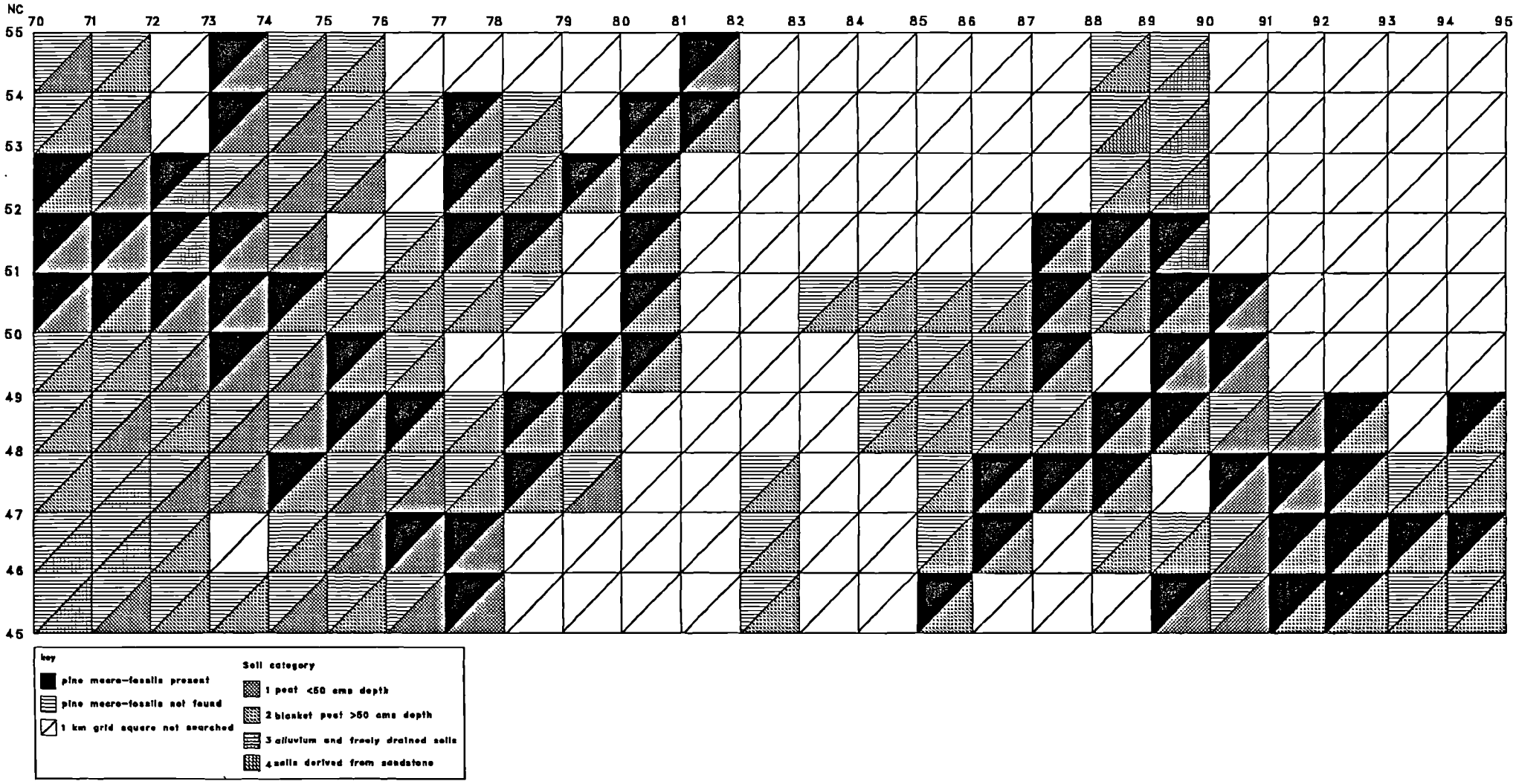

NC
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
55
54
53
52
51
50
49
48
47
46
45
key
pine macro-fossils present
pine macro-fossils not found
1 km grid square not searched
Soil category
1 peat <50 cms depth
2 blanket peat >50 cms depth
3 alluvium and freely drained soils
4 soils derived from sandstone

Fig. 5.6 (continued) 1 km map of the area of the intensive survey illustrating the location of the surveyed 1 km grid squares, pine stump distribution, and soil types

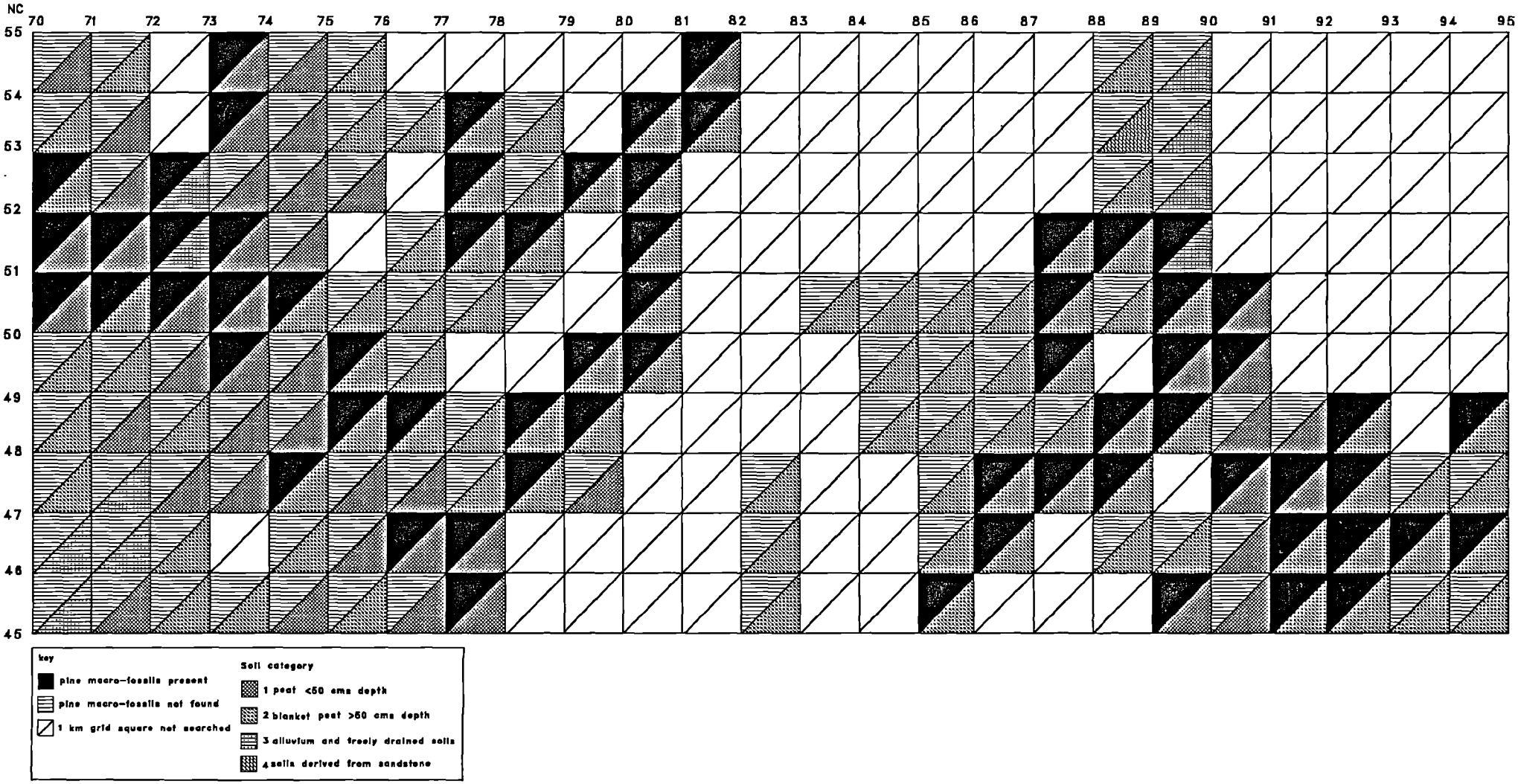

NC
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
55 54 53 52 51 50 49 48 47 46 45
key
pine macro-fossils present
pine macro-fossils not found
1 km grid square not searched
Soil category
1 peat <50 cms depth
2 blanket peat >50 cms depth
3 alluvium and freely drained soils
4 soils derived from sandstone

Fig. 5.7 Distribution of *Pinus sylvestris* trunks plotted on a 10 km grid square basis - illustrating that good conditions for preservation occured widely. Many stumps were preserved with thick layers of bark. Pine trunk records are only documented for the area that the present author has surveyed and does not include the findings of previous surveys .

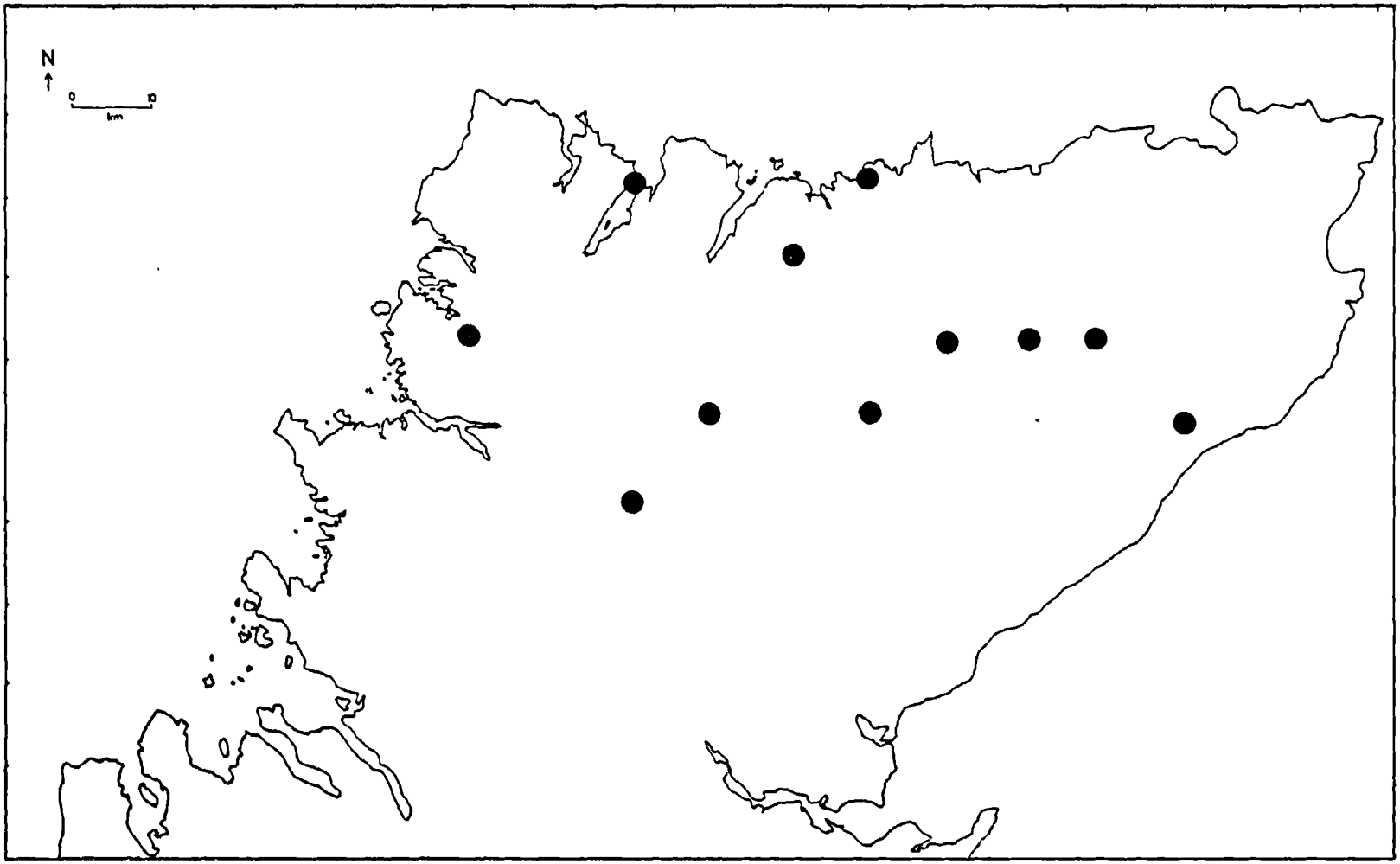

N
0
10
km

Fig. 5.8 The distribution of pine with altitude - The relationship between altitude and grid easting. The dots mark the altitude that pine macro-fossils were found at within a 1 km grid easting. The arrows indicate the maximum and minimum potential altitude that pine could have attained within the 1 km grid squares that were searched for a grid easting. The dashed lines indicate that no pine macro-fossils were found within a grid easting.

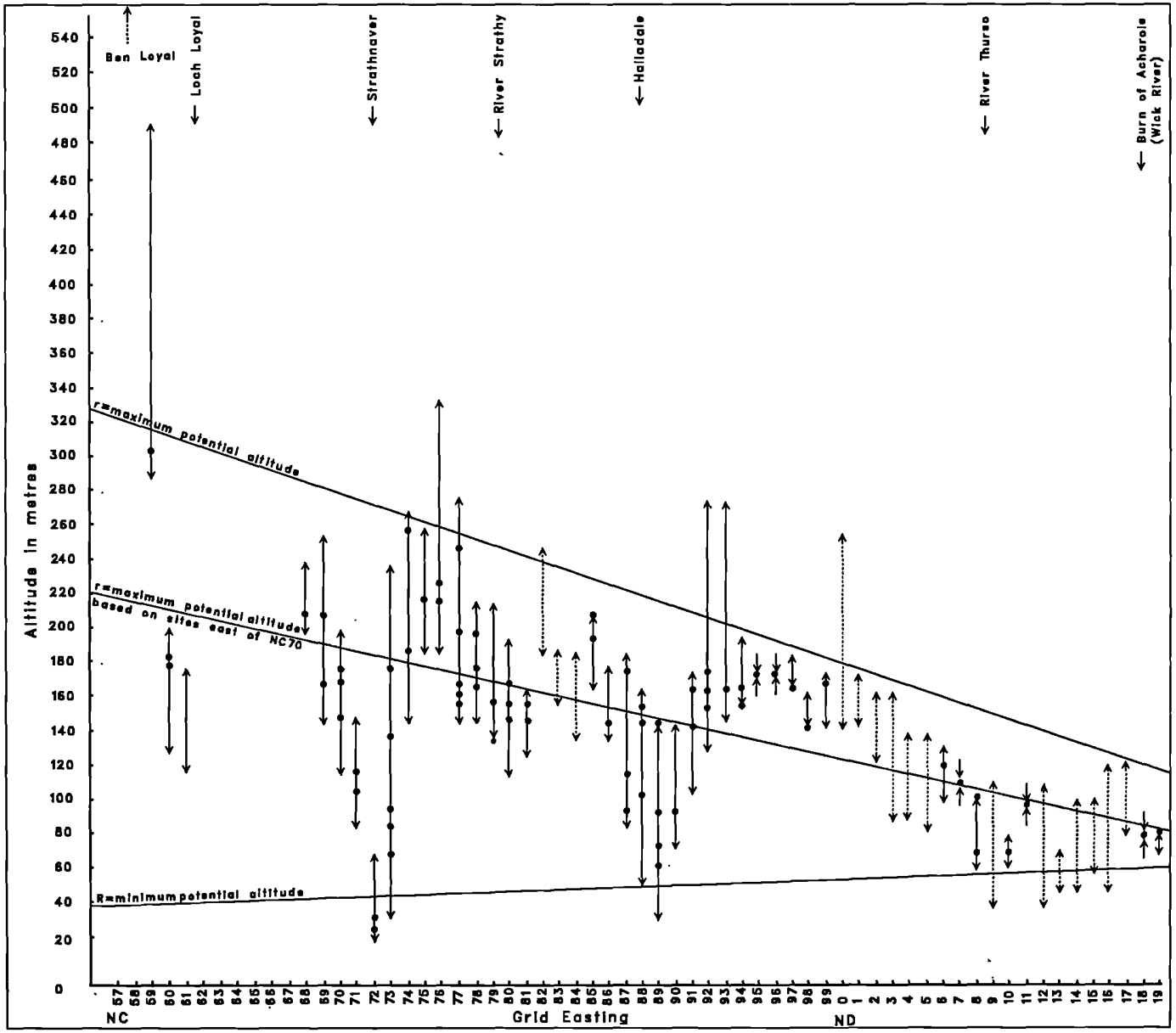

Ben Loyal
Loch Loyal
Strathnaver
River Strathy
Halladale
River Thurso
Burn of Acharole (Wick River)
r=maximum potential altitude
r=maximum potential altitude based on sites east of NC70
R=minimum potential altitude
Altitude in metres
Grid Easting
NC
ND

Fig. 5.9 The location of the sub-fossil and extant sites used to construct the density maps

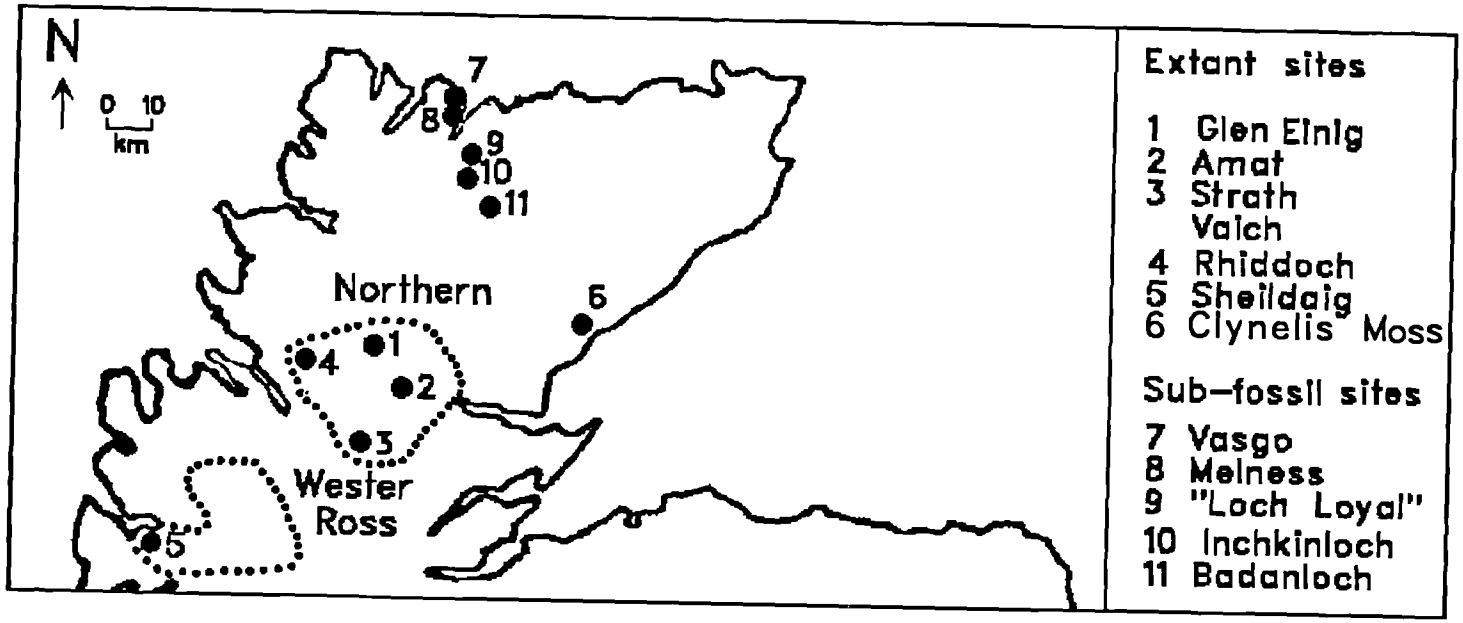

N
0 10
km
Northern
Wester
Ross
1
2
3
4
5
6
7
8
9
10
11
Extant sites
1 Glen Elnig
2 Amat
3 Strath
Valch
4 Rhiddoch
5 Sheildaig
6 Clynelis Moss
Sub-fossil sites
7 Vasgo
8 Melness
9 "Loch Loyal"
10 Inchkinloch
11 Badanloch

Fig. 5.10a,b,c, and d. Maps illustrating the spatial positions and size classes of trees in both sub-fossil (F) and extant localities (M). All the x-y co-ordinates are in metres. Basal area size classes are as follows: 1 = 0-10, 2 = 10-100, 3 = 100-500, 4 = 500-2000, 5 = 2,000-4,000 and 6 = >4,000 $cm^2$.

Fig. 5.10a Badanloch site 1

Fig. 5.10b Badanloch site 2

Fig. 5.10c Amat site 1

Fig. 5.10d Amat site 2

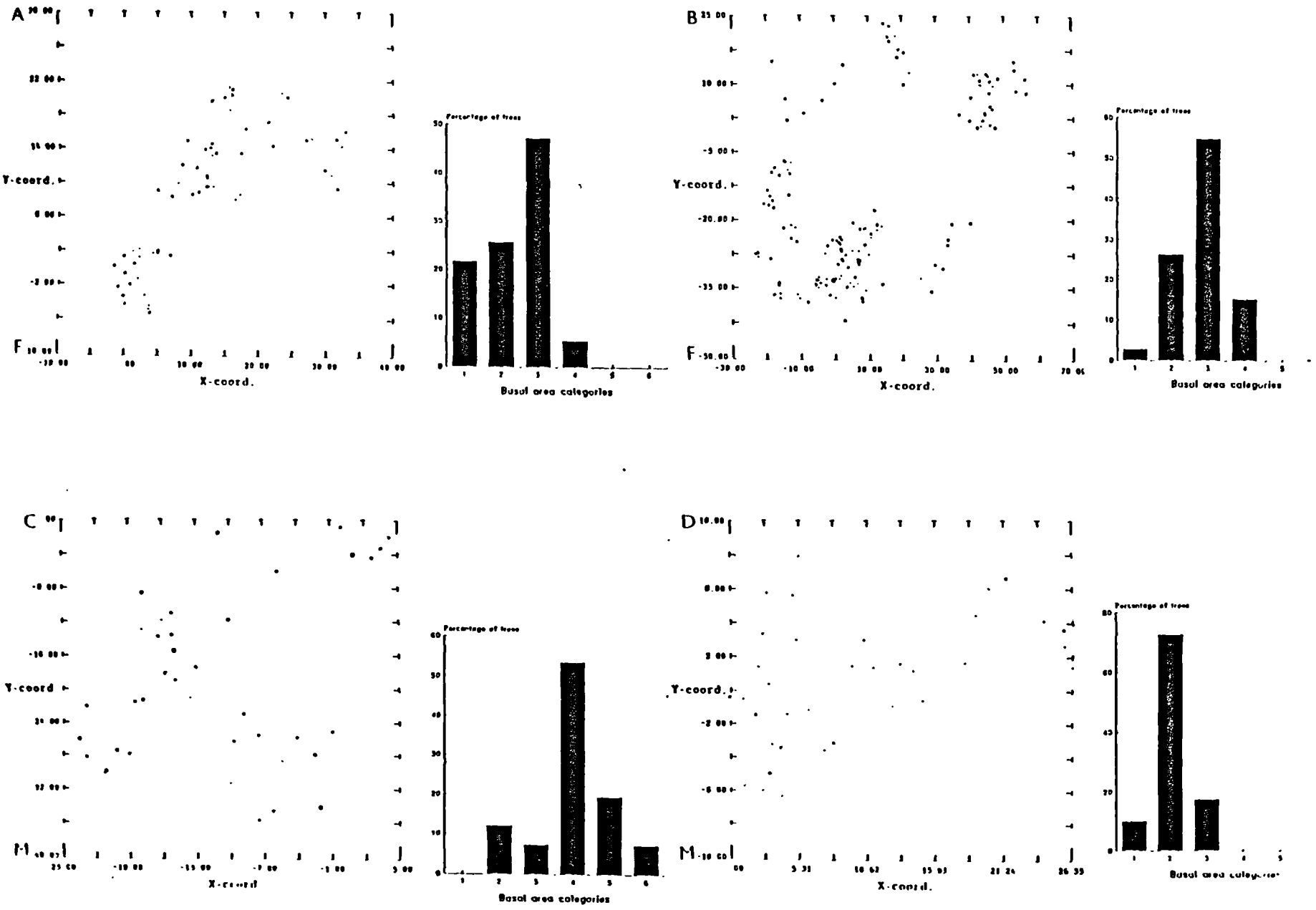

A
B
C
D
Y-coord.
X-coord.
Percentage of trees
Basal area categories

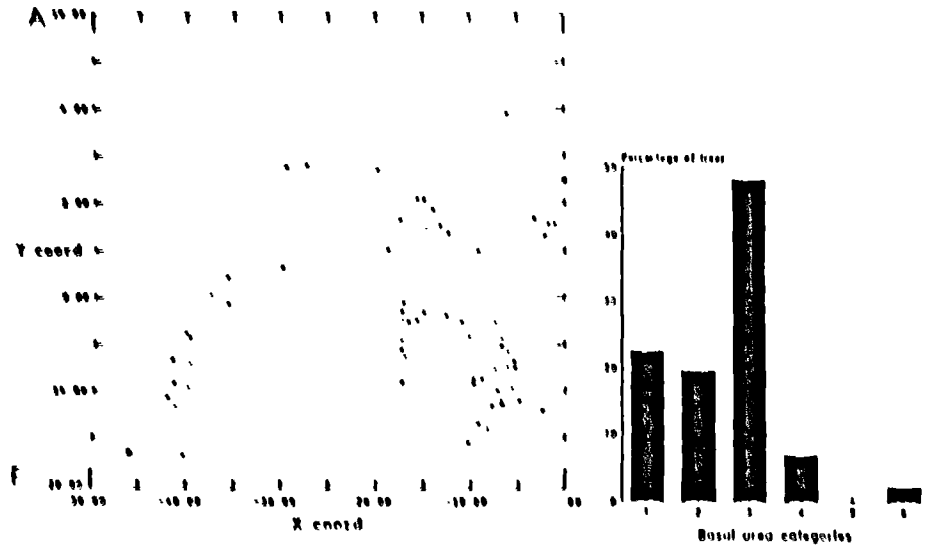
Fig. 5.11a,b,c, and d. Maps illustrating the spatial positions and size classes of trees in both sub-fossil (F) and extant localities (M). All the x-y co-ordinates are in metres. Basal area size classes are as follows: 1 = 0-10, 2 = 10-100, 3 = 100-500, 4 = 500-2000, 5 = 2,000-4,000 and 6= >4,000 $cm^2$.

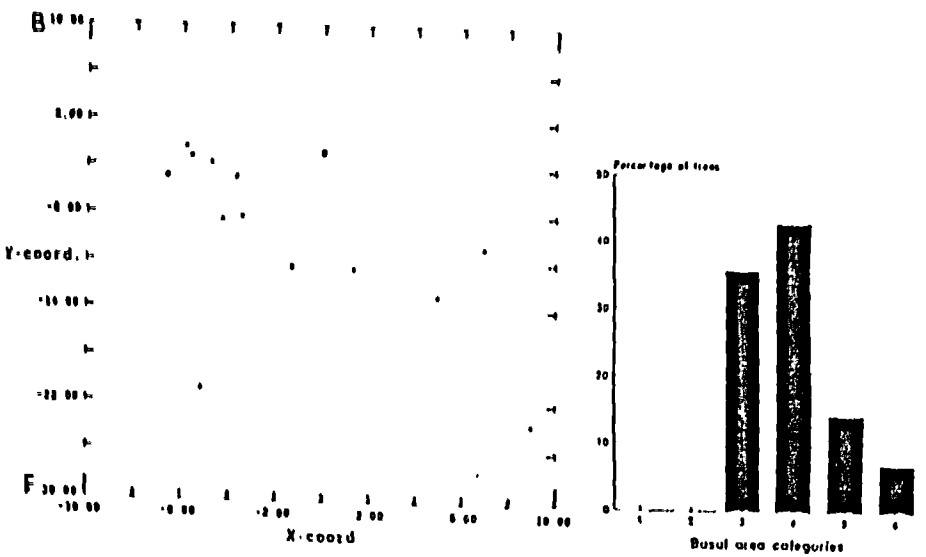
Fig. 5.11a "Loch Loyal"1

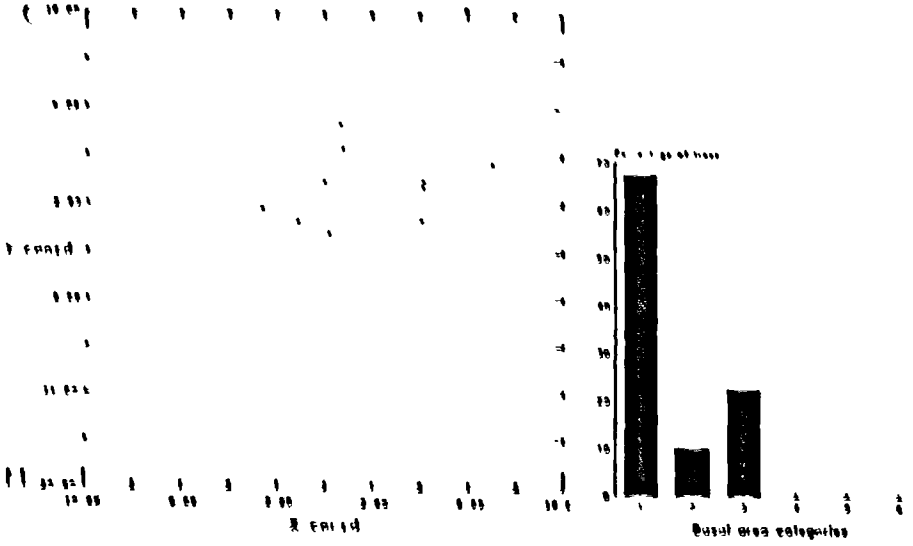
Fig. 5.11b Vasgo

Fig. 5.11c Moss

Fig. 5.11d Glen Einig


A
Y coord
X coord
Basal area categories


B
Y-coord.
X-coord
Basal area categories


C
Basal area categories

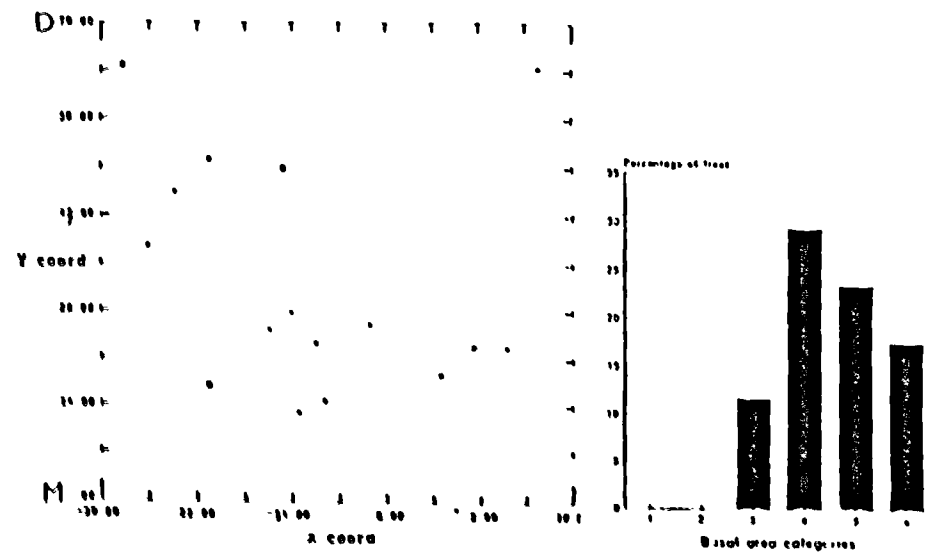

D
Y coord
X coord
Basal area categories

Fig. 5.12a,b,c, and d. Basal area and tree density plots for Melness and Inchkinloch based on both stump and root postitions illustrating the substantial increase in tree density when root positions are used to estimate tree positions. Maps illustrating the spatial positions and size classes of trees in both sub-fossil (F) and extant localities (M). All the x-y co-ordinates are in metres. Basal area size classes are as follows: 1 = 0-10, 2 = 10-100, 3 = 100-500, 4 = 500-2000, 5 = 2,000-4,000 and 6= >4,000 $cm^2$.

Fig. 5.12a Inchkinloch - Tree density based on stump positions

Fig. 5.12b Inchkinloch - Tree density based on root positions

Fig. 5.12c Melness - Tree density based on stump positions

Fig. 5.12d Melness - Tree density based on root positions

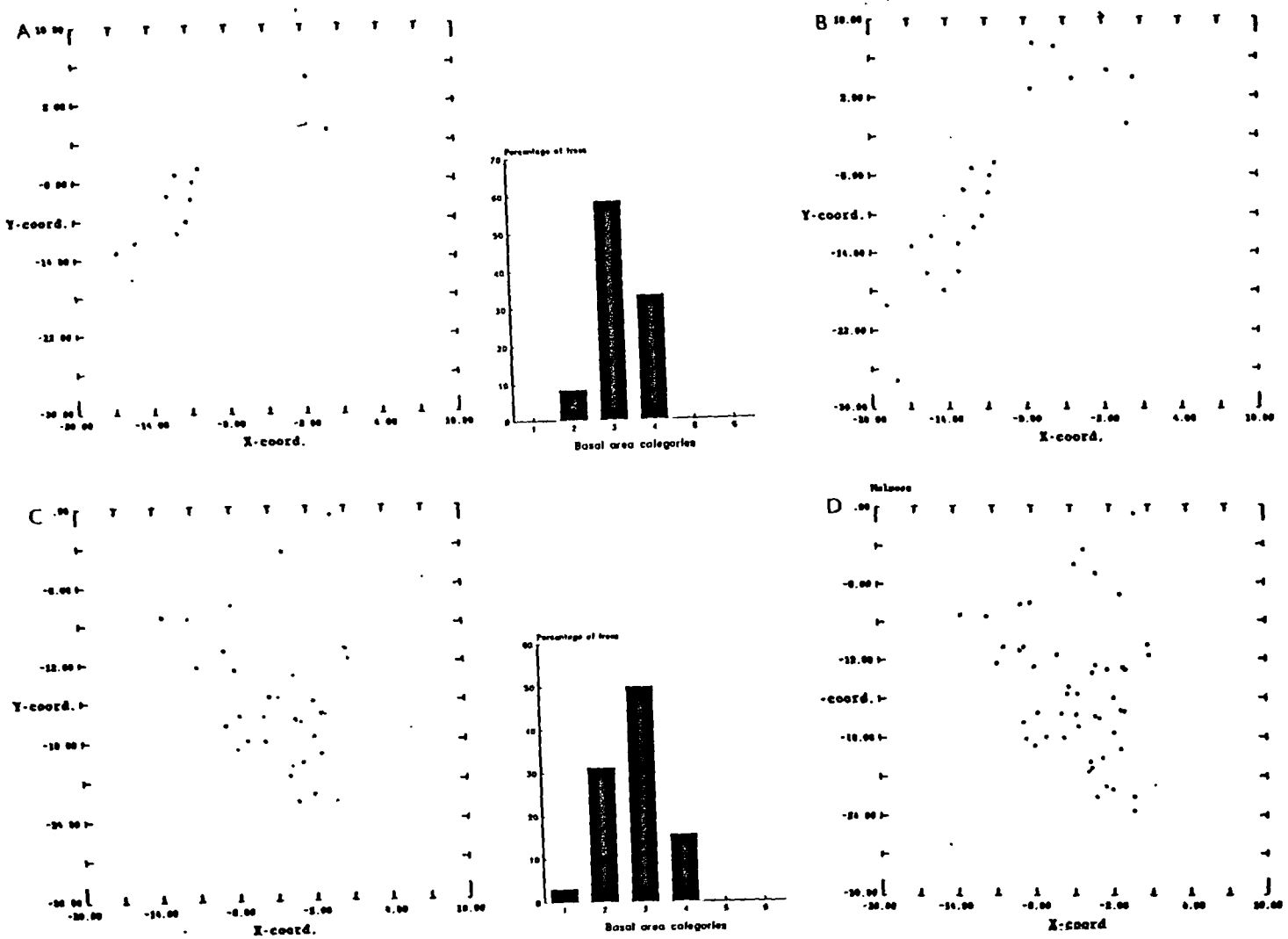

A
B
C
D
Y-coord.
X-coord.
Basal area categories

Fig. 5.13a and b. Two stands from different woods with approximately similar basal areas, but quite different age-class distributions. Maps illustrating the spatial positions and size classes of trees in both sub-fossil (F) and extant localities (M). All the x-y co-ordinates are in metres. Basal area size classes are as follows: 1 = 0-10, 2 = 10-100, 3 = 100-500, 4 = 500-2000, 5 = 2,000-4,000 and 6= >4,000 $cm^2$.

Fig. 5.13a Rhiddoch site 1

Fig. 5.13b Sheildaig

Fig. 5.13c and d. Two stands from the same wood with quite different basal area estimates, but with similar age-class distributions

Fig. 5.13c Strath Vaich site 1

Fig. 5.13d Strath Vaich site 2

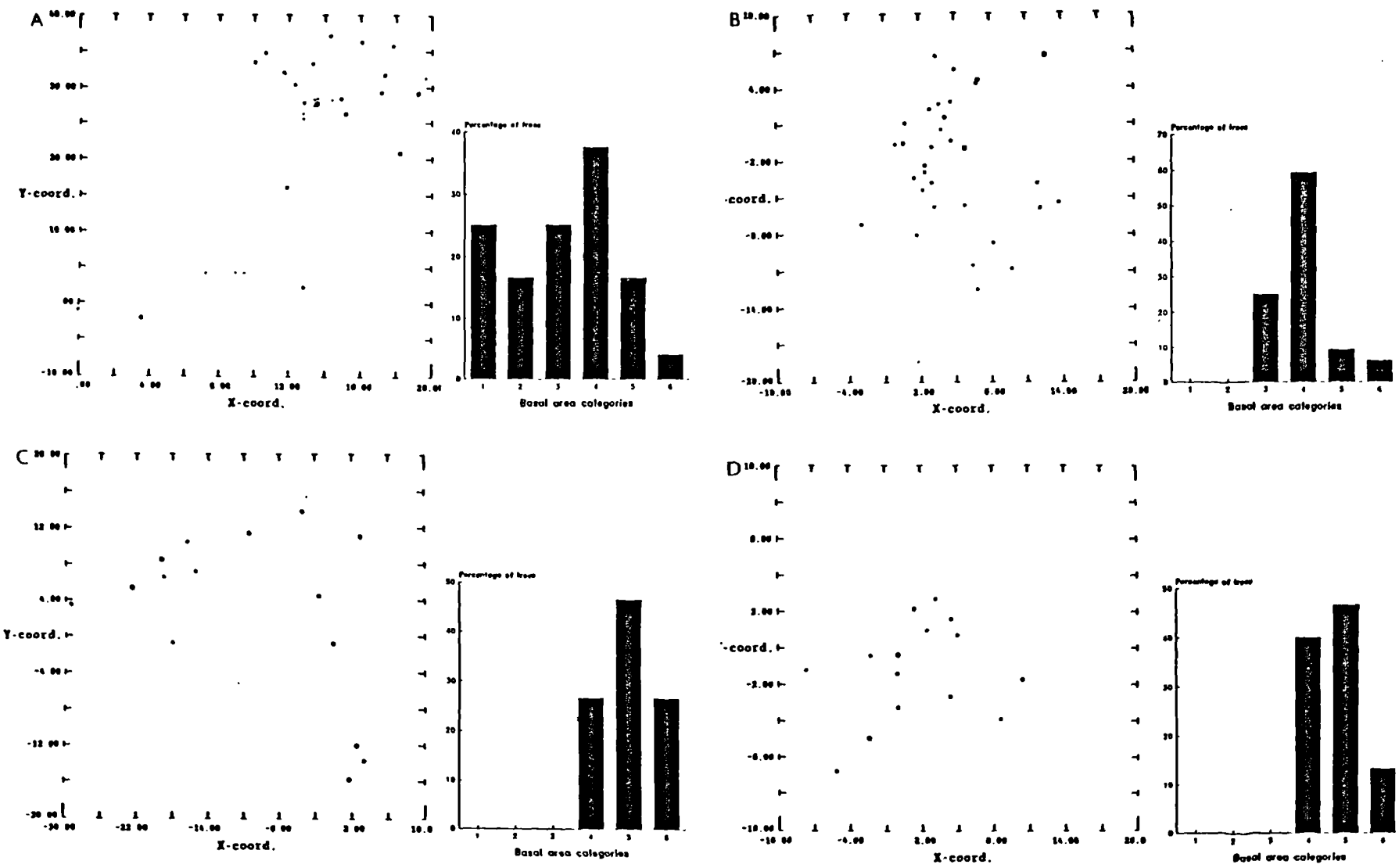

A
Y-coord.
X-coord.
Basal area categories
B
X-coord.
Basal area categories
C
Y-coord.
X-coord.
Basal area categories
D
X-coord.
Basal area categories

Fig. 5.14 Modern tree density and percentage canopy cover

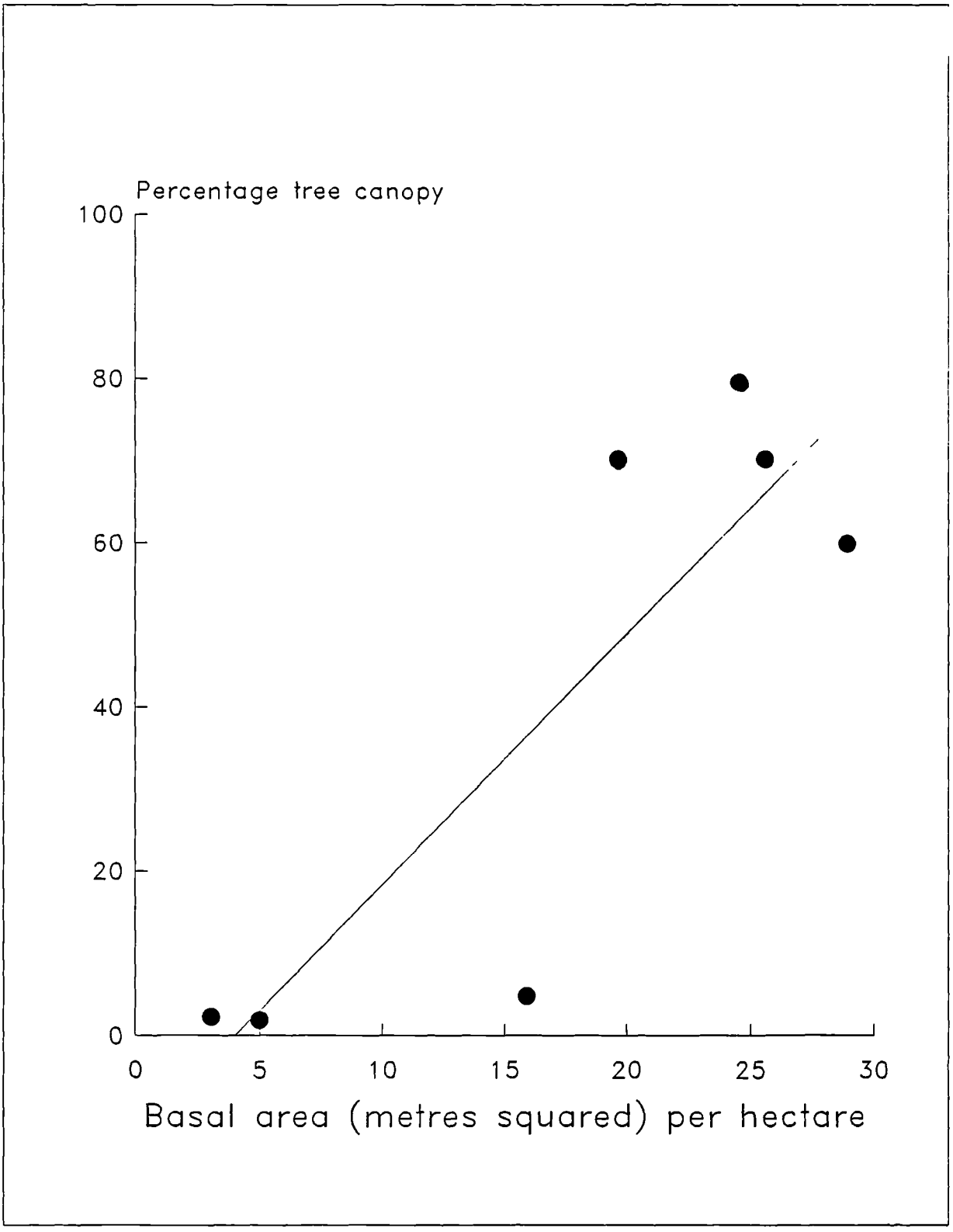

Percentage tree canopy
100
80
60
40
20
0
0
5
10
15
20
25
30
Basal area (metres squared) per hectare

Fig. 6.1 The location of Lochstrathy

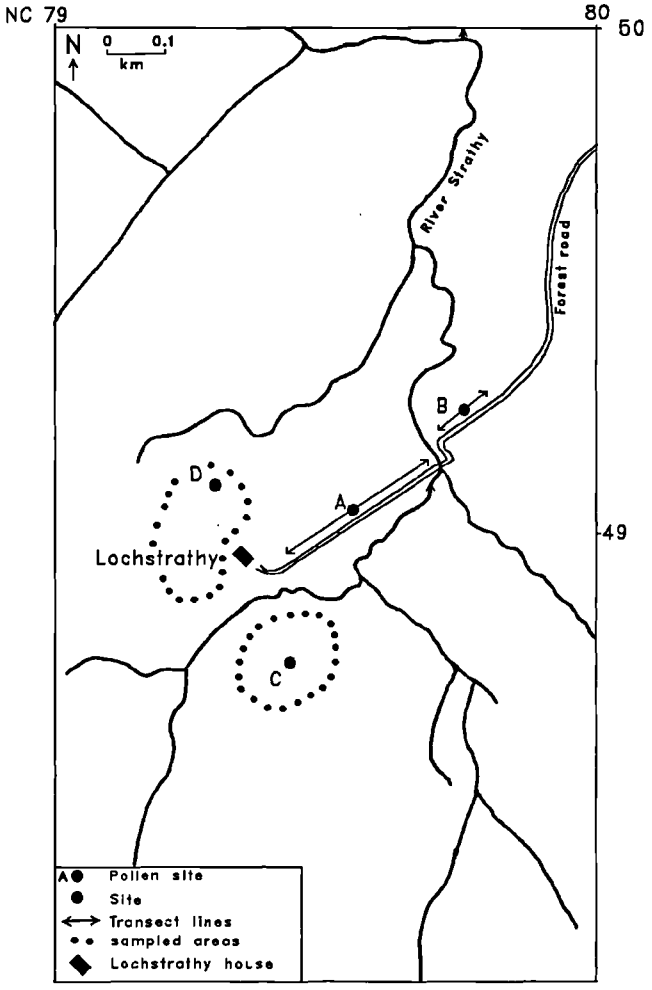

NC 79
80
50
49
N
0 0.1
km
River Strathy
Forest road
B
A
D
C
Lochstrathy
A● Pollen site
● Site
Transect lines
sampled areas
Lochstrathy house

Fig. 6.2 Coarse-resolution percentage total land pollen diagram for Lochstrathy

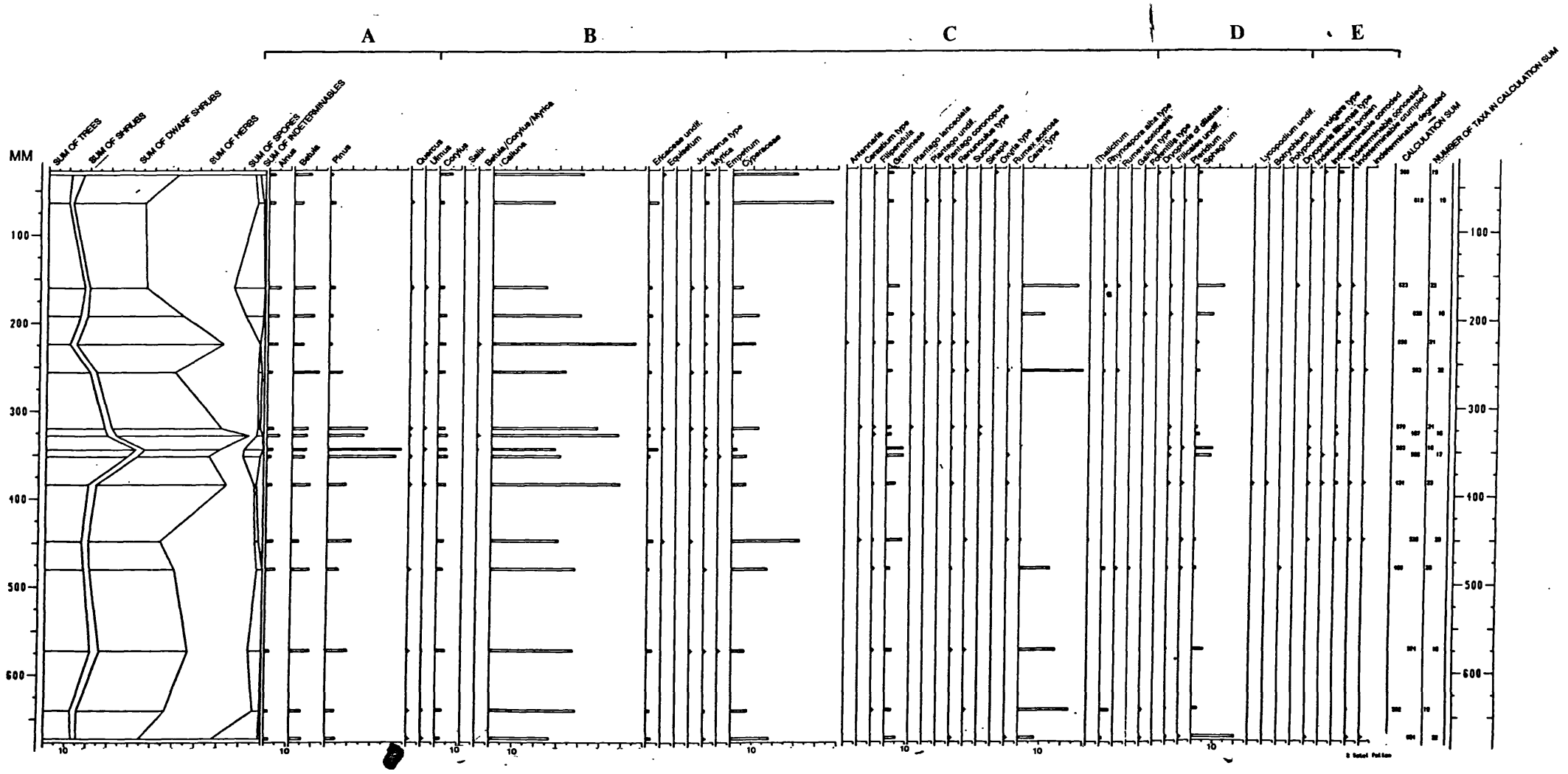

A
B
C
D
E
MM
SUM OF TREES
SUM OF SHRUBS
SUM OF DWARF SHRUBS
SUM OF HERBS
SUM OF SPORES
SUM OF INDETERMINABLES
Alnus
Betula
Pinus
Quercus
Ulmus
Corylus
Salix
Betula/Corylus/Myrica
Calluna
Ericaceae undif.
Equisetum
Juniperus type
Myrica
Empetrum
Cyperaceae
Artemisia
Cerealia type
Filipendula
Gramineae
Plantago lanceolata
Plantago undif.
Plantago coronopus
Ranunculus type
Succisa
Sinapis
Onagra type
Rumex acetosa
Carex type
Thalictrum
Rhynchospora alba type
Rumex acetosella
Galium type
Potentilla type
Dryopteris cf. dilatata
Filicales undif.
Pteridium
Sphagnum
Lycopodium undif.
Botrychium
Polypodium vulgare type
Dryopteris filix-mas type
Indeterminable broken
Indeterminable corroded
Indeterminable concealed
Indeterminable crumpled
Indeterminable degraded
CALCULATION SUM
NUMBER OF TAXA IN CALCULATION SUM
100
200
300
400
500
600

Fig. 6.3 Fine-resolution percentage total land pollen diagram for Lochstrathy

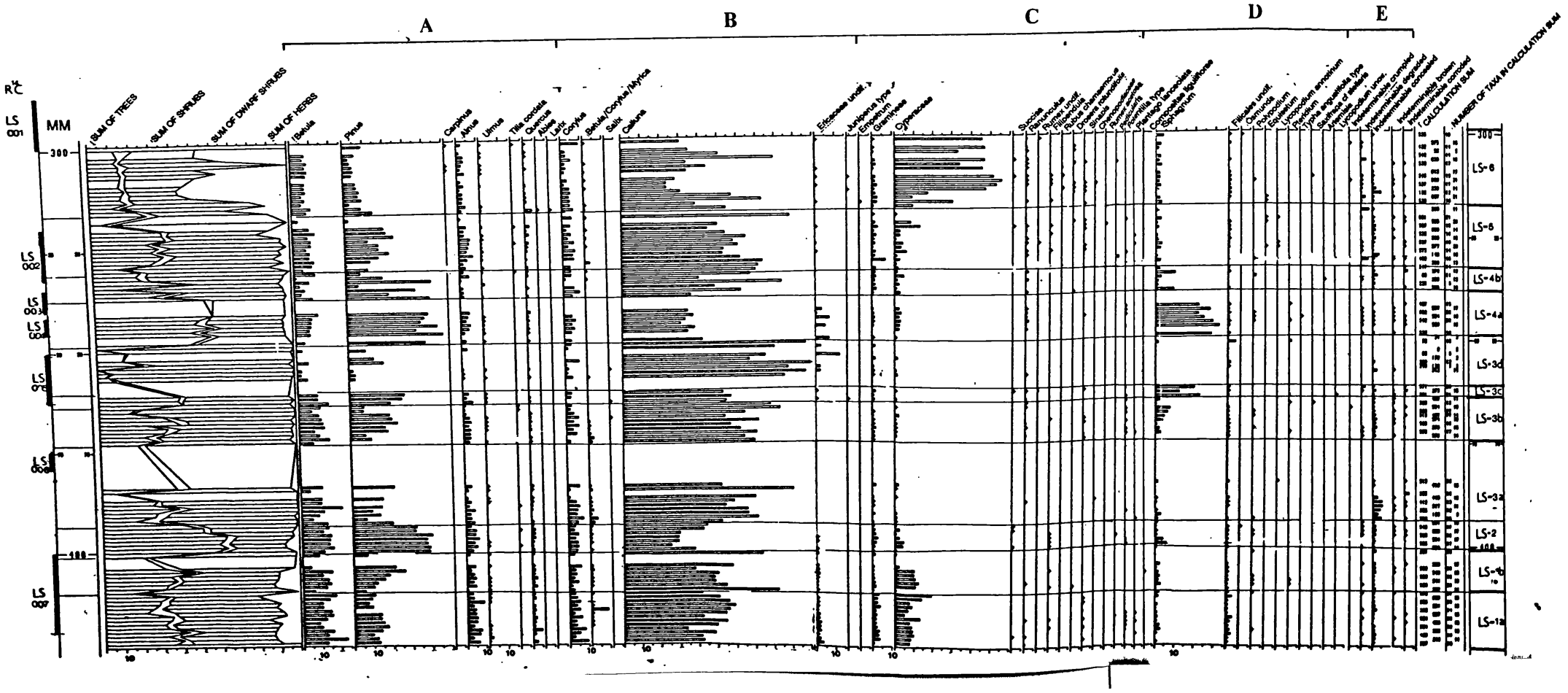

A
B
C
D
E
MM
SUM OF TREES
SUM OF SHRUBS
SUM OF DWARF SHRUBS
SUM OF HERBS
Betula
Pinus
Carpinus
Alnus
Ulmus
Tilia cordata
Quercus
Abies
Larix
Corylus
Betula/Corylus/Myrica
Salix
Calluna
Ericaceae undif.
Juniperus type
Empetrum
Gramineae
Cyperaceae
Succisa
Ranunculus
Rumex undif.
Filipendula
Rubus chamaemorus
Drosera rotundifolia
Oxycoccus quadripetalus
Rumex acetosa
Potentilla type
Plantago lanceolata
Compositae liguliflorae
Sphagnum
Filicales undif.
Osmunda
Polypodium
Equisetum
Lycopodium annotinum
Pteridium
Typha angustifolia type
Sparganium
Artemisia
Lycopodium undif.
Indeterminable crumpled
Indeterminable degraded
Indeterminable broken
Indeterminable corroded
Indeterminable concealed
NUMBER OF TAXA IN CALCULATION SUM
LS-6
LS-5
LS-4b
LS-4a
LS-3d
LS-3c
LS-3b
LS-3a
LS-2
LS-1b
LS-1a

Fig. 6.4 Macro-fossil diagram for Lochstrathy

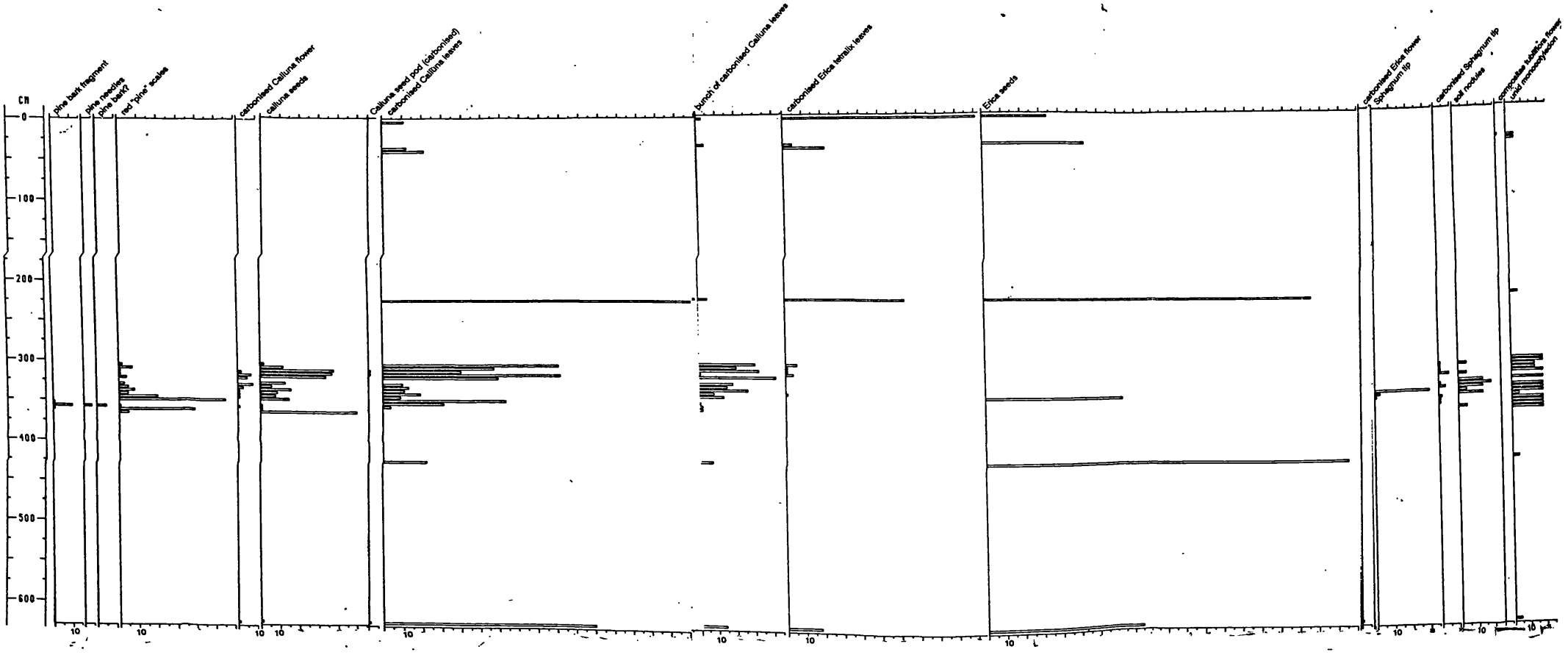

cm
0
100
200
300
400
500
600
pine bark fragment
pine needles
pine bark?
red "pine" scales
carbonised Calluna flower
calluna seeds
Calluna seed pod (carbonised)
carbonised Calluna leaves
bunch of carbonised Calluna leaves
carbonised Erica tetralix leaves
Erica seeds
carbonised Erica flower
Sphagnum filp
carbonised Sphagnum filp
soil nodules
cornicopolae bulbifera flower
und monocotyledon
10

Fig. 6.5 The stratigraphic position of the pine pollen in relation to the position of the pine stump, and other pine macro-fossils

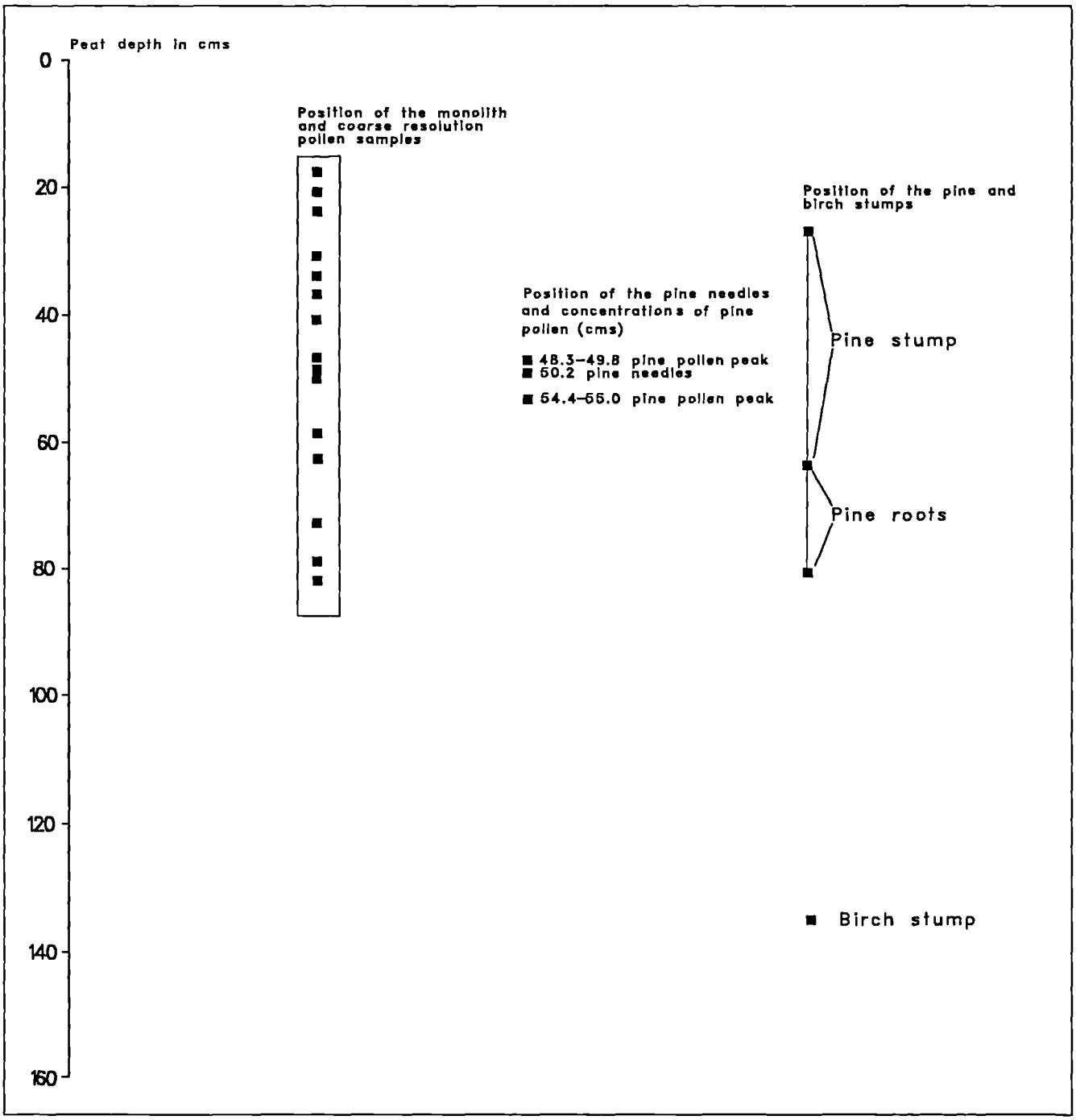

Peat depth in cms
0
20
40
60
80
100
120
140
160
Position of the monolith and coarse resolution pollen samples
Position of the pine needles and concentrations of pine pollen (cms)
48.3–49.8 pine pollen peak
50.2 pine needles
54.4–55.0 pine pollen peak
Position of the pine and birch stumps
Pine stump
Pine roots
Birch stump

Fig. 6.6 Lochstrathy fine-resolution pollen concentration diagram. The pollen values have been divided by a factor of 1000.

300
100
10
CALCULATION SUM
Indeterminable carbonized
Indeterminable boiled
Indeterminable concealed
Indeterminable degraded
Indeterminable crumpled
Indeterminable undif.
Lycopodium type
Typha angustifolia
Typha undif.
Lycopodium annotinum
Lycopodium
Equisetum
Lycopodium
Polypodium
Osmunda undif.
Filicales undif.
Sphagnum
Compositae liguliflorae
Compositae lanceolata
Plantago type
Potentilla
Polygonum bistorta
Rumex acetosa
Fagopyrum
Cyperaceae
Betula
Ranunculus
Rumex undif.
Filipendula
Rubus chamaemorus
Dryas octopetala
Salix
Cichoriaceae
Rumex
Polygonaceae undif.
Ericaceae undif.
Empetrum type
Empetrum
Graminae
Cyperaceae
Betula
Ranunculus
Calluna
Salix
Betula /Corylus/Myrica
Corylus
Betula
Alnus
Ulmus
Tilia cordata
Quercus
Abies
Larix
Corylus
Alnus
Ulmus
Pinus
Betula
MM
300
100
10

Fig. 6.7a,b,c, and d. Maps illustrating the spatial positions and size classes of trees at Lochstrathy sites A, B, C, and D

All the x-y co-ordinates are in metres. Basal area size classes are as follows: 1 = 0-10, 2 = 10-100, 3 = 100-500, 4 = 500-2000, 5 = 2,00-4,00 and 6= >4,000 $cm^2$.

Fig. 6.7a Lochstrathy site A

Fig. 6.7b Lochstrathy site B

Fig. 6.7c Lochstrathy site C

Fig. 6.7d Lochstrathy site D

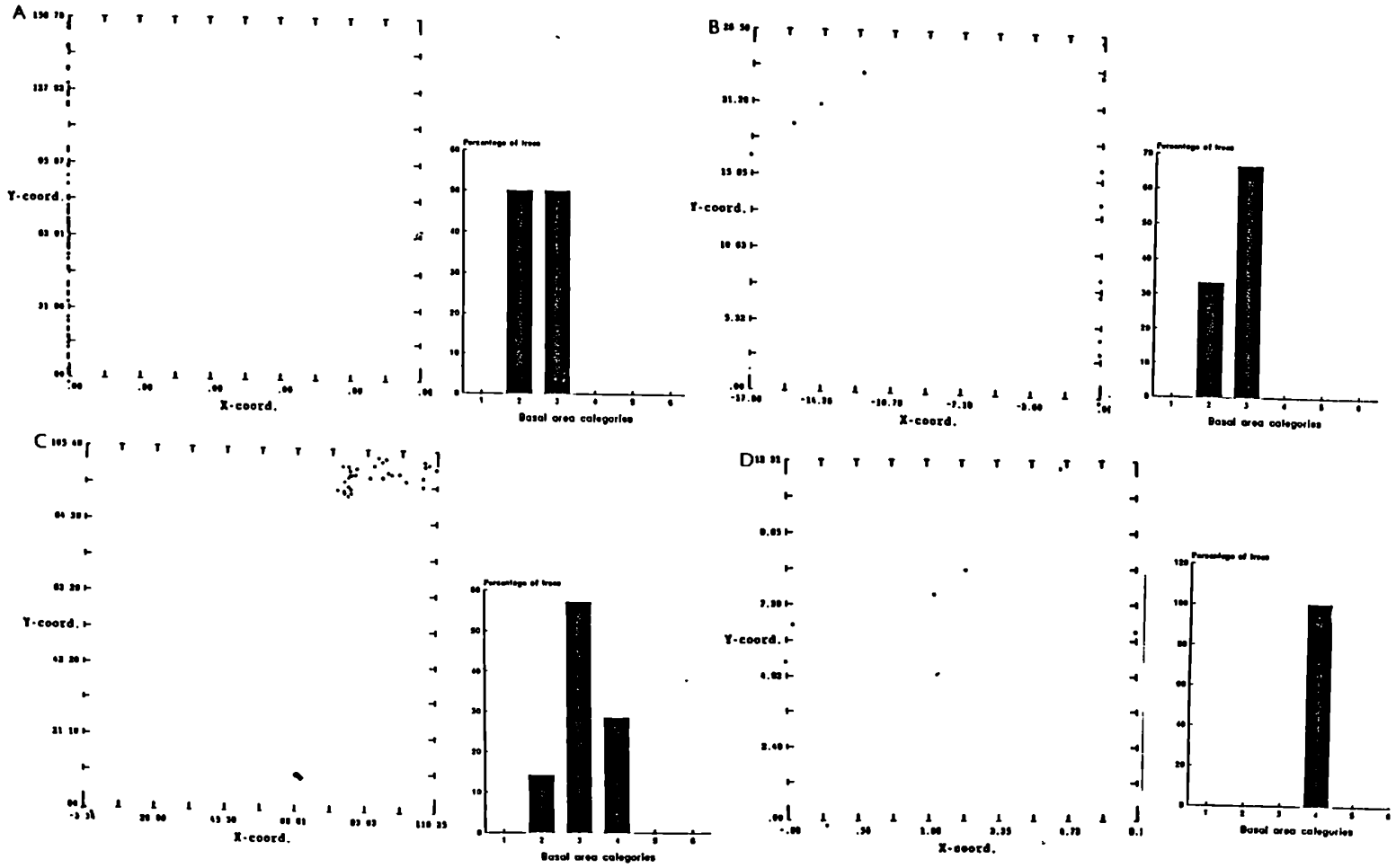

A
Y-coord.
X-coord.
Percentage of trees
Basal area categories
B
Y-coord.
X-coord.
Percentage of trees
Basal area categories
C
Y-coord.
X-coord.
Percentage of trees
Basal area categories
D
Y-coord.
X-coord.
Percentage of trees
Basal area categories

Fig. 6.8 Relative position of dendrochronological samples for Lochstrathy. Series 1 indicates the birth and death of a tree. Series 2 indicates the positions of fire scars. Note that y co-ordinate 50 is the master fire chronology for Lochstrathy. Radiocarbon determinations are being made on samples 4, 7, 18, 35 and 39

| Y co-ordinate | Sample code | Lochstrathy site code | Radius no. | Core present |
|---|---|---|---|---|
| 1 | 244 | C | 3 | + |
| 2 | 252 | D | 1 | + |
| 3 | 245B | C | 1 | |
| 4 | 060 | A | 1 | |
| 5 | 047 | A | 3 | + |
| 6 | 046 | A | 1 | |
| 7 | 050 | A | 4 | |
| 8 | 243 | C | 1 | |
| 9 | SNK2 | - | 1 | |
| 10 | 231 | - | 1 | |
| 11 | 245A | C | 2 | |
| 12 | SNK1 | - | 2 | |
| 13 | 067 | B | 3 | |
| 14 | 066 | B | 1 | |
| 15 | 190 | - | 1 | |
| 16 | 233 | C | 1 | |
| 17 | 049 | A | 2 | |
| 18 | 044 | A | 1 | |
| 19 | 256A | D | 2 | |
| 20 | 142 | - | 2 | + |
| 21 | 253 | D | 2 | |
| 22 | 237 | C | 1 | |
| 23 | 249 | C | 1 | |
| 24 | 235 | C | 1 | |
| 25 | 250B | C | 1 | |
| 26 | 100 | - | 1 | + |
| 27 | SNK3 | - | 2 | |
| 28 | 250A | C | 2 | |
| 29 | 059B | A | 2 | |
| 30 | 260 | D | 2 | |
| 31 | 043 | A | 1 | |
| 32 | 255 | D | 3 | |
| 33 | 234A | C | 1 | |
| 34 | 264 | D | 1 | |
| 35 | 054 | A | 3 | |
| 36 | 068 | B | 3 | |
| 37 | 251 | C | 2 | |
| 38 | 254 | D | 1 | |
| 39 | 246 | C | 1 | |
| 40 | 257 | A | 3 | |
| 41 | 041 | A | 2 | |
| 42 | 059A | A | 1 | |
| 43 | 234B | C | 1 | |
| 44 | 062 | B | 2 | |
| 50 | Master fire scar chronology | | | |

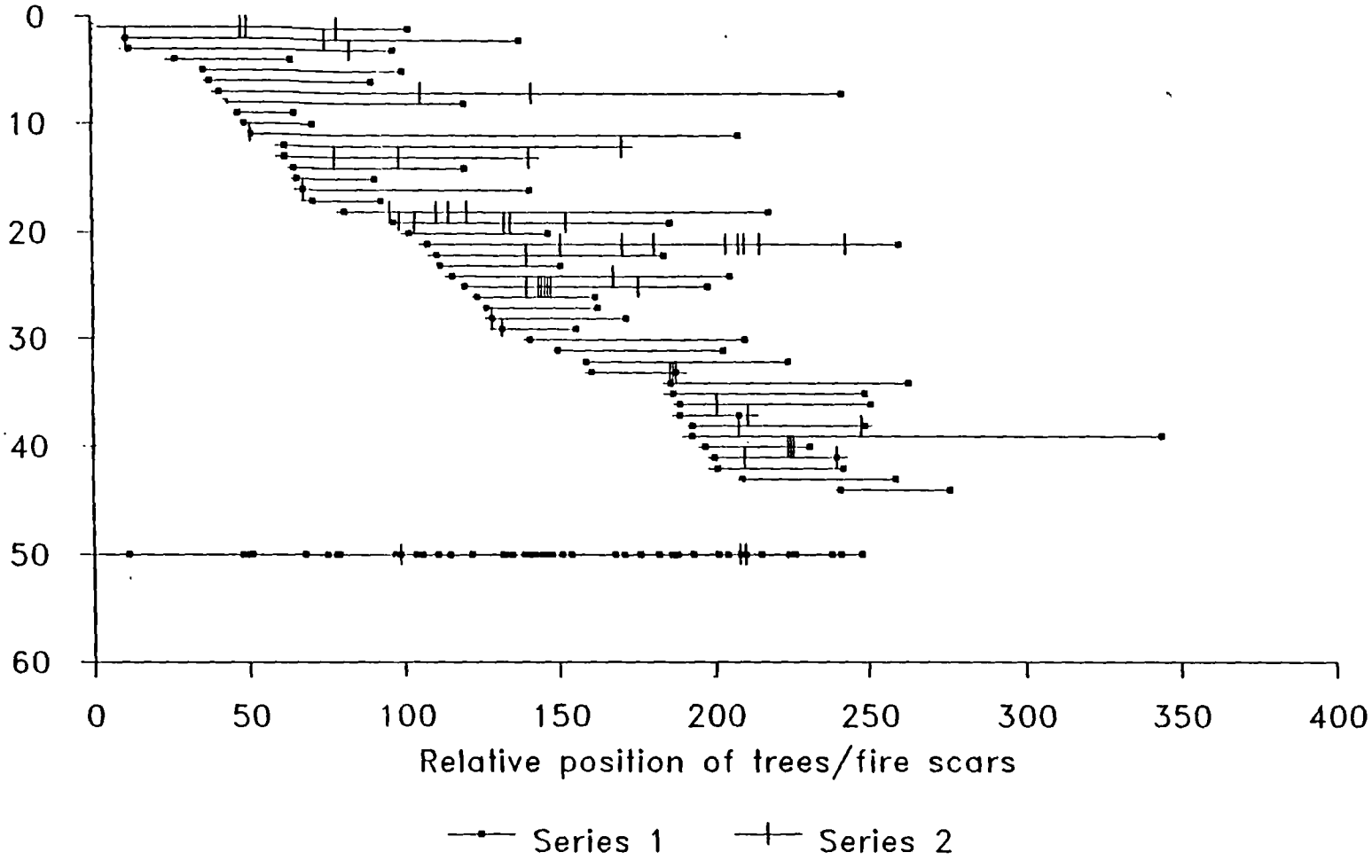
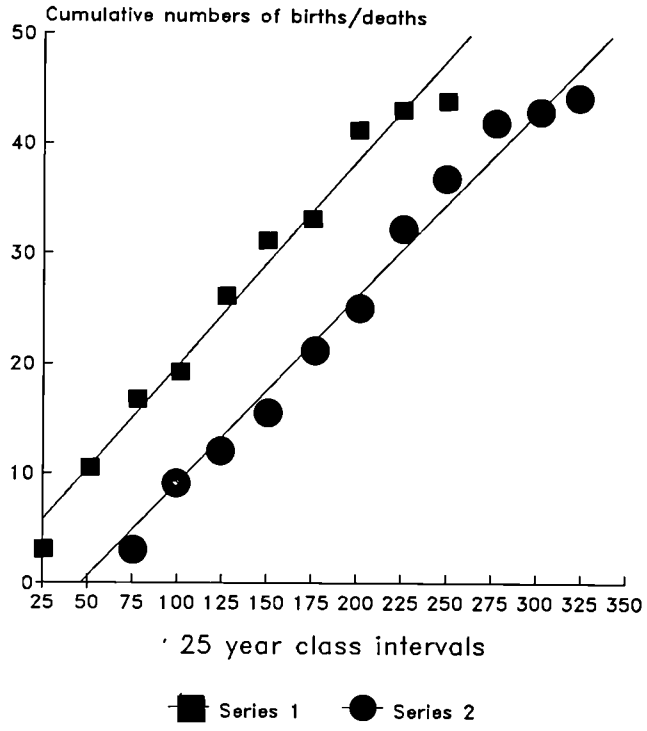

0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
400
Relative position of trees/fire scars
Series 1
Series 2

Fig. 6.9a. Cumulative plots of births and deaths (after McNally and Doyle, 1984). Series 1 represents births and series 2 deaths

Fig. 6.9b. The log of the ratio of births to deaths plotted at 25 year intervals


Cumulative numbers of births/deaths
50
40
30
20
10
0
25 50 75 100 125 150 175 200 225 250 275 300 325 350
25 year class intervals
Series 1
Series 2

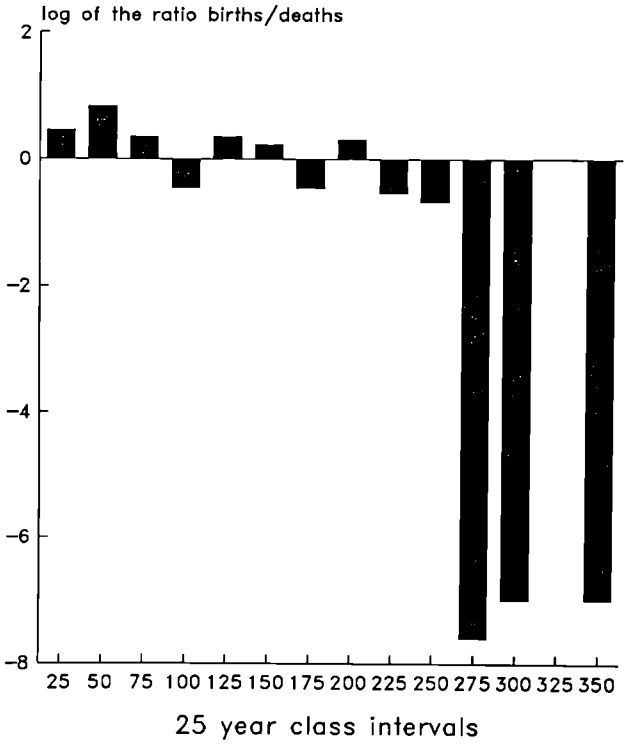

log of the ratio births/deaths
2
0
−2
−4
−6
−8
25 50 75 100 125 150 175 200 225 250 275 300 325 350
25 year class intervals

Fig. 6.9c. The population dynamics at Lochstrathy illustrating the number of trees that were germinated in a 25 year period (y-axis) and then subsequently, the number that of those individuals still alive at the beginning of each subsequent 25 year period.

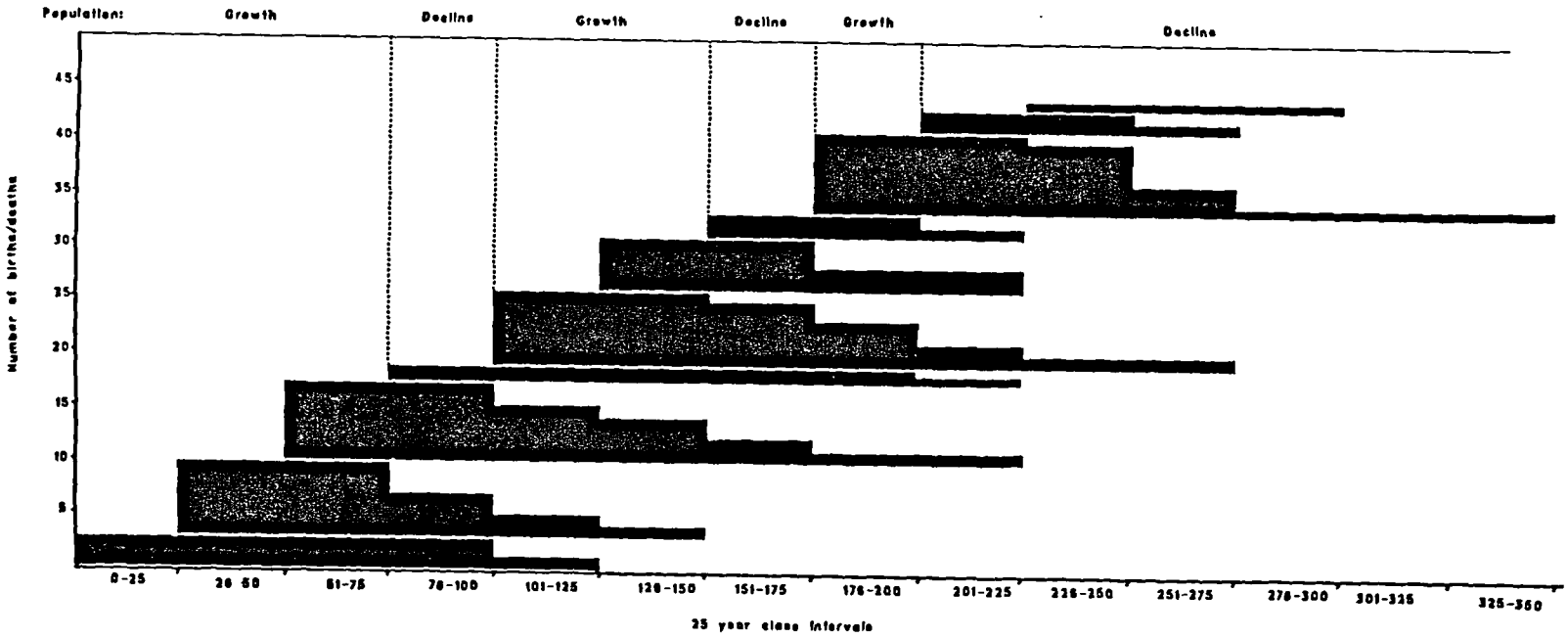

Population:
Growth
Decline
Growth
Decline
Growth
Decline
Number of births/deaths
45
40
35
30
25
20
15
10
5
0-25
26-50
51-75
76-100
101-125
126-150
151-175
176-200
201-225
226-250
251-275
276-300
301-325
325-350
25 year class intervals

Fig. 6.10 The relative distribution of regeneration patterns at Lochstrathy sites A and B. Series 1 represents the births and deaths of individual trees. Series 2 represents the positions of fire scars. From left to right the sample codes are as follows: 041, 043, 044, 046, 047, 050, 054, 059, 066, 067, 068.

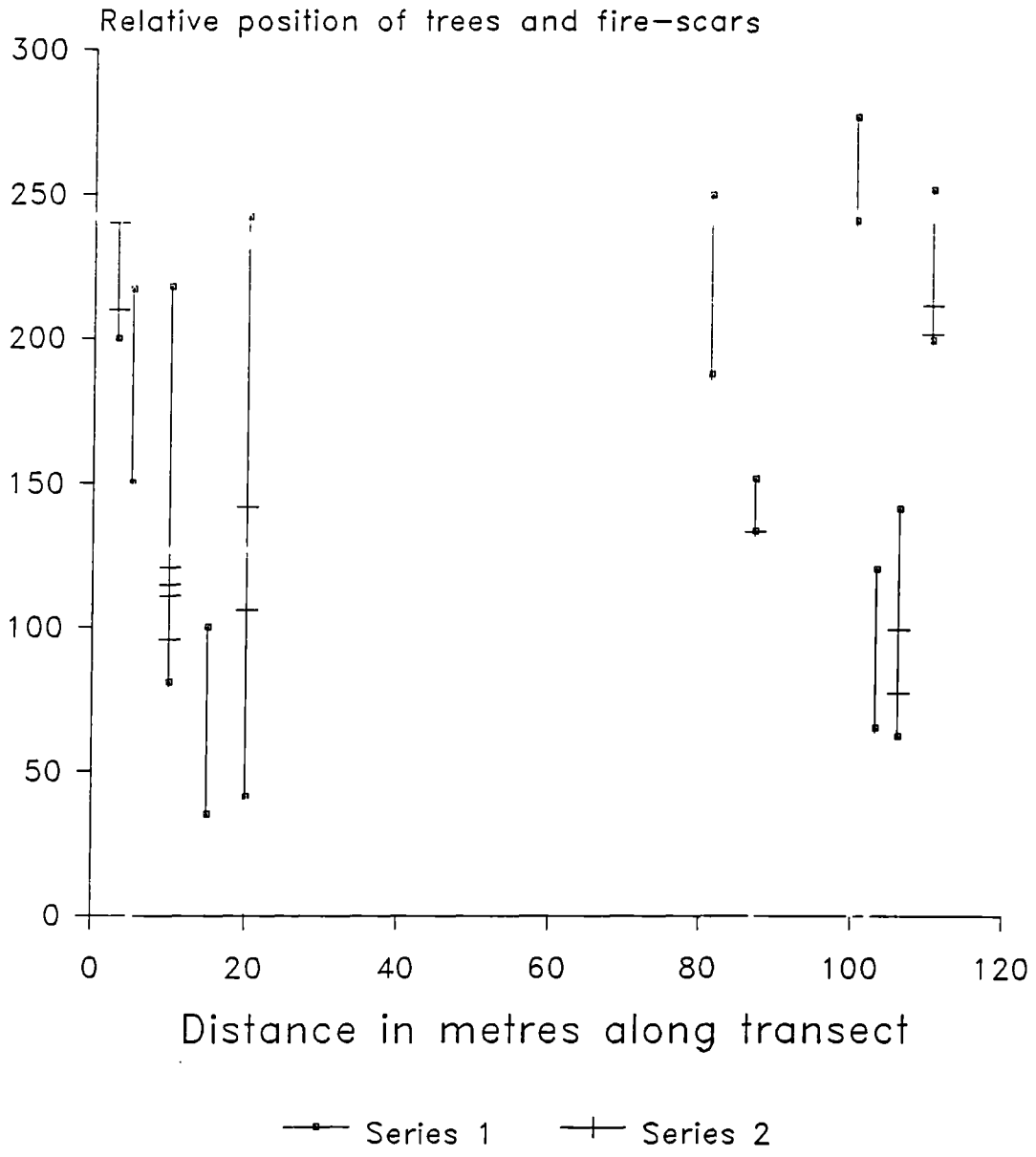

Relative position of trees and fire-scars
300
250
200
150
100
50
0
0
20
40
60
80
100
120
Distance in metres along transect
Series 1
Series 2

*Fig. 6.11 1 mm, fine resolution, charcoal diagram for Lochstrathy. The curves from left to right are as follows: 1. total number of charcoal particles >2mm, 2. total number of charcoal particles < 2mm, 3. weighted running mean, 4 = number of charcoal particles >2mm $cm^{-2}.yr^{-1}$, 5 = number of charcoal particles <2mm $cm^{-2}.yr^{-1}$.*

N.B. Curve 2 has been divided by a factor of 5.

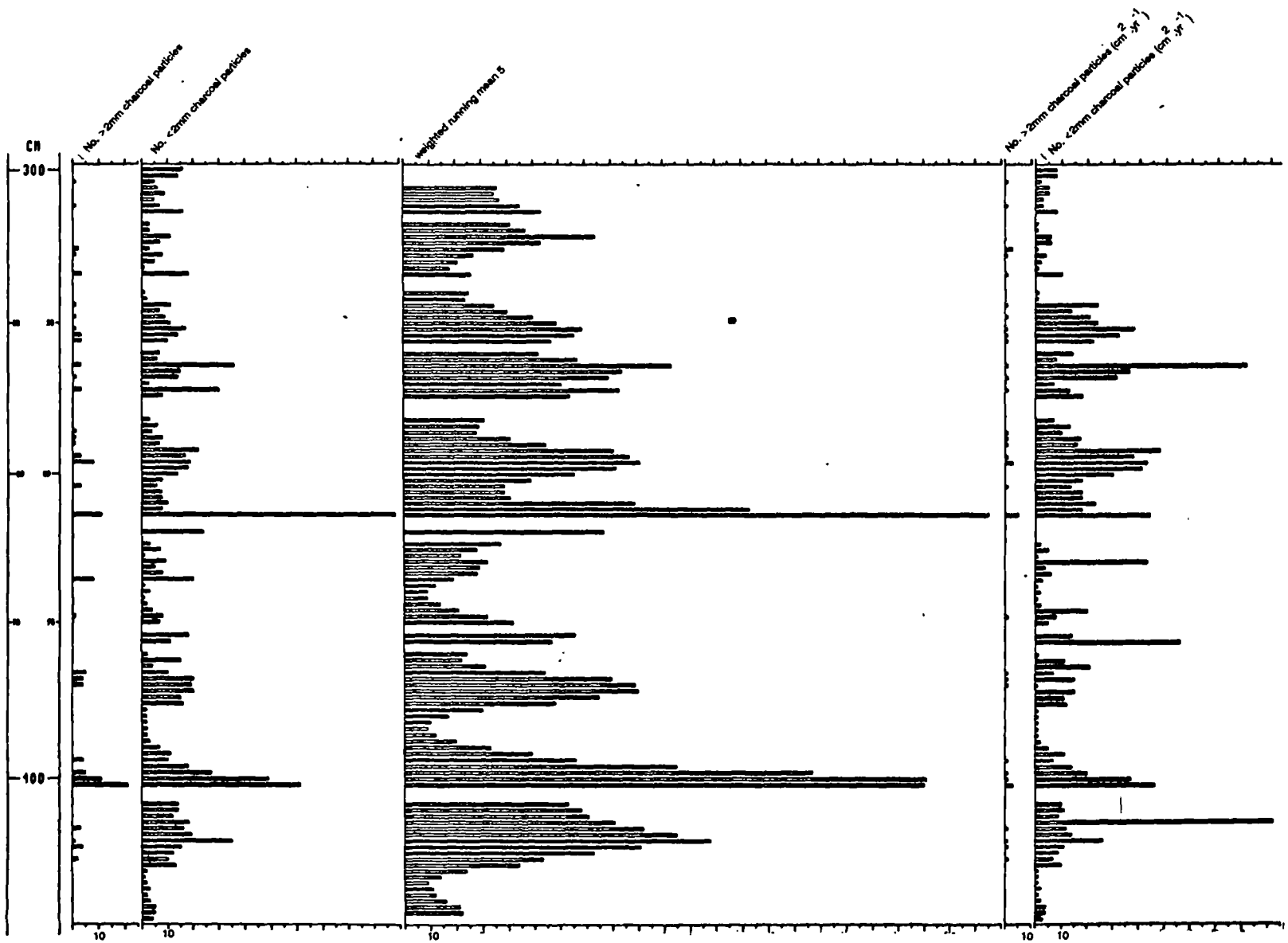
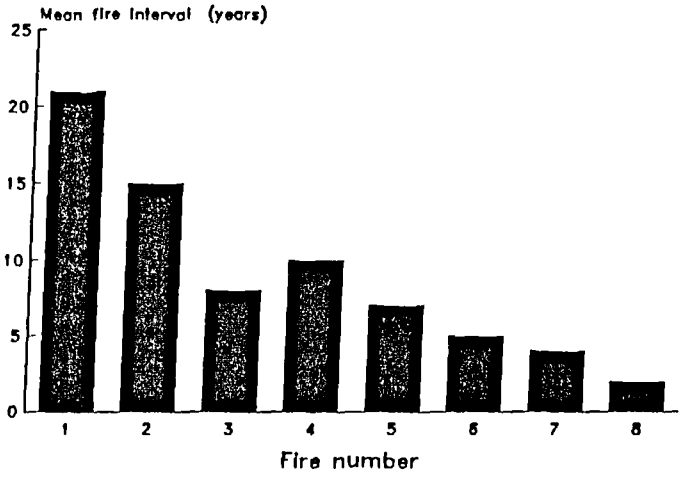
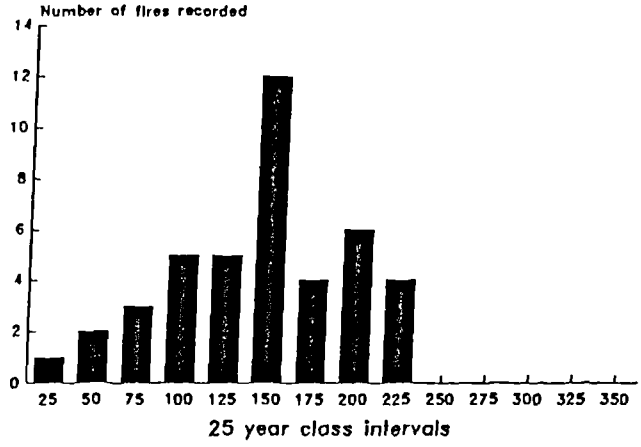

CM
300
100
No. >2mm charcoal particles
No. <2mm charcoal particles
weighted running mean 5
No. >2mm charcoal particles (cm⁻² yr⁻¹)
No. <2mm charcoal particles (cm⁻² yr⁻¹)
10
10
10
10
10

Fig. 6.12a Histogram illustrating the decline in the mean fire interval between consecutive fires for individual samples

Fig. 6.12b Histogram illustrating the number of fires recorded per 25 year class intervals

Fig. 6.12c Histogram recording the number of fires recorded in 25 year class intervals in relation to the number of trees that were alive during the 25 year periods


Mean fire interval (years)
25
20
15
10
5
0
1
2
3
4
5
6
7
8
Fire number


Number of fires recorded
14
12
10
8
6
4
2
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25 year class intervals

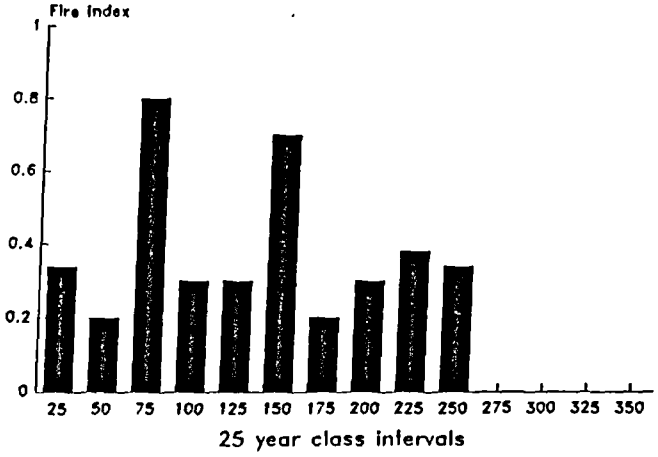

Fire index
1
0.8
0.6
0.4
0.2
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25 year class intervals

Fig. 6.13 The extent of forest fires in the "fire years" 99, 208, and 210

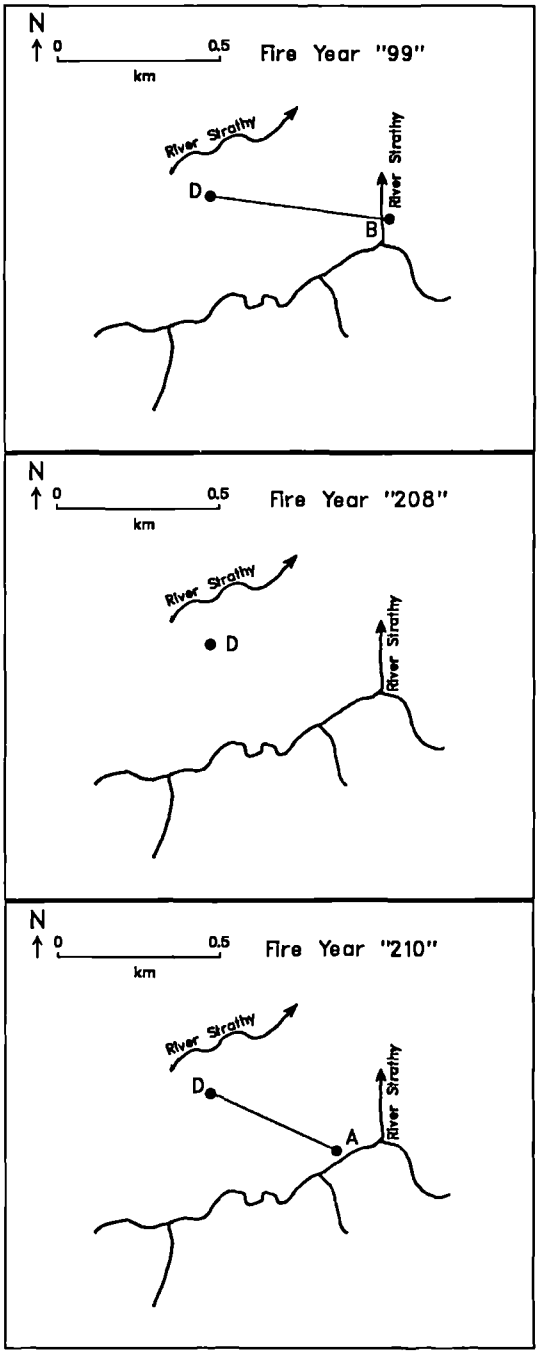

N
0
0.5
km
Fire Year "99"
River Strathy
River Strathy
D
B
N
0
0.5
km
Fire Year "208"
River Strathy
D
River Strathy
N
0
0.5
km
Fire Year "210"
River Strathy
D
A
River Strathy

Fig. 6.14 The distribution of sub-fossil *Pinus sylvestris* cones and seedlings on a 10 km square basis. Diamonds represent the presence of pine seedlings while dots the presence of pine cones. 1 = cones discovered by Mr. A. Scott (per. comm), 2 = cones recorded by Lewis (1906), 3 and 4 = cones discovered by the author.

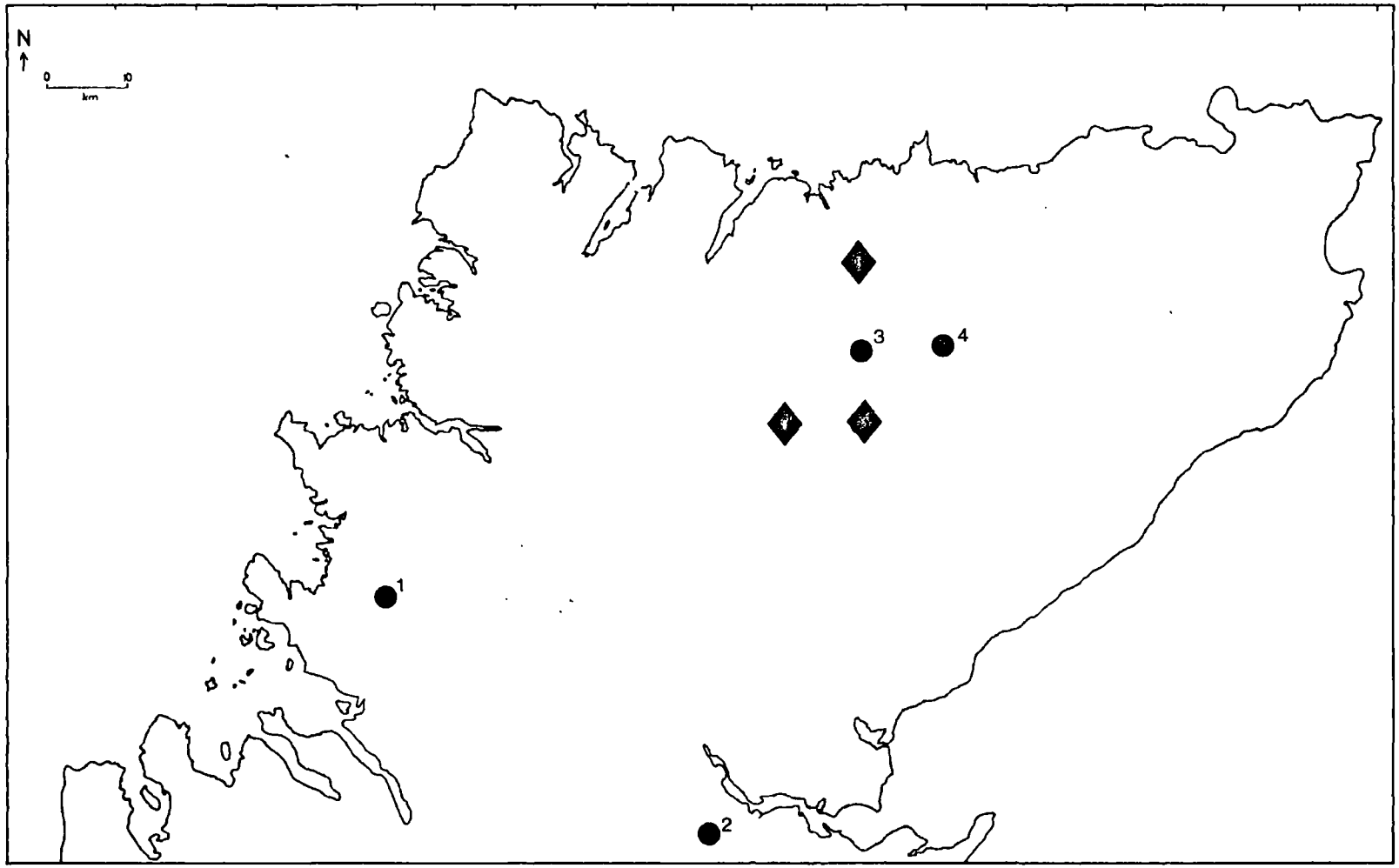

N
0
10
km
1
2
3
4

Plate 5.1a *Pinus sylvestris* stumps exposed along the shores of Badanloch - general view

Plate 5.1b *Pinus sylvestris* stumps exposed along the shores of Badanloch showing that all the stumps were once interstratified within the peat

Plate 6.1 The gently undulating topography of Lochstrathy

Plate 6.2 The location of the Lochstrathy monolith in relation to the *Pinus sylvestris* stump layer

Plate 6.3 *Pinus sylvestris* seedlings found at Lochstrathy

Plate 6.4a *Pinus sylvestris* cones and bark found near Ben Griam

Plate 6.4b Close-up of some of the *Pinus sylvestris* cones that contained seed


WASSERFESTER MARKER
Nach Gebrauch Kappe aufsetzen.
★Nur in gut belüfteten Räumen verwenden.
Von Kindern fernhalten.
MARQUEUR INDÉLÉBILE
Bullet Point

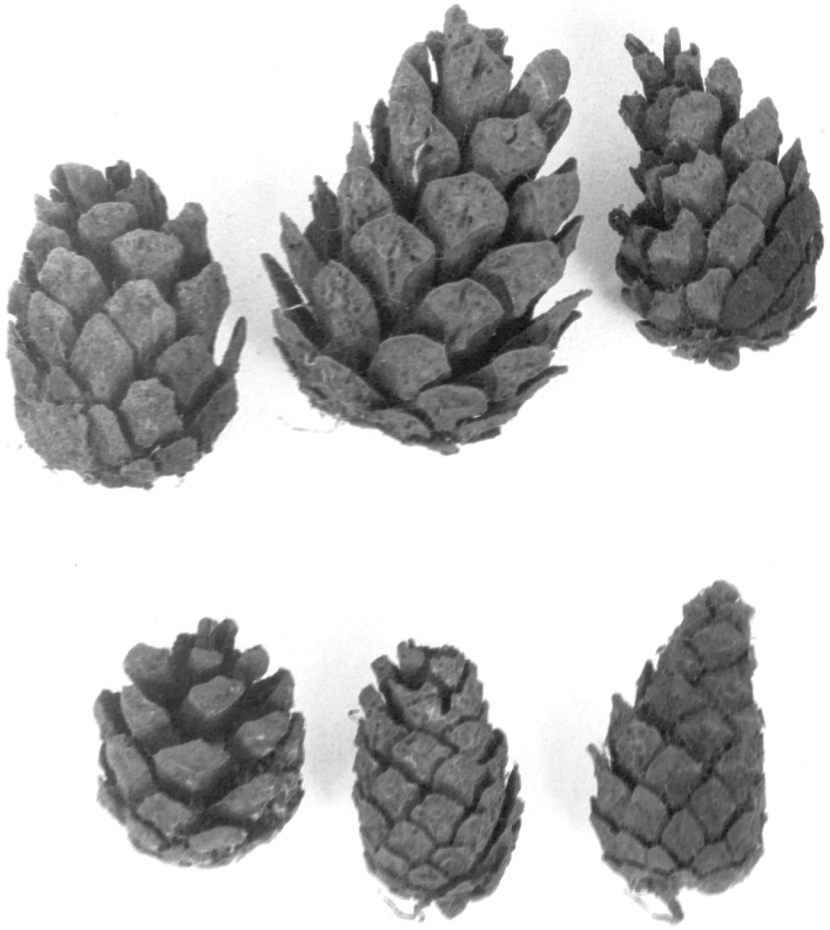


Plate 6.5 Tap roots at Badanloch

Plate 6.6 A wind-thrown sub-fossil pine tree -This sub-fossil pine tree was lifted out of Lochan na Uimheachd with its roots still attached to its trunk

## APPENDIX 1

### Special variables recorded during the vegetation survey and notes on Tables 3.6-3.15

Altitude in metres - taken from the Ordnance Survey maps

Bare rock - distinguishes the presence/absence of bare rock within a quadrat. 1 = present, 2 = absent.

Bare soil - distinguishes the presence/absence of bare soil within a quadrat. 1 = present, 2 = absent.

Geology - 1 = Fluvio-glacial, 2 = Moine Gneiss, 3 = Alluvial terrace, 4 = Hornblend, scheist, gneiss, 5 = Injection rocks formed of granite and siliceous semi-peltic and peltic rocks, 6 = Hornblendic rocks of the injection complex, 7 = First lowest terrace, 8 = Margins of older glacial terrace, 9 = Siliceous and semi-peltic granulities invaded by many granite veins, 10 = Hornblendic gneiss or schist, sometimes Biotite or Muscovite, 11 = Granite of the Loch Choire complex, 12 = Injection rocks formed from granite and mica-schist, 13 = Older raised beach, 14 = Schistose marble, 15 = Thrust Lewisian Gneiss, 16 = Margins of glacial terrace or Moine schist, 17 = Silcous schists and quartz-biotite granulites, 18 = Siliceous granulites, 19 = Granulite Syenite, 20 = Moine schist, Mioaoeous Gneiss and Quartzose flagstones, 21 = Peltic Gneiss and schist, 22 = Peltic Gneiss and schist, 23 = Torridon, 24 = Granulitic schists, indifferentiated.

The map reference is a full 8-figure Ordnance Survey reference that has been divided into 3 sections: 1 = Grid reference easting, 2 = Grid reference northing, 3 = Grid reference 100 km square

Herb percentage cover (%)

Herb height (cm)

Moss percentage cover (%)

Moss height (cm)

Shrub percentage cover

Shrub height (cm)

Tree canopy cover (%)

Tree height (m)

Slope category - 1 = Flat, 2 = gentle, 3 = moderate, 4 = steep, 5 = very steep

Soil moisture category - 1 = stream/flush present

Soil type - 1 = Humus iron podsols, 2 = Brown forest soils (Arkaig 25), 3 = Fluvio-glacial sands and gravels (Corby), 4 = Freely drained drift derived from schists of Moinian age, 5 = Mixed bottom land (Corby KMC), 6 = Iron humus podsols, 7 = Peaty gleys, peaty podsols and peaty rankers (29), 8 = Peaty podsols, peat, peaty gleys (26, 185, 554), 9 = peaty podsols, peaty gleys and deep peat ($SR_C$), 10 = Freely drained below iron pan, drifts derived from granulites and schists of Moinian age (QD), 11 = Basin and valley peat >100 cm (BPT2), 12 = Peat, peaty gleys and peaty podsols (23), 13 = Humus iron

podsols, some brown forest soils, noncalcareous gleys and peaty gleys (20), 14 = Humus iron podsols some gleys and rankers (Countesswell 125), 15 = Peaty gleys, peat and some peaty podsols (119), 16 = Humus iron podsols and some brown forest soils (29, 20), 17 = Peaty gleys, peaty podsols and peaty rankers (31), 18 = Brown forest soils, humus-iron podsols, some brown rankers and non-calcareous gleys (Arkaig 18), 19 = Brown forest soils, humus-iron podsols, some gleys and peat (Arkaig 25), 20 = Alluvial soils, flood plain terraces, and former lake beds (Alluvial soil 1), 21 = Brown forest soils, humus iron podsols, rankers, some peaty gleys and peat (Countesswell 121), 22 = Brown forest soils, brown rankers, some humic gleys and peaty podsols (Torridon 555), 23 = Peaty gleys, peat, peaty rankers, some peaty podsols (Lochinver 395), 24 = Peaty podsols, peaty gleys, shollow and deep peat, some peaty rankers (Asc), 25 = blanket peat >100 cm, 26 = Poorly drained gleys, 27 = Humus-iron podsols and alluvial soils (Corby 98), 28 = Peaty podsols, peaty gleys, shallow and deep peat (Plc), 29 = Peaty podsols, shallow and deep peat (TQc), 30 = Peaty podsols, some humus iron podsols and peat.

Thematic Mapper image colour - 1 = emerald green, 2 = dark green, 3 = light green, 4 = green, 5 = royal blue, 6 = turquoise blue, 7 = blue, 8 = turquoise blue/emerald green, 9 = white, 10 = turquoise blue/white, 11 = white/yellow, 12 = white/blue, 13 = white pink, 14 = red, 15 = red/orange, 16 = orange, 17 = orange/yellow, 18 = yellow/orange, 19 = pink, 20 = yellow, 21 = mosaic of >3 colours, 22 = red/pink, 23 = pink/golden, 24 = white/pink, 25 = black, 26 = black/white, 27 = green/red

Species - all species are listed in alphabetical order. The following list of higher taxa were only identified down to generic level or the family level in some cases: *Hypericum* sp., *Salix* sp., *Rosa* sp., *Agrostis* sp., *Umbelliferacae* sp., and *Festuca* sp. No *Viola* sp. were seen in flower but all were classified as *Viola riviana.*

In records 1-153 *Betula pendula* was recorded when in the majority of cases it should have been *Betula pubescens* subsp. *carpatica.* Checking with Perring and Walters (1962) it is probable that only in relatively few records (relevées 124-142) that were collected from the southern part of the study area actually contained *Betula pendula.* As a result of all the records in these relevées have been converted to *Betula pendula,* although it would be best to read them as *Betula pubescens/pendula.*

The Domin 10-point scale has been used throughout with a "+" sign denoting species presence in the same community immediately surrounding the sample, but not in the quadrat.

For convenience several noda have been placed in some tables with a blank row sparating one noda from the next. The remaining noda are placed in a single table.

## APPENDIX 2

**Ordnance Survey grid references of "pine" Gaelic place names. From a list compiled from a Nature Conservancy Council (1987) - internal report by Mrs M. Eagleson.**

NH 717930 - Loch a' Ghiubhais - (Loch of the pine)

NH 693963 - Lon Ghiubhais - (Pine pond/marsh)

NH 483894 - Lon Giuthas nan Leac - (Pond/marsh of the pine grave/tombstone)

NH 418983 - Allt a' Ghiubhais - (Stream of the pine)

NC 657065 - Loch a' Ghiubhais - (Loch of the pine)

NC 698012 - Lochan a' Ghiubhais - (Little loch of the pine)

NC 222091 - Blar a' Ghiubhais - (Pine moor)

NC 380001 - Linne a' Ghiubhais - (Pool or stream of the pine)

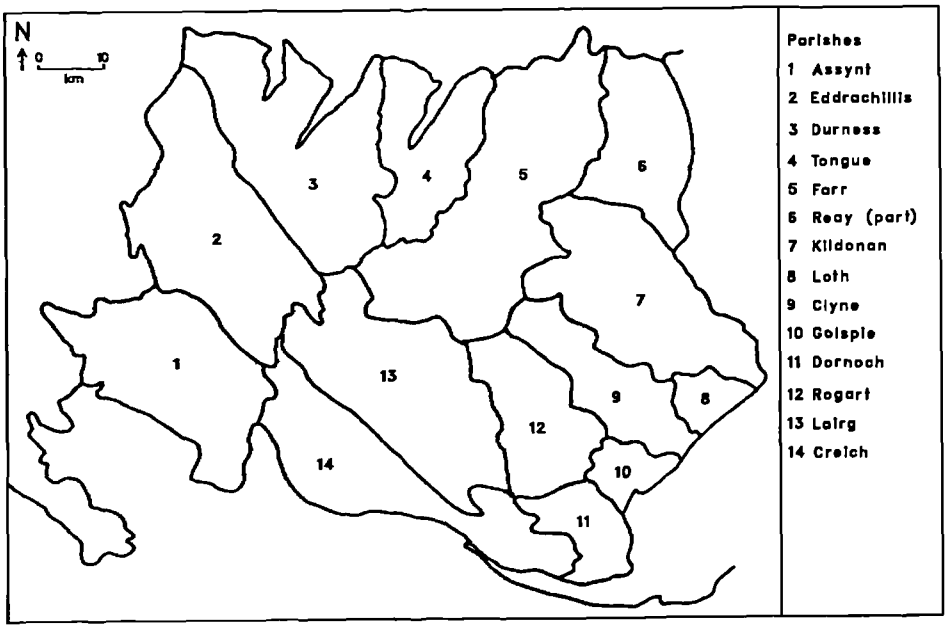
NC 350192 - Allt a' Chnaip Ghiubhais - (Stream of the clump pine trees)

NC 556237 - Loch a' Ghiubhais - (Loch of the pine)

NC 548238 - Cnoc a' Ghiubhais - (Hill of the pine)

NC 267703 - Cnoc a' Ghiubhais- (Hill of the pine)

**Map showing the location of the 1745 parishes of Sutherland. Obtained from a Nature Conservancy Council (1987) - internal report by Mrs M. Eagleson.**


N
0
10
km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Parishes
1 Assynt
2 Eddrachillis
3 Durness
4 Tongue
5 Farr
6 Reay (part)
7 Kildonan
8 Loth
9 Clyne
10 Golspie
11 Dornoch
12 Rogart
13 Lairg
14 Creich

## APPENDIX 3

**The records of sub-fossil Pinus sylvestris, for the counties of Sutherland and Caithness, found in the old (1791) and new (1845) statistical accounts. From Andersen (1967), Appendix D, pp. 637-638.**

The records found in Andersen are categorised according to County, parish and which statistical account they are derived from.

O refers to a record found in the old statistical account (Sinclair, 1791)

N refers to a record found in the new statistical account (Anon, 1845).

* denotes whose parishes which record *Pinus sylvestris* macro-fossil presence

*The County of Sutherland*

Parish

**Dornoch* (O) - A great quantity of *Moss Fir* is found underground. It serves as light for the poorest sort. This sort of timber is remarkably durable.

**Criech* (O) - In many mossess there are roots of old fir trees dug up ...Often the large fir trees quite fresh and sound, and of considerable length, have been dug up, when split they are useful for rafters in building houses and last very long.

**Durness* (N) - In low and sheltered situations, however, the mosses retain the roots of fir, birch, willow, etc., and decayed trunks of from thirty to fifty feet are occasionally dug from the mosses.

**Edderachillis* (N) - There are appearances of the whole country having been at some period covered with wood, in the remains of trees, principally fir, which have been found in the mosses.

**Kildonan* (N) - ...but the generally received belief is that the old trees died from natural decay when at maturity, their trunks being still dug out of the bogs in great numbers (the native fir).

**Farr* (N) - Where extensive forests of fir grew in this country, the remains of which are still found deeply embedded in the moss, and are raised by the parishioners for roofing their houses, and other domestic purposes.

*The County of Caithness*

Parish

*Dunnet* (N) - There are also about 3,000 acres of moss in the low ground...from two to sixteen feet...In these mosses, dwarf birch, hazel and saughs are found near the bottom in considerable quantities, which show they were formerly covered with brushwood.

*Watten* (N) - Of peat there is a considerable quantity, varying in depth from a few inches to sixteen or twenty feet, and always resting on a bed of clay. It contains, as usual, immense quantities of wood, oak, birch and pine: very large pine trunks are frequently found, being sometimes met with even at the depth of sixteen feet, with the bark and wood apparently quite entire, very light and highly inflammable. The bark is generally of a silvery-grey colour, and the wood dark brown.

*Wick* (O) - ...for in many moss grounds, large logs have been and are to this day, dug up.

*Wick* (N) - Between the links and the sand, and running down under the sea, there are found the remains of a submarine forest. These are like peat mosses, entirely composed of decayed wood. The barks of various kinds of trees are quite discernible; and even the seeds of the birch and ash are so well preserved, as to appear but lately from the tree. No large trunks are found; only small specimens of oak, ash, birch and plane-tree; but none of fir (Bay of Keiss).

## APPENDIX 4

**1 km Ordnance survey grid references for all the off-shore islands that have been searched for sub-fossil Pinus sylvestris. No Pinus sylvestris macro-fossils were found at any of these sites.**

Eilean nan Ròn (Island Rhone) - NC 6664

Neave or Coomb Island - NC 6465, NC 6364, NC 6365

Eilean nan Gaill (Rabbit Islands) - NC 6063, NC 6163

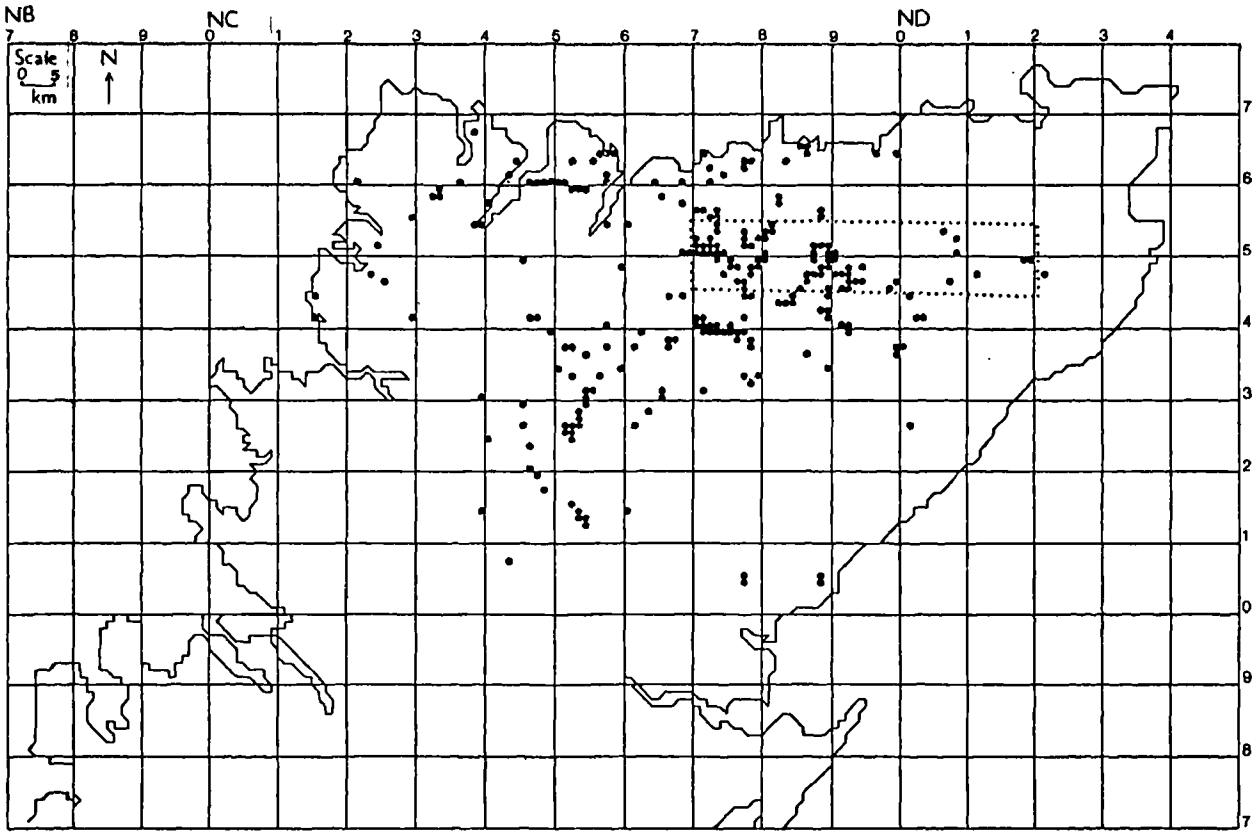
## APPENDIX 5a.

## Listing of all 1 km Ordnance survey grid references for sub-fossil Pinus sylvestris macro-fossils.

| NC | 5314 | 7141 | 7851 | ND |
|---|---|---|---|---|
| 1541 | 5326 | 7150 | 7851 | 0037 |
| 3854 | 5326 | 7151 | 7863 | 0126 |
| 3867 | 5327 | 7156 | 7933 | 0144 |
| 1544 | 5328 | 7164 | 7948 | 0241 |
| 2160 | 5359 | 7239 | 7948 | 0341 |
| 2347 | 5359 | 7239 | 7949 | 0341 |
| 2451 | 5412 | 7240 | 7949 | 0653 |
| 2546 | 5413 | 7250 | 7952 | 0746 |
| 2941 | 5429 | 7251 | 8049 | 0850 |
| 2955 | 5430 | 7252 | 8050 | 0852 |
| 3258 | 5430 | 7255 | 8052 | 1147 |
| 3358 | 5430 | 7260 | 8053 | 1849 |
| 3359 | 5430 | 7262 | 8053 | 1949 |
| 3660 | 5431 | 7339 | 8153 | 2147 |
| 3854 | 5431 | 7339 | 8154 | |
| 3854 | 5436 | 7340 | 8257 | |
| 3867 | 5459 | 7349 | 8258 | |
| 3914 | 5531 | 7350 | 8363 | |
| 3930 | 5531 | 7351 | 8363 | |
| 3954 | 5563 | 7351 | 8636 | |
| 3954 | 5633 | 7353 | 8646 | |
| 4024 | 5737 | 7353 | 8665 | |
| 4057 | 5740 | 7354 | 8747 | |
| 4307 | 5740 | 7354 | 8749 | |
| 4309 | 5754 | 7354 | 8750 | |
| 4361 | 5761 | 7439 | 8751 | |
| 4463 | 5764 | 7439 | 8804 | |
| 4549 | 5934 | 7447 | 8842 | |
| 4641 | 6014 | 7447 | 8847 | |
| 4641 | 6054 | 7450 | 8848 | |
| 4660 | 6126 | 7461 | 8851 | |
| 4719 | 6137 | 7539 | 8855 | |
| 4741 | 6239 | 7540 | 8856 | |
| 4760 | 6328 | 7548 | 8934 | |
| 4817 | 6460 | 7549 | 8944 | |
| 4860 | 6460 | 7638 | 8948 | |
| 4860 | 6530 | 7639 | 8949 | |
| 4939 | 6531 | 7646 | 8949 | |
| 4960 | 6558 | 7648 | 8949 | |
| 5002 | 6637 | 7733 | 8950 | |
| 5034 | 6638 | 7739 | 8951 | |
| 5060 | 6638 | 7741 | 9049 | |
| 5125 | 6644 | 7744 | 9050 | |
| 5126 | 6738 | 7745 | 9147 | |
| 5160 | 6844 | 7746 | 9245 | |
| 5215 | 6850 | 7751 | 9246 | |
| 5224 | 6857 | 7752 | 9247 | |
| 5224 | 6860 | 7752 | 9248 | |
| 5225 | 6860 | 7753 | 9346 | |
| 5225 | 6950 | 7762 | 9446 | |
| 5226 | 6950 | 7763 | 9448 | |
| 5226 | 7040 | 7832 | 9664 | |
| 5233 | 7041 | 7833 | 9845 | |
| 5237 | 7050 | 7833 | 9936 | |
| 5237 | 7051 | 7837 | 9937 | |
| 5237 | 7056 | 7838 | 9946 | |
| 5259 | 7131 | 7844 | 9964 | |
| 5263 | 7139 | 7847 | | |
| 5313 | 7140 | 7848 | | |

## APPENDIX 5b.

**1 km map illustrating the distribution of all sub-fossil Pinus sylvestris records recorded by the author in northern Scotland.**


NB
NC
ND
Scale
0 5
km
N

## APPENDIX 6

### Description and use of the probe designed to locate sub-fossil Pinus sylvestris macro-fossils.

The probe was made from 1 cm diameter stainless steel and was 200 cm long. For ease of use the probe was divided into two sections, joined by means of a screw thread. At the lower end of the probe was another thread to which could be attached either a solid, pointed nail like head or a mini corer which was surrounded by a stainless steel cylinder. The first head was designed to probe the peat and to "feel" for woody material within the peat. It was relatively easy to differentiate between rock, peat, wood or gravel. The second head was used to retrieve pieces of subterranean fossil wood for species identification.

An experiment was carried out to assess the workability and efficiency of using the probe in routine surveying. A 16 x 16 m area was defined in an area where pine stumps were known to be extremely abundant. This area was subdivided into two areas: a 3 x 16 m area, which was probed at 0.5 m intervals; and a 13 x 16 m area which was probed at 1 m intervals. In total 144 soundings were made in 3 hours and 5 "hits" were recorded in an area where 15 pine stumps were visible on the surface. It should also be noted that sub-surface woody material could not always be recovered due to decomposition making the material too "soft" for the borer to work.

A chi-square test with a correction for continuity was calculated (Parker, 1979). The results were as follows:

| | 1 Metre survey | 0.5 Metre survey |
|---|---|---|
| Total area surveyed | 800,000 $cm^2$ | 48,0000$cm^2$ |
| Total area of pine stumps | 7060 $cm^2$ | 2120 $cm^2$ |
| % of area covered by pine stumps | 0.88% | 0.44% |
| Number of probes | 80 | 64 |
| Number of "hits" | 3 | 2 |
| Expected "hits" | 0.7 | 0.28 |
| Number of "misses" | 79.2 | 62.0 |
| Expected "misses" | 76.3 | 63.7 |
| Chi-square statistic with correction for continuity | 4.72 | 5.38 |
| % Confidence with one degree freedom | 95% | 95% |

The results of the Chi-square test show that pine stumps are located with the probe more frequently than would be expected. The reason for this deviation is that pine stump area was based on the mean diameter of the stump and did not take into account the extensive root systems which substantially increase the total area occupied by *Pinus sylvestris*. Despite the apparent statistical efficiency of using the probe to locate pine stumps, the time-resources expended in executing this exercise were considerable. It was therefore decided that this was an impractical method for routine survey of large geographical areas, but would be useful for surveying small (20 x 20 m) areas where time constraints were not important, and where a record of pine presence would be particularly interesting. As a result the probe was only used in surveying off-shore islands were no exposed stumps were visible (a list can be found in 4). No pine stumps were, however, located.

## APPENDIX 7

**List of the Ordnance survey grid references where Pinus sylvestris macro-fossils were found along with at least one other layer of tree macro-fossils.**

| Grid. Ref. | Total Number of Layers | Descending stratigraphic order of of macro-fossils |
|---|---|---|
| N 6844 | 2 | *Pinus /Betula* |
| NC 719402 | 3 | *Betula /Betula /Pinus* |
| NC 7948 | 2 | *Pinus /Betula* |
| NC 8050 | 4 | *Pinus /Betula /Betula /Betula* |
| NC 836637 | 2 | *Betula /Pinus* |
| NC 8050 | 4 | *Pinus /Betula /Betula /Betula* |
| NC 923465 | 2 | *Pinus /Betula* |
| NC 925475 | 2 | *Pinus /Betula* |
| NC 938460 | 2 | *Pinus /Betula* |
| NC 975645 | 4 | *Betula /Pinus /Betula /Betula* |
| NC 995466 | 3 | *Pinus /Betula /Betula* |
| ND 054583 | 2 | *Pinus /Betula* |
| ND 0653 | 3 | *Betula /Pinus /Salix* |

## APPENDIX 8a

**Listing of the Ordnance survey grid references where Salix sp. macro-fossils were found. T.K. denotes a 10 km grid reference provided by Dr. T Keatinge (personal communication)**

NC 6036
NC 6328
NC 9664
NC 6925
NC 6957
NC 7740
NC 9546
NC 9646
NC 9664
NC 9745
ND 0064
ND 0553
ND 0557
ND 0653
ND 15 (T.K.)
ND 1949
ND 2662
ND 2848

## APPENDIX 8b

**Listing of the Ordnance Survey grid references where sub-fossil Betula macro-fossils were the exclusive tree taxa. The number of layers of Betula sp. are also recorded ** denotes 2 layers, *** 3 layers, **** 4 layers.**

NC 8363
NC 7161
NC 7164
NC 7255
NC 7361
NC 7740
NC 6844
NC 7057
NC 7161
NC 7164
NC 7262
NC 7354***
NC 7744
NC 8050
NC 9546
NC 9664
NC 9945
NC 9946
NC 9964
ND 0557
ND 0558
ND 0653
ND 0064****
ND 0852
ND 0858
ND 1131**
ND 2050
ND 2248
ND 2638
ND 2748
ND 2973
ND 3973

## APPENDIX 9

### The terms and equations used for each of the dendrochronological filters

Baillie and Pilcher (1973) 5-point filter

Baillie and Pilcher's (1973) *t* test is caluculated on "transformed" raw ring widths. Each raw ring width is converted to a percentage of the mean of the five ring widths of which it is the centre value. The data is then normalised by taking $\log_e$ of the percentage figures.

Fritt's (1976) 13-term low-pass filter

Weight number is expressed as values relative to the centre value to be summed:

| Weight number | Weight value |
|---|---|
| +6 | -0.0003 |
| +5 | -0.0030 |
| +4 | -0.0161 |
| +3 | -0.0537 |
| +2 | -0.1208 |
| +1 | -0.1933 |
| 0 | +0.7744 |
| -1 | -0.1933 |
| -2 | -0.1208 |
| -3 | -0.0537 |
| -4 | -0.0161 |
| -5 | -0.0030 |
| -6 | -0.0003 |

Fritt's (1976) 13-term high-pass filter

Weight number is expressed as values relative to the centre value to be summed:

| Weight number | Weight value |
|---|---|
| +6 | 0.0003 |
| +5 | 0.0030 |
| +4 | 0.0161 |
| +3 | 0.0537 |
| +2 | 0.1208 |
| +1 | 0.1933 |
| 0 | 0.2256 |
| -1 | 0.1933 |
| -2 | 0.1208 |
| -3 | 0.0537 |
| -4 | 0.0161 |
| -5 | 0.0030 |
| -6 | 0.0003 |

Munrow's (1984) 23-term 8-year cut-off filtered log widths

The weights for the filter are expressed as values 1 to 11

| Weight number | Weight value |
|---|---|
| $W_0$ | 0.250000 |
| $W_1$ | 0.220333 |
| $W_2$ | 0.146079 |
| $W_3$ | 0.061750 |
| $W_4$ | 0.000000 |
| $W_5$ | -0.025742 |
| $W_6$ | -0.023252 |
| $W_7$ | -0.010089 |
| $W_8$ | 0.000000 |
| $W_9$ | 0.003025 |
| $W_{10}$ | 0.001888 |
| $W_{11}$ | 0.000409 |

Munrow's (1984) 23-term 9-year cut-off filtered log widths

The weights for the filter are expressed as values 1 to 11

| Weight number | Weight value |
|---|---|
| $W_0$ | 0.222222 |
| $W_1$ | 0.200291 |
| $W_2$ | 0.143860 |
| $W_3$ | 0.075628 |
| $W_4$ | 0.019160 |
| $W_5$ | -0.012451 |
| $W_6$ | -0.020137 |
| $W_7$ | -0.014051 |
| $W_8$ | -0.005277 |
| $W_9$ | 0.000000 |
| $W_{10}$ | 0.001213 |
| $W_{11}$ | 0.000569 |

Munrow's (1984) 23-term 10-year cut-off filtered log widths

The weights for the filter are expressed as values 1 to 11

| Weight number | Weight value |
|---|---|
| $W_0$ | 0.200000 |
| $W_1$ | 0.183152 |
| $W_2$ | 0.138929 |
| $W_3$ | 0.083054 |
| $W_4$ | 0.032927 |
| $W_5$ | 0.000000 |
| $W_6$ | -0.013667 |
| $W_7$ | -0.013569 |
| $W_8$ | -0.007808 |
| $W_9$ | -0.002515 |
| $W_{10}$ | 0.000000 |
| $W_{11}$ | 0.000340 |

BH's 5-point tricube-weighted filter

Weight number is expressed as values relative to the centre value to be summed:

| Weight number | Weight value |
|---|---|
| -2 | -0.1001 |
| -1 | -0.2564 |
| 0 | 0.713 |
| +1 | -0.2564 |
| +2 | -0.1001 |

BH's 9-point tricube-weighted filter

Weight number is expressed as values relative to the centre value to be summed:

| Weight number | Weight value |
|---|---|
| -4 | -0.02 |
| -3 | -0.0833 |
| -2 | -0.1417 |
| -1 | -0.1686 |
| 0 | 0.8272 |
| +1 | -0.1686 |
| +2 | -0.1417 |
| +3 | -0.0833 |
| +4 | -0.02 |

BH's 13-point tricube-weighted filter

Weight number is expressed as values relative to the centre value to be summed:

| Weight number | Weight value |
|---|---|
| -6 | -0.0063 |
| -5 | -0.0317 |
| -4 | -0.0664 |
| -3 | -0.0965 |
| -2 | -0.115 |
| -1 | -0.1224 |
| 0 | 0.8766 |
| +1 | -0.1224 |
| +2 | -0.115 |
| +3 | -0.0965 |
| +4 | -0.0664 |
| +5 | -0.0317 |
| +6 | -0.0063 |